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***Abstract*— Increasing requirement for sustainable resources in a variety of applications, considerable attempts have been made to create lightweight, biodegradable, and renewable composites that reduce greenhouse gas emissions. They are all plant fibers and share certain characteristics, including the fact that they all produce highly nutritious seeds and have lengthy, durable fibers. Natural fibers reinforced with biopolymers obtained from either plant or animal sources have been recycled since ancient times to meet eco-friendly social needs such as clothing, handicrafts, composites, carrier bags, biodynamic agriculture, automotive, and textiles. Because of the extensive use of synthetic fibers, the use of natural fibers has declined substantially since the turn of the century. Natural Plant-based fibers include nettle, hemp, flax, cotton, coir, jute, kenaf, sisal, pineapple, banana, bamboo, etc. Natural plant fibers are mostly made of cellulose, which can be found in hillsides, former plantations, and wastelands. The fiber surface treatment (retting) process enhances the dissolution of the components that hold fibers together (primarily pectin, hemicelluloses, and lignin), which is a prerequisite for getting fibers suitable for use in the textile industry. Water, dew, chemical, and enzymatic retting procedures were used to remove natural fibers from raw materials. This paper proposes different categories of ecological surface treatment for natural fiber biodegradability, an approach aimed at promoting high-value-added natural products. The chemical retting method pollutes the environment and causes skin problems that affect human health, so we review the natural methods of surface treatment like fungi, bacteria, and enzymes.**

Keywords— Natural Plant fiber, Biodegradable, Cellulose, Retting process, Bio-composites, Textiles

I. INTRODUCTION

Since environmental concern and the drive for economic development have grown in recent years, regular strands are more important than ever as plant fibers in polymer composites alter synthetic fibers like glass. In this fiber surface treatment, the textile industry employs a wide range of chemicals, including poisonous, non-biodegradable, and carcinogenic dyes that pose serious environmental and human health dangers. Natural fibers from plants are simply fibers created by plants and animals rather than by humans or synthetic materials. Natural fibers formed from plants are well known, depending on their origin, and due to increased environmental concern, the creation of advanced materials manufactured from natural fibers or eco-friendly composites has remained a hot topic in recent years. Natural plant fibers provide low density, low cost, long-term availability, unrestricted use, and low scratchiness. Natural fiber-reinforced composite (NFRC) materials have recently been used to make components such as cylinders [1]. Natural plant fibers are also CO_2-neutral, environmentally friendly, and biodegradable. An excellent natural process can also be performed to boost their strength. Many investigations have been carried out to examine whether natural fibers generated from plants can improve polymer composites. Natural plant fibers can be employed in very tiny aggregated amounts, and there is substantial research and effort underway to identify new applications with higher aggregated pricing, such as material composite strengthening. Because of their compressive qualities, NFRC materials are also finding use. On the other hand, investigations completed up until now have proven that natural fiber is not always a powerful strengthening agent for polymer matrix composites. Non-stop filaments are available in a variety of fibers for use in high-overall-performance composite materials, including aramid fiber, glass, and carbon [4]. Many of the biologically active photochemical values are obtained from natural fiber products obtained from plants with their own medicinal properties, which can be found in barks, leaves, roots, and plant flowers. The plant-source natural fiber concentration (1.1–1.8 grams/ cubic cm) is less dense about plant fiber (2.3 grams/ cubic cm), allowing for production of frivolous compounds. As a result, the demand for natural fiber-based material in the industrial field and a range of commercial sectors may increase [2]. As a result, the use of natural fibers instead of composite reinforcement materials is gaining popularity. Plant fibers are a broad category that can refer to a variety of various goods. The fractions produced from the initial transformation of the stems or straws are short or long fibers and aggregates for specialized crop plants like flax and hemp. It is possible to create progressively complicated materials, from basic fibers to final applications like composites, through a series of consecutive changes. In recent years, composites have found

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widespread application in the aviation sector. The aerospace industry has generally employed two types of fiber-reinforced materials: glass/phenolic composites and carbon/epoxy composites. Composting and landfilling are two methods that contribute to global warming. As a result, reusing trash from renewable sources for commercial purposes can help reduce the rate of global warming. Glass/phenolic composites are employed in cabin furnishings, while carbon/epoxy composites are usually found in heavy-duty structures [3].

II. Properties of Natural Plant Fibers

A. Natural Fibers Classification

First, Natural fibers have been separated as triclasses. Plant, animal, and minerals. Plant fibers are essential types of natural fibers that contain cellulose, hemicelluloses, lignin, and pectin in abundance. Natural plant fiber composites (NFC), which are being 78 produced in India, are being touted as a low-cost fabric for the introduction of automobiles and textiles. Cellulose fibers are primarily included in production of paper and fabric. Plant fibers are classified as leaf fibers, seed fibers, bast fibers, stem fibers, wood fibers, and stalk fibers. Bast fibers are gathered from the inner bark, or bast, that surrounds the plant's stalk. These fibers are stronger than other plant fibers in terms of tensile strength. As a result, these fibers are used in the production of strong yarn, packaging, cloth, and paper. This can be classified, as shown in Fig. 1. Natural plant fiber, extracted from the plant's bast, has long been used as a substitute for jute, kneaf, and nettle. The fiber from kenaf, jute, and nettle is the major reason they are grown in Asian countries; the fiber is extracted by soaking the stalks (a process known as retting) and then physically extracting the fibers. This method has been found to generate higher reinforcement quality. kenaf fiber is that it has nearly twice as much useful fiber recovered from the stalk than jute, hemp, or flax—up to 40%. In comparison to other plants, the fiber is more economical due to its output percentage. In addition, kenaf plants mature from seed to a height of 3.6–4.3 meters (12–14 feet) in under a six-month period.

Natural fibers come in a variety of types after being processed and removed, including discontinuous, particulate, and continuous. On the basis of rudimentary microscopic analyses, ancient fabric samples have frequently been diagnosed as flax. The introduction of commoners like styrene could significantly improve the mechanical characteristics and processability of AESO resins, prompting the growth of Biocomposite materials based on styrene-AESO resin and NFs. Moreover, new methodologies for recognizing and analyzing ancient plant fiber samples are already being developed. Resin acts like folder, maintaining the fibers of applied stress, keeping them separate as entities, protecting the supporting yarn from motorised damage, transmitting masses. Composites used in structural applications are designed and manufactured differently than those used in non-structural applications, which are primarily concerned with aesthetics Natural fibers provide the mechanical qualities [hardness and strength] needed for the composite. The SEM photographs examine the microstructure of the sample's fibers and surface modifications after the retting process. Another important aspect influencing composite qualities was the composition of the resin matrix As a result, the composite can withstand shear, compression, and flexural stress [4].

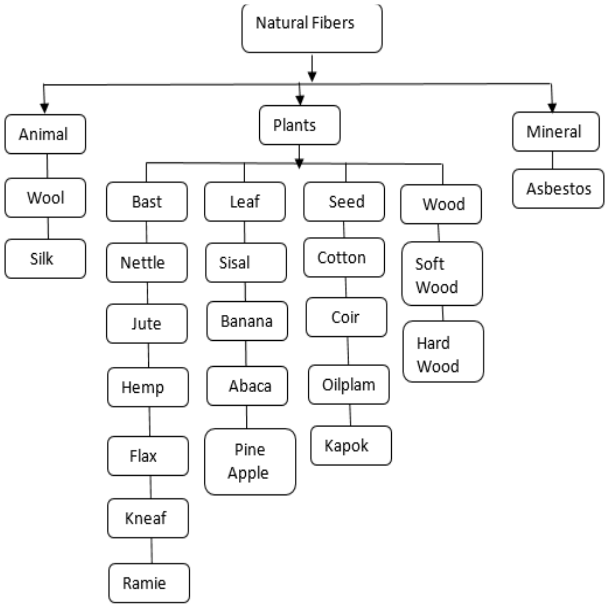

Fig. 1. Organization structure of Natural Fibers.

B. Applications of Natural Fibers

Water retting process water is high in chemicals and is occasionally used as liquid fertilizer after being treated to remove hazardous toxic substances. This research explains the primary precept of various styles of composite substances and their direct and oblique impacts on fabric elements, together with the period of fiber. For measuring the performance of spun fabric constructed from composite yarns, diffusion rate, water concentration capacity, and drying percentage were all taken into account. Bamboo is a type of grass belonging to the Bambusoideae family and is composed of cellulose fibers encased in a lignin matrix. Bamboo has the ability to fix atmospheric carbon dioxide and is rigid, inexpensive, strong mechanically, rapidly reproducing, and light in weight. Similarly, many other car manufacturers began to follow in the same footsteps. Natural fiber-primarily based total composites maintain their first-rate capability, specifically in the automotive industry, where research has mentioned. Natural fiber-reinforced composite substances are normally applied to indoor elements like door panels, backrests, dashboard components, seat cushions, parcel shelves, and cable linings. Because of the high demand for mechanical energy, applications outside are limited. Creating fashions for this type of data may be quite genuine, and no additional data processing is required [7]. Natural fibers have several applications, including structural composites, vehicles, non-structural composites, geotextiles, packaging, molded goods, sorbents, filters, and material combinations. In the development, fabrication, and assessment of structural beams and panels, bio-based composite materials such as plant oil-based resins and natural fibers were used. The undesired smooth tissue records are eliminated earlier than they are dispatched to a speedy prototyping system for fabrication. This process may be a frightening assignment for complicated shapes, and one has to copy the process frequently until the best result is achieved. Also, this paper describes speedy tooling methods that have been mentioned in motorcycle helmet protection layout studies through reading market studies on the consequences of bike helmets Mirrors, visors, seat coverings, indicator covers, L-side covers, and name plates were just some of the many automotive parts made using hybrid composites of sisal and roselle fiber. This natural fiber proposes an improved motorbike helmet protection layout after discussing helmet function, ergonomics, shape, substances, color, and lots of other characteristics [5].

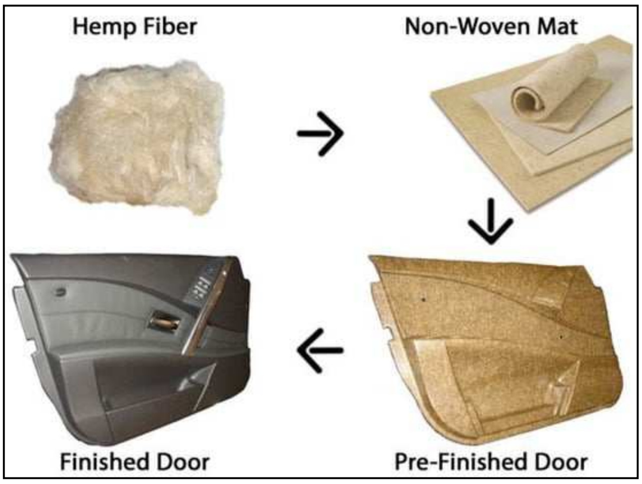

Fig. 2. Natural fiber applications in the automotive industry.

C. Plant-based Fiber structure

Fig. 3a shows how the cell walls of the maximum plant source fibers can be crushed by crushing the stem or wool. Fig. 3b depicts a schematic diagram of a native plant's cell wall, which is commonly referred to as a "microfibril." A hollow tube with four layers—a main cell wall, three subordinate cell walls, and a tubule—makes up the cell wall. A lumen is an open channel in the microfibril's middle. Each cellulose layer is encased in a hemicellulose and lignin matrix. Fig. 3c shows how microfibrils are made up of crystalline and amorphous areas. The design of filaments, as well as their synthetic organization, is heavily influenced by the stage of the plant, environmental conditions, and fiber handling strategies. Cellulose is hydrophilic since it contains hydroxyl bunches. Light, heat, water, and mineral salts are all directly tied to plant growth. Flax and hemp serve as carbon sinks because they synthesize their carbonaceous skeletons by absorbing ambient CO2 and using it to produce glucose through photosynthesis. The risk of nitrates leaching into the soil is reduced when they are planted in the spring because they require very little soil preparation and no irrigation at all for their growth. They also require far less nitrogen fertilization than cereals do. Also, they are rather simple to harvest [5]. The moisture content of plant-based fibers could range from 8–12.6%. Cellulose is a highly transparent, glass-like material that covers up to 80% of translucent areas. The cellulose microcrystalline scheme includes high-request transparent districts (higher pressing thickness) that are widely scattered across the fiber as well as lower-request formless locales (lower pressing thickness). Cellulosic links are formed in micro-fibrils with diameters ranging from 2 to 20nm. Hemicellulose is made up of a variety of sugar units. It's also a highly expanded polymer (distinguishing itself from direct cellulose) with a polymerization frequency 10–1000 times lower than cellulose. Lignin is a polymer of phenyl-propane units that is indistinct, perplexing, and essentially sweet-smelling. Lignin serves as a protective barrier for cellulose by solidifying cell dividers. Lignin's capability makes it an essential platform material in plants. Lignin, cellulose, and hemicelluloses Cellulose is hydrophilic since it contains hydroxyl groups. Plant-based fiber may have a moisture content of 8–12.6. Cellulose is a highly transparent, glass-like material that covers up to 80% of translucent areas. The cellulose microcrystalline scheme includes high-request translucent districts [higher pressing thickness] that are widely scattered across the fiber as well as lower-request formless locales [lower pressing thickness]. Hemicelluloses are made up of a group of highly concentrated polysaccharides, such as galactose, and xylose, that are connected to the cellulose after the gelatin has been removed. Lignin is a polymer of Phenylpropane units that is indistinct, perplexing, and essentially sweet-smelling. Lignin serves as a protective barrier for cellulose by solidifying cell dividers. Lignin's capability makes it an essential platform material in plants [6].

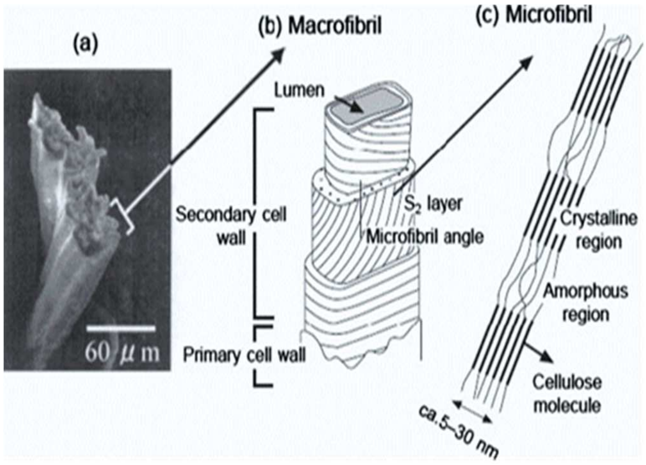

Fig. 3. (a) Schematic representations of a kenaf bark Fiber, (b) microfibrils (c) microfibrils of the natural plant .

III. RETTING PROCESS EFFECTS ON THE FIBER SURFACE

The surfaces of natural fibers have been altered through the application of chemical and biological techniques. According to recent studies, it has been shown that sisal and hemp fibers have the ability to generate cellulose nanofibrils on their surfaces through the process of bacterial cellulose fermentation, as illustrated in Figure 3. The adhesion of natural fibers to polymeric matrix, such as polylactic acid and cellulose acetate butyrate, was seen to be significantly enhanced following treatment with approximately 5-6% bacterial cellulose. The development of a novel surface modification procedure has led to the creation of an advanced generation of natural fiber composites that exhibit enhanced fiber/matrix interactions. The non-cellulosic components of the fibers are eliminated through the process of alkaline treatment. The increase in tensile modulus may not be greatly influenced by the extent of removal of non-cellulosic constituents. The addition of nanoclay to epoxy composites reinforced with banana fiber results in a 25% increase in Young's modulus. Numerous synthetic and natural fabrics have been subjected to chemical treatment in order to enhance their durability or enhance their visual appeal. Certain chemical treatments, such as the alkali treatment seen in Figure 4, have been empirically demonstrated to significantly enhance the mechanical properties of natural fibers by the modification of their crystalline structure and the elimination of vulnerable constituents such as hemicelluloses and lignin. A commonly used method for chemically altering natural fibers is alkaline treatment. By altering or dissolving the hydrogen bonds that keep the entire system structure together, the alkaline treatment significantly improves surface roughness [10].

Fig.4. Water retting process of bast fiber

The modulus of nano clay-infused banana fiber-reinforced epoxy composites is seven times greater than that of untreated bamboo fiber-reinforced epoxy composites. The reinforcing effect of nanoclay is significantly greater in flexural mode than in tensile mode. We treated the outside of lignocellulosic fibers to make the bonding between them better and stop them from absorbing too much water. Such alterations are accomplished through biological, physical, and chemical means. Fig. 4 shows the SEM micrographs of the fiber surface and diameter of the treated and untreated single nettle fibers. Surface imperfections are clearly visible on the untreated nettle fiber surface. According to different sources, the alkaline treatment mostly employs NaOH solution and has a few notable impacts on fiber. It initially changes the fiber structure by increasing surface roughness. Raising the surface area or roughness of the matrix and fiber will increase mechanical interlocking. Following that, the cellulose on the fiber surface is exposed as a result of the alkaline treatment, increasing the number of possible reaction sites. When water seeps into the stem's core and tears the outer layer off harvested plants, it causes water retting. In aquatic environments like lakes, ponds, tiny streams, or artificial water tanks or vats, microorganisms present in the plant stem aid in the degradation of big cellular tissue, pectin, and other gums around the fibers [8].

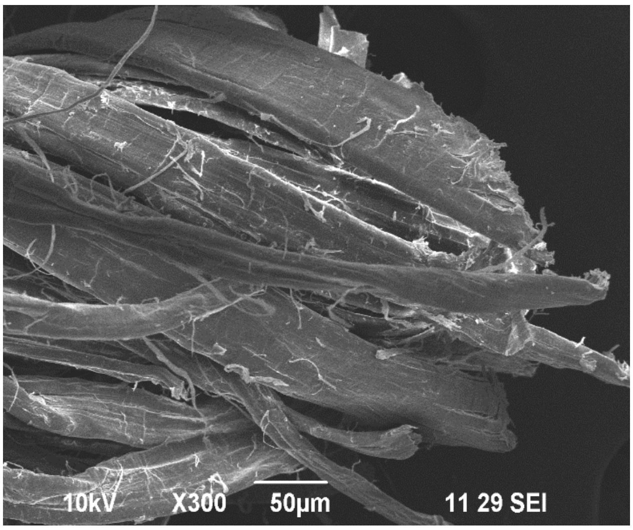

Fig.5. SEM images of fiber after surface treatments.

When water seeps into the stem's core and tears the outer layer off harvested plants, it causes water retting. When a plant is immersed in water, such as in natural bodies of water like lakes, ponds, or small streams, or in man-made containers like water tanks or vats, microorganisms present in the plant's stem initiate the degradation of the plant's major cellular tissue, specifically pectin and other gums that surround the fibers. Natural Fiber properties

A. Chemical Properties and Compositions of Natural Fibers

The chemical composition of natural fibers exhibits significant variation depending on the type of fiber and its source. The features of each constituent exert an influence on the fundamental characteristics of the fiber. It is obvious how diverse the chemical makeup of different plants is from one another and within the unique portions of the same plant. Cellulose and hemicellulose, the two most abundant sugar-based polymers when dried, make up the bulk of cell walls. Table 1 displays the chemical composition of a selection of commonly used natural fibers. Natural fibers evolved from logically continuous chemical composites, which typically consisted of helically coiled cellulose microfiils encased in an amorphous lignin matrix. As illustrated in Fig. 5, the basic components of natural plant fiber are cellulose, lignin, hemicellulose, pectin, and waxes. The internal semi-cellulose of natural fibers appears to be compatible with both lignin and semi-cellulose. Lignin, due to its low resistance, is accountable for the thermal breakdown, absorption of moisture, and biodegradation of the fiber. Nevertheless, lignin has high thermal stability and plays a significant role in the degradation of ultraviolet (UV) radiation. It entails fractionating the lignocellulosic biomass fibers using neutral and acid detergents and measuring the dry, insoluble fibers recovered after filtration using gravimetric [9].

Non-structural polysaccharides, pectins, gums, mucilages, tannins soluble at neutral pH, lipids, proteins soluble in neutral detergent, and certain ashes can be extracted. Chemical retting is costlier and no longer produces the advanced fine fiber. The sisal treated with NaOH, there is a five percent increase in fluid transference within the plant. The chemical remedy advanced the thermal balance of the weight reduction process with a temperature range of 15°C to 12°C, and sisal was handled with NaOH at 10% at approximately 18°C. Additionally, when evaluating composites, sisal fiber performed well. In its unprocessed state, it was additionally found that there was a distinction. A composite material containing 10% sisal treated with NaOH composite reinforcement and unprocessed sisal reinforcement was created. The chemical compound phenylpropane. The composite material used in this research was strengthened with 10% sisal fibers and then treated with NaOH for added durability. It is a linear polymer chain made up of D-glucopyranose devices that are coupled together by The stretching of the carbonyl (C=O) group is observed in semi-cellulose and lignin, leading to the formation of acetyl and aldehyde functionalities, respectively. The capacity to generate crystalline structures, along with other intriguing physical attributes, is facilitated by the hydrogen bonding that occurs between the specific macromolecules, namely hemicellulose and lignin. Their Fourier-transform infrared spectroscopy (FTIR) has a scan rate of 32 scans per minute and a wave number range of 400 to 4000 cm1. Various bands were obtained: the band at 3400 cm1 was assigned to cellulose, the bands that appeared at 1740 and 1510 cm1 were associated with lignin, and the band at 1612 cm1. Furthermore, the FTIR spectra of acetylated flax showed a considerable improvement in the O-H bands. They came to the conclusion that both treatments boost interfacial strength due to effective O-H bonding [10].

TABLE 1. THE CHEMICAL COMPOSITION OF NATURAL PLANT FIBER.

Fibers	Cellulose [%]	Hemi cellulose [%]	Lignin [%]	Pectin [%]	Moisture [%]	waxes	Micro fibril angle[°]
Flax	70-73	18.6-20.6	2.2	2.3	8-12	1.7	5-10
Hemp	70-75	17.9-22.4	3.7-5.7	0.9	6.2-12	0.8	2.62
Nettle	70-82	11-14	9-10	1.3-2.12	-	0.5-1.3	-
Jute	61.0-70.4	12.5-21.2	11-12.5	0.5	11.3-12.5	0.7	7
Kneaf	30-38	20.6	14-18	4-6	10	0.5	6.5
Ramie	67.5-75.3	12.0-15.6	5-6.7	1.8	7.2-15	0.4	6.4
Sisal	65-77	11-13	11.5-13	9	11-20	3.1	9.8
Banana	64-66	7-18	4-9.5	3.5-5.2	8.2	0.8	6.6
Cotton	84-91	6.2	1-2	6.75-7.9	0.5	0.71	9.8
Coir	31-42	11.0-13.7	41-46	2.9-4.5	8.1	31-48	7.1

B. *Mechanical and Physical Properties of natural Fiber composites*

Fiber-supported composite materials' mechanical and physical properties depend on how the fiber is attached to the polymer network, the type of fiber used, how its volume is divided, how it is oriented, and how it is latched. Natural filaments often have poor mechanical properties when compared to their manufactured equivalents. Table 2 shows the mechanical properties of several prominent natural plant fibers. The fiber volume component typically determines the mechanical properties of common fiber composite materials. The increased fiber content improves the mechanical characteristics of the composite. Furthermore, the most extreme volume partition is represented by the fiber orientation and bundling readiness of normal strands. Researchers have been working hard for decades to develop a composite material made from natural fibers as a replacement for carbon fiber because of its harmful effects on the environment. This replacement option needs to be cheap to produce while also being environmentally friendly, readily available, recyclable, and renewable. The purpose of the research was to examine the mechanical characteristics and water absorption behavior of a composite material called a nettle/bamboo hybrid natural fiber reinforced polymer (NFRP). Loads are transferred to the defining filaments via shear stresses at the fiber-network interface. Mostly, a solid interfacial bond conveys high strength. The Archimedes Test with canola oil as a submerged fluid is a simple and successful method for determining fiber density in general. Interfacial strength is important if stresses are to be moved The chosen materials are appropriate for the filaments and provide them with necessary functionality. The occurrence of fiber pull-out and energy retention can be attributed to the heightened susceptibility of interfacial connections. The point at which the lattice is likely to fracture under a load is contingent upon the interfacial bond between the network and the fiber, which ultimately determines the effectiveness of the pressure-transfer mechanism from the lattice to the fiber.

As a regular outcome, the expansion of strands, paying little heed to the fiber plan and the sort of stacking of fiber. On the other hand, the diverse fiber course of action influenced the pliable and flexural strengths similarly. The properties of natural fiber composites are improved by customizing them through various chemical treatments. These ideas inspired the creation of a number of hybrid composites reinforced with natural fibers and filler components. The diameters of selected fibers were then measured under a microscope using a calibrated eyepiece with a magnification of 100 times [7].

TABLE 2. THE CHEMICAL COMPOSITION OF NATURAL PLANT FIBER.

Fibers	Density [g\cm3]	Young's Modulus[GPa]	Tensile Strength [MPa]	Elongation at break %
Bamboo	0.5-1.0	12-16	141-231	7-10
Abaca	1.25	12	400	3-10
Flax	1.55	27.4-86	345-2000	1.2-3.8
Hemp	1.48	18-71	370-800	1.5
Jute	1.45	11-31	395-775	1.6-1.8
Kneaf	1.32	15-52	239-929	1.7
Nettle	1.49	23.9-79	564-1655	2.0-2.6
Ramie	0.6-1.47	26-119	395-950	1.4-3.9
Sisal	1.35-1.6	8-21	360-710	3-6.5
Pine apple	0.8-1.6	1.44	400-627	14.5
Coir	1.2	4-6	175-225	3.0
Banana	1.4	7-20	500-700	-

IV. CONCLUSION

Natural plant-sourced fibers Polymeric composites are an effective way to improve component quality in terms of atmosphere, cost, and technological feasibility. The physical and mechanical properties of natural fibers were tested using numerous matrix combinations, with the strongest grouping matrix consisting of hemp, sisal, nettle, flax, bamboo, kneaf, and jute. A plant-based natural fiber has been suggested as a replacement for carbon fiber-reinforced polymers. This study found that the combination of cellulose and hemicellulose in these composites has a significant impact on their mechanical properties. Other parameters that influence the mechanical properties of composites include fiber diameter, fiber length, fiber content, and production procedure. Natural fibers are being studied as an additional material in concrete structures to increase strength, resilience, and load-carrying capacity. Currently, green composites can be manufactured at a reasonable cost and have mechanical properties comparable to those of non-biodegradable composites, allowing for a balance of ecology, economy, and technology. Mechanical strength and durability are needed by these various industries, such as automobiles, furniture, textiles, aerospace, and crafts. The utilization of recycled materials not only contributes to environmental sustainability but also helps to minimize carbon dioxide (CO_2) emissions. By substituting plant-based natural fibers for petroleum-based composites in binding agents in polymeric, cement, and matrix products, customers can reap benefits.

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