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A Comprehensive Review Article on Natural Fiber Polymer Composites

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Abstract:

Natural fibers (NFs) have notably piqued the interest of professionals in the field due to the significant benefits they offer over traditional reinforcing agents, and the advancement of natural fiber composites has become a widely researched topic. Natural fibers do have a promising future as reinforcing materials in polymer composites (PCs) (thermoplastics, thermosets and elastomers). Natural fibers have become more popular in composite materials as lightweight, minimal price, and environmentally preferable alternatives to synthetic fibers. Due to a variety of factors, such as increased environmental problems and prolonged resource sustainability, reusability, biocompatibility, and weight-specific performance, natural fibers are becoming more popular as reinforcement material for polymer composites (PCs). The advancement of natural fiber reinforced polymer composites (NFRPCs) has had a significant impact on polymer composite technology and development in the last decade. NFPCs are gaining popularity as a result of their tremendous benefits, including minimal cost, biodegradability, eco-friendliness, and comparatively excellent mechanical characteristics, as well as focus on the environmental sustainability aspects of engineering materials. Moreover, because of the obstacles in industrial production, inadequate information of its machinability, relevant parameters, and the risk of machining-induced discrepancies, industrial use of NFRCs remains a challenge. This article addresses various processing techniques of NFPCs, properties, particularly mechanical properties, and applications. Some major challenges in manufacturing NFPCs and drawbacks of natural fibers have also been discussed.

Keywords: Natural Fiber, Polymer Composites, Natural Fiber Polymer Composites, Reinforcement

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Introduction:

The creation of innovative materials that improve the efficient consumption of natural resources, especially renewable resources, is gaining popularity. Natural fiber is a new era of reinforcements as well as supplements for polymeric products made from renewable origins[1], [2]. Due to rising environmental concerns, the research on natural fiber composite materials or ecologically friendly composites has become a popular topic in recent times[2]–[4]. Natural fibers are one such capable material that can be used to replace synthetic materials and their related goods in applications that require less weight and energy[5], [6]. Numerous traditional metals/materials have already been replaced by polymers in a variety of applications during the last few decades, due to the overall advantages of polymers over traditional materials[7]. The convenience of processing, performance and efficiency gains are the most significant benefits behind using polymers[8]. To meet the necessary strength/high modulus specifications, the characteristics of polymers are amended using fillers as well as fibers in many of these application areas[9], [10]. NFPCs and natural resins are increasingly being used to replace conventional synthetic polymer composites (SPCs) or glass fiber reinforced polymer composites (GFRPCs)[8], [9], [11], [12]. Aerospace, marine, civil construction and automobile companies have already been constantly manufacturing distinct types of natural fibers for internal components, primarily hemp, flax, as well as bio-resins systems[13]–[16]. Natural fiber composites are appealing for a variety of applications due to their high specific characteristics and affordable pricing[5], [6]. Natural fibers will play a significant role in the arising "green" economy, which is centered on energy efficiency, by the use of renewable sources in polymeric composites, industrial processing that reduce carbon footprint, and waste-recyclable materials[7], [8], [12].

NFPCs have a unique combination of properties that make them ideal for a wide range of industrial applications[17], [18]. Natural fibers have often been plentiful around the world. When compared to synthetic fiber, it has distinctive properties and uses less plastic. NFPCs are now becoming able to compete with all other synthetic polymer composites in terms of mechanical properties and price; tensile, flexural and impact strength values are nearing synthetic values[9], [12]. The main benefits are its higher strength and rigidity, as well as its less density, which enables a reduction of weight there in the final component when compared to bulk counterparts. Natural fibers are popular today because of their environmental benefits[8], [10], [12].

However, natural fibers have a high moisture sensitivity, which is one of their biggest drawbacks[1], [19]. The incongruence of fibers and weak moisture resistance frequently reduce the scope of natural fibers in the improvement of these composite materials, and all these downsides become a major issue[11], [20], [21].

Natural fibers can be divided into three major types according to their source of origin;

1. **Mineral Fibers –** Mineral fibers are fibers derived from minerals that are either found naturally or have been slightly altered. Asbestos, ceramic, and metallic fibers and some inorganic whiskers are some of the mineral fibers known[13], [22].

2. **Plant Fibers –** Plant Fibers like sisal, hemp, bamboo, coir, flax, kenaf, and others, as well as animal origin such as wool, silk, and chicken feather Fibers, can all be used to make natural Fibers. Natural Fibers are classified into seven groups based on the component of the species from which they have been extracted[4]. Natural Fibers have historically been harvested and utilized extensively for quasi uses, as well as for housing purposes such as roof covering and wall insulation[13]–[15], [23].

3. **Animal Fibers –** These fibers can be subdivided into 2 types wood and silk. Animal fibers have notably gained considerable interest as a reinforcing agent for composite materials, especially traditional animal fibers like silk and wool[4], [24]. Animal fibers have attracted attention due to their unique characteristics, which include surface hardenability, flexibility, a high aspect ratio, as well as lower hydrophilicity than other natural fibers[12], [17], [20].

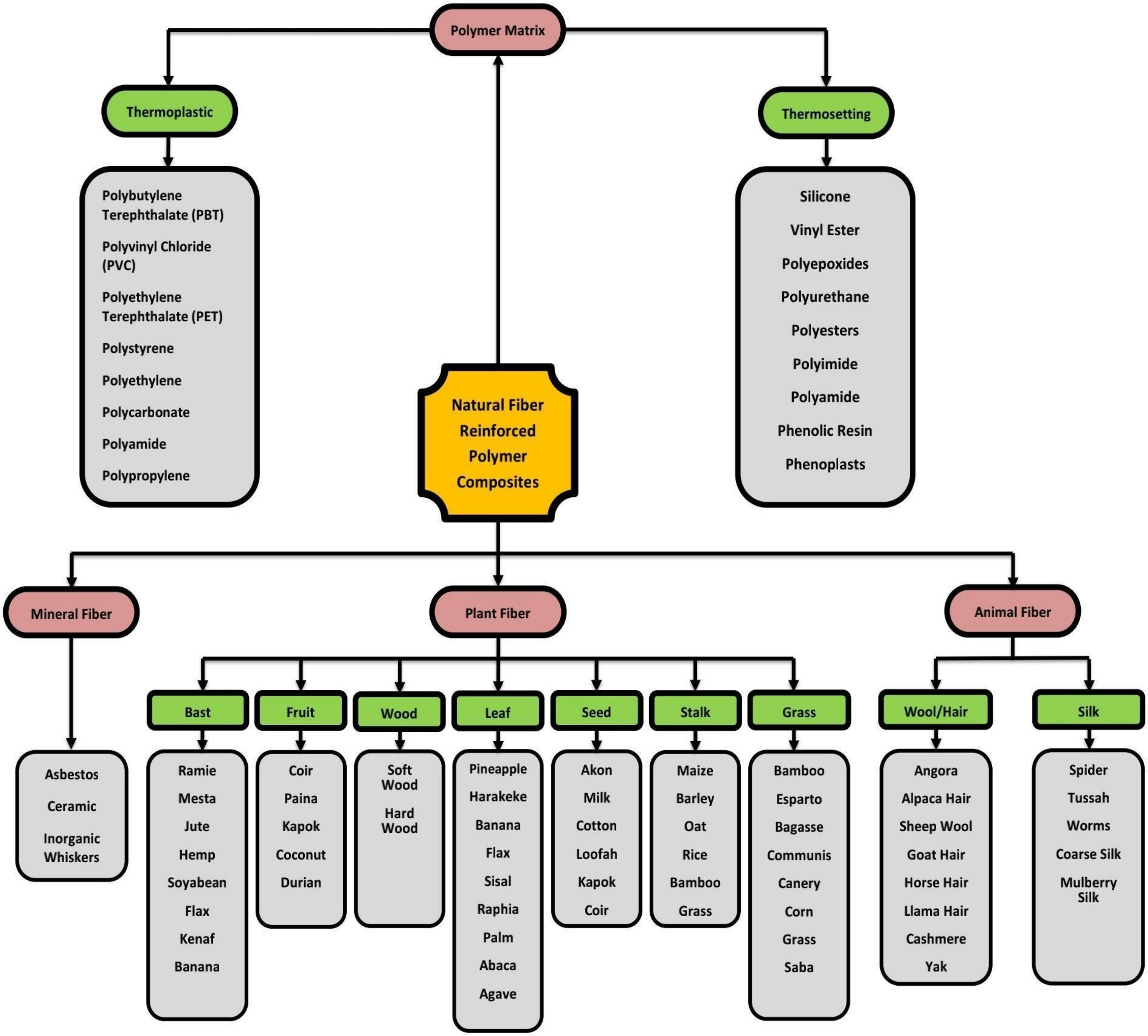


Fig 1 – Classification of Natural Fiber Reinforced Polymer Composites

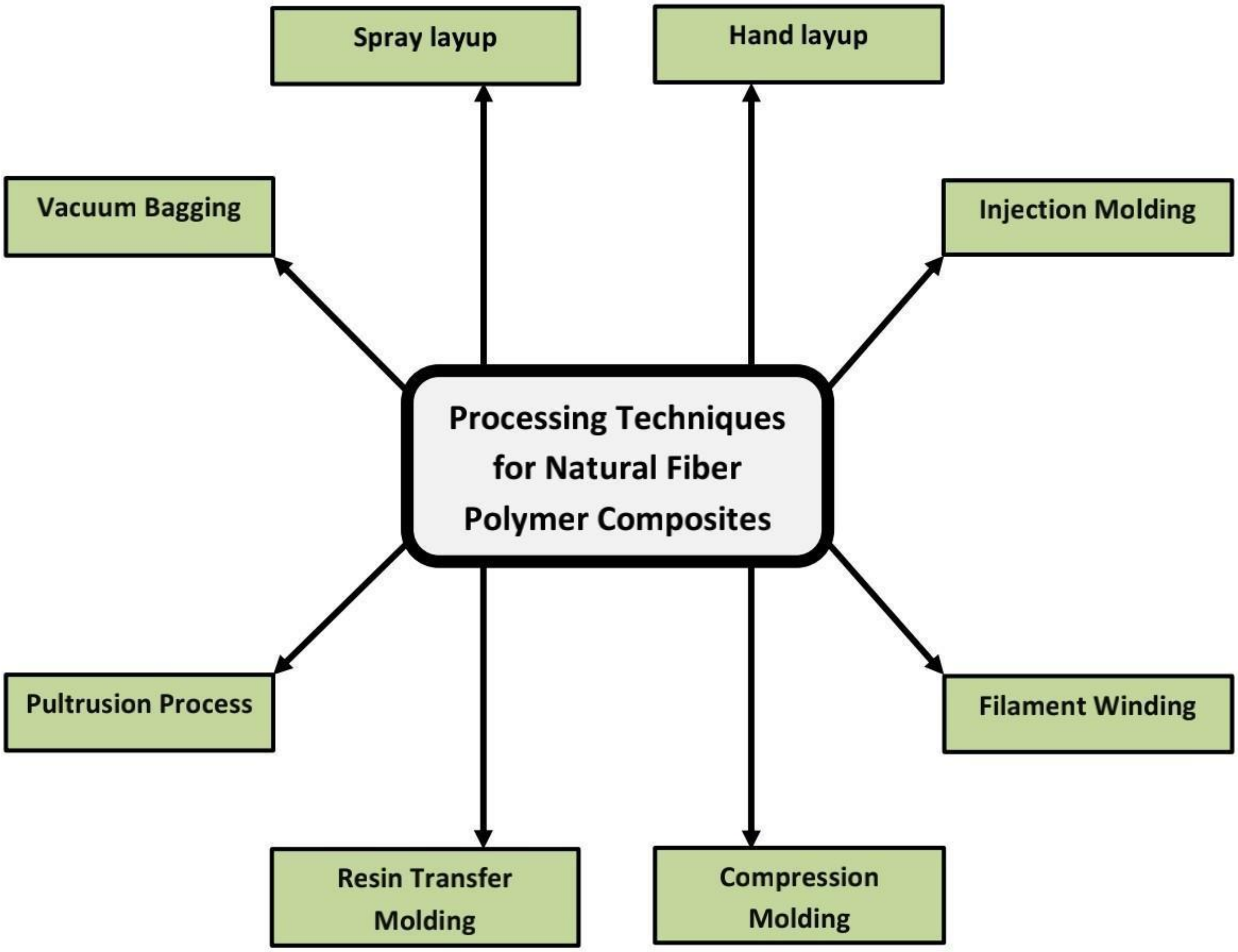


Fig 2 – Processing Techniques of NFPC

Table 1 - Name of the Processing Technique and Type of Natural Fiber Polymer Composite Manufactured

Sr. No.	Name of the Processing Technique	Type of Natural Fiber Polymer Composite Manufactured
1.	Spray Layup Process	• Nano Silicon Dioxide and Different Flax Structures • Coconut Sheath Fiber Reinforced Epoxy Composites • PLA-Based Green Composites • Sisal and Jute Fiber Composites • Development Of a Kraft Paper Box Lined with Thermal-Insulating Materials by Utilizing Natural Wastes
2.	Hand Layup Process	• Calotropis Gigantea Fruit Fiber Reinforced Polyester Composites • Banana Fiber Reinforced Polymer Composites • Hybrid Glass Fiber- Sisal/Jute Reinforced Epoxy Composites • Sisal–Jute–Glass Fiber Reinforced Polyester Composites • Bi-directional Jute Fiber Epoxy Composites • Natural Fiber Reinforced Soya-Based Polymer Composites • Hybrid Glass-Sugar Palm Fiber Reinforced Unsaturated Polyester Composites
3.	Compression Molding	• Short Natural-Fiber Reinforced Polyethylene and Natural Rubber Composites • Jute Fiber Reinforced Composites with Polyester and Epoxy Resin Matrices • Banana/Sisal Reinforced Hybrid Composites • Kenaf and Thermoplastic Polyurethane • Natural Fibers as Reinforcement in Polylactic Acid (PLA) Composites • Sugarcane Bagasse Fibers Reinforced Polypropylene Composites
4.	Filament winding	• Cellulose Aceto-Butyrate (CAB) And Natural Rubber (NR) Reinforced with Renewable Polymer Matrices • Ramie Fiber Yarn Reinforced Composites • Jute Yarn-Biopol Composites • Natural Fiber-Based Reinforcements in Epoxy Composites Processed by Filament Winding • Kenaf Fiber Reinforced Unsaturated Polyester Composite

5.	Injection Molding	• Woven Sisal Fibers and Natural Rubber Modified Epoxy Resin • Bamboo-Glass Fiber Reinforced Polymer Matrix Hybrid Composites • Vetiver–Polypropylene Composites • Sugarcane Bagasse Fibers Reinforced Polypropylene Composites • Polypropylene Reinforced Palm Fibers Composites
6.	Pultrusion Process	• Pultruded Kenaf Fiber Reinforced Vinyl Ester Composites • Hemp/Wool Fiber Reinforced Composite Rods Made by Pultrusion Process • Natural Fibers Reinforced Thermoplastics Made from Commingled Yarns of Polypropylene and Flax Fibers
7.	Resin Transfer Molding	• Hemp/Kenaf Fiber-Unsaturated Polyester Composites • Polyester/Natural Fiber Composites • Jute Fiber Nonwoven Mats Reinforced with Unsaturated Polyester-Styrene
8.	Vacuum Bagging	• Bagasse Fiber Reinforced Unsaturated Polyester Composites • Setaria Italic (Foxtail Millet) Fiber Reinforced Lapox L-12 Resin Polymer Composite • Jute, Sisal Fiber Reinforced with Epoxy Composite • Hemp and Bamboo Fiber Reinforced Epoxy Polymer Resin

1. Synthesis Methods for Manufacturing Natural Fiber Polymer Composites

1.1 Spray Layup

Spray layup is a hand mounding technique that is a continuation of the hand layup technique. For spraying up pressurized resin as well as reinforcement into the geometry of chopped fibers, this technique uses a spray gun. Spraying up of matrix as well as reinforcement material can be carried out at the same time or one after the other. For the removal of air trapped in the layups, a roller is rolled over the sprayed surface with some strain. Upon spraying to the desired thickness, the material is removed from the mold and the curing process is performed at room temperature[13], [17], [20]. Low viscosity resins are utilized in this process because mechanical properties are affected. This method is best for smaller batches. A good surface finish is obtained only on one side by this process. Manufacturing the material at a cheaper cost is possible by this method [19]–[21][6], [7].

1.2 Hand Layup Process

For decades, the hand lay-up, renowned as the wet lay-up, is the process that has been followed to create components by utilizing composites of natural fiber. It is a polymer composite product manufacturing technology that uses an exposed forging process. This is a labor-intensive procedure that necessitates the use of a highly-skilled operator to complete the production work. For ease of removal of final composite goods, a mold releasing agent is sprayed to the surface of the mold. The application of gel coat to the surface of the mold is the first step in the laying-up of a unit. It's a resin-rich layer with the goal of preventing fibers from sticking to the mold surface. After that, the composites are created by adding a fiber reinforcement and polymer resin to it. For composite solidification, a roller is utilized, and layer by layer building of the composites is carried out. This technique is repeated several times unless the desired thickness is achieved by adding further layers. Then the curing of the composites is carried out either at room temperature or by using an oven. The most regularly used thermosetting resins used in this process are vinyl ester, unsaturated polyester, and epoxy[13], [22], [25]–[27].

1.3 Compression Molding

Compression molding is another common process that is used for the manufacturing of composite structures with high volume, for example, Parts of Automobiles. Cold and hot moldings are the 2 types of compression molding techniques. A molding compound is typically used as an intermediate material in this technique for thermosetting matrices[1], [2]. It's a composite that's been partially cured. The thermosetting-based molding compounds, sheet molding compound (SMC) and bulk molding compound (BMC) are two of the most commonly used thermosetting-based molding compounds. Glass sheet thermoplastics (GMT) are commonly used as a molding compound for thermoplastic polymers[5], [6]. Preparation of composite pellets is usually carried out by employing an internal mixer as well as a twin-screw intruder. They are used to prepare specimens of the composites by compression molding at the laboratory level[25], [28], [29].

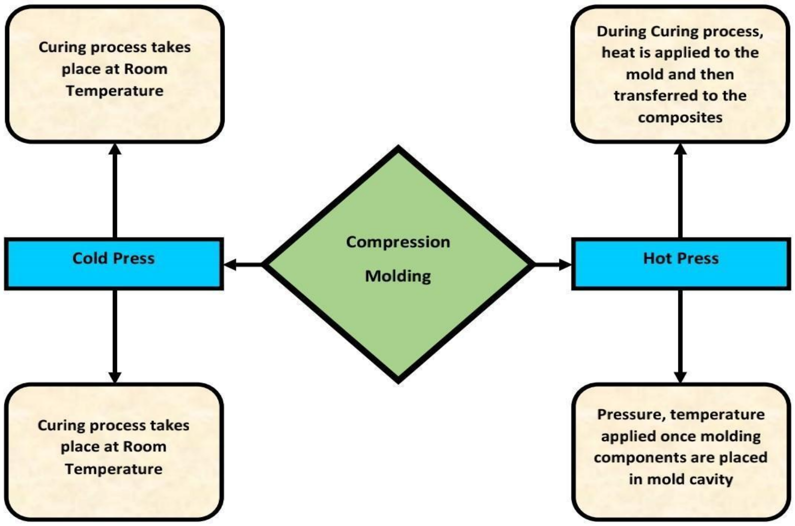


Fig 3 – Processes Involved in Compression Molding

1.4 Filament Winding

Filament winding is a process that is used for the manufacturing of composites used to create components with a circular geometry. The mold is actually a revolving mandrel; thus, it's deemed to be an open mold procedure. In this procedure, long fiber rovings are dragged throughout a resin bath by a puller[1], [30]. The pre-impregnated composites are twisted around the revolving mandrel one by one. Composites get traversed in the x-direction in order to ensure a homogenous distribution of composites throughout the mandrel. This process inculcates 3 types of winding patterns namely hoop, helical and polar windings[13], [25].

1.5 Injection Molding

Injection molding is amongst the most extensively used plastic component production processes. Polymer composite products can also be made with injection molding, however, the fibers used in the composites are short in the form of particles or powder. The twin-screw extruder is being used to make an injection molding compound (IMC) in the granular form. The granules are then pumped into the mold via a hopper and heated barrel. The IMC melted due to the shearing action of a reciprocating screw and the heating process in a heated barrel. To make a composite part, molten composites are injected into a mold. After that, the composite part is ejected from the mold. This method produces a good surface finish. This is appropriate for larger volumes. The tensile strength of this technique is lower than that of most thermoset systems[27], [28].

1.6 Pultrusion Process

The words "pull" and "extrusion" are combined to form the word "pultrusion," which refers to the process. Pultrusion seems to be similar when compared with extrusion, however, in this process pulling is preferred over pushing of the raw material across the die which is the case in extrusion. loops of fiber rovings or either tape of the same are pulled using a puller across the thermosetting polymer's resin bath. Epoxy, as well as unsaturated polyester, are some of the famous examples of thermosetting polymers which can be utilized in Pultrusion[30]. Finally, the emerging saturated fiber composites are drawn and processed through a succession of shaping dies after leaving the resin stream. The ultimate product's shape is dictated by the geometry of the dies' cross, which might be circular, rectangular, square, or other shapes. In one of the dies, the composite gets cured as well. Rods, as well as bars, are typical end products. The resultant products are trimmed to the desired lengths after the pultrusion is complete[29], [31].

1.7 Resin Transfer Molding

RTM is a well-known composite material processing method that is commonly used to create automotive and aerospace components. A dry preform of reinforcement fibers is inserted into a mold, which is then sealed. Resin injection is carried out. The near-net shape component is removed from the mold once the resin has cured. Fiber reinforcement, either long or woven, is first cut out with a template and a knife or scissors in this process. In the closed mold process, these reinforcements, known as performs, are bound with a thermoplastic binder and then placed inside the mold cavity[30], [32]. Resin is injected into the mold cavity using a variety of methods, including pressure and vacuum. Polyester, epoxy, vinyl ester, and phenolic resins are commonly used in this process. RTM is distinct as it differs from other composite manufacturing processes that involve long-distance resin flow through the pore space between the fibers of reinforcement[25], [33], [34].

1.8 Vacuum Bagging

One of the techniques in the class of prepreg molding process is vacuum bagging. Autoclave molding is a different method. The way by which the method of curing is carried out distinguishes the 2 processes. In one process, it is done in a vacuum bag (oven), while in the other process, it is done in an autoclave. In order to apply compaction pressure to the piles inside the laminate and also to consolidate them, the process of vacuum bagging uses a vacuum bag. It is more advanced than the hand or the wet lay-up method. Vacuum bag molding is another name for it[29]. A horizontal mold cavity base is used in this method. The mold base is then stacked with composite prepreg laminates[35]. The composite layers are then covered with a variety of equipment and materials, including a release film layer, an air-bleeder layer, a blocked film layer, and a breather layer. Eventually, composite laminate and all other layers are covered with a vacuum bag. Sealers are then used to seal the vacuum bag. Epoxy, phenolic, and polyimide are examples of polymeric materials that could be utilized in this process[35].

2. Mechanical Properties

A material's mechanical qualities are those that involve its response to a linked load[36]–[39]. The mechanical qualities of metals determine a material's range of usefulness and determine how long it can be managed. Mechanical characteristics are also utilized to classify and differentiate materials[40]–[44].

2.1 Tensile Strength:

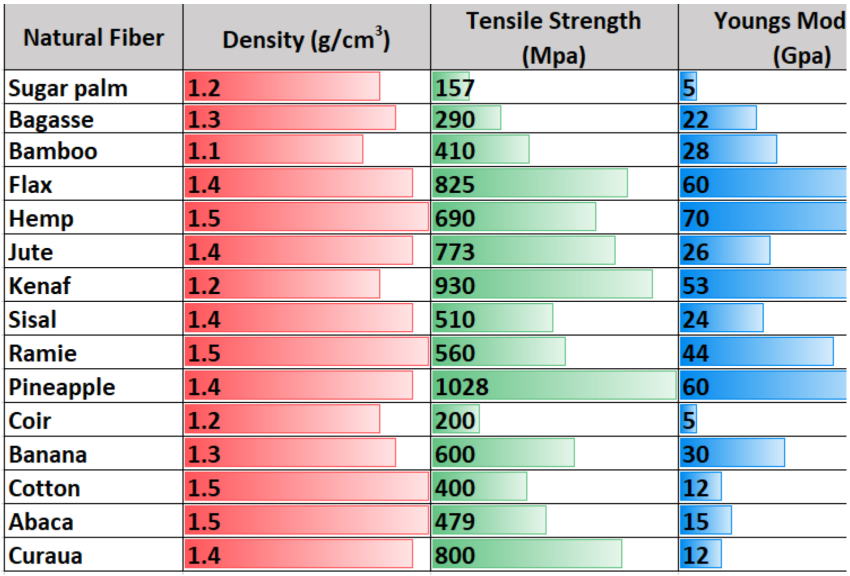
The ability of a material to endure a force that tries to break it apart is referred to as tensile strength[36], [38], [41]. The fiber's strength was determined by the fiber loading. Elongation, which represents a material's ability to endure changes in shape without cracking, can also be measured through tensile testing. Natural fibers have a low tensile strength when compared to synthetic fibers. Hemp, flax, kenaf, abaca, and other natural fibers are similar to synthetic fibers[45]–[47].

2.2 Young's Modulus:

Young's modulus (E) is a material parameter that indicates how easily it may stretch and deform. The natural fiber's Young's modulus is also affected by the fiber weight ratio. When the fiber weight ratio reaches a maximum value, it is increased; after that, it decreases[38], [40], [41]. The young's modulus of some natural fibers is higher than that of glass fibers. Young's modulus values for jute, hemp, flax, and pineapple are the highest among natural fibers[48]–[51].

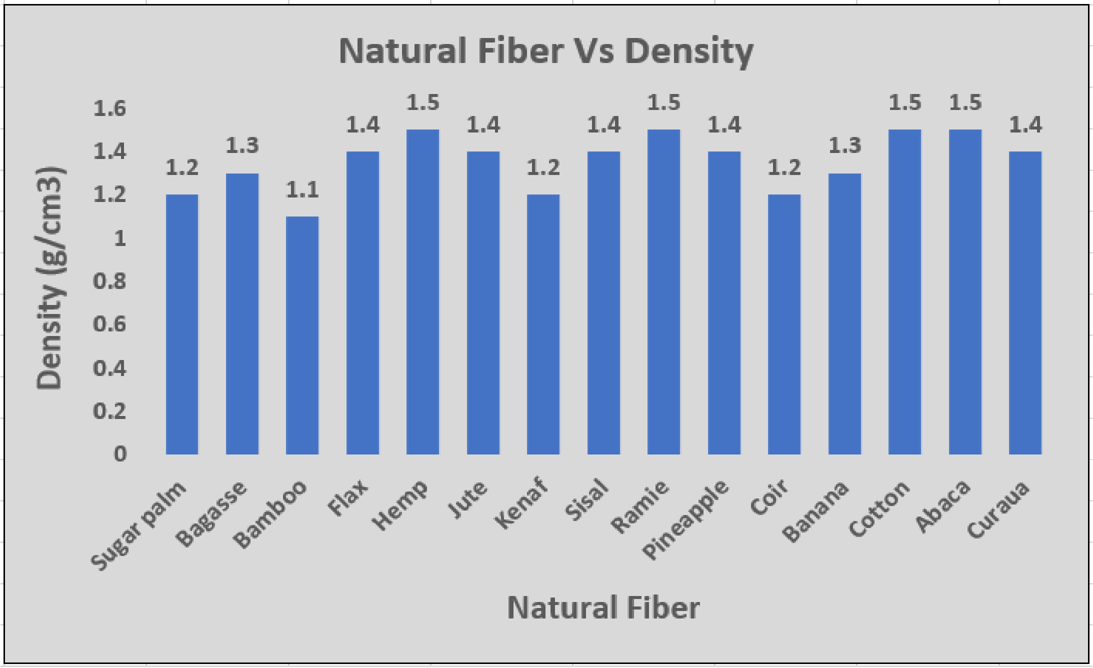
2.3 Flexural Strength:

The ability of a material to endure bending forces applied perpendicular to its longitudinal axis is known as flexural strength[45]–[47], [50]. Indentation loads normal to fiber diameter and normal to fiber length can be used to evaluate the hardness properties of hybrid natural fiber-reinforced polymer composites. Composite materials require fatigue testing, especially in high-demand applications like aircraft and wind power[45], [46], [48], [49].

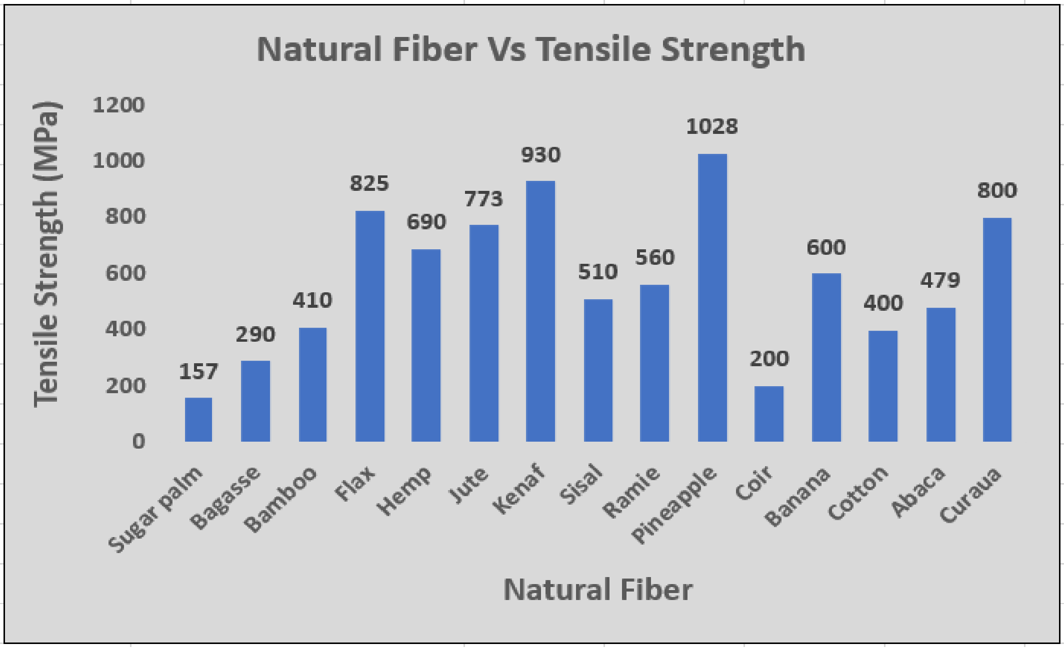


Natural Fiber	Density (g/cm^3)	Tensile Strength (Mpa)	Youngs Mod (Gpa)
Sugar palm	1.2	157	5
Bagasse	1.3	290	22
Bamboo	1.1	410	28
Flax	1.4	825	60
Hemp	1.5	690	70
Jute	1.4	773	26
Kenaf	1.2	930	53
Sisal	1.4	510	24
Ramie	1.5	560	44
Pineapple	1.4	1028	60
Coir	1.2	200	5
Banana	1.3	600	30
Cotton	1.5	400	12
Abaca	1.5	479	15
Curaua	1.4	800	12

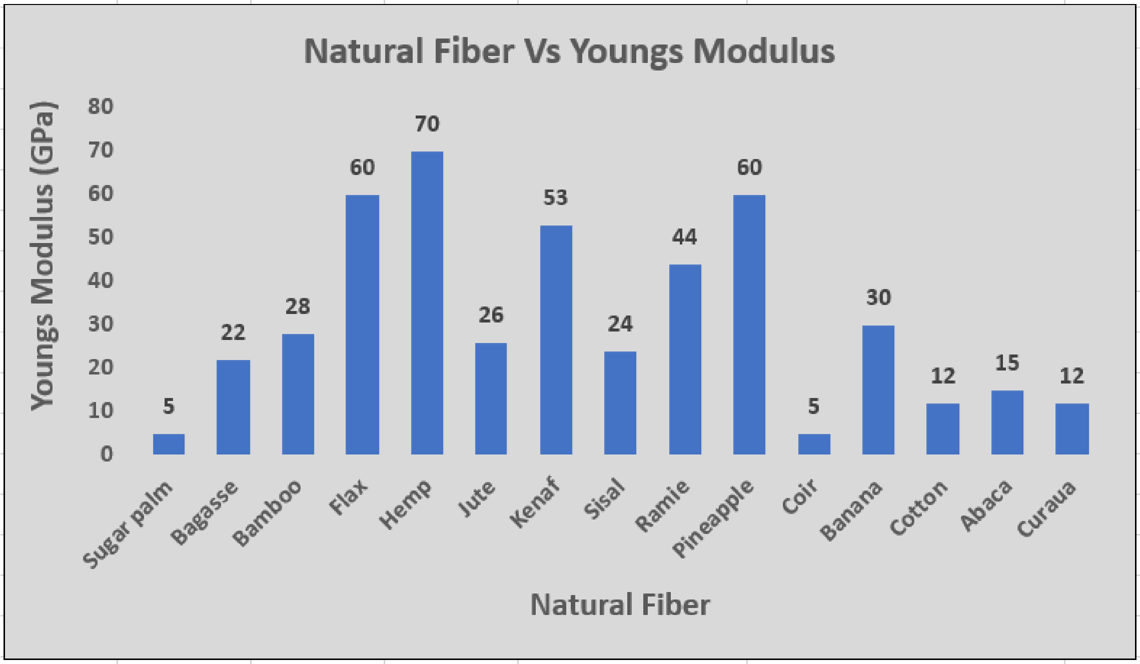
Table 2 – Properties of Mechanical Natural Fibers

- 

Bar Plot of Natural Fiber Vs Density (g/cm^3)

- 

Bar Plot of Natural Fiber Vs Tensile Strength (MPa)



Bar Plot of Natural Fiber Vs Youngs Modulus

3. Failure Mechanism of Natural Fiber Hybrid Composites

Polymer-based composites can fail or fracture in an instant, and the results can be disastrous.

3.1 Crack Propagation and Delamination

The biggest contributor to structure failure is crack propagation in the composite's structure. The primary source of crack propagation is composite fracture, which is primarily caused by the formation of displacement discontinuity surfaces inside the composites. Under the action of stress, a fracture occurs when an object or materials are separated into two additional parts. Tensile cracks and shear cracks are the two types of displacement that determine the type of crack. Tensile fractures occur when displacement occurs perpendicular to the displacement surface, whereas shear cracks, slip bands, and dislocations occur when displacement occurs tangentially to the displacement surface[37], [40], [42], [43], [52].

3.2 Fatigue

When a material is subjected to repeated cycles of loads, it loses its required stiffness and strength, which is known as fatigue. Fatigue failure can also occur in other sorts of structural components that are below the material's ultimate tensile strength. Fatigue failure is thought to be responsible for 50% of structural component failure. Fifty percent of structural component failure is considered to be due to fatigue failure[49], [51]–[55].

A composite material that has been fatigued

1. Matrix and/or fibers are broken.
2. fiber breaking, matrix fiber peeling, and/or crevice cracking
3. delamination

4. Delamination and fiber breakage cause crack propagation.
5. The materials have been broken.

3.3 Micro buckling

Micro buckling is a type of Fiber buckling characterized by transverse displacement under compression in one direction. The micro buckling of Fiber composite laminates begins at the open hole and spreads outward from the hole's edge[9]. The matrix stiffness in shear, which came from sensitivity to time, strain rate, and test environment, has an impact on the fracture of natural Fiber composites through the micro buckling process[37], [38], [52].

Several causes influencing hybrid mechanical failure have been discussed; to summarize

1. Composite cracking, which is generated by the creation of displacement discontinuity surfaces inside composites, is the most common source of crack propagation.
2. Fatigue failure can occur in a number of structural components when the material's ultimate tensile strength is less than the material's ultimate tensile strength.
3. Half of all structural component failures are estimated to be due to fatigue failure.
4. Micro buckling in Fiber composite laminates starts at the open hole's tip and spreads outward[30], [56], [57].

As a result, more research is needed to expand their application range, which includes the following:

1. Moisture resistance and fire resistance are being improved.
2. To popularize the use of these novel materials, appropriate concept details can be established. More research on the impact of natural Fibers on ageing is essential when hybridization is tried.
3. Because natural fiber-reinforced polymer composites do not meet the projected strength values based on the law of mixtures, extensive basic research on issues linked to strength, such as interface bonding and fracture mechanisms, is required[52]–[54].

3.4 Fillers

Fillers have an impact on the characteristics of composites in a variety of ways. Furthermore, they discovered that increasing the Fiber and filler enhanced hardness, strength, flexural and tensile modulus, whereas increasing the Fiber and filler lowered inter laminar shear strength on composites[39], [40].

4. PROS & CONS of NFRPCs

Table 3 – Following are the benefits and limitations of NFRPCs based on the foregoing discussion.

PROS	CONS
When compared to synthetic fibers like glass, aramid, carbon, and steel fibers, they are eco-friendly, biodegradable, abundant, renewable, inexpensive, and are less dense.	Natural fibers have a high moisture absorption capacity, which is their main disadvantage. Interfacial bonding in between the polymeric matrix and the natural fiber is reduced as a result of this occurrence, which has a negative impact on mechanical characteristics.
NFRPCs' low cost as well as high performance satisfied the industrial economic needs.	
In comparison to SFRPCs, NFRPCs are easier to dispose of.	
The abrasiveness of fiber is substantially lower, resulting in benefits in terms of technical process as well as recycling of the composite materials.	Poor wettability and incompatibility with a few polymer matrices are two of their drawbacks.
Natural fiber composite materials are generally employed in nonstructural applications instead of glass. NFRPCs are increasingly being used to replace glass fiber reinforced composites (GFRC) in automotive parts like doors and bonnets.	Plant fibers can't be used in their natural state. To enhance interfacial bonding between fibers and polymer matrix, it needs chemical treatment to eliminate the waxy layer.

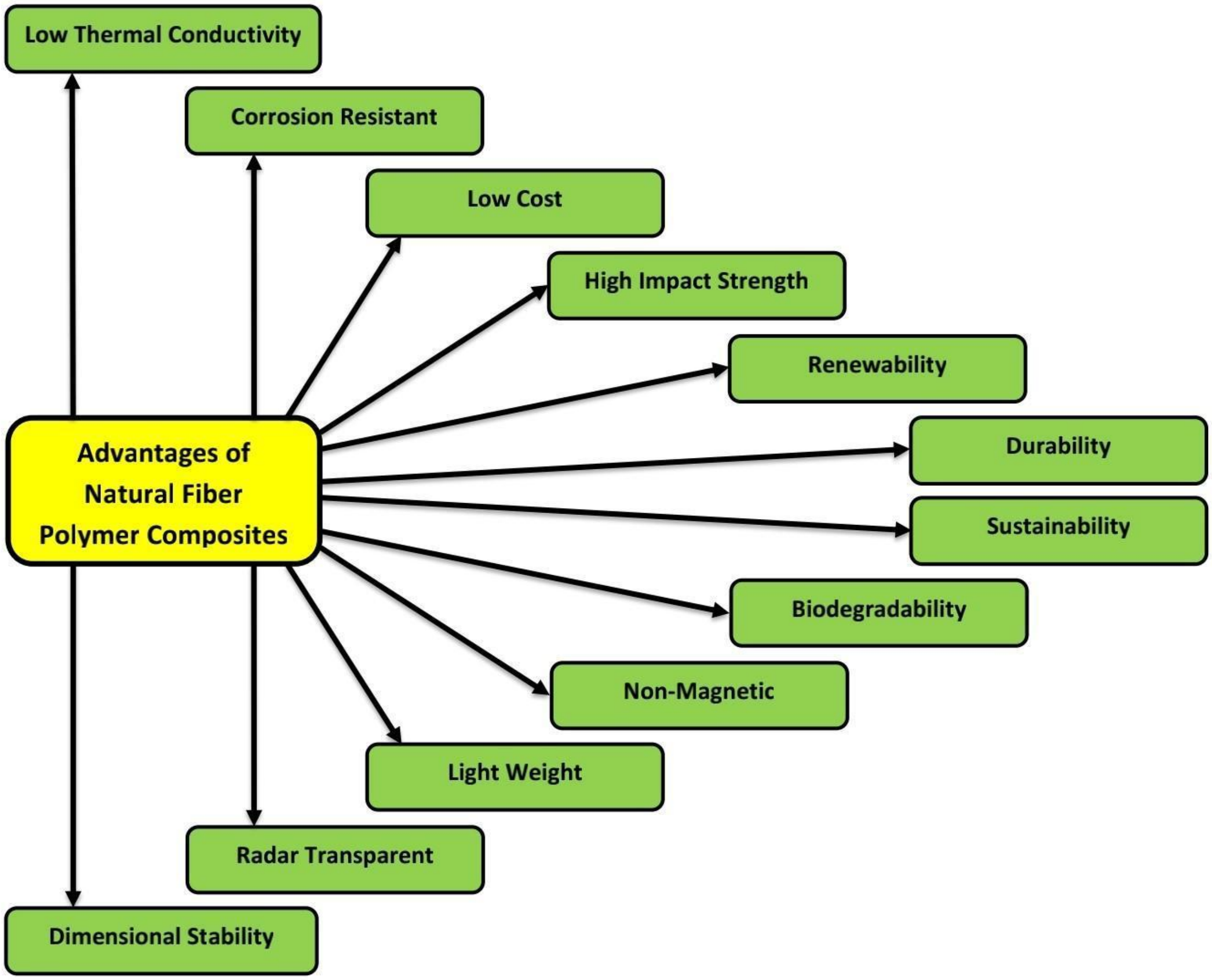


Fig 4 – Advantages of NFPC

Table 3 – Applications of NFPC

Sr. No.	Natural Fiber	Polymer Matrix	Applications of Natural Fiber Polymer Composites
1.	Hemp	Epoxy	• Due to its high yield and flexibility, this fiber is used to manufacture ropes, clothing, and paper. • Also, the constructed cellular beams and plates with jute, hemp, and flax fiber-reinforced unsaturated polyester as load-bearing structural components, revealing that natural fiber polymer composites may be employed as load-bearing components with some improvement in structural component efficiency by organizing the cellular material. • The mixtures of building materials and animal beddings all contain these fibers. It has recently been employed to create various composites.
2.	Flax	Epoxy Glass	• The sound absorption coefficient of flax fiber in hybrid fiber-reinforced epoxy matrix composites was roughly 20% higher than that of glass fiber at both low and high-frequency levels, according to research. • As a result, flax hybrid natural fiber composites showed potential for wideband sound absorption and met the requirements for airplane interior panels. • Even though the bending strength and modulus of flax/glass fiber composite laminates are lower than those of full glass laminates, researchers found that these parameters can be improved by 90% and 128%, respectively. • The findings showed that using a combination of flax and glass fiber-reinforced polymer composites to replace traditional steel is a viable way to improve aging durability, especially in marine environments. • Tennis rackets, bicycle frames, forks, and seat posts, snowboarding, and laptop cases are just a few examples.
3.	Kenaf	Glass Epoxy	• Based on the greatest overall scores in AHP, the kenaf bast fiber gets prior selection to hybridize with glass fiber-reinforced polymer composites for the construction of a parking brake component. • Kenaf/glass epoxy composite material is used to make the passenger automobile bumper beam. • Packing materials, transportable cases, bags, insulations, clothing-grade cloth, soilless potting mixes, animal bedding, oil and liquid-absorbing materials are also available from kenaf polymer composite. • With the growing use of kenaf fibers in composites, more testing is required to gain a better understanding of the materials interfacial bonding.

4.	Banana	Glass Polyester	• Banana fiber is used in the textile and packaging sectors. Banana fiber can be used to make a variety of high-value items, including fruit transportation boxes and other materials, files, covers, and packaging materials, among others. • We can reduce deforestation caused by various wood processing companies, thereby protecting our ecosystem and ecology. • Design and construction of a multipurpose table out of an epoxy and banana pseudo stem fiber composite. • Banana trunk fiber-woven fabric-reinforced composites are a great material for furniture production because of their aesthetic value as well as their strength and mechanical capabilities. • In comparison to pure glass fiber composites, banana/glass fiber biocomposites may sustain higher pressures.
5.	Sisal	Epoxy Polyurethane	• The viability of developing composites integrating one of the widely accessible natural fibers for application in consumer items, low-cost housing, and civil buildings was demonstrated in this work. • Sisal has long been used for agricultural twine due to its high strength. • When Audi was first introduced, the door trim panels were constructed of polyurethane reinforced with a flax/sisal mix. • Thin-walled elements with good properties such as high tension and compression strength, made of sisal fiber-reinforced composite, have a wide range of applications, including structural building members, permanent formwork, tanks, facades, long-span roofing elements, and pipe strengthening of existing structures. • Panels, doors, shutting plates, and roofing sheets are used in the construction industry, as well as paper and pulp processing.
6.	Cotton	Polyester Glass	• Production cotton fabric-polyester was started for use in aviation fuel cell backing sheet materials. • Cotton fabrics are said to add a variety of qualities to composites, including strength, weather resistance, machinability, and toughness. • first employed by the military for radar domes on aircraft as fiber-reinforced plastics. • During that time, cotton-phenolic systems were used to make ship bearings, brake linings constructed of plywood-phenolic trainer wings. • Cotton is primarily used in the manufacture of clothes, coverings, and carpets in the furniture sector, textile and yarn, goods, and cordage, trunk panel, glove box.

7.	Jute	Polyester Polypropylene	• Jute fibers are commonly used in the building industry and in structural applications like to make windows, doors, floor matting, room partitions, pre-fabricated buildings and ceilings. • They're even utilized to build chairs, tables, and other kitchen accessories. Jute-coir in the transportation sector as seat and backrest backings in buses. • Due to its strengthening properties of jute fibers and their compatibility with polymers, extensive research has been conducted to fabricate jute-epoxy, jute-poly-ester, and jute-phenol-formaldehyde composites/laminates for social applications such as low-cost housing elements, grain storage silos, and small fishing boats. • Jute fiber is currently utilized mostly in the textile sector to manufacture garments, ropes, bedsheets, sacks, bags, shoelaces, etc. • Jute fiber has also made its way into automobile manufacturing where it is used to construct cup holders, other dashboard components, and door panels. Jute fibers can assist various car manufacturers in reducing weight and increasing mileage.
8.	Bamboo	Epoxy	• Bamboo has been widely employed in domestic products and industrial uses, including the use of bamboo fiber in structural concrete parts. • The rooftop work was improved by using it as a split rooftop and providing a gentle surface to encourage airflow and water within the bamboo. • Various types of bamboo-based mixtures have been established in recent years, ranging from roof plans, dividers, floors, entryways, window outlines, stairs to frill. • Benefits in the production of many types of furniture and parts, such as the remarkable structural bamboo spring Chair twisting. • In the case of air transportation, bamboo filament materials were used to construct prior flying machines since bamboo filaments are light and strong.
9.	Pineapple	Epoxy	• PALF (pineapple leaf fiber) is currently used in textiles, sporting goods, luggage, vehicles, cabinets, rugs, and other applications. Surface-modified PALF has been created for the manufacture of machinery parts such as belt cords, conveyor belt chords, transmission cloth, air-bag tying cords, and other cloths for industrial applications. • PALF is ideal for carpet production due to its chemical processing and coloring characteristics. PALF can be used for a variety of other things, including cosmetics, medicine, biopolymers coatings for chemicular and attractive fibers.

10.	Coir	Polypropylene Epoxy Ester	• Coir fiber-reinforced polymer composites have been developed for a variety of industrial and socioeconomic applications, including automotive interiors, building materials such as paneling and roofing, storage tanks, packing materials, helmets and post-boxes, mirror casing, paperweights, projector covers, and voltage stabilizer covers, padding for mattresses and seat cushions, brushes and brooms, ropes and yarns for nets, bags, and mats. • The composites generated with these treated fibers and polyester resin showed a 15-29% increase in tensile strength and other mechanical parameters, indicating that coir fiber reinforced polymer composites applications are improving.
11.	Bagasse	Polypropylene	• Composites including bagasse ash as a filler material have been found to be thermally stable up to roughly 3% filler content. • When bagasse ash is used as a filler in composites, the mechanical properties of hybrid composites increase. • When used as a binder in concrete, bagasse ash provides acceptable thermal stability for concrete structures at high temperatures. • Bagasse fiber composites could be used in lightweight structures with ordinary to good characteristics where the capacity to bear the load is important and engineering applications maintained.

CONCLUSION:

Nature has been the biggest source of providing Natural Fibers and multiple engineering applications have been established by reinforcing this material with various polymeric materials via composite production. The eco-friendly properties, non-toxicity and also the exhibition of biodegradable behavior by NFPC is motivating the corporate sector to replace traditional synthetic material with this cheap, renewable, less thick, and lightweight, extra-ordinary, high-quality material. Natural fibers have many shortcomings like extreme moisture content, inconsistent properties, lack of proper bonding with polymer resin, natural fibers are flammable, uneven product dispersion, a swelling effect resulting in poor quality composites. Natural fibers being incompatible as well as incompetent offer poor moisture resistance and this is a key factor limiting potential use of this material in the manufacture of composites and hence chemical variations and modifications are needed for a property as well as workability enhancement. Currently, NFPC has been employed in bullet-proofing, automotive, construction and domestic household applications because several unique production techniques are now used in the composites sector as a result of efforts to develop composite components that are economically attractive. However, in order to utilize natural fibers at their extreme potential, there is a necessity to overcome several limitations. At the first approach, development and implementation of treatment of fiber surface should be conducted in a proper manner. Improvement of the fiber-matrix surface is needed cause % volume of fiber and the resin is the factor on which the properties of NFPC depend. The importance of study in this direction is enormous, as several problems remain unsolved. Designing NFP composites as well as selecting the right production technique will undoubtedly help them become one of the most dominant structural blocks in engineering applications in the mere future.

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