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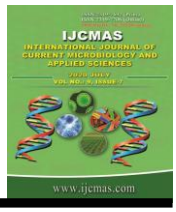

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Natural Fibers: Innovative Sustainable and Eco-Friendly

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A B S T R A C T

Natural fiber is an emerging and environment friendly product, which is widely applied in textile and other related sectors. The natural fibers are used for textiles application in fiber, yarn, fabric form and also for other application like automobiles, boards, construction in individual or in blended structure. This research paper aims to enlighten the existing natural fiber in textile sector produces from natural sources, which pave the way for clean and green environment and also a positive effect on human health. Additionally, this paper emphasized on the concept of journey of eco-friendly textile along with the sustainability related to textile sector in relationship with natural products.

Introduction

Fashion is the way in which our clothes reflect the individual personality and clothing gives fashion the way to communicate our vision, linking us to time and space. The demand for textile varies form with the changing fashion; the consumer preference which directly or indirectly influences the exploration of new varieties of fibre. The increase in the world demand for textile fibre is expected to continue not only due to the increase in the world population but also due to the standard of living. Therefore, emphasis has been put on exploration of natural fiber resources to produce various textile materials for safer use.Natural fibres have unique properties compared to synthetic fibres. In different wears like athletic wear, hosiery the manufacturing processes, the properties and the blending ratio are considered.

In such special wear comfort properties, such as air flow, moisture exchange and absorbancy are important. Nature has provided an abundant source of fibres - plant, animal, and minerals of different dimensions and properties.

Historically, the natural fibres have served the mankind clothing needs for thousands of years.The natural fibres are renewable resources, thus providing a better solution of sustainable supply like it has low-cos, t low density, least processing expenditure, no health hazards, and mechanical and physical properties. The most important property of natural fibres is biodegradability and non-carcinogenic which bring it back into fashion, with an advantage of being cost-effective (Satyanarayan *et al.,* 1990 and Yan et al., 2014).

Fibre is the basic unit that is being utilized for fabrication of textile yarn and fabric. It is a hair like structure occurs as continuous filament or as short length like cotton. Until about a century ago, all the fibres used in making fabric were obtained from natural sources but the growing demand had created different manmade fibres which make diverse sort of textile available in the market (Roy et al., 2016).At the start of 20^{th} century suddenly changes occurred and new developments were made in the field of synthetic fibers. But the advantage of using natural fibre is again reviving and demands for it, is increasing continuously.

The paper mainly emphasized on the classification of structure, properties of different fibers. However blending is also associated with natural fiber as all natural fiber cannot use individually. Hence blending is done to improve the properties and make it available for different end uses. Sustainability is also very important to remain firm in the market of textiles competing with the world of synthetic textiles.

Classification of natural fibers

There are many sources of non-conventional fibre yielding plants in our country which have potential to use in diversified field but they remain unexplored so far (Kundu *et al., 2*004). Presently many research works on extraction of different non- conventional fibre from natural sources has been gaining importance to utilize these fibres in different field. Natural fibres are obtained from different parts of plants, animals and mineral based on their originate. Use of natural fibres for industrial components especially in the parts of automobiles and housing improves the environmental sustainability. The natural fibres have more insulation properties than synthetic materials which make it use in building sectors. The properties of natural fibres depend mainly on the nature of the plant, locality in which it is grown, the age of the plant, and the extraction method used (Joseph et al., 1999).

Vaisanen *et al.,* (2016) stated that natural fibre can be categorized according to their sources namely lingo cellulosic material, animals and minerals. Lignocellulosic fibres can be divide into wood and non- wood or plant fibre. Natural fibres can be classified according to their origin. The vegetable, or cellulose-base, class includes such important fibres as cotton, flax, and jute. Cellulose is the worlds' most ubiquitous and abundant natural occurring polymer which is produced by plants. It is a linear polymer of same glucose ($C_6H_{10}O_5$) with different number of repeating units (Ghosh *et al., 2*018).

Hemicellulose is similar in structure to cellulose, but chains of hemicellulose are shorter and less stable. Soluble hemicellulose chains attract water and form gels. Lignin polymers are often found in most plant structures along with cellulose which is primarily composed of hydrocarbon. The structure of lignin is not well defined, but lignin appears to be made up of polymers of propylbenzene with hydroxy and methoxy groups attached. The vegetable plants can be classified as (Van Dam *et al.,* 2003).

Seed fibers which are collected from seeds or seed cases. Cotton and kapok are floss form of seed with 90% of pure cellulose. The cotton ball contains dozens of seeds with a capacity of producing 1000-2000 fiber with in a length of 20-60 nm. In elongation fibers the amount of cellulose per unit length of fiber remains constant about $1ngmm^{-1}$ and increased up to 139 $ngmm^{-1}$ at maturity.

Leaf fibers are collected from leaves. Sisal is grown nearly 7 thousand hectare of area in the country having nearly 10 quintals of yield with a productivity of 145 kg/hac. Sisal fiber can be used for making cordage, composite material, woven material, geo textiles. It is a very strong fiber and has the ability to construct bags for carrying loads and is also used for reinforcement (Das *et al., 2*010, Nayak *et al., 2*018). Pine apple leaf fibers are the fibers extracted from the waste leaf of pineapple after harvesting of fruits it contains 2.5-3.5 % of fiber beneath the waxy layer of leaf. Pineapple is cultivating around in 87.2 thousands hectares of land and 600 thousand of leaf can be extracted and utilized (Banik *et al.,* 2010).

Fibers are collected from the skin or bast surrounding the stem. Stem act as a major component of plants and they keep the plant alive and have higher strength than other fibers extracted from other parts. Fibers like flax have been cultivated in China and India at least 5,000 years ago. Today fifty nine countries in the world are cultivating the flax accounting 2.79 million tones and Kazakhstan contributes a major contribute (around 24%) of total world production. India stands 5^{th} in the world production of 0.184 tons (Debnath *et al.,* 2018).Water retting for different duration of time is used for extraction of roselle fiber and ramie fibers. Bhindi fiber is also an agro fiber extracted from the waste plant using water retting (Gogoi *et al., 2*017). It has more elongation compared with other natural fiber.

India is largest producer of coir fiber which is extracted from the outer layer of the fruit. It is a very strong fiber used for construction of ropes but the retting process is very long and labourious.

Some fibers are extracted from the stalks of the plant like straws of wheat, rice, barley, and other crops remained unused after harvesting of crops. Corn stalks, rice stalks as a potential source of fibre extraction and revealed that corn stalks and rice stalks have the structure and properties required for textile and other industrial applications. The Fibers contain about 80% cellulose, 8% lignin and 8% moisture (Reddy *et al.,* 2005).

Animal fibers are obtained from animals like sheep, rabbit, angora etc. It mainly comprise of amino acid protein. Silk fibers are collected from the cocoons of worms. There are mainly four varieties of silk worms from which silk is extracted. Out of which mulberry and eri are reared indoor while muga and silk reared outdoor. Silk is considered as the queen of all the fibres due to its lustrous, thin and elegacy. Silkfibers have the most exciting characters like extra lustre, extreme smooth feeling and very good moisture absorbency.

Moreover, the attractive characters are brilliant shade for better resilience. The other most attractive property is the very good elastic recovery of silk fibre (Vetala *et al.,* 1992). Avian fibers are extracted from feathers of birds. Mineral fibers are naturally occurring fiber or slightly modified fiber procured from different minerals like Asbestos. The glass fibers include aluminum oxide, boron carbide, silicon carbide etc. Glass wood and quartz can be categorized into the glass fiber group (Chandramohan *et al., 2*011). The major Agro based fiber producing states in India are given in table-1.

Properties and application of natural fiber

The demand for natural fiber keeps growing as the environmental issues regarding synthetic polymer worsen. Natural fiber can be described as the product obtained from plants and animals that can be shaped into filaments thread or even rope.

They exist hair-like materials which are interrupted filaments or in distinct elongated pieces. They can be used as one of the constituent materials in producing a component or a product.

The main reason for natural fibers are much preferable compared to synthetic fibers such as glass is because they have wide ranges of fibers and easily available besides being environmentally friendly. Natural fibers are also famous for their excellent properties such as low density, high specific strength and effectual costing (Asilah *et al., 2*011; Khalil *et al.,* 2011)

Natural fiber composites for building products such as panels, door shutters, roofing sheets it is used alone or combination with other materials. In china bagasse is used for making particle boards (Verma *et al., 2*011). Thailand use thai wood fiber for hardboard making hardboards (Garacia *et al., 2*011). The Philippians use coir and banana stalks for particle board (Khalil *et.al.* 2012).
Some automobile industries have been using natural fiber for their parts Audi, BMW, Fiat, Ford, Mitsubishi, Renault, Volvo (Bledkzi *et al., 2*006). Natural fibers are used for packaging industry (Hirvikrpi *et al.,* 2011) and are degradable (Johansson *et al., 2*012). Currently, the use of natural fibre in different applications like composites is limited to interior and non-structural applications due to their poor moisture resistance and low mechanical properties (Dittenber *et al., 2*012).

Natural fibers are used for making ropes, dusters, seed pots etc. After processing of natural fibers to yarn forms fabrics can be constructed in different weave structure. Diversified products like coats, Kurti, tie, upholstery items can be made depending upon the properties of fibers.

Natural fiber has its own properties. The properties of natural fibers are tested for its strength, elongation according to Booth (1968) by using the formulae

$$\text{Tensile strength (g/tex)} = \frac{\text{Breaking load}}{\text{Bundle weight (mg)}} \times 100$$

Density indicates the mass-per unit volumes expressed as grams per cubic centimetre or pound per cubic feet. (ASTM, 1970). Length, diameter and wall thickness are observed under Dokuval photo microscope scale. Moisture content is the weight of water in a material expressed as a percentage of the total weight was determined according to BIS Method: IS: 1999. The surface morphology of fibers can be examined using electron microscope at a definite accelerating potential. Colour measurements of fibre in regards to whiteness index (WI), yellowness index (YI), brightness index (BI) and colour strength can be measured.Tensile strength and elongation are important properties of natural fibers.

Natural fiber blended

All fibers do not have all the requisite physical, aesthetic and serviceable properties to be a natural fiber. So, blending serve the purpose. It is the mixing of two fibers from same or different origin having dissimilarity in their properties, with a view to achieving or improving the weak properties and make a yarn with better properties and capable of having good performances. Fabric produced from the blended yarn might have better characteristics than what could be obtained in

a fabric produced from a single fibre (Ali. *et al.*, 2012).

Fibre blending has been a common practice in the textile industry, stimulated to a great degree by the availability of an ever-increasing number of manmade fibres. Fibre blending can achieve quality products that cannot be realized using one fibre type alone. The reasons for the development of blends are economy or economic reasons; expensive fibres can be extended by blending them with more plentiful fibres. Blending different types of fibres is a widely practised means of enhancing the performance and the aesthetic qualities of a fabric.

Different fibres can be blended in different stages in textile structures, in carding stage, sliver stage etc. to obtain the desirable properties of each of the fibres in the blend. A blended yarn or fabric generally displays an averaging of the properties of the constituent fibres. For example cotton/polyester blended has higher wrinkle recovery than a 100 per cent cotton fabric, but lower recovery than all polyester fabric.

Blend ratio used to describe textile blends is the percentage by weight of each fibre in the blend (Charnakar *et al., 2*007). Different blending portion and processes are different for different fiber. Blending of jute and ramie in fibre stage tends to create processing troubles. To avoid such difficulty of ramie and jute fibre, blending in conventional jute spinning system. Jute mills have developed jute sisal blended yarns using traditional jute mill technology which can advantageously utilized jute through co pitiable blending with sisal that is flexible and durable compared to control jute. Blending of natural fibers with jute and silk waste is used to produce good quality fabric with minimum cost. So, that all classes of people can afford such fabrics.

Textile and sustainability

Economy, society, culture and Environment are the four working principles of sustainability. Thinking about the new generation and keeping in mind about all the wastes and extra materials we are disposing off. We have to overcome and solve these issues we need complete and efficient management systems along with resources to maintain sustainability (Ali. *et al.*, 2012) . Use of synthetic textile is harming our environment, which indirectly influencing our society and economy. As per the environment and health concern, the goods should be environmental friendly and also can support economy.

Table.1 The major Agro based fiber producing states in India

Sl.	Fiber	Major Fiber producing state
1)	Sisal	Sisal Maharastra
2)	Screw pine	Kerela
3)	Palm leaf	Tamil Nadu and kerela
4)	Korai grass	Tamil Nadu and kerela
5)	Pineapple leaf fiber	Meghalaya
6)	Sitalpati	Assam, Meghalaya
7)	Bamboo	North eastern India
8)	Sikki and Mung grass	Bihar
9)	Hemp, Sisal, Himalayan nettle	Uttarakhand
10)	Bananan	Southern India state

(Source :Goel. A, 2019)

Table.2 Tensile strength andelongation are important properties of natural fibers

Sl.no	Fiber	Tensile strength(MPa)	Elongation at break(%)
1)	Cotton	264-654	3.0-7.0
2)	Wool	120-174	25-35
3)	Silk	252-528	20-25
4)	Flex	300-900	2.7-3.2
5)	Jute	342-672	1.7-1.8
6)	Sisal	444-552	2.0-2.5
7)	Ramie	348-816	3.6-3.8
8)	Bamboo	140-1150	-
9)	Bagasse	290	-
10)	Kenaf	930	-
11)	Pineapple	400-627	8.7
12)	Roselle	264-300	1.59
13)	BHindi	147-200	8.7

(Gogoi*et.al.*,2017,Ramlil,2016)

Early 1990's, communities and companies all around the world start taking interest in green movement. The thought to developed eco-friendly products like organic cotton, bamboo fibers, biodegradable detergents and papers made from managed and controlled forests, these all product sold and market under the label 'eco-friendly'. But the products cannot survive in the market like Esprit Company launched their first collection made of organic cotton with natural dyes called 'Ecollection'. Bt after a peak it decline.it was due to consumer intersest in only the appearance product, not the ec- benefit as a result green revolution vanish (Horrocks *et al.*, 2007).

In textiles all over the world cotton and polyester are the predominant fibers which contribute about 80% of total use. These results in large scale production of limited fibers in a specific agricultural sector that reduces the customer choice and increases many risks like ecological and environmental risks (Fletcher *et al.*, 2008). So, we have to think various sources of natural fiber. We should have more varieties especially the fibers extracted from waste parts of plants. Textile depends on Agriculture as the basic raw materials especially in natural fiber parts. Hence we have to concentrate on no use of chemical during production and also to minimize and use of environmental friendly chemicals during processing. Natural fibers like organic cotton, bamboo, flax, hemp, jute, ramie, sisal, abaca, jute, bhindi etc, are the examples of sustainable fibers in textile industry. As per the environmental problems and issues of global warming. Now the people are realizing the use of natural products. So use of sustainable fibers as a raw material for producing textile fashion product is an approach towards sustainability and it will boost our economy and build a healthy clean environment (Holme 2009).

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