CHAPTER – I
INTRODUCTION

Natural fibre production, processing and export are vital to the economies of many developing countries and the livelihoods of millions of small-scale farmers and low-wage workers. Many of those economies and livelihoods are currently under threat: the global financial crisis has reduced demand for natural fibres as processors, manufacturers and consumers suspend purchasing decisions or look to cheaper synthetic alternatives. Natural fibres are obtained from plants, animals and mineral sources. Many beneficial fibres have been obtained from various parts of plants, including leaves, stems (bast fibres), fruits and seeds. The most used plant fibres are cotton, flax and hemp, although sisal, ramie, banana, jute, kenaf, bamboo and coconut are also widely used. Increased utility of natural fibre will encourage farmers and other people involved in producing and using natural fibres.

Based on the usage, the fibres obtained from natural sources are classified as major (widely used) and minor (limited used). Minor cellulosic fibres are hemp, sisal, kapok, banana, ramie, lotus, coir and pina fibres. The usage of minor fibres in composite non-wovens has increased remarkably during the last few years. According to the World Apparel Fibre Consumption Survey made in 2005-2008, the report stated that the ratio of consumption of natural to synthetic fibres in the world was around 60:40. However, today, the ratio is 40:60 because of the increase in market share by synthetic fibres (Textile Progress, 2012). Some natural fibres are cheaper than conventional synthetic fibres. Since they have the potential to be recycled and are eco-friendly through their biodegradability and renewability, they can be explored for their advantages in textiles.

Fibres are available in agro-waste, which has not been explored for use as textile fibres. The fibres thus obtained have some inherent properties. Sugarcane bagasse can be explored for its use in textiles. Among agricultural residues, Sugarcane bagasse is one of the residues produced in large quantities in several countries of the world. India has the largest area under sugarcane cultivation and is the world's second-largest producer, next to Brazil. With the production, proportionately, waste is generated.

Sugarcane (Saccharum officinarum) family Gramineae (Poaceae) is a widely grown crop in India. It employs over a million people directly or indirectly, contributing significantly to the national exchequer. Broadly, there are two distinct agro-climatic regions of sugarcane cultivation in India: tropical and subtropical. The tropical region shared about 45% and sub-tropical 55% of the country's total sugarcane area and production.The tropical sugarcane region consists of sugarcane agro-climatic zone 4 (peninsular zone) and 5(Coastal zone), which includes the states of Maharashtra, Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat, Madhya Pradesh, Goa, Pondicherry and Kerala.These nine states are the most important sugarcane-producing states of India. Around 55 per cent of the total cane area in the country is in the sub-tropics. U.P., Bihar, Haryana, and Punjab are part of this region.

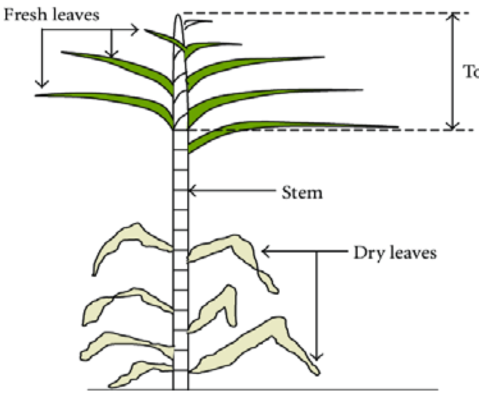

Plate 1.1: Sugarcane plant morphology
Source:https://www.researchgate.net/figure/The-sugarcane-plant-morphology

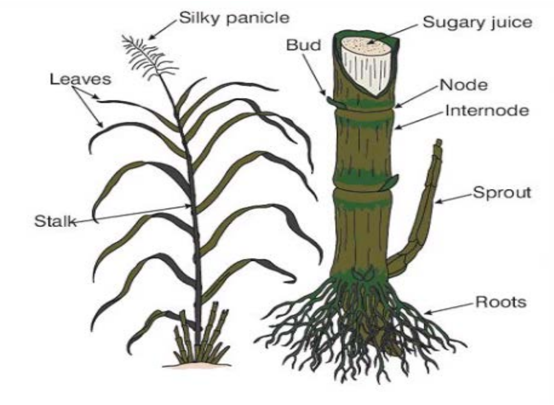

Plate 1.2: Structure of Sugarcane stalk
Source: https://www.google.com/search?q=structure+of+sugarcane+stalk&sxsrf

In the Tropical zone, Maharashtra is the major sugarcane-growing State, covering an area of about 9.4 lakh ha and producing 61.32 million tons, whereas Tamil Nadu's productivity is highest in tropical zones. Uttar Pradesh is the highest sugarcane-producing State in the subtropical zone, having an area of about 22.77 lakh ha and producing 135.64 million tons of sugarcane, whereas Haryana has the highest productivity of sugarcane in the subtropical zone.

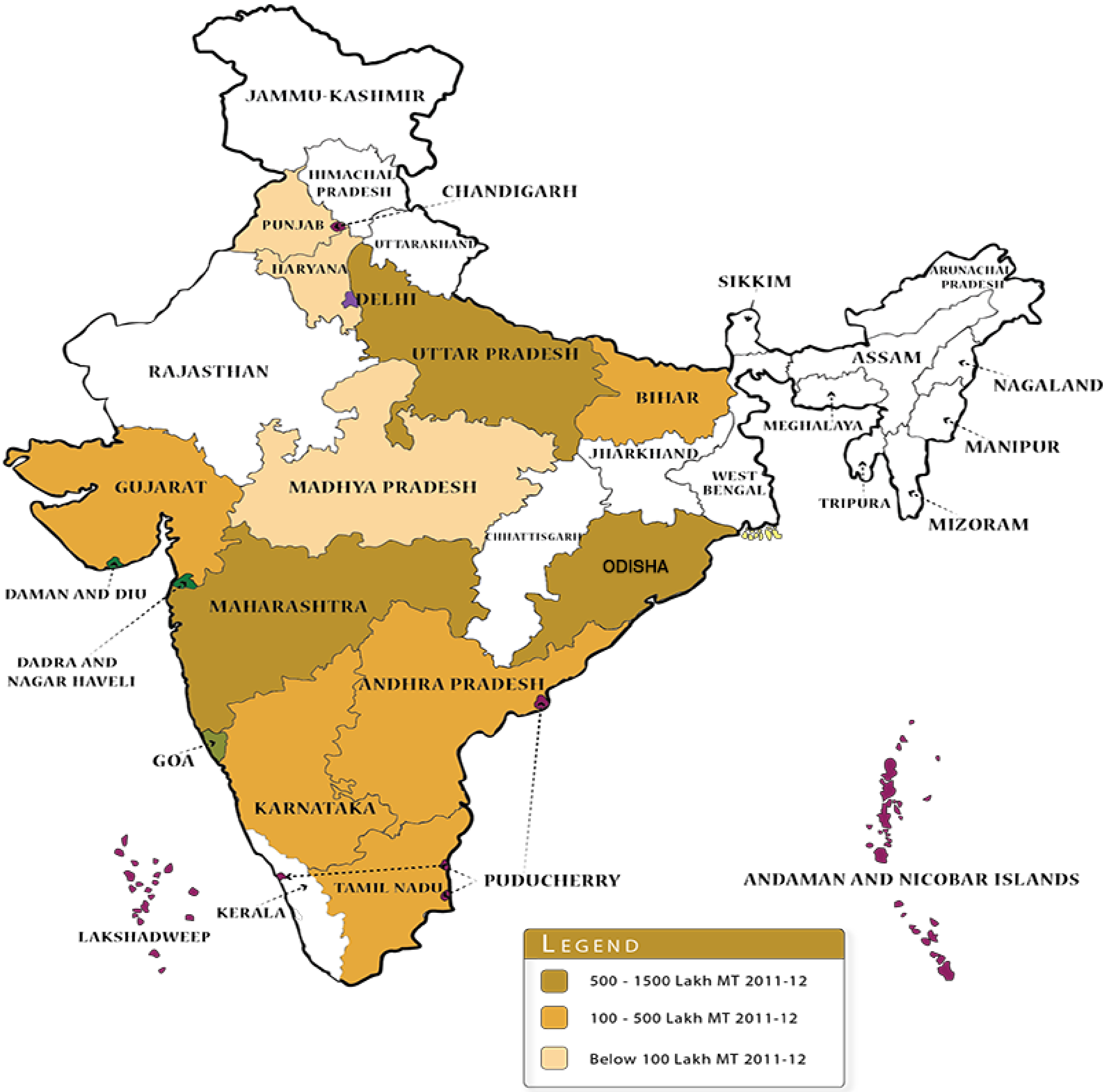

Plate 1.3: Major sugarcane-producing states

(Source: http://www.sugarcane.res.in/index.php/mis/sugarcane-statistics/281)

In 2020, the global sugarcane production was 1.87 billion tons, with Brazil producing 40% of the world's total, India 20%, and China 6%. Worldwide, 26 million hectares were devoted to sugarcane cultivation in 2020.

Table 1.1: Production of Sugarcane (Country wise)

S.No.	Country	Production (Million tons)
1	Brazil	757.1
2	India	370.5
3	China	108.1
4	Pakistan	81.0
5	Thailand	75.0
6	Mexico	54.0
7	United States	32.7
8	Australia	30.0
	World total	**1,869.7**

In the sugar industry, approximately 279 million metric tons of sugarcane waste aregenerated annually worldwide (Jugwanth et al.,2020). From the global amount of sugarcane waste, South Africa has an annual share of over 1.353 million metric tons, of which more than 50% are recovered in cogeneration facilities (Smithers, 2014). The uncontrolled disposal of sugarcane waste can generate major problems with environmental factors and, consequently, human health. These wastes are of a solid, semi-solid, and liquid nature. They can be classified into two categories: waste from the harvesting operation, represented by leaves and cane tips, and waste from the cane processing stream, which includes bagasse.

Bagasse is a fibrous residue that remains after crushing the stalks and contains short fibres (Plate 1.4). A considerable amount (millions of metric tons per year) of this waste is produced worldwide. However, only a small portion of the total waste is reused as fuels in sugar factories or as raw materials for pulp and paper products (Behnood et al., 2016). The sugarcane stem is roughly cylindrical and consists of nodes and internodes (Plate 1.5). Bundles of fibres are arranged randomly throughout the stem. The stem is composed of an outer rind and an inner pith. The outer ring mainly comprises fibres, which can be separated from cementing materials like hemicellulose and lignin by alkali treatment. Lignin removal depends upon alkali concentration, ultimately determining fibre characteristics (Asagekar and Joshi, 2014).

Plate 1.4: Dry waste bagasse

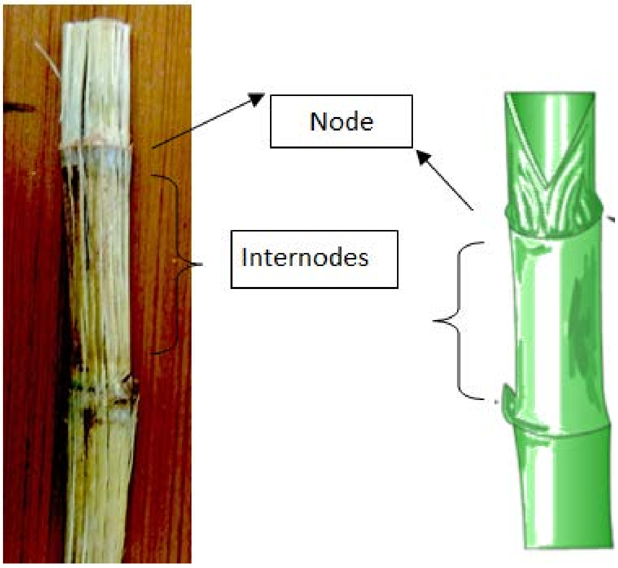

Plate 1.5: Structure of stalk consisting of Internodes nodes

Plate 1.6: Waste bagasse after Juice Extraction

Table 1.2: Average bagasse Composition

Content	Bagasse (%)
Moisture	49.00
Fibre	48.70
Soluble Solids	2.30

It is a waste product that causes mills to incur additional disposal costs. It consists of water, fibres and small amounts of soluble solids. The percentage contribution of each of these components varies according to the variety, maturity, method of harvesting, and efficiency of the crushing plant. A typical bagasse composition is given in Table 1.2 (Elsunni et al., 1996). Fibres extracted from waste bagasse are called Sugarcane bagasse fibres. The sugar cane stalk is composed of an outer rind and an inner pith (Plate 1.7)

Plate 1.7: Billets of Sugarcane stalks

The inner pith of Sugarcane is an abundant source of short bagasse fibres, which can be used as a raw material for wood pulp. The outer ring of Sugarcane gives longer and finer fibres. These are extracted from the Sugarcane after the juice has been extracted through mechanical or chemical means.

Table 1.3: Chemical constituents of bagasse

Chemical constituents	Content (%)
Cellulose	32-48
Hemi-cellulose	27-32
Lignin	18-26

The fibres are arranged in a random manner inside the stem and kept together using binding materials such as lignin and hemicelluloses (Table 1.3).

Minor cellulosic fibres, which are abundantly available, can be modified for technical textiles. Therefore, this process can be termed converting waste to wealth by extracting the fibres from waste sugarcane and using them for technical textile applications. This will simultaneously reduce waste and provide innovative technical textiles.

Technical textile is a textile product manufactured for non-aesthetic purposes, where the function is the primary criterion. It is a large and growing sector and supports many other industries. Technical textiles include textiles for automotive applications, medical textiles (e.g., implants), geotextiles (reinforcement of embankments), geotextiles (textiles for crop protection), and protective clothing. (Kanimozhi,2012). Technical textiles offer new ways, means and opportunities for the Indian textile industry to sustain its growth and thrive shortly. It would offer not only an opportunity to augment the growth but also a new direction for the advancement of the industry. Technical textiles have not received adequate importance in the Indian context. However, it is a potential area where the textile industry can excel.

Technicaltextiles is a high-technology sunrise sector that is a necessity in India. The potential of technical textiles in India still needs to be explored. The global growth rate of technical textiles is about 4% per year, more significant than that of home and apparel textiles, growing at 1% per year. Globally, technical textiles contribute to about 27 per cent of the textile industry; in some Western countries, their share is even 50 per cent, while in India, it is 11 per cent.Technical Textiles provide a new opportunity for the textile industry to have a long-term sustainable future. Currently, technical textile materials are widely used to filter clothing, furniture, hygiene medicals and construction materials.

Nonwovens are used in a wide range of consumer and industrial products with diverse properties like geotextiles, medical and healthcare, agriculture and horticulture, filters, packaging, home furnishing, etc. Nonwovens are unique, high-tech, engineered fabrics made from fibres bonded together by chemical, mechanical, heat or solvent treatment. Nonwovens are innovative, versatile and indispensable (Dhange et al., 2012). Nonwovens present several advantages over woven and knitted fabrics, such as lower cost, no edge fraying, random fibre distribution, low density, high tear strength, patternless surface appearance, high water retention capacity and good adhesion.

Needle-punched fabrics are bonded mechanically by needling. The needles punch vertically in and out of the material. The machine then transports the material, and the needles come down again. This process locks the fibres together. In the needle punching process, the determination of the appropriate level of needle punching is complex. Excessive punching damages the fabric layers considerably, but insufficient punching minimises bridging between the fabric layers (Kanimozhi, 2012).

Oil is one of the essential sources of energy in the modern industrial world. It has to be transported from the source of production to many places across the globe through oceans and inland transport. During transportation, the chance of oil spillage over the water body occurs due to accidents or deliberate action during wartime, which causes environmental pollution. An oil spill releases a liquid petroleum hydrocarbon into the environment, mainly marine areas, due to human activity, and is a form of pollution. The term is usually applied to marine oil spills, where oil is released into the ocean or coastal waters, but spills may also occur on land. Oil spills may be due to releases of crude oil from tankers, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products (such as gasoline and diesel) and their by-products, heavier fuels used by large ships such as bunker fuel, or the spill of any oily refuse or waste oil.

Oil spills can have disastrous consequences for society economically, environmentally, and socially. Despite substantial national and international policy improvements on preventing oil spills adopted in recent decades, large oil spills keep occurring. It also disturbs the aquatic life and water cycle. Oil spills at sea are generally much more damaging than those on land since they can spread for hundreds of nautical miles in a thin oil slick, which can cover beaches with a thin coating of oil. These can kill seabirds, mammals, shellfish and other organisms they coat.

Bayat et al. (2005) studied the performance of three sorbents to determine their potential for oil spill cleanup. The sorbents were selected from natural and synthetic categories. Bagasse and rice hull were used as natural materials, and polypropylene nonwoven web was used as a synthetic sorbent. The results obtained that polypropylene can sorb almost 7 to 9 times its weight from different oils. Bagasse, 18 to 45 mesh size, follows polypropylene as the second sorbent oil spill cleanup. Bagasse, 14 to 18 mesh size, and rice hull have comparable oil sorption capacities, which are lower than those of the two former sorbents. It was found that oil viscosity plays a vital role in oil sorption by sorbents.

Waste bagasse is considered an unconventional fibre because of its minimal applicability in the textile industry. More processing steps are needed before it can be used as an alternative fibre. Fibres are to be modified chemically for specific end uses. Based on previous research, sugarcane bagasse is expected to be modified to increase its sorption property, which can help in the separation and recovery of oil from oil spills.

1.1 Purpose of the study

- Sugarcane is a major crop in tropical regions worldwide. Because of the increasing demand for sugar, large areas in tropical and subtropical countries were allotted for Sugarcane crops.

- In India, Uttar Pradesh is the largest Sugarcane-producing state, with a 38.61% shareof overall sugarcane production. Besides the main product, sugar juice, several by-products are available in the sugarcane extraction process. The most important is bagasse. It is an eco-friendly renewable resource found in nature. Bagasse is a waste product that causes mills to incur additional disposal costs.

- The review found that Sugarcane bagasse has some inherent properties of oil sorption and is waste and biodegradable.

- The oil spill is the major problem in the present context. It affects not only the resources but also marine life, birds, and mammals. A solution to this problem is needed.

- Conventional oil removal techniques generate secondary pollution and cause the loss of oil either due to burning or consumption by microorganisms.

- Due to the inherent property of oil sorption, Sugarcane bagasse fibre can be explored for its use in separating and recovering oil from oil spills.

Hence, the study explored the feasibility of using this waste and optimising the treatment conditions at different stages. Keeping all the above factors into consideration, the researcher decided to take up this study with the following objectives:

1.2 Objectives of the study

1.2.1 To extract and optimise conditions for extraction of fibre.

1.2.2 To test the physical and chemical properties of extracted fibres.

1.2.3 To fabricate an apparatus for extraction of fibre.

1.2.4 To modify the extracted fibres to enhance their sorption capacity through Acetylation, Cyanoethylation and Enzymatic treatment.

1.2.5 To test the modified fibres and optimise the treatments:

i. Oil sorption capacity

ii. Recovery of sorbed oil

iii. Reusability of sorbents

iv. Oil retention ability

1.2.6 To study the characterisation of optimised fibres: FTIR, SEM analysis.

1.2.7 To prepare oil sorbent Non-woven and test its sorption and recovery properties.

1.3 Delimitation of the study

1.3.1 The study was limited to three modification treatments: Acetylation, Cyanoethylation and Enzymatic.

1.3.2 The study was limited to the sorption capacity of bagasse in three different viscosities of oil.

1.3.3 The study was limited to four types of oil testing: oil sorption capacity, recovery of sorbed oil, reusability of sorbents, and oil retention ability.

1.3.4 The study was limited to the manufacturing of Non-woven through the needle punching method.

1.4 Scope of the study

The study aimed to use waste Sugarcane bagasse fibre as a valuable natural fibre for technical textile applications. In the present scenario, new job opportunities are expected to be generated in the local industry. The local manufacturers will have access to new technologies for processing and producing sugarcane bagasse fibres. Because of their innovative products, they will be able to enter new markets.

One of the expected outcomes of the study is the production of high-quality natural fibres and oil-sorbent materials from Sugarcane bagasse fibre with high sorption capacity. These fibres have a high potential to substitute synthetic fibres (Polypropylene) in multiple technical textile applications. The use of these natural fibres might be very beneficial for the oil sorption process because they can be substantially absorbed and recovered oil.

Utilising these natural fibres will decrease the cost of the components considerably due to no cost of the raw material, which is a waste that is available in abundance. Moreover, the production costs of fibre extraction will be reduced with the help of an apparatus fabricated by the researcher. Local production can have an increasing share in the future.