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POTENTIAL SUBSTITUTION OF PLASTICS BY JUTE PRODUCTS: A REVIEW

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ABSTRACT

Plastics are a crucial segment of modern society with many applications in various industries, commerce, packaging, and households. The increase in population, economic development, need for commodities, and lifestyle variations are significantly boosting the necessity and manufacturing of plastic goods globally. The inevitable use of plastics in our contemporary life has drastically increased waste accumulation, creating severe environmental pollution and threats to plants, terrestrial and aquatic animals, and human health. Plastic pollution has also caused the death of thousands of seabirds and marine animals. In this context, jute products could be a viable substitute for conventional plastic as it is strong, highly durable, renewable, biodegradable, compostable, and recyclable natural products with promising options for its, Width spirit use in our daily life with regards to sustainability. Therefore, the main objective of this paper is to review plastics and jute products and find out the best products in terms of mechanical properties and environmental footprint.

Keywords: *Biodegradable, Carbon footprint, Environment pollution, Jute & Plastic Products*

INTRODUCTION

Plastics are manmade polymeric materials usually made from petrochemical sources. The majority of typical petrochemical-based plastics comprise polyethylene terephthalate (PET), polyvinylchloride (PVC), polyester, polyethylene, polypropylene, and polystyrene, etc. (Nanda et al., 2022; Geyer et al., 2017). Today, plastics are a crucial component of our modern civilization, with endless applications in commerce, household products, and other industries. Population growth, financial growth, the need for commodities, and lifestyle changes substantially boost the global requirement and manufacturing of plastic goods (Nanda et al., 2022). Plastics are suitable for a diversity of applications due to their lightweight, tensile strength, flexibility, low cost of production, and ease of availability. Even glass and paper have been overtaken in packaging by plastics (Nanda et al., 2022; Shafqat et al., 2020). Global plastics production increased by 36% from 2010 to 2020 (Figure 1). Currently, the annual global production of plastic waste is close to 150 million tons (Thakur & Thakur, 2016). The whole quantity of new plastics generated now is around 8300 million metric tons. The plastic waste generated is around 6300 Mt, of which only 9% has been recycled, and 12% has been incinerated, leaving the lingering 79% in landfills or the environment. If current trends continue until the year 2050, it is anticipated that 12,000 Mt of plastic leftover will be amassed in landfills or the environment (Geyer et al., 2017).

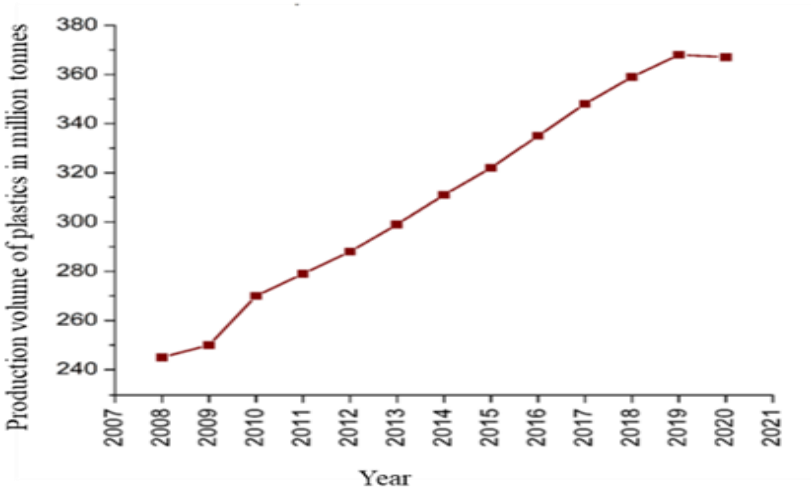


Figure 1. Global Plastics Production (Source: Statista, 2020)

Nearly, 8% of plastic wastes are microplastics, whereas 92% are floating plastics. (Floating plastic waste in the oceans has been discovered to amass pollutants and carry them through ocean currents because persistent organic contaminants in the marine environment adhere to the surface of the debris. Also discovered to be carrying invasive marine organisms are floating and migrating plastic litter.)Microplastics, typically less than 5 mm, are more dangerous for soil, water, and air pollution because of their petty size and ability to enter the food chain by marine species, humans, and animals (Chia et al., 2021). According to a recent investigation, microplastics have been found for the first time in the placentas of newborn children, which is seriously concerning (The Guardian, 2020). The inevitable use of plastics in our lives has extensively augmented their waste accumulation. Traditional petroleum-based plastics are not biodegradable; as a result, they persist for thousands of years in a landfill and the ocean, affecting the quality of the soil, microbial activity, flora, and fauna. (Nanda & Berruti, 2021a; Nanda & Berruti, 2021b). Additionally, most plastic waste pollutes the environment by ending up in landfills, soil, oceans, and water bodies, endangering both humans and other creatures and plants. Over a million seabirds and 100,000 marine species worldwide have died due to plastic pollution (Othman et al., 2021). Furthermore, a significant amount of energy is used during the production of plastics. Another alarm being raised globally is the high carbon footprint fragmentation of petroleum-based plastics and the associated environmental issues. Scientists and researchers are continually looking for viable alternatives to plastics due to the gradually rising price of crude oil and the fact that it is a non-renewable resource (Ismail et al., 2016).

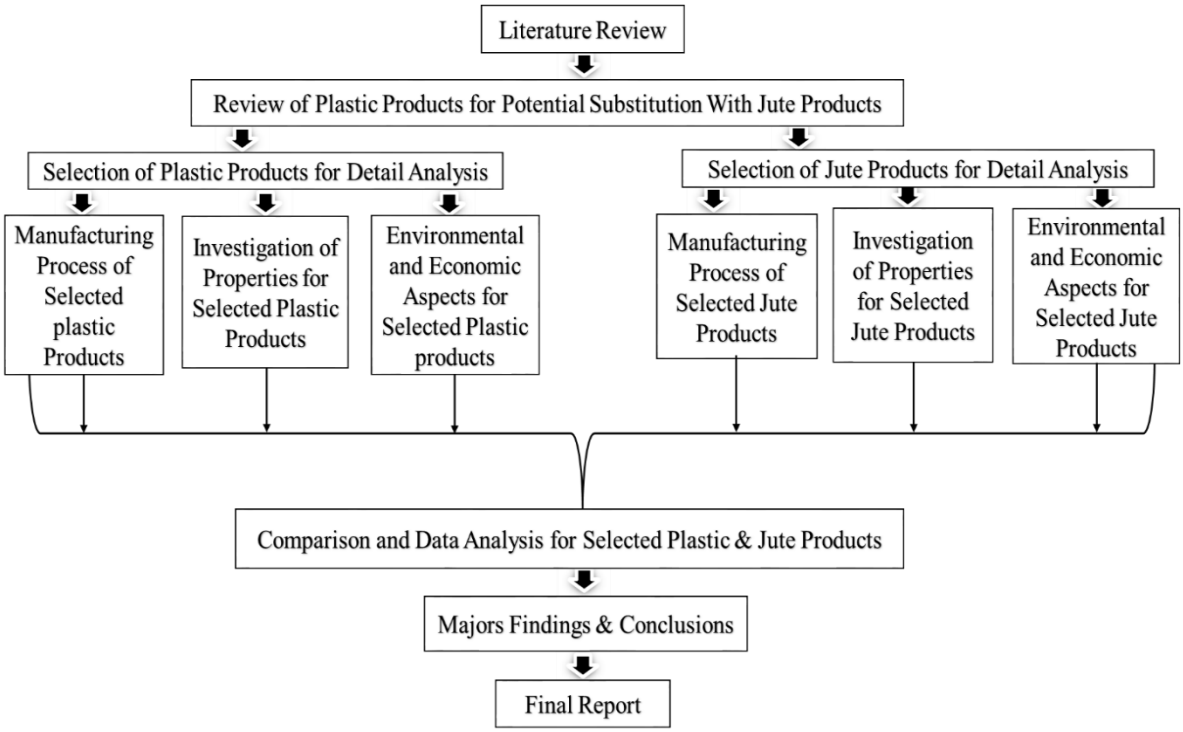
Nevertheless, jute is a strong, compostable, highly durable, renewable, biodegradable, and recyclable natural fiber with a little carbon footprint. Moreover, it consumes carbon dioxide (CO_2) and liberates oxygen more than trees, lessening the greenhouse effect and balancing the ecosystem (Pavel & Supinit, 2017; Singh, 2017). Jute returns CO2 to the environment when it decomposes after absorbing it during growth. Jute assimilates CO2 at a rate that is many times greater than other trees, according to studies. According to studies, during the jute growth season, 1 hectare of jute plants may expel up to 11 tons of oxygen while consuming up to Fifteen tons of carbon dioxide (about 100 days). Additionally, one-sixth of the CO2 produced during the production of PP is emitted during the transport and processing of jute fiber. Likewise, products made from Jute require less energy and generate a tiny carbon footprint than traditional plastic products (Singh et al., 2018). Several daily useable plastic products, such as plastic rice bags, shopping bags, plastic rope, and plastic files, can be substituted by similar jute products with superior mechanical and biodegradable properties and a minimum carbon footprint, causing no threat to the environment, animal and human health (Saha & Sagorika, 2013; Singh, 2017). This study reviews plastics and jute products in terms of

mechanical properties and environmental footprint.

RESEARCH PLAN

The chronological research activities for this study are outlined as below (Figure 2):

Figure 2. Work plan of this study



VARIOUS INITIATIVES FOR PLASTICS SUBSTITUTION BY JUTE

For this current review, all information was collected from published online journals, Google Scholar, ResearchGate, Government sites, Web links, Springer Link, and Policy documents. The relevant information selected for this study was for the last two decades (2005-2022) in order to get current data. Moreover, more than 58 articles were reviewed and 33 published articles were chosen for citation. By giving scientifically valuable information on the behavior of jute and plastic products and their environmental effects, these findings will help policymakers, academics, and government and non-governmental organizations globally.

In literature, various researchers used jute products as substitutions of plastics for different purposes as depicted in Table 1.

Table 1. Literature review of jute products as a substitute of plastic products

Year	Researchers	Products	Significance	Remarks
2005	Craig. M, Clemons and Daniel F. Caulfield	Jute	The primary steps in creating organic materials for use in polymers include harvesting the plants that produce the fibers, extracting the fibers, and finally processing the raw fiber to achieve the necessary purity and performance requirements for use in polymeric combinations.	Public awareness was not adequately represented in the research evidence base.

2009	Asian textile Journal	Jute bag	Jute fiber has some special physical features including high tenacity, bulkiness, sound, and heat insulation capability, and low thermal conductivity, and is mostly used in the production of hessian, Sacking, cloths, bags, ropes, cords, and handicrafts.	Public awareness was not adequately represented in the research evidence base.
2011	Tania Afrin	Jute bag	Sustainable growth, the lifespans of jute and plastic bags, innovation development, the corporate environment, and consumption patterns are the primary areas of this thesis's theoretical framework.	Population studies or public awareness was not adequately represented in the research evidence base.
2013	Md. Abdul Jalil, Md. Nannu Mian	Jute bag	Using a literature analysis to analyze the negative impacts of plastic bags on agriculture and recommending jute shopping bags as a biodegradable and environmentally suitable substitute.	Need laboratory test results, tables, and figures
2016	Mohammad Muzahidul Islam , Jian Xiaoying	Jute Bag	Customers have favorable opinions about the variety of jute products, but steps need still to be performed to ensure their satisfaction. Therefore, knowing customer behavior or buying determinants is crucial for business owners to implement successful green marketing. More research, branding, and ecological marketing are needed for a sustainable, diversified jute sector.	Population studies or public awareness was not adequately represented in the research evidence base.
2017	Shaharia Pavel	Jute poly bag	Invented jute biodegradable poly bag.	Lack of skilled marketers make it difficult for the conventional plastics and bioplastics to compete each other in the global market.
2018	Khan, Shbhendu Dutta, Joystu, choudury, Moharana	Jute goods	Discussing plastics, their effects on the environment, and replacements to plastic substitutes helped raise awareness of the problem of plastic pollution.	Population studies or public awareness was not adequately represented in the research evidence base.
2019	Project Report: “Jute Instead of plastic 2.0”	Jute Bag	Making people aware of the consequences of using plastic items and sensitizing stakeholders to adopt ecologically responsible behavior.	Empirical Testing of research conclusions or hypotheses was required.

POTENTIAL JUTE ALTERNATIVES FOR PLASTIC PRODUCTS

Considering the plastic pollution in the errestrial and marine environment, the major contribution is from ssingle-usedpolythene shopping bags, which could be substituted by mmultiple-usedjute bags

(Figure 3). Plastic sacks, ropes, and file holders could also have promising substitution potetials by jute products. Considering plastic pollution in terrestrial and marine environments, the main contribution is single-use polyethylene shopping bags, which can be replaced by multiple-use jute bags (Figure 3). Plastic sacks, ropes and file holders may also have the potential to be replaced by jute products. Jute multiple-use bags and single-use polythene shopping bags LCA showed that substitution can already be established.(Tania Afrin;2011)

These products have been selected because the aim is to try to replace plastic by jute products from KUET campus.

1. So, plastic vs. jute sacks have been chosen as rice comes in plastic sacks in dormitories, canteens, and teachers' quarters.

2. The reason for choosing plastic vs. jute shopping bag is that plastic shopping bags are used in large quantities in all canteens, campus grocery stores and tea shops in the campus.

3. Plastic File Holders vs Jute File Holders, - Plastic file holders are commonly used by students, teachers and officials too. At many conferences they give away jute file holder bags or jute multipurpose bags.

4. Plastic vs jute rope,- plastic rope is used in campus construction sites, canteens, campus grocery stores, and tea stalls also.

Figure 3. Potential Substitution of Plastic products by Jute Products

HISTORICAL UPSURGE OF PLASTICS

The advancement of plastic was supposed to be initiated in about 1860. After a while, in 1869, the first synthetic plastic was developed by John Wesley Hyatt. Through the subsequent few years, more plastics were created and presented. Ultimately, in 1907, American chemist Leo Hendrik Baekeland made the first truly synthetic plastic named Bakelite for electrical insulation (Worm et

al., 2017). The major and remarkable development of plastics, comprising Nylon, Teflon, Plexiglas, and so on, happened between the 1920s and 1930 (Islam, 2012). Wallace H. Carothers of Dupont invented Nylon, and Chemist Julian Hill later developed it. Roy Plunkett invented Teflon in 1938, and manmade rubber was manufactured during the World War (Islam, 2012; Islam & Hasan, 2014). Subsequent to the world war, the progress of the Plastics industries remained their improvement. Chemist Karl Ziegler made Polyethylene (PE) in 1953, & chemist Giulio Natta prepared polypropylene (PP) in the following years. For this reason, they acquired the Nobel Prize together in 1963 due to their outstanding research contribution. Today, PE and PP are the best frequently useable plastics. The world has grasped today's position due to the hard work and successes of 3rd generation throughout the time from 1978 to 2000 (Islam et al., 2017; Worm et al., 2017). Plastics are continually advancing and are constantly replacing matters similar to wood and glass to discover the newly developed plastics in the new epoch of the present society (Islam, 2012; Islam & Hasan, 2014).

THE MANUFACTURING PROCESS OF PLASTIC

Organic substances like crude oil, natural gas, and other such substances are used to make plastic. Several hazardous chemicals, including acetone, methylene, chloride, styrene, benzene, sulfur oxides, nitrogen oxides, methanol, etc., as well as several volatile organic molecules, are routinely produced during the production of plastics.(Hossain et al., 2016)

Organic molecules derived from petroleum, including natural gas, petroleum oil, crude oil, and other similar substances, are used to make plastics. Monomers are made up of carbon-carbon bonds with additional molecules like hydrogen, oxygen, nitrogen, chlorine, phosphorous, etc. Briefly detailed here is "how polymers are made from crude oil" (Figure 4):

- The refinery sector transforms crude oil into petroleum products including ethane, propane, and other petrochemical byproducts like diesel, fuel gasoline, and so on.
- Ethane and propane are broken down to propylene at a temp of 760 o C.
- These two hydrocarbons, ethylene, and propylene are isolated from other petroleum-derived hydrocarbons petroleum-derived hydrocarbons.
- In a reaction chamber, these hydrocarbons are combined with a catalyst to create a lengthy polymer chain that is known as plastic during the procedure of additional reactions.

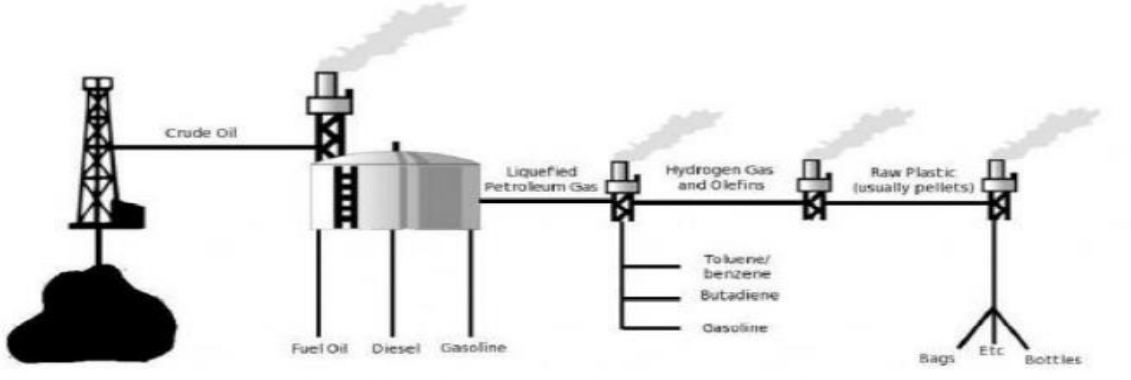


Figure 4. Plastic from crude oil (Source: Nazmul Hossain, 2016)

The main five methods used to manufacture plastic are injection molding, extrusion, blow molding, blow molding with injection molding, and extrusion blow molding. Below is a brief explanation of each of these processes:

One of the most significant and well-liked manufacturing procedures for creating plastic items in the plastic industry is injection molding. By using this procedure, plastic goods can be made from practically all types of thermoset and thermoplastic plastics. The polymers are heated into a mold

cavity under high pressure and at specific temperatures, where they solidify. Due to the ability to produce complicated and much more cross-sectioned items in addition to creating them, this is the most preferred method for making plastics, even more so than extrusion. It's also possible to perform tiny part-by-part modifications for the items using this approach. This procedure can be used to create bottle caps, packaging, pocket combs, wire spools, etc.

An additional well-liked method for producing plastics is extrusion. The two basic ways to complete this process are as follows:
1. Extrusion would be used to shape pieces immediately the following mixing.
2. In a system that is associated with other process is carried, an extruder can be employed as a melting device.

However, the process of blow molding is used to produce plastic, primarily for hollow objects like bottles. It is comprehensible in three easy steps:
1. Resin being melted.
2. Constructing a perform tube.
3. Creating the desired form by blowing the tube.

PROPERTIES OF PLASTIC PRODUCTS

The mechanical and physical properties of various types of plastics are reviewed from different literatures and outlines as below (Table 2, 3):

Table 2. Mechanical Properties of Various Plastics

Plastics	Density (g/cm^3)	Tensile Strength (MPa)	Tensile Modulus (GPa)	Flexural Strength (MPa)	Flexural Modulus (GPa)	Impact Strength	Ref.
Epoxies	-	55-130	2.7-4.1	110-150	3-4	-	Crosky, N. Soatthi yanon, 2014
Phenolic	-	50-60	4-7	80-135	2-4	-	Crosky, N. Soatthi yanon, 2014
Polyester (PET)	-	34-105	2.1-3.5	70-110	2-4	-	Crosky, N. Soatthi yanon, 2014
Vinylesters	-	73-81	3-3.5	130-140	3	-	Crosky, N. Soatthi yanon, 2014
Polylactide	1.24	56.3	3.6	-	-	-	F. Duc et al.,2014
Polyester (PCDT)	1.2	61	4	-	-	-	S.B. Brahim et al.,2007
Polyvinyl chloride(PVC)	1.35	48	3.300	-	-	0.32 J/cm	R.D. Dianin et al.,2012
Polystyrene	-	46	2.9	-	-	0.17 J/cm	R.D. Dianin et al.,2012
Polypropylene (PP)	0.899 - 0.920	26 - 41.4	0.95 - 1.776	55.2	0.83-1.73	21.4 - 267 J/m	D.V. Rosato et al.,2000
Low density polyethylene (LDPE)	0.910 - 0.925	4-78.6	0.055 - 0.38	-	-	>854 J/m	D.V. Rosato et al.,2000

High density polyethylene (HDPE)	0.941-1	14.5- 38	0.413-1.490	-	0.41-1.07	26.7 J/m	D.V. Rosato et al.,2000

IJIRA conducted a comparison study to evaluate how well jute and polythene bags performed from the perspective of the end user. The study's results have been tabulated (Tables 3 and 6), and it is clear that, with the exception of cost, jute bags are much better than their polythene counterparts. (Textile today; 2010)

Table 3. Physical Properties of Plastics

Sl. No	Properties	Remarks
01	Seam strength	Very weak
02	Heft and chemical stability	Low
03	Molded into a variety of shapes and sizes	Easily
04	Insulation	Good
05	Thermal conductivity	Low
06	Impact resistance	Good
07	Durability	High
08	Transparency	High
09	Dimension instability	Poor
10	Cost	Low
11	Storage space utilization	Poor
12	Surface textures	Fine
13	Stacking Durability	Poor
14	Reusability	Poor
15	Effect on atmospheric temperature and sunlight	Prone to rapid deterioration

EFFECT OF PLASTICS PRODUCTS ON THE ENVIRONMENT

Plastic harms the environment, as is well known. The first problem is pollution. Pollution of the land and water is largely caused by plastic. It can harm marine life if it ends up in our rivers and oceans when it is improperly disposed of. Additionally, it may end up in landfills, where it takes hundreds of years to degrade. The threat of deforestation exists. Global warming is a concern. Greenhouse gases are released during the manufacture of plastic, and they aid in climate change. (Alsabri et al., 2022) showed how much greenhouse gases people are spewing into the sky, climate change poses a serious threat to both people and nature. People's health is a concern. Chemicals in plastic can contaminate food and water since they are highly reactive. Cancer, troubles with reproduction, and other health concerns have all been linked to these substances. Fishing lines, plastic 6-pack rings, and other types of rubbish can entangle wildlife, causing harm or even death. Additionally, animals may confuse plastic for food and ingest it, which could result in intestinal obstructions or even force them to starve to death. Due to their propensity to confuse floating garbage for jellyfish and consume it, sea turtles are particularly susceptible to plastic contamination (Pinto Costa et al., 2020).

ECONOMIC ASPECTS OF PLASTIC INDUSTRIES IN BANGLADESH

Plastic has quickly become a necessary component of our lives since its development thanks to its commercialization. With a net profit of $13.2 billion, the world's plastic output in 2018 totaled more than 359 million metric tons. In terms of Bangladesh's international export trade earnings, plastic is now the 12th biggest source. The healthcare, automobile, and apparel industries all often utilize plastic. Plastic may be very important to the economy of the country in the future. During the 2017–18 fiscal year, Bangladesh exported products made of plastic and other materials worth $1 billion, of which 1.9 billion dollars were used locally. It was 20% greater than the prior year. The increased

demand for plastic in the local market is brought on by the rising popularity of plastic toys, home goods made of plastic, hardware made of plastic, and furniture. However, the country's resources are not particularly rich in polyolefin, one of the essential components of plastic. Nevertheless, 142 distinct kinds of plastic are already employed in production, and more are anticipated in the future. The plastics sector is expanding; there are now over 5000 production facilities. SMEs are included in 98%. Approximately 15 lakh people are engaged in Bangladesh's plastic industry, including 6 lakh indirect workers and 2 lacks each in the lower, medium, and top units.

Table 4. Plastic sector in Bangladesh, Source: UN-ESCAP Report-2099 (UPDATED)

Domestic Market	TK 7000, Corer (US $950 Million)
Per Capita Plastic Consumption	About more than 5 Kg/ year
Direct Export Earning	TK 500, Corer (US$ 69 Million)
Deem Export: RMG Accessories	TK. 2000, Corer (US$ 286 Million)
Manufacturing Units	Medium and large plastic manufacturing units operate across the country
Recycling Sector	There are 300 small units in Dhaka City which recycle about 138 tonnes/day
Growth	20 percent per annum During the 1990s
Employment	Half a million workers are got employed in the sector

HISTORY OF JUTE INDUSTRY IN BANGLADESH

Historically, Bengali handlooms were used to make rope and clothing from manufactured jute. In 1838, a request for jute sacks for Java sugar fields under Dutch administration came to Dundee Mills. Using the methods of the Balfour and Melville firms, they produced jute burlap sacks. The sacks created a huge demand, which led to the promotion of Bengali-produced jute. The very first jute factory was then created by George Auckland near Rishra in 1855. In 1873, the British Raj appointed a commission to investigate jute farming and industry in Bangladesh. The report on the Jute Trade and Cultivation in Bengal was published in 1877 (Akter et al., 2020). In British India, the jute trade was centered in Kolkata. East Bengal was where jute was produced, and West Bengal was home to all 108 jute mills. Jute production encountered challenges following India's Partition. In East Pakistan by 1970, there was Seventy-seven jute mill with one hundred and seventy thousand workers. Victory Jute Products Ltd., Adamjee Jute Mill, and Bawa Jute Mills Ltd. were all founded in East Bengal in 1951. The Pakistan Industrial Development Corporation provided financial assistance for the construction of Adamjee Jute Mills 14 jute mills were operating in 1960.

TRENDS OF CURRENT JUTE INDUSTRIES IN BANGLADESH

Bangladesh Jute Mills Corporation is in charge of regulating the price, purchase, and trade of jute in Bengal. The government established the Jute Division in 1973 and placed it under the Treasury department. In 1979, a parliamentary commission proposed privatizing the factories. Between 1979 & 1980, 3 jute mills were returned to their original proprietors, while 2 others were privatized.(Abdullah, n.d.) Bangladesh Jute Mills Corporation is in charge of regulating the price, purchase, and trade of jute in Bengal. The government established the Jute Division in 1973 and placed it under the Treasury department. In 1979, a parliamentary commission proposed privatizing the factories. Between 1979 & 1980, 3 jute mills were returned to their original proprietors, while 2 others were privatized. (Bell & Cave, 2011) Bangladesh's jute industry is worth over $1 billion to its economy. The government banned the export of unprocessed or raw jute in January 2018. The limitation was abolished in June 2019 as a result of demand from the Bangladesh Jute Association.

THE MANUFACTURING PROCESS OF JUTE FROM

On cultivated soil, farmers distribute the seeds to grow jute. The plants are trimmed down after they are 15 to 20 cm tall. Harvesting gets under way four months after planting. Prior to the flowers

setting seed, plants are often plucked after flowering. The stalks are chopped off just above the earth, bundled together into bundles, and submerged in water for around 20 days. The tissues become softer as a result of this process, which also weakens the rigid pectin connection holding the inner woody fibers (bast) and [Jute hurd] together, allowing the fibers to be detached. Long strands of the fibers then are separated from the stalks and cleaned in clean, flowing water. They are then stretched out or put out to dry on thatched roofs. The fibers are bundled and knotted after drying for two to three days. Relative humidity between 70% and 90% and temperatures over 25 °C are ideal for good growing. Every year, jute needs 160–200 cm of rain, with more needed during the planting season. Retting is the technique of removing fibers from the fibrous bast of bast fiber plants. The many retting methods include mechanical retting (hammering), chemical retting (boiling and adding chemicals), steam/vapor/dew retting, and water or microbiological retting. Along with other gases including methane, carbon dioxide (CO2), and hydrogen sulfide, the manufacturing of jute produces organic acids like acetone, ethyl alcohol, and butyl alcohol. When it comes to jute, CO2 and methane are the substances that cause global warming. Mainly during retting, the latter one is discharged.

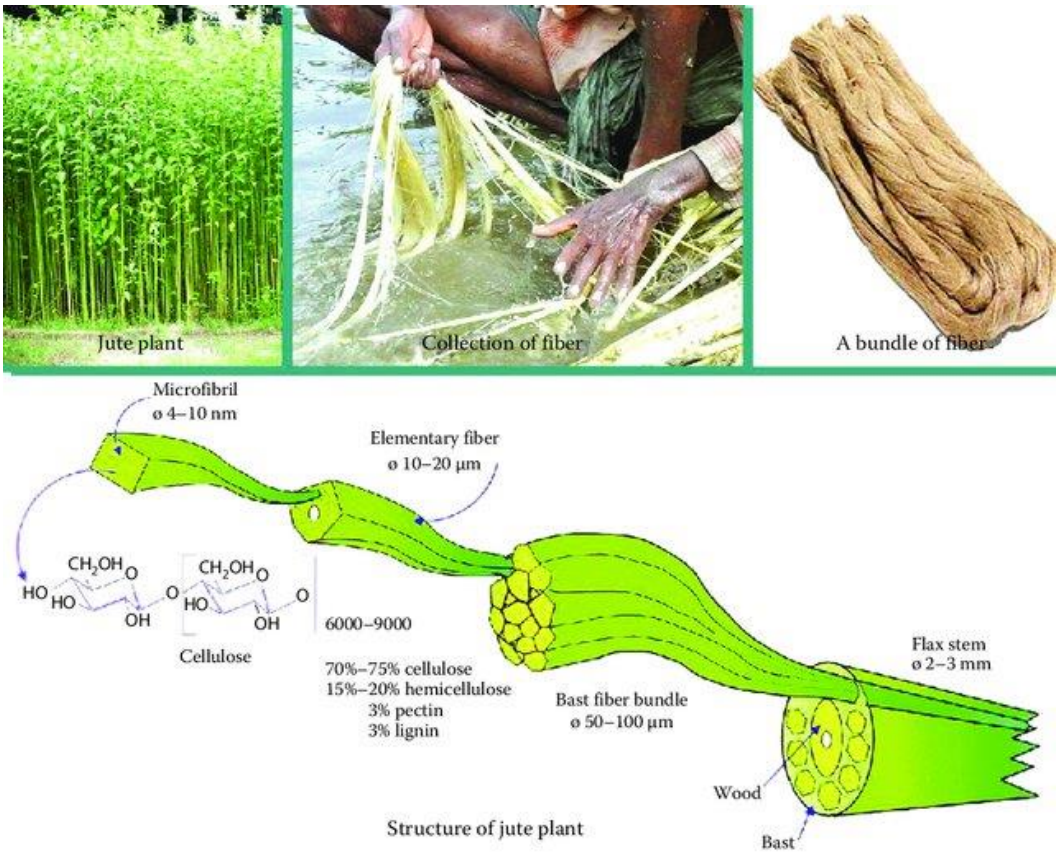


Figure 5. Structure of a jute plant and jute fiber. Source: Khan, et. al. 2015)

Jute is one of the most environmentally favorable 100% biodegradable crops. It has a cultural history that dates back hundreds of years. Jute is crucial to the economic growth of large parts of Bangladesh. Its durability and iridescent sheen set it apart from the competition (Shakil et al., 2013). The flow diagram delineated below shows the jute manufacturing process (Figure 5).

Jute Bath Selection: Fresh jute bundles are opened as part of the selection process for raw jute to identify flaws and be removed from the more by professional employees. Raw jute comes in two

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weights: 150 kg and 180 kg. Similar to Hessian, raw Jute bales are classified based on their intended purpose.

Patch Up: Jute that is faulty is separated by skilled personnel and utilized to make low-quality yarn. The roots of bale cuttings are exceedingly tough and challenging to remove from the bale.

Softening: Jute fiber is softened using a jute excellent spreader and a softening machine. Fiber becomes moist and malleable under the pressure of the fluted rollers it goes through and the emulsification of oil and water. The types of manufactured products are used to categorize the different emulsion types.

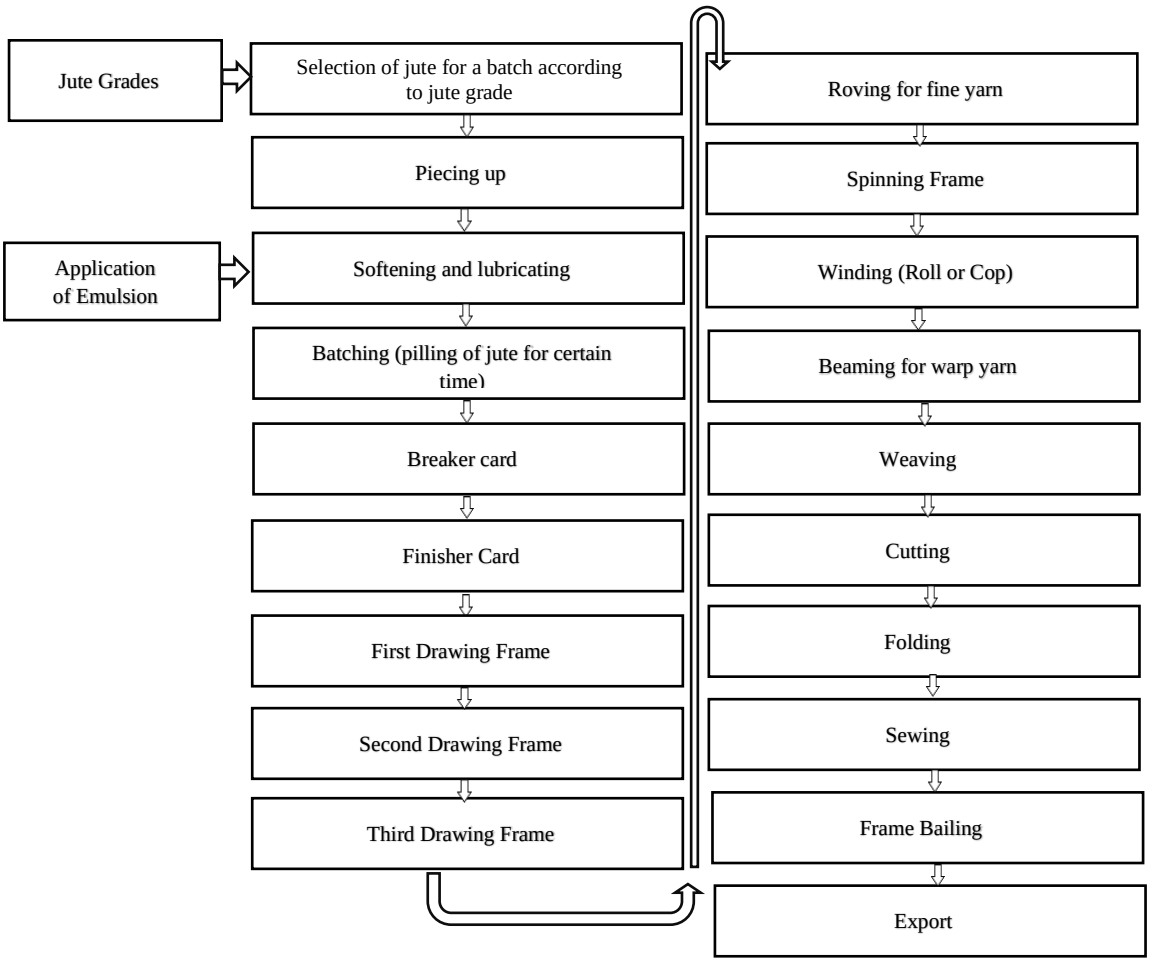

Figure 5: Process Flow Chart of Jute Production

Batching: The hard part of the root is softened during piling because the moisture from the surface seeps into the fiber and a "Thermo fillic" action occurs. The material is transported to the carding machine by pile breakers after having been piled for over 24 hours.

Carding: Carding jute is an important step in the process of turning jute into a spinnable fiber.

Breaker Carding: The breaker card is a device that breaks down the meshy structure into as many separate lengths entities of filament as it can while also removing dust and other contaminants. After being manually fed in the proper weight, the breaker carding machine softens the jute.
Inner Carding: The end result is now finer, softer. The fibers which make up the cards are slightly jumbled and far from being straight or parallel, and it is then transferred through the inner and finishing cards, which are only marginally uniform.

Finisher Carding: The Finisher carding machine makes the sliver obtained from the Breaker carding machine more uniform in terms of weight and length. The Finisher carding machine is quicker than the Breaker carding machine and features more pairs of rollers, staves, and a different pinning configuration.

Drawing: Drawing Frame machines come in three different varieties. Majority of mills employ three drawing passageways for hessian and two for sacking. First Drawing frames machines blend, level, and offer quality and color by duplicating or equalizing two or more slivers.

Wandering for Exquisite Yarn: The silver that comes from the comber is heavier and unsuitable for feeding directly into the ring frame used to manufacture yarn. The thick drawn silver is transformed into thin, low-twist silver by the roving frame. In this instance, the drawing frame is handled before going into the inner ring frame.

Spinning: The spinning frame machine has a slip draft zone and is equipped with auto-doffing mechanisms to produce high-quality yarns with great efficiency.

Precision: Through careful winding, successive coils of yarn are arranged parallel or nearly parallel. This method makes it feasible to create incredibly thick packages that contain the most yarn per unit of volume.

Beaming: Wrap yarns are coated with starch paste as part of a beaming operation, which improves the quality of woven fabric and weaving efficiency. In this operation, yarn from a spool is looped across a beam with the right width and number of ends to weave jute fabric.

Weaving: Two kinds of yarn are woven together to produce a rigid cloth, known as weft and warp or ends. There are distinct looms for sacking and hessian in the weaving department.

Cutting: The drive consists of a linear motor that is electrically powered and functionally coupled to at least one of the blade carriers in order to perform the yarn-cutting operation between the blades.

Folding: The folding station uses pneumatically operated cooperative claws to fold the yarn in half.

Sewing: Sewing threads are designed for effective, smooth sewing that won't break or deform for the duration of the sewed item. Its primary purpose is to keep together components made of leather, textile, or other materials. The technique involves using sewing machines to attach the components with sewing thread.

PROPERTIES OF JUTE PRODUCTS:

The mechanical and physical properties of jutes are given below (Table 5, 6):

Table 5. Mechanical Properties of Jute Fiber

Reinforcement	Tensile Strength (MPa)	Tensile Modulus (GPa)	Flexural Strength (MPa)	Flexural Modulus (GPa)	Impact Strength	Ref.
Bidirectional jute fiber mat	110	4.450	55.80	3.02	4.87	V.Mishra et al.,2013
Jute	69.66	6.19	94.08	5.91	-	Y. Seki et al.,2009
Woven jute	15.53	0.2554	79.20	1.355	0.28J	M.M. Owen et al.,2014
Woven jute	12.69	0.1985	81.81	1.381	0.35J	M.M. Owen et al.,2014

Jute laminate (Longitudinal 0-0)	112.69 39.1	14.59	-	-	-	M.R. Hossain et al.,2013
Jute laminate (Transverse 0-90)	39.1	8.97	-	-	-	M.R. Hossain et al.,2013
Jute	16.62	0.667	57.22	8.956	13.44kJ/m2	M. Bhoopalan et al.,2013
Jute	26.53	6.32	66.67	5.78	80J/m2	N. Venkatesh waran et al.,2012
Jute	60	7	92.5	5.1	29 KJ/m2	T.M. Gowda et al.,1999
Jute	48.52	4.23	63.01	3.62	-	Y. Seki et all.,2009
Jute	77.1	5.07	176	19.26	24.7KJ/m2	D. Shanmugam et al., 2013
Long jute (Longitudinal)	162	5.58	-	-	1295 J/ m	A. Crosky et al.,2014
Long jute (Transverse)	0.43	0.98	-	-	148J/m	A. Crosky et al.,2014
Jute mat	23.0	4.0	-	-	-	T. Hojo et al.,2014
Jute	-	-	199.1	11.890	22.10	D. Ray et al.,2001
Jute mat	42.0	1.61	56.2	3.78	-	A. Crosky et al.,2014

Table 6. From previous discussion of table 3.

Table 6. Physical Properties of Jute

Sl. No	Properties	Remarks
01	Natural fiber	smooth and golden sheen
02	Seam Strength	Strong
02	Sunlight and ambient temperature effects	unaffected
04	Efficiency for grain preservation	Excellent
05	Stack Stability	Outstanding
06	Biodegradability	Completely
07	Environmentally	friendly
08	Jute stem can supply the need for wood	4-6 months
09	Cellulose that obtained	very large amount
10	Weight	Heavy
11	Dimensional stability	Good
12	Reusability	Excellent
13	Cost	expensive
14	Surface Texture	Rough
15	Storage space utilization	Excellent

EFFECTS OF JUTE PRODUCTS ON THE ENVIRONMENT

The environment benefits greatly from the use of jute. In many ways, it is a fiber that is favorable to the environment. Fiber is better than synthetic fibers in terms of environmental friendliness, and so are its products. It also indirectly affects the economy by having an impact on the environment. Vegetables come from green leaves, while dry leaves improve soil fertility. Jute's roots boost fertility while its leaves and roots serve as pesticides. The use of jute as a composite material and particle lowers reliance on wood as a fuel, hence reducing forestry. Environmentalists contend that a country's forest area should be 25% larger than it is; sadly, Bangladesh is just 8% to 9% larger. The gap can be filled to some extent by the fast-growing jute plant. To prevent the ozone layer from being destroyed, the jute absorbed carbon dioxide from the atmosphere. Additionally, it releases oxygen into the air to support human life. According to studies, during the jute growth season, one

hectare of jute plants may expel up to 11 tons of oxygen while consuming up to 15 tons of carbon dioxide (about 100 days). Additionally, one-sixth of the CO2 produced during the production of PP is emitted during the transport and processing of jute fiber. Jute plants can purify the air and also give fertility to the land (Islam & Ahmed, 2012).

Plastic has many different harmful consequences on the environment. They include anything from the devastation of our marine life to the contamination of our waterways. We must take steps to lessen our reliance on plastic because we can no longer ignore the issue. We can start by introducing minor adjustments to our daily routines, such as using reusable bags and water bottles (Srivastava, 2012). Bangladesh is already at significant risk of plastic pollution and will remain so if necessary measures are not taken right away. Even though there hasn't been enough research on the amount of plastic waste generation, its fate, and its impact on different environmental compartments of Bangladesh. Through its impact on the environment, pollution harms every living thing, including humans and zooplankton. Without proper monitoring of plastic production and waste management, it would also be difficult to achieve the goal for sustainable development set by the United Nations in 2015 to preserve a peaceful, poverty-free planet Earth by 2030 (*Green Marketing Of Jute and Jute Products: A Study on Bangladesh*, 2015). The nation has already taken certain actions in response to this, but it seems that the usage of plastic and the ensuing pollution has not yet been reduced expectedly. Therefore, it is suggested that the following actions be taken to address this global issue sustainably:

- By promoting consumer knowledge of the harmful effects of plastic use through media commercials and campaigns by governmental and non-governmental groups, as well as by encouraging end users to refrain from using it.
- To discourage people from throwing plastic debris wherever reward-based plastic collection programs are being introduced.
- Enhancing inter-university and inter-institutional research collaboration to evaluate the effects of plastic trash on several environmental compartments.
- Growing research prospects and financing for the search for biodegradable polymers and commercially viable plastics, particularly for packaging.
- For firms and industries involved in the creation of biodegradable alternatives to plastics, preferential tax treatment, simple bank financing, and duty-free importation of tools and machinery are offered.
- Utilizing the nation's enormous jute production capacity to produce affordable biodegradable plastic substitutes and offering incentives for these kinds of firms.
- Levying substantial tariffs on industries involving plastic, from importing raw materials to marketing finished goods. People will stop utilizing plastic products due to high prices.
- Examining eco-friendly alternatives to plastic production companies and plastic recycling as a long-term solution to the nation's escalating unemployment issue
- More research is required to determine the most cost-effective ways to manufacture and sell jute products.
- Making sure jute products are always accessible will encourage people to buy and utilize them.

ECONOMIC ASPECTS OF JUTE INDUSTRIES IN BANGLADESH

Between 2010 and 2019, the Bangladeshi government donated more than 7.5 billion takas to the Bangladeshi Jute Industries Company. The business has been going to lose money every year since 1980, except for the tax year 2010–2011, and has never been able to turn a profit. Bangladesh Jute Mills Corporation was referred to be a "bottomless pit" in 2019 by The Daily Star. The need for sustainable and biodegradable natural fabric is increasing, which has rekindled interest in jute in the business sector in Bangladesh. An organization from Bangladesh called Khiyoo Fashion House uses jute to make clothing and footwear. In 2017, India implemented pro-government taxes on jute cloth material, sacks, and thread. The anti-dumping charges on jute sacks in India increased in 2019 by USD 125.21 per ton. Given that India was a significant market for Bangladeshi jute, Concerns were expressed as a result of the Bangladeshi Jute Factories Union and Bangladeshi Jute Bowlers Organization. The two biggest privately owned jute mills in Bangladesh are still Janata and Akij. Jute Hessian, often known as burlap, is a higher-grade jute fabric that has been used for

a long time as the go-to packing material for all manner of items. Hessian is used for bags as well as many other coarse fabric applications as wraps and wall coverings. Hessian textiles are being used to make shopping bags. Hessian production in Bangladesh was estimated at 1,856.000 metric tons in August 2022. The previous figure for July 2022 was 1,798.000 Metric tons, therefore this represents an increase. Hessian data has 343 observations and is updated monthly with an average of 4,484.000 metric tons from February 1994 to August 2022. A record high of 11,646.000 Metric tons was achieved in October 1994, and a record low of 1,648.000 Metric tons was attained in March 2021. Bangladesh Bureau of Statistics continues to submit Hessian production statistics, which have an active status in CEIC. The information is arranged under Bangladesh's Table BD. B013: Production by Commodity in the Global Database. To increase production, improve quality, guarantee fair prices for jute farmers, and increase yield per hectare, the National Jute Policy was created in 2005. The United States, Canada, Russia, the United Arab Emirates, the United Kingdom, and Australia are the major markets. A new market for jute goods has emerged as a result of the expanding global demand for environmentally friendly, biodegradable materials.

COMPARISON OF PLASTIC AND JUTE PRODUCTS

Since there is no environmental comparison between organically produced agricultural produce and synthetic plastics made by the petrochemical sector, we can assume that the advantages of jute over polypropylene are clearly evident from an environmental point of view. While the benefits of polypropylene are obvious in terms of financial cost, the ecosystem's downsides may not be as obvious. For these reasons, businesses and organizations that use pricier jute goods are unquestionably setting the bar high and prioritizing the environment (Bell & Cave, 2011).

Table 7 is written by comparing Table 3 and Table 6. Here is a comparison of some common features of plastic products and jute products such as biodegradability, renewability, carbon footprint, Effect of atmospheric temperature etc.

Table 7. Comparative performance of Jute and Plastic Products

Properties	Jute products	Plastic products
Biodegradability	Biodegradable	Not Biodegradable
Renewability	Renewable	Not renewable
Carbon footprint	Very lower Carbon footprint	Very high Carbon footprint
Compostability	Compostable	Not compostable
Effect of atmospheric temp.	Unaffected	Highly affected
End-used performance	Good	Poor
Stack stability	Excellent	Poor
Resistance for hooking	Fair	Poor

Table 8 told about two products (plastic product- polythene and jute product-hessian) Energy input and carbon footprint output difference. (Source: Chandan and sagorika, 2013)

Table 8. Energy input and carbon footprint output for plastic and jute products (Saha and Sagorika, 2013)

Products	Energy (GJ/1000kg)	Carbon footprint, (Tons CO_2 eq.)
Plastic(polythene)	63	1340
Jute(hessian)	02	0.15

CARBON FROOTPRINT OF PLASTIC AND NATURAL FIBER (JUTE):

According to the report, the worldwide carbon footprint of plastic has nearly double since 1995,

capable of reaching 2 billion GtCO2-tonnes of CO2-equivalent (CO2e) in 2015 and constituting 4.5% of annual greenhouse gas emissions(Nature Sustainability, 2021). The carbon footprint of plastic, including the fossil resources needed as fuel and feedstock for plastic materials manufacturing, has quadrupled since 1995 as a result of the growing reliance on coal. According to the report, the combustion of fossil fuels used to produce plastics globally resulted in the release of 1.7 GtCO2e in 2015. According to the study, over the same time (1995-2015), the global health impact of plastics from fine particle air pollution grew by 70%, resulting in over 2.2 million disability-adjusted life years (DALY) in 2015.

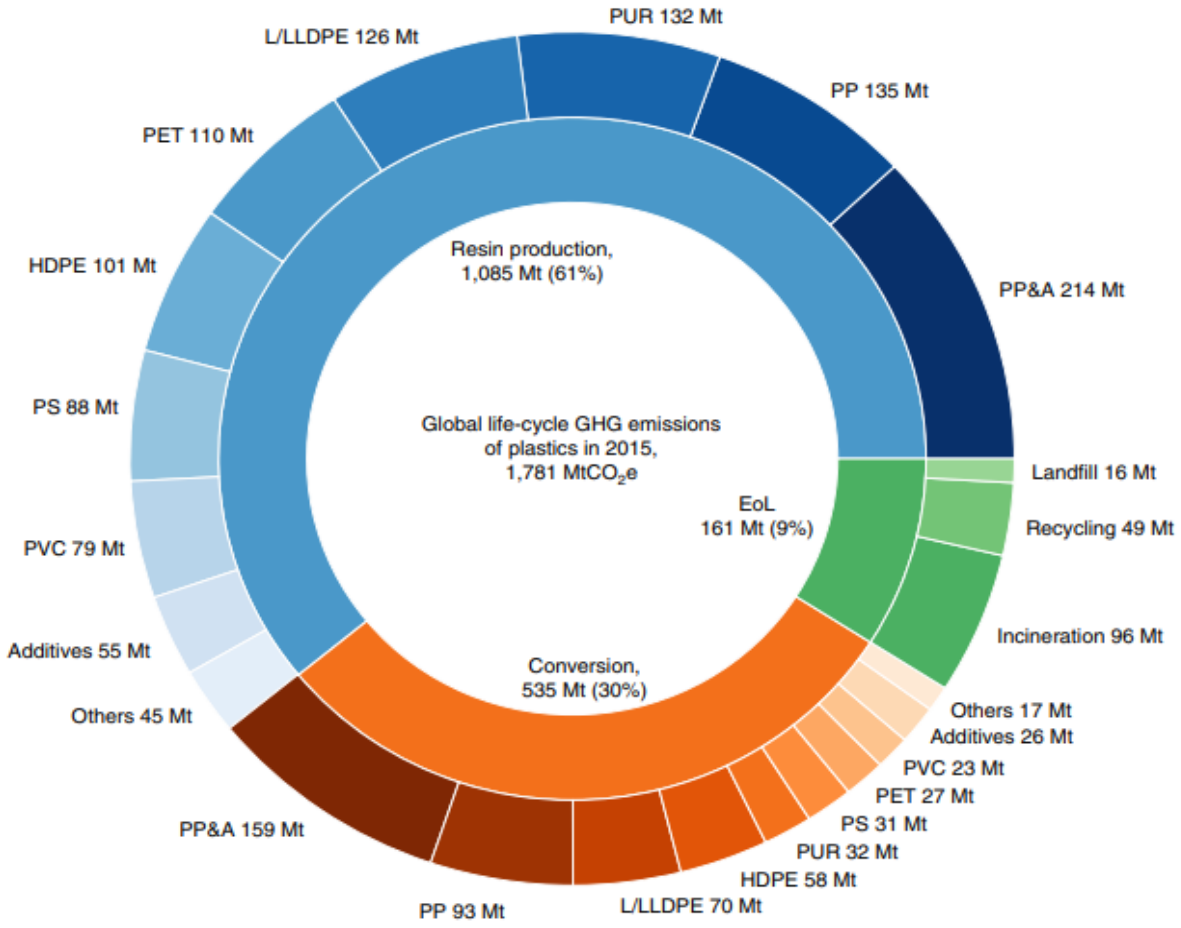

Figure 6. Carbon Footprints of Plastics (Source: Jiajia Zheng and sangwon Suh, 2019)

Natural plant fiber cultivation and processing need synthetic fertilizers and pesticides, consume water, and release greenhouse gas emissions (Rana et al., 2014). Alluvial soil that is uncomplicated and with standing water is essential for growing plants. During monsoon season, a warm, moist atmosphere that is ideal for cultivating jute is available. It is best to cultivate plants at temperatures between 20°C and 40°C with a relative humidity of 70%–80%. During the sowing season, the jute needs 58 cm of rainfall per week or more. Bangladesh is hence the perfect place to cultivate it. The second-most significant vegetable fiber in terms of usage, consumption, production, and availability is jute, which has a golden and silky sheen. Natural plant fiber production needs water, artificial fertilizers, and pesticides, and releases greenhouse gases. In addition to using synthetic fertilizers and pesticides, growing and processing natural plant fibers needs water and emit greenhouse gases.

The growing methods and post-harvest processing of natural fibers affect their carbon footprints. One of the best methods to reduce a carbon footprint is to reduce the amount of energy required for crop production. This is because, of the approximately 334.41 million tonnes of CO_2 equivalent that agriculture produces, 13.76 million tonnes are CH4 and 0.15 million tonnes are N_2O.

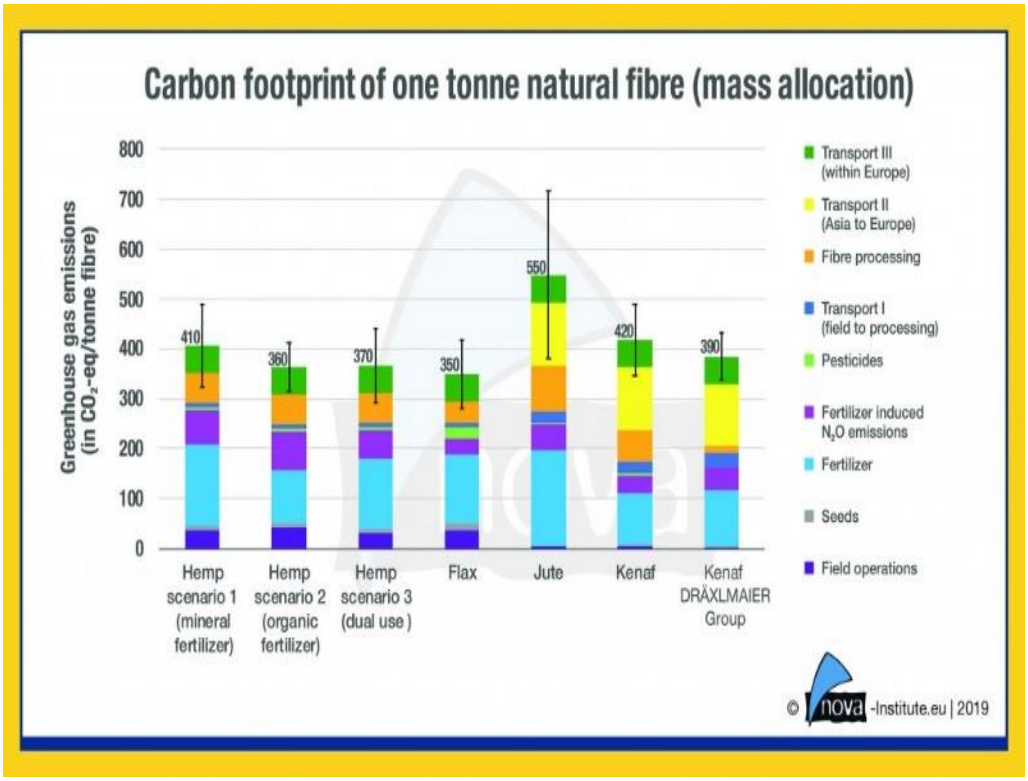

Figure 7. Carbon footprints of Natural fiber (Source: Nova-inistitut GMbH, 2019)

CONCLUSIONS

The usage of plastics is increasing rapidly in our modern civilization in various industries, commerce, packaging, and household with the rise in population, economic development, and lifestyle changes. However, plastics are tremendously dangerous for the environment, plants, terrestrial and aquatic animals, as well as human health because of their non-biodegradability. On the other hand, jute products are a game-changer invention that can be a fantastic eco-friendly substitute over petrochemical-based plastics because they are compostable, highly durable, renewable, biodegradable, sustainable, reusable, and recyclable natural origin products. Moreover, jute, the main material for jute products, consumes carbon dioxide (CO_2) and liberates oxygen, reducing the greenhouse effect, which equalizes the ecosystem. Also, jute products require less energy during manufacturing and produce a trivial carbon footprint than usual petrochemical-based plastic products. Equally, jute products are cheaper than plastics because of the multiple and longtime usages of jute products. Therefore, there is no doubt that jute products can help reduce the dependency on plastics made from high price non-renewable crude oil, lessening plastic waste generation and resulting in the protection of our environment. Hence, governmental support and social awareness are essential to building a model and moving from petrochemical products to jute products. Our future study plans to do a life cycle analysis of jute and plastic products and work on it is in progress. Life cycle analysis of jute and plastic products can be done to replace plastic with jute products.

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