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Investigating the Behavior, Properties, and Environmental Implications of Jute and Plastic Products for a Sustainable Future

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Abstract This comprehensive review paper critically evaluates the environmental implications and performance characteristics of plastic and jute products, drawing upon extensive literature and empirical data. Beginning with an examination of the physical and chemical behaviors of plastic, including its manufacturing rate and environmental impact, the paper navigates through key aspects of the jute industry in Bangladesh, from historical perspectives to current trends. Through meticulous analysis, the properties and environmental effects of jute products are elucidated, showcasing their biodegradability, renewable sourcing, and minimal carbon footprint. A meticulous comparison between jute and plastic products underscores the superior sustainability and performance of jute across various metrics. Notably, the evaluation of energy consumption and carbon footprint reveals stark disparities, with plastic products exhibiting significantly higher environmental burdens compared to jute counterparts. The discussion extends to the future prospects of jute and plastic products, advocating for urgent shifts towards sustainable materials and robust waste management strategies. Grounded in scientific rigor and critical inquiry, this paper contributes nuanced insights into the complex interplay between material choices, environmental impact, and pathways toward a more sustainable future.

Keywords Environmental Impacts, Prospects, Jute, Plastic, Physical & Chemical Properties.

1. Introduction

The development of plastics marked a critical turning point in human history and improved living conditions. Because of their low weight, durability, resistance to corrosion from most chemicals, variety of applications, ease of processing, and affordability, plastics have supplanted a wide range of materials in the production of consumer goods since they were first synthesized in the early 1900s, including wood, metals, and ceramics. Apart from the aforementioned advantages, research has demonstrated that plastic-based products contribute to reduced production costs across a range of human endeavors, product diversification, and global market expansion, with a notable increase in the packaging industry and corresponding profits for chemical, oil, and manufacturing firms (Sartorius, 2010; Dauvergne, 2018).

Petrochemicals are typically used to create plastics, which are artificial polymeric materials. Most common polymers derived from petrochemicals are polyester, polyethylene, polypropylene, polyethylene terephthalate (PET), polyvinyl chloride (PVC), and polystyrene, among others (Nanda et al., 2022; Geyer et al., 2017). Today, plastics play a vital role in commerce, household goods, and other industries. They are an indispensable part of our modern civilization. Global demand for plastic items is driven by factors such as population growth, economic expansion, the need for commodities, and lifestyle changes (Nanda et al., 2022). Because they are lightweight, flexible, tensile strong, inexpensive to produce, and widely available, plastics can be used in a wide range of applications. Plastics are now more common in packaging than even glass and paper (Nanda et al., 2022; Shafqat et al., 2020). Between 2010 and 2020, the manufacturing of plastics rose by 36% worldwide (Figure 1). According to Thakur & Thakur (2016), the yearly generation of plastic garbage worldwide is currently approaching 150 million tons. Currently, 8300 million metric tons of new plastic are produced worldwide. About 6300 Mt of plastic garbage is produced a year; only 9% of this is recycled, and another 12% is burned, leaving the other 79% to be disposed of in landfills or the environment. It is projected that 12,000 Mt of residual plastic will accumulate in landfills or the environment by the year 2050 if current trends continue (Geyer et al., 2017). Furthermore, the majority of plastic garbage pollutes the environment when it ends up in soil, water, oceans, and landfills, putting humans, other animals, and plants in danger. Plastic pollution has killed 100,000 marine species and over a million seabirds globally (Othman et al., 2021). Moreover, the manufacturing of plastics requires a substantial quantity of energy. The significant carbon footprint fragmentation of plastics derived from petroleum and the related environmental problems are other concerns being voiced around the world. Molla et. al. (2023) & (2024) works with different production related work and chemical process in production that is important for our future research.

Because crude oil is a non-renewable resource and its price is steadily rising, scientists and researchers are always searching for practical substitutes for plastics (Ismail et al., 2016). Jute is a natural fabric that is robust, biodegradable, compostable, extremely resilient, recyclable, and has a low carbon footprint. In addition, it releases more oxygen and consumes less carbon dioxide (CO2) than trees do, which reduces the greenhouse effect and maintains the ecosystem's balance (Pavel & Supinit, 2017; Singh, 2017). Similar to conventional plastic items, jute products use less energy and have a lower carbon footprint (Singh et al., 2018). Several commonly used plastic products, including shopping bags, rice bags, plastic rope, and file folders, can be replaced with comparable jute products that have better mechanical and biodegradable qualities, a lower carbon footprint, and don't harm people, animals, or the environment (Singh, 2017; Saha & Sagorika, 2013). Overall, this study gives an overview of the chemical and physical properties of plastic and jute as well as the effects they have on the environment. In consideration of social and economic factors, as well as obstacles to achieving sustainable goals, a few carefully chosen substitute sustainable plastic technologies have also been put forth.

2. Approach and Methodology

All of the data used for this review was gathered from Google Scholar, ResearchGate, government websites, Web links, Springer Link, published online journals, and policy papers. To obtain current data, pertinent data covering the last 20 years (2002–2022) were used for this study. Additionally, 20 published articles were selected for citation out of a review pool of approximately 46 articles. The behavior of jute and plastic products and their consequences on the environment are scientifically useful, and these findings will benefit academics, government agencies, and non-governmental groups worldwide.

3. Results and Discussion

This review paper is split into nine sections based on relevant literature that was found: Plastic's physical and chemical characteristics (3.2), its manufacturing rate (3.1), and the environmental impact of its products (3.3), The following sections cover the history of the jute industry in Bangladesh (3.4), the trends of the country's current jute industries (3.5), the properties of jute products (3.6), the effects of jute products on the environment (3.7), a comparison of jute and plastic products (3.8), the prospects for jute and plastic products in the future (3.9), and a conclusion.

3.1 Physical and Chemical Behaviors of Plastic

Plastics, also known as synthetic polymers, have only been mass-produced for about 70 years, but they have outgrown the majority of man-made materials. Plastic can be subdivided broadly into seven categories in current modern days. Table 1 shows various plastic types, their usage, physical properties, and associated health challenges. The table provides a critical overview of various plastic polymers, detailing their usage, time to decompose, physical properties, leached toxins, safety status, and tensile strength. Polyethylene terephthalate (PETE), commonly used in bottles, ropes, and tote bags, exhibits high heat resistance and toughness but raises concerns due to the leaching of carcinogenic antimony, rendering it unsafe. High-density polyethylene (HDPE), prevalent in milk jugs and detergent bottles, boasts excellent chemical resistance and strength, yet poses risks due to estrogen-mimicking chemicals (Dhara et al., 2024). Low-density polyethylene (LDPE), found in plastic wrap and garbage bags, offers flexibility but shares concerns with HDPE regarding hormonal disruption. Polyvinyl chloride (PVC), utilized in plumbing and credit cards, provides durability but is associated with the leaching of hazardous compounds like BPA and phthalates, rendering it unsafe. Polypropylene (PP), used in various applications including yogurt containers and car parts, demonstrates good chemical resistance but leaches certain chemicals leading to health issues. Polystyrene (PS), employed in plastic cutlery and foam cups, presents high toxicity and leaches styrene, a carcinogenic compound affecting human health adversely. This critical analysis underscores the complex trade-offs between the desirable physical properties of plastic polymers and their detrimental environmental and health impacts, urging a reevaluation of material choices towards safer and more sustainable alternatives.

Table 1: Various plastic types and their usage, physical properties, and associated health challenges

Plastic Polymers	Usage	Time to Decompose (years)	Physical Properties	Leached Toxins	Status	Tensile Strength (Mpa)	Ref.
PETE	Bottles, rope, combs, tote bags	10	high heat-resistant, tough, solvent-resistant, and environmentally sustainable due to the high recycling rate	Antimony (Carcinogenic)	Not safe	1700	(Achilias et al., 2008)
HDPE	milk jugs, soap, detergent, bleach bottles, toys, buckets	100	excellent chemical resistance, hard to semi-flexible and strong, permeable to gas	estrogen-mimicking chemicals (disrupting hormones)	Usually, safe and low risk	1000	(J. Akhtar, & Amin, 2011)
LDPE	plastic wrap, irrigation pipes, hot and cold beverage cups, garbage bags	500-1000	tough and flexible, soft, scratches easily, low melting point, stable electrical properties	estrogen-mimicking chemicals same as HDPE	safe	300	(Bhattacharyya et al., 2019)
PVC	plumbing pipes, credit cards, floor covering, pipes and fittings	never	good chemical resistance, hard and rigid, long-term stability, low gas permeability	BPA, phthalates, lead, mercury	Not safe	2900-3300	(Bhattacharyya et al., 2019)

PP	yogurt containers, potato chip bags, packing tape, thermal vests, car parts, disposable diapers	20-30	excellent chemical resistance, hard but flexible, strong	leaching some chemicals leading to asthma or hormone disruption	Micro-wave safe	1325	(Verma et al., 2016)
PS	plastic cutlery, egg cartons, take-out food containers, disposable foam cups, coat hangers	50	clear to opaque, rigid or foamed, hard, brittle, high clarity, affected by fats and solvents	highly toxic, leaching styrene can cause cancer and damage to the nervous system, affect genes	Not safe	3250	(Zhou et al., 2016)

Figure 3 displays the biological formula, production, and recycling rate of various plastic kinds. Out of these seven categories, LDPE accounts for the largest waste generated (7.4 billion kg), whereas PVC has the lowest mass production (0.9 billion kg). PP is the most common plastic, produced in mass quantities at a rate of roughly 7.2 billion kg, behind LDPE. PP's recycling rate is 5.3% and its general formula is (C2H4)n. Due to their relatively moderate rate of decomposition, PET and PETE have a maximum recycling rate of 19.5%. Furthermore, PVC-type plastic never deteriorates, which accounts for its 0% recycling rate. A category-wise description has been added below.

Polypropylene (PP): The material polypropylene (PP) has a low melting point and is incredibly pliable and soft. At their melting point—roughly 130 degrees Celsius in the case of polypropylene—thermoplastic and thermoplastic polymers turn liquid. Composite plastic can be produced by simply copolymerizing PP with polyethylene. Water is not able to pass through polypropylene. (C3H6) n is the chemical formula for PP. Mustaquim et al. (2023) & (2024) with Noman et. al (2020) discusses in a very good way how large data set and land surface temperature works in different situations.

Polyethylene Terephthalate (PET or PETE): The typical chemical formula of PET, an aliphatic polyester, is $(C10H8O4)_n$. It absorbs moisture at a very low rate and has great strength, stiffness, and hardness. PET cannot decompose naturally.

High-Density Polyethylene (HDPE): HDPE has a remarkable temperature range; heating it for brief periods to 248°F (120°C) or for extended periods to 230°F (110°C) is deemed safe. Low branching and slow biodegradation characterize HDPE. incredibly little absorption of water. The general formula for it is (C2H4)n. Hasan et. al. (2023) interprets how motor vehicles produce electricity and this is a requirement in our chemical process.

Low-Density Polyethylene (LDPE): When compared to other plastics, LDPE degrades more readily. 290 to 350 °C is when it breaks down. Thermal oxidation happens when LDPE is processed at high temperatures in the presence of air. In typical temperature conditions, LDPE is insoluble. It has strong permeability to oxygen and carbon dioxide, but it essentially does not permeate in water or steam. Elastic, the same monomer as HDPE, is also used in LDPE. Noman et al. (2020) and Mustaquim et al. (2024) have initiated an admirable endeavor, introducing a robust data retrieval approach and an advanced framework for predicting data accuracy. This initiative stands as a valuable addition to ongoing efforts in the realm of sentiment analysis and emerging trends within the context of this research. It presents an array of supplementary features poised to enhance the research experiences of aspiring students, particularly those engaged in studies related to sentiment analysis and the dynamics of COVID-19 discourse. This project significantly contributes to the evolving landscape of research within the field, offering innovative tools and methodologies tailored to advance knowledge and understanding in the analysis of sentiments and emerging trends.

Polyvinyl Chloride (PVC): PVC is available in two primary forms: flexible and rigid (sometimes referred to as RPVC). When compared to most polymers, it is extremely dense (specific gravity of about 1.4). The tensile strength of polyvinyl chloride is exceptional. (H2C–CHCl)n, where n is the degree of polymerization, is the formula for PVC.

Polystyrene (PS): PS is a nonpolar, transparent, amorphous thermoplastic commodity. Methyl methacrylate can be used to copolymerize it. In water, it is insoluble. Alcohol does not dissolve polystyrene, although many aromatic and chlorinated solvents do. Pure polystyrene is transparent, inflexible, breakable, and quite robust. PS has the chemical formula (C8H8)n.

Other Plastics: Plastics such as polycarbonate, polylactide, acrylic, acrylonitrile butadiene, styrene, fiberglass, and nylon are included in this group. Most plastic CDs and DVDs, infant bottles, huge water bottles with multiple gallon capacities, medical storage containers, eyeglasses, outdoor lighting fixtures, etc. are made of these polymers.

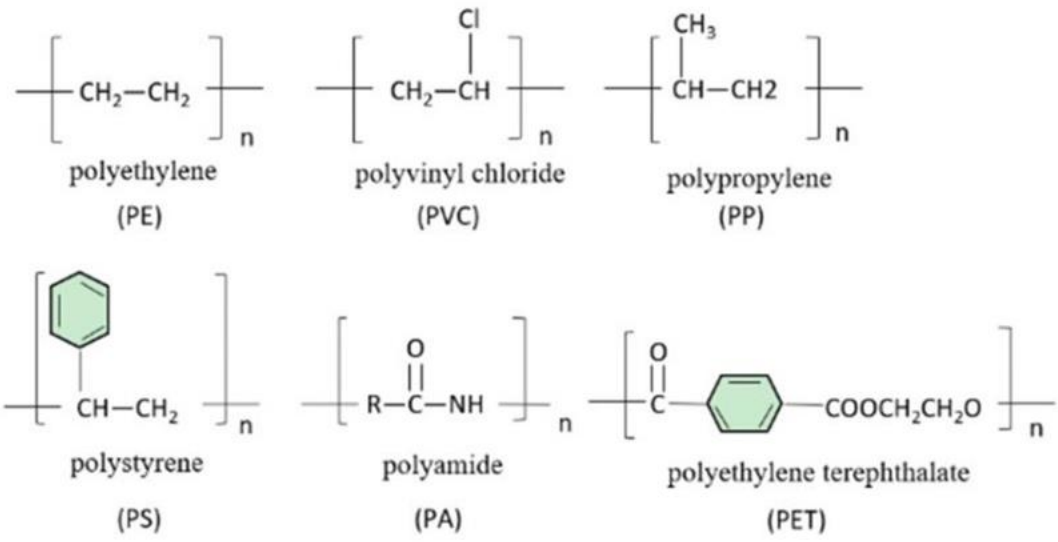

Figure 3: Chemical formula of various types of plastic waste

3.3 Effect of Plastic Products on The Environment

There is no doubt that plastic is bad for the environment. The pollution issue is the first one. Plastic is a major contributor to land and water pollution. If it is disposed of incorrectly and gets up in our rivers and oceans, it can harm marine life. Moreover, it can wind up in landfills, where its degradation takes hundreds of years as opposed to the other organic waste such as fecal sludge, microalgae, and organic solid waste (Khalekuzzaman et al., 2024; Khalekuzzaman et al., 2023). There is a risk of deforestation. An issue is global warming. The process of making plastic releases greenhouse gasses, which contribute to global warming (Dhara et al., 2024; Hasan et al., 2023). Climate change poses a major threat to both people and nature, as demonstrated by the amount of greenhouse gases we are releasing into the sky (Alsabri et al., 2022). It is a worry about people's health. Plastic contains highly reactive chemicals that can contaminate food and water. These drugs have been related to cancer, reproductive issues, and other health issues. Plastic 6-pack rings, fishing lines, and other trash can entangle wildlife, harming or even killing it. Furthermore, animals may mistake plastic for food and consume it, which could cause intestinal blockages or even cause them to go hungry to death. Sea turtles are especially vulnerable to plastic pollution because they often mistake floating trash for jellyfish and eat it (Pinto Costa et al., 2020).

3.4 History of the Jute Industry in Bangladesh

Historically, manufactured jute was used to make rope and garments on Bengali handlooms. Dundee Mills received a request in 1838 for jute bags for Java sugar fields that were governed by the Dutch. They made burlap bags out of jute by following the processes used by the Melville and Balfour companies. The sacks generated a great deal of demand, which helped to promote jute made in Bengal. George Auckland then established the first jute factory close to Rishra in 1855. A commission was established by the British Raj in 1873 to look into Bangladesh's jute industry and farming. 1877 saw the publication of the Jute Trade and Cultivation in Bengal report (Akter et al., 2020). Kolkata served as the hub of the jute trade in British India. Jute was made in East Bengal, and all 108 jute mills were in West Bengal. Production of jute faced difficulties after India's Partition. By 1970, there were seventy-seven jute mills in East Pakistan, employing one hundred and seventy thousand people. In East Bengal, three companies were established in 1951: Adamjee Jute Mill, Bawa Jute Mills Ltd., and Victory Jute Products Ltd. Adamjee Jute Mills was constructed with financial help from the Pakistan Industrial Development Corporation. In 1960 there were 14 jute mills in operation. Production sequence is analyzed for jute mills (shakil et al.,2017).

3.5 Trends of Current Jute Industries in Bangladesh

Jute pricing, procurement, and trading in Bengal are governed by Bangladesh Jute Mills Corporation. The Jute Division was created by the government in 1973 and was housed inside the Department of Treasury. A commission appointed by the legislature suggested selling the factories in 1979. A total of two jute mills were privatized and three were returned to their original owners between 1979 and 1980. (Abdullah, 2017) Jute pricing, procurement, and trading in Bengal are governed by Bangladesh Jute Mills Corporation. The Jute Division was created by the government in 1973 and was housed inside the Department of Treasury. A commission appointed by the legislature suggested selling the factories in 1979. A total of two jute mills were privatized and three were returned to their original owners between 1979 and 1980. According to Bell & Cave (2011) The economy of Bangladesh benefits from the jute sector to the tune of nearly $1 billion. In January 2018, jute exports that were raw or unprocessed were prohibited by law. In response to a request from the Bangladesh Jute Association, the restriction was lifted in June 2019.

3.6 Properties of Jute Products

The mechanical properties are shown in Table 4. This comparative analysis of mechanical properties across various jute-based materials highlights their potential as reinforcement components in composite applications. Extracted from diverse studies, the data showcases significant variations in tensile strength, modulus, flexural strength, and impact resistance among different jute compositions. For instance, bidirectional jute fiber mats exhibit a tensile strength of 110 MPa and a tensile modulus of 4.45 GPa, along with a flexural strength of 55.8 MPa and a flexural modulus of 3.02 GPa. Woven jute configurations demonstrate moderate tensile and flexural properties, with tensile strengths ranging from 12.69 MPa to 15.53 MPa and flexural strengths from 79.20 MPa to 81.81 MPa. Jute laminates display high tensile strength and modulus values along the longitudinal axis, with a tensile strength of 112.69 MPa and a tensile modulus of 39.1 GPa. Jute mats offer reasonable tensile strength and modulus values, with a tensile strength of 42.0 MPa and a tensile modulus of 1.61 GPa. Overall, these findings underscore the versatility of jute as a reinforcement material, with potential for use in diverse industries, pending further optimization and research into manufacturing processes and treatment methods to enhance mechanical performance and broaden application horizons.

Table 4: Mechanical Properties of Jute Fiber

Reinforcement	**Tensile Strength (MPa)**	**Tensile Modulus (GPa)**	**Flexural Strength (MPa)**	**Flexural Modulus (GPa)**	**Impact Strength**	**Ref.**
Bidirectional jute fibre mat	110	4.450	55.80	3.02	4.87	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	Owen et al., 2014
Woven jute	12.69	0.1985	81.81	1.381	0.35J	Owen et al., 2014
Jute laminate	112.69	14.59	-	-	-	Hossain et al., 2013

(Longitudinal 0-0)	39.1					
Jute laminate (Transverse 0-90)	39.1	8.97	-	-	-	Hossain et al., 2013
Jute	16.62	0.667	57.22	8.956	13.44kJ/m2	Bhoopalan et al., 2013
Jute	26.53	6.32	66.67	5.78	80J/m2	Venkatesh waran et al., 2012
Jute	60	7	92.5	5.1	29 KJ/m2	Gowda et al., 1999
Jute	48.52	4.23	63.01	3.62	-	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	Crosky et al., 2014
Long jute (Transverse)	0.43	0.98	-	-	148J/m	Crosky et al., 2014
Jute mat	23.0	4.0	-	-	-	Hojo et al., 2014
Jute	-	-	199.1	11.890	22.10	Ray et al., 2001
Jute mat	42.0	1.61	56.2	3.78	-	Crosky et al., 2014

Table 5 presents a critical evaluation of various physical properties associated with natural jute fibers. Jute fibers are characterized by their smooth texture and distinctive golden sheen, contributing to their aesthetic appeal. In terms of strength, jute fibers exhibit strong seam strength, ensuring durability in various applications. They are resistant to the effects of sunlight and ambient temperature, making them suitable for use in diverse environmental conditions. Notably, jute demonstrates excellent efficiency for grain preservation and outstanding stack stability, further highlighting its utility in agricultural contexts. Moreover, jute is celebrated for its complete biodegradability and environmentally friendly nature, aligning with sustainable practices. Jute stems boast a rapid growth cycle, replenishing in 4-6 months, and yield a large amount of cellulose, adding to their ecological value. While jute fibers are heavy, they offer good dimensional stability and excellent reusability, contributing to their longevity. However, the cost of jute remains relatively high, reflecting its premium quality and limited availability. Additionally, jute surfaces tend to have a rough texture, which may influence certain applications. Nonetheless, jute excels in storage space utilization, making it a practical choice for various storage solutions.

Table 5: Physical Properties of Jute

S.N.	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

3.7 Effects of jute products on the environment

Jute products are renowned for their eco-friendly attributes, with properties such as biodegradability and renewable sourcing contributing to their sustainability. Jute exhibits high biodegradability, ensuring that products made from this material can decompose naturally without causing long-term environmental harm. Additionally, jute's renewable nature, with a rapid growth cycle of 4-6 months and abundant cellulose yield, underscores its potential as a sustainable alternative to conventional materials. However, certain drawbacks are evident, including the heavy weight of jute products, which may increase transportation-related emissions and energy consumption. Furthermore, while jute offers excellent stack stability and efficiency for grain preservation, its rough surface texture and relatively high cost could limit its widespread adoption. Despite these limitations, jute products excel in maximizing storage space utilization and demonstrate outstanding seam strength, indicating their versatility and potential for various applications.

When it comes to environmental friendliness, fiber, and its products are superior to synthetic fibers. Because of its effects on the environment, it also has an indirect effect on the economy. Green leaves are used to make vegetables, while dry leaves increase the fertility of the soil. While jute's leaves and roots act as insecticides, its roots also increase fertility. By using jute as a particle and composite material, less wood is used as fuel, which reduces the need for forestry. According to environmentalists, a nation's forest area ought to be 25% larger than it is; regrettably, ours is just 8% to 9% larger. The jute plant grows swiftly and can fill the gap to some extent. The jute took up carbon dioxide from the atmosphere, keeping the ozone barrier intact. It also releases oxygen into the atmosphere, which is necessary for human survival. In addition to bringing nutrients to the ground, jute plants can filter the air (Islam & Ahmed, 2012).

3.8 Comparison of plastic and jute products

The comparison between jute and plastic products in Table 6 reveals stark differences in their environmental impact and performance characteristics. Jute products are biodegradable and renewable, offering a sustainable alternative to non-biodegradable and non-renewable plastic items. This difference extends to their carbon footprint, with jute products having a very low carbon footprint compared to the high carbon footprint associated with plastic. Furthermore, jute products are compostable, contributing to waste reduction and environmental conservation, whereas plastic products are not compostable. Jute's resilience to atmospheric temperature changes contrasts with the susceptibility of plastic to such variations, emphasizing jute's environmental resilience. In terms of end-use performance, jute products generally demonstrate good performance, characterized by excellent stack stability and fair resistance to hooking, whereas plastic products tend to perform poorly in these areas. Overall, the comparison underscores the environmentally friendly nature and superior performance of jute products relative to plastic counterparts, highlighting the importance of transitioning towards more sustainable materials (Bell & Cave, 2011).

Table 6: Comparative Performance of Jute and Plastic Products

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

Additionally, the comparison between plastic and jute products in terms of energy consumption and carbon footprint reveals significant disparities in their environmental impact as presented in Table 7. Plastic products require substantially more energy per ton, with an energy consumption of 63 GJ/ton compared to just 2 GJ/ton for jute products. This vast difference in energy consumption directly translates to their carbon footprint, with plastic products emitting a staggering 1340 tons of CO2 equivalent per ton produced, while jute products emit only 0.15 tons of CO2 equivalent. These findings underscore the unsustainable nature of plastic production, with its high energy requirements and significant greenhouse gas emissions contributing to environmental degradation and climate change. In contrast, jute products offer a much more environmentally friendly alternative, requiring significantly less energy and producing negligible carbon emissions, thus highlighting the importance of transitioning towards more sustainable materials like jute to mitigate the adverse effects of climate change.

Table 7: Energy input and carbon footprint output for plastic and jute products(Saha and Sagorika, 2013)

Products	Energy (GJ/Ton)	Carbon footprint, (Tons CO_2 eq.)
Plastic	63	1340
Jute	02	0.15

3.10 Future Prospects of Jute and Plastic Products

Plastic has a wide range of negative environmental effects. These range from the poisoning of our streams to the destruction of our marine life. We can no longer afford to ignore the issue, so we need to take action to reduce our reliance on plastic. To begin with, we can make small changes to our everyday schedules, such as bringing reusable bags and water bottles (Srivastava, 2012). With collective efforts, we can effect change, even in little ways. The majority of global studies and a few regional studies indicate that Bangladesh is already at significant risk of plastic pollution and will continue to be so if immediate action is not taken. This is despite the fact that there hasn't been enough research on the amount of plastic waste generated, its fate, and its impact on various environmental compartments of Bangladesh. Pollution affects all living things, including humans and zooplankton, by its effects on the ecosystem. The United Nations' 2015 sustainable development goal, to maintain a peaceful, impoverished Earth by 2030, would also be challenging to accomplish without adequate oversight of plastic production and waste management (Green Marketing of Jute and Jute Products: A Study on Bangladesh, 2015). The country has already made some steps to address this, but it doesn't appear that the use of plastic and the associated pollution has decreased as was anticipated. Consequently, it is advised that the following steps be taken in order to address this global issue sustainably:

- Through media advertising and initiatives by governmental and non-governmental groups, ending users are encouraged to abstain from using plastic and increasing consumer awareness of the detrimental impacts of plastic use.
- The aim is to dissuade individuals from discarding plastic waste in areas where incentive-based initiatives for plastic collecting are being implemented.
- Improving collaboration between universities and institutions to assess the impact of plastic waste on many environmental domains.
- Expanding opportunities for research and funding in the pursuit of biodegradable polymers and economically feasible plastics, specifically for packaging.
- Simple bank financing, duty-free imports of tools and machinery, and preferential tax treatment are provided to businesses and industries engaged in the development of biodegradable alternatives to plastics.
- Using the country's vast jute production capacity, inexpensive biodegradable plastic alternatives can be produced. These companies can also be provided with incentives.
- Imposing significant levies on plastic-related sectors, ranging from the import of raw materials to the sale of final items. The exorbitant cost of plastic products will cause people to quit using them.
- Examining environmentally sustainable substitutes for plastic production firms and plastic recycling as a long-term fix for the country's mounting unemployment problem
- Further investigation is necessary to ascertain the most economical methods for producing and marketing jute goods.
- Encouraging consumers to purchase and use jute products can be achieved by ensuring their constant availability.

4. Conclusions

As a result of population growth, economic expansion, and lifestyle changes, plastic is being used more and more in our contemporary society across a wide range of industries, commerce, packaging, and households. But because plastics cannot decompose, they pose a serious threat to human health, the environment, vegetation, and both terrestrial and aquatic creatures. On the other hand, because they are naturally sourced, compostable, reusable, biodegradable, and extremely durable, jute goods are a game-changing invention and can be an excellent eco-friendly alternative to plastics derived from petrochemicals. Additionally, the primary component of jute products, jute, absorbs carbon dioxide (CO_2) and releases oxygen, lowering the greenhouse impact and balancing the ecosystem. Additionally, jute products have a negligible carbon footprint and need less energy to manufacture than typical plastic products made from petrochemicals. Because jute items may be used repeatedly and for a longer period than plastics, they are also less expensive. Consequently, it is undeniable that jute goods can contribute to lowering reliance on plastics manufactured from costly, non-renewable crude oil, reducing the production of plastic trash, and protecting the environment. Governmental backing and societal consciousness are therefore necessary for creating a model and switching from petrochemical to jute products.

References

[1]. Abdullah, J. (2005). Jute-jute products and their disposal. https://www.researchgate.net/publication/312623445.

[2]. Akter, S., Sadekin, M. N., & Islam, N. (2020). Jute and Jute Products of Bangladesh: Contributions and Challenges. Asian Business Review, 10(3), 143–xxx. https://doi.org/10.18034/abr.v10i3.480.

[3]. Ashok Kumar Nanda, S.Neelakandan, M.Prakash, B.T.Geetha, Ahmed, MohammedMetwally, Madhappan Santhamoorthy, M. SatyanarayanaGupta, 2022, Metaheuristics with Deep Transfer Learning Enabled Detection and classification model for industrial waste management.

[4]. Ayeleru, O. O., Dlova, S., Akinribide, O. J., Ntuli, F., Kupolati, W. K., Marina, P. F., Blencowe, A., & Olubambi, P. A. (2020). Challenges of plastic waste generation and management in sub-Saharan Africa: A review. Waste Management, 110, 24–42. https://doi.org/10.1016/j.wasman.2020.04.017.

[5]. Barnes, D. K., Galgani, F., Thompson, R. C., & Barlaz, M. (2009). Accumulation and fragmentation of plastic debris in global environments. Philosophical transactions of the royal society B: biological sciences, 364(1526), 1985-1998.

[6]. Bazgir, Ehteshamul Haque, Md. Maniruzzaman and Rahmanul Hoque, "Skin cancer classification using Inception Network", World Journal of Advanced Research and Reviews, 2024, 21(02), 839–849.

[7]. Brooks, A. L., Wang, S., & Jambeck, J. R. (2018). The Chinese import ban and its impact on global plastic waste trade. Science advances, 4(6), eaat0131.

[8]. Chen, H. L., Nath, T. K., Chong, S., Foo, V., Gibbins, C., & Lechner, A. M. (2021). The plastic waste problem in Malaysia: management, recycling and disposal of local and global plastic waste. SN Applied Sciences, 3(4), 1-15.

[9]. Crosky, N. Soatthiyanon, Thermoset matrix natural fiber- reinforced composites. DOI: 10.1533/9780857099228.2.233.

[10]. D. Ray, B.K. Sarkar, A.K. Rana, N.R. Bosc (2001). The Mechanical Properties of Vinyl Ester Resin Matrix Composites Reinforced with Alkali- Treated Jute Fiber (2014). Compos. Part-A. vol. 32, pp-119-127.

[11]. D. Shanmugam, M. Thiruchitrambalam. Static and dynamic mechanical properties of alkali treated unidirectional continuous Palmyra palm leaf stalk fiber reinforced hybrid polyester composites, 50 (2013) 533-542.

[12]. D. V. Rosato, M. G. Rosato, M. G. Rosato, (2000). Concise Encyclopedia of plastic. ISBN 978-1-4613-7068-0.

[13]. Dauvergne, P., 2018. Why is the global governance of plastic failing the oceans? Glob. Environ. Chang. 51, 22–31. https://doi.org/10.1016/j.gloenvcha.2018.05.002.

[14]. Dell, J. (2021). 157,000 Shipping Containers of U.S. Plastic Waste Exported to Countries with Poor Waste Management in 2018. Available online: https://www.plasticpollutioncoalition.org/blog/2019/3/6/157000-shipping-containers-of-us-plastic-waste-exportedto-countries-with-poor-waste-management-in-2018.

[15]. Dhara, F. T., & Fayshal, M. A. (2024). Waste Sludge: Entirely Waste or a Sustainable Source of Biocrude? A Review. Applied Biochemistry and Biotechnology, 1-22.

[16]. Dhara, F. T., Fayshal, M. A., Khalekuzzaman, M., Adnan, H. F., & Hasan, M. M. PLASTIC WASTE AS AN ALTERNATIVE SOURCE OF FUEL THROUGH THERMOCHEMICAL CONVERSION PROCESS-A REVIEW.

[17]. F. Due, P. E. Bouraban, C. J. G. Plummer, (2014). J. A. E. Manson, a review on the damping properties of fiber reinforced polymer composites, Part A 65, pp-115- 123.

[18]. Geyer, R. (2020). Production, use, and fate of synthetic polymers. In Plastic Waste and Recycling (pp. 13–32). Elsevier. https://doi.org/10.1016/B978-0-12-817880-5.00002-5.

[19]. Hasan, M. M., Fayshal, M. A., Adnan, H. F., & Dhara, F. T. (2023). The single-use plastic waste problem in bangladesh: finding sustainable alternatives in local and global context.
[20]. Hasan, M. R., Hossain, M. S., & Rahman, K. P. (2017). Design and construction of a portable charger by using solar cap. Global Journal of Researches in Engineering: A Mechanical and Mechanics Engineering, 17(5), 14-18.
[21]. Hossain, M. Z., Rahman, S. A., Hasan, M. I., Ullah, M. R., & Siddique, I. M. (2023). Evaluating the effectiveness of a portable wind generator that produces electricity using wind flow from moving vehicles. Journal of Industrial Mechanics, 8(2), 44-53.
[22]. Ibtisum, S., Bazgir, E., Rahman, S. A., & Hossain, S. S. (2023). A comparative analysis of big data processing paradigms: Mapreduce vs. apache spark. World Journal of Advanced Research and Reviews, 20(1), 1089-1098.
[23]. Islam D.M.S, Hasan, E.M.M., and Hossain, E.M.M. (2017). Current status of plastic production, prospects and training of manpower in Bangladesh, Journal of Chemical Engineering, IEB Vol. 30, No. 1, pp. 69-76.
[24]. Islam, M.S.and Hasan, M. M. (2014). "Need Assessment to set-up Bangladesh Institute of Plastic Engineering & Technology", Souvenir of 8th International Fair, 2014.
[25]. Islam,2016, Synthesis and Characterization of Biodegradable Starch-Based Bioplastics, Material science forum, Volume 846.
[26]. Ismail, N. A., Tahir, S. M., AbdulWahid, M. F., Khairuddin, N. E., Hashim, I., Rosli, N., and Abdullah, M. A. 2016. Synthesis and Characterization of Biodegradable Starch-Based Bioplastics. Materials Science Forum, 846: 673 -678.
[27]. K. V. D. Velde, P. Kiekens, (2001). Biopolymers: Overview of several properties and consequences on their applications. polym.Test. 20, pp- 885-893.
[28]. Khalekuzzaman, M., Fayshal, M. A., & Adnan, H. F. (2024). Production of low phenolic naphtha-rich biocrude through co-hydrothermal liquefaction of fecal sludge and organic solid waste using water-ethanol co-solvent. Journal of Cleaner Production, 140593.
[29]. Khalekuzzaman, M., Jahan, N., Kabir, S. B., Hasan, M., Fayshal, M. A., & Chowdhury, D. R. (2023). Substituting microalgae with fecal sludge for biohythane production enhancement and cost saving through two-stage anaerobic digestion. Journal of Cleaner Production, 427, 139352.
[30]. Law, K. L., Starr, N., Siegler, T. R., Jambeck, J. R., Mallos, N. J., & Leonard, G. H. (2020). The United States' contribution of plastic waste to land and ocean. Science Advances, 6(44), eabd0288. https://doi.org/10.1126/sciadv.abd0288.
[31]. M. Boopalan, M. Hiranjanua, M. J. Umapathy, (2012). Study on the mechanical properties and thermal properties of jute and banana fiber reinforced epoxy hybrid composite. Part-B 51, pp- 907-914.
[32]. M. M. Owen, (2014). Potential of jute fiber reinforced polymer composite: A review. Int. J. Fib. Tex. Res. 4(2), pp-32-40.
[33]. M. R. Hossain, M. A. Islam, A.V. Vuurea, I. Verpoest, (2013). Effect of fiber orientation on the tensile properties of jute epoxy laminated composite. J. Sci. Res. 5 (1), pp-43-54.
[34]. Meijer, L. J. J., van Emmerik, T., van der Ent, R., Schmidt, C., & Lebreton, L. (2021). More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean. Science Advances, 7(18), eaaz5803. https://doi.org/10.1126/sciadv.aaz5803.
[35]. Molla, S., Hasan, M. R., Siddique, A. A., & Siddique, I. M. (2024). SMED Implementation for Setup Time Reduction: A Case Study in the Electronics Manufacturing Landscape. European Journal of Advances in Engineering and Technology, 11(1), 1-15.
[36]. Molla, S., Siddique, I. M., Siddique, A. A., & Abedin, M. M. (2023). Securing the Future: A Case Study on the Role of TPM Technology in the Domestic Electronics Industry amid the COVID-19 Pandemic. Journal of Industrial Mechanics, 8.
[37]. Mondal, M. R. H., Bharati, S., Podder, P., & Podder, P. (2020). Data analytics for novel coronavirus disease. informatics in medicine unlocked, 20, 100374.

[38]. Mustaquim, S. M. (2024). Utilizing remote sensing data and ArcGIS for advanced computational analysis in land surface temperature modeling and land use property characterization. World Journal of Advanced Research and Reviews, 21(1), 1496-1507.
[39]. Mustaquim, S. M., Noman, A. H. M., Molla, S., Siddique, A. A., & Siddique, A. A. (2024). Enhancing Accident Risk Prediction with Novel Data and Findings from Heterogeneous Sparse Sources. Journal of Data Mining and Management, 9(1), 1-16.
[40]. N. Venkateshwaran, A. Elaya Perumal. Mechanical and water absorption properties of woven jute/banana hybrid composites, Fib. Polym. 13 (7) (2012) 907-914.
[41]. Naayem, N. (2021) The Inherent Problem with the Global Plastic Waste Trade. Available online: https://rethinkplasticalliance.eu/news /the-inherent-problem-with-the-global-plastic-waste-trade.
[42]. Noman, A. H. M. (2018). WHO Data: A Modified Approach for Retrieval (Doctoral dissertation, Lamar University-Beaumont). Available at: https://scholar.google.com/scholar?oi=bibs&hl=en&q=related:WqiaY1iFCtUJ:scholar.google.com/.
[43]. Noman, A. H. M., Das, K., & Andrei, S. (2020). A Modified Approach for Data Retrieval for Identifying Primary Causes of Deaths. ACET Journal of Computer Education and Research, 14(1), 1-13.
[44]. Noman, A. H. M., Das, K., & Andrei, S. (2020). A Modified Approach for Data Retrieval for Identifying Primary Causes of Deaths. ACET Journal of Computer Education and Research, 14(1), 1-13.
[45]. Noman, A.H.M., Mustaquim S.M. Molla, S., and Siqqique, M.I., (2024). Enhancing Operations Quality Improvement through Advanced Data Analytics. Journal of Computer Science Engineering and Software Testing. Vol. 10, Issue 1 (January – April, 2024) pp: (1-14). https://doi.org/10.46610/JOCSES.2024.v10i01.001.
[46]. Noman, A.H.M., Mustaquim S.M. Molla, S., and Siqqique, M.I.,(2024). Enhancing Operations Quality Improvement through Advanced Data Analytics. Journal of Computer Science Engineering and Software Testing. Vol. 10, Issue 1 (January – April, 2024) pp: (1-14). https://doi.org/10.46610/JOCSES.2024.v10i01.001.
[47]. Peter Dauvergne, 2018, The power of environmental norms: marine plastic pollution and the politics of microbeads, Environmental Politics, https://doi.org/10.1080/09644016.2018.1449090.
[48]. Pintu Md. Nazmul Hossain, (2016). The prospects and challenges of plastic industries in Bangladesh, Degree Thesis.
[49]. Plastic Market Size, Share & Trends Report, 2022—2030. (n.d.). Retrieved December 16, 2022, from https://www.grandviewresearch.com/industry-analysis/global-plastics-market.
[50]. Plastic waste inputs from land into the ocean. (n.d.). Science in the Classroom. https://doi.org/10.1126/science.1260352.
[51]. Plastics recycling: Challenges and opportunities | Philosophical Transactions of the Royal Society B: Biological Sciences. (n.d.). Retrieved December 17, 2022, from https://royalsocietypublishing.org/doi/10.1098/rstb.2008.0311.
[52]. Podder, P., Das, S. R., Mondal, M. R. H., Bharati, S., Maliha, A., Hasan, M. J., & Piltan, F. (2023). Lddnet: a deep learning framework for the diagnosis of infectious lung diseases. Sensors, 23(1), 480.
[53]. R. D. Deanin, J. L. Mead, M. Wei, B. M. Bludlhall, Handbook of industrial chemistry and biotechnology. ISBN: 978-1-4614-4259-2 (2012).
[54]. Rahman, M. A., Bazgir, E., Hossain, S. S., & Maniruzzaman, M. (2024). Skin cancer classification using NASNet. International Journal of Science and Research Archive, 11(1), 775-785.
[55]. Rahman, S. A., and S Shohan (2015). Supplier selection using fuzzy-topsis method: A case study in a cement industry, IASET: Journal of MechanicalEngineering.,4(1).31-42.
[56]. Rahman, S. M., Ibtisum, S., Bazgir, E., & Barai, T. (2023). The significance of machine learning in clinical disease diagnosis: A review. arXiv preprint arXiv:2310.16978.
[57]. Rahmanul Hoque, Suman Das, Mahmudul Hoque and Ehteshamul Haque, "Breast Cancer Classification using XGBoost", World Journal of Advanced Research and Reviews, 2024, 21(02), 1985–1994.

[58]. Rahmanul Hoque, Suman Das, Mahmudul Hoque and Ehteshamul Haque, "Breast Cancer Classification using XGBoost", World Journal of Advanced Research and Reviews, 2024, 21(02), 1985–1994.

[59]. S M Mustaquim, A H M Noman, Selim Molla, Anamika Ahmed Siddique, Iqtiar Md Siddique. (2024). Enhancing Accident Risk Prediction with Novel Data and Findings from Heterogeneous Sparse Sources, Journal of Data Mining and Management, 9(1),1-16.

[60]. S. B. Brahim, R. B. Cheikh, Mechanical properties of polyester/corn husk fiber composite produced using vacuum infusion technique. Compos, Sci Tech. 67 (2007) 140-147.

[61]. Sarker, N., Podder, P., Mondal, M. R. H., Shafin, S. S., & Kamruzzaman, J. (2023). Applications of Machine Learning and Deep Learning in Antenna Design, Optimization and Selection: A Review. IEEE Access.

[62]. Sartorius, 2010, The impact of policy interactions on the recycling of plastic packaging waste in Germany, Working Paper Sustainability and Innovation No. S8/2014.

[63]. Sartorius, I. (2010). Materials case study 4: plastics. Mechelen, Belgium.

[64]. Sasaki, S. (2021). The effects on Thailand of China's import restrictions on waste: measures and challenges related to the international recycling of waste plastic and e-waste. Journal of Material Cycles and Waste Management, 23(1), 77-83.

[65]. Shafqat, A., Tahir, A., Mahmood, A. and Pugazhendhi, A. (2020). A Review on Environmental Significance Carbon Foot Prints of Starch Based Bio-plastic: A Substitute of Conventional Plastics, Biocatalysis and Agricultural Biotechnology, https://doi.org/10.1016/j.bcab.2020.101540.

[66]. Shakil, M., Ullah, M. R., & Lutfi, M. (2013). Process flow chart and factor analysis in production of jute mills. Journal of Industrial and Intelligent Information Vol, 1(4).

[67]. Sharmin N et al (2016) Commercial feasibility study of PET bottles recycling by solvent extraction method. Int J Adv Res 4(4):421– 426. https://doi.org/10.21474/IJAR01.

[68]. Swift, G., & Wiles, D. M. (2004). Degradable Polymers and Plastics in Landfill Sites. In Encyclopedia of Polymer Science and Technology. John Wiley & Sons, Ltd. https://doi.org/10.1002/0471440264.pst457.

[69]. Sydow, Z., & Bieńczak, K. (2019). The overview on the use of natural fibers reinforced composites for food packaging. Journal of Natural Fibers, 16(8), 1189–1200. https://doi.org/10.1080/15440478.2018.1455621.

[70]. T. Hojo, Z. Xu, Y. Yang, H. Hamada, Tensile properties of bamboo jute and kenaf mat-reinforced composite, Energy. Procedia. Vol. 56, pp-72-79.

[71]. T. M. Gowda, A. C. B. Naidu, C. Rajput. Some mechanical properties of untreated jute fabric-reinforced polyester composite Compos. Part- A. 30 (1999) 277-284.

[72]. Tansel, B., & Yildiz, B. S. (2011). Goal-based waste management strategy to reduce persistence of contaminants in leachate at municipal solid waste landfills. Environment, Development and Sustainability, 13(5), 821–831. https://doi.org/10.1007/s10668-011-9290-z.

[73]. Ullah, M. R., Molla, S., Mustaquim, S. M., Siddique, I. M., & Siddique, A. A. (2024). Exploratory Approaches for Improved Cost Effectiveness and Profitability: Utilizing Mathematical Analysis and Value Stream Mapping on Production Floors. World Journal of Advanced Engineering Technology and Sciences, 11(01), 076-085.

[74]. Ullah, M. R., Molla, S., Mustaquim, S. M., Siddique, I. M., & Siddique, A. A. (2024). Exploratory Approaches for Improved Cost Effectiveness and Profitability: Utilizing Mathematical Analysis and Value Stream Mapping on Production Floors. World Journal of Advanced Engineering Technology and Sciences, 11(01), 076-085.

[75]. V. Mishra, S. Biswas, (2013). Physical and mechanical properties of bi-directional jute fiber epoxy composites. Proceed, Eng. 5, pp- 561-566.

[76]. Y. Seki, (2009). Innovative multifunctional siloxane treatment of jute fiber surface and its effect on the mechanical properties of jute/ thermoset composite. Mater. Sci Eng. A. 508, pp-247-252.