World Journal of Research and Review (WJRR)
ISSN:2455-3956, Volume-5, Issue-3, September 2017 Pages 35-42

A REVIEW OF TECHNICAL UTILIZATION OF NATURAL FIBRES (JUTE)

Natural Fibre Composite (NFC): New Gateway for Jute, Kenaf and Allied Fibres in Automobiles and Infrastructure Sector

Suriya Ferdous, Md Sarwar Hossain

***Abstract* — This paper closely reviews the prospective utilization of natural fibres e.g. jute, kenaf and allied fibres in the technical production of automobiles and infrastructure sectors as a sustainable substitute over expensive synthetic fibres e.g. carbon, aramid, glass etc. Jute fibre (density 1.4 g/cc) being lighter than glass fibre (density 2.5 g/cc) offers additional advantages as regards specially in fuel efficiency in automobiles and lighter weight in infrastructures. The cost of natural fibre as raw material is also remarkably lower-priced than any synthetic fibres being utilized for manufacturing the reinforced products. Renowned car manufacturers e.g. Mercedes Benz, Daimler Chrysler, Ford Motors, Toyota, Hyundai, Volkswagen and Suzuki have already started using 10 to 20 kg of natural fibres to make interior body parts of automobiles as a part of their commitments for taking action against CO_2 emissions, thus making greener world. It is estimated that the market size of NFC will increase from the level of USD 2.1 billion in 2010 to USD 3.8 billion in 2016 which is wide open for more eco-friendly and economic jute/ kenaf fibres to tap.**

***Index Terms* — Automobile, Infrastructure, Jute, Natural Fibre Composite (NFC)**

I. INTRODUCTION

Since the 1990s, Natural Fibre Composites (NFC) are emerging as realistic alternatives to the synthetic fibre reinforced composites in many applications mainly in the automotive and infrastructure sectors. Technologies have been developed to incorporate jute fibre with synthetic polymers/resins for partial replacement of high cost synthetic fibre for low load bearing applications. The prominent advantages of natural fibers include acceptable specific strength properties, low cost, low density, high toughness and good thermal properties. Low specific weight, which results in a higher specific strength and stiffness than glass is a benefit especially in parts designed for bending stiffness. Jute fibre (density 1.4g/cc) being lighter than glass fibre (density 2.5 g/cc) [1] offers additional advantages as regards specially in fuel efficiency in automobiles.

Due to some unique physical properties like high tenacity, bulkiness, low thermal conductivity, antistatic property, jute/ kenaf is more suited for the manufacturing of technical textiles in certain specific areas. In the fields of automotive industries, reduction of energy consumption in production of motor vehicles and improvement of their day to day fuel economy are growing upwards due to accelerating use of natural fiber composites. As an ideal substitute of wood a range of products that are presently being produced from jute/kenaf composites are sheets/boards, door, window, furniture, corrugated sheet, chequered board, wall panels, coffins etc. The natural fibres have additional advantages as they are biodegradable, renewable, unbreakable, maintenance free, durable, fire retardant and water resistant, acid-and alkali-resistant, less abrasive, less costly, with low thermal conductivity, eco-friendly and stronger than wood. Found to be cheaper, lighter natural fibre composites have strength properties comparable and almost twice as stiff as glass fibre reinforced PP composites.

The review paper not only unleashes the sustainable features of NFC over the synthetic materials but also aims to make the renowned investors interested in Foreign Direct Investment (FDI) on natural fibre composites in the automobile and infrastructure sectors in the largest producer of natural fibres, Bangladesh and India. This paper envisages a future outlook of technical utilization of natural fibres which will provide a ground to the international business conglomerates for initiating a new business of jute/ kenaf composite in the emerging economics like Bangladesh/ India and also attracts the consumers devoting their capitals in green products.

II. METHODOLOGY

This is an evaluative paper result of close analysis of information, experiences, scenarios, statistics and evidence regarding the technical, environmental and economic perspective of NFC from the secondary sources. Numbers of researches and studies have been completed in this area worldwide specially in India, Malaysia, Europe and USA. This paper has accumulated the accomplished global experiences and findings on the research subject for making it more acceptable in the research and development arena. The secondary sources included: online researches & publications, articles, papers published in accredited and other journals, conference and meeting papers, newspaper articles and academic books. For the literature study, the following databases are also visited: UPM library, IJSG resource centre, other industrial resources, individual experiences of entrepreneurs, Bangladesh Jute Research Institute (BJRI) library, sciencedirect, springerlink and google scholar.

Suriya Ferdous, Programme Officer, United Nations Office for Project Services (UNOPS) and Former Senior Project Assistant of International Jute Study Group (IJSG). Dhaka, Bangladesh

Md Sarwar Hossain, Lead Specialist (Network Infrastructure), Banglalink Digital Communication Ltd and Independent Consultant, Dhaka, Bangladesh

III. Result and Discussion

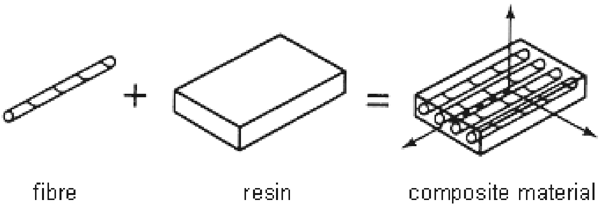


Fig-1: Composition of fibre-plastic composites

A.The NFC Products

Composites consist of two (or more) distinct constituents or phases, which when coupled together result in a material with entirely different properties from those of the individual components. Typically, a manmade composite would consist of a reinforcement phase of stiff, strong material, frequently fibrous in nature, embedded in a continuous matrix phase. The main functions of the matrix are to transmit externally applied loads by shear stresses at the interface, to the reinforcement and to protect the matrix from environmental and mechanical damage. The advantage of such a coupling is that the high strength and stiffness of the fibres (which in most practical situations would be unable to transmit loads) may be exploited. In a composite, the fiber contributes high tensile strength, enhancing properties in the final part, such as strength and stiffness while minimizing weight. Polymer matrix composites reinforced with manmade fibres e.g., glass, carbon, aramid, Electrical or E-glass, polyethylene (PE) fibers etc. are getting a steady expansion in end-uses because of their favorable mechanical properties.

These polymer matrixes are also expensive materials. To optimize cost of the natural fibers composite materials, such as abaca, coconut, flax, hemp, jute, kenaf and sisal etc are the growing interest for the alternative use of polymer or synthetic fibre in the composite industry. To accelerate this process of switching to recyclable and biodegradable constituents, the legislations in USA & Europe have been issued a specific directive on the end-of-life vehicles that also promotes the use of environmentally safe products and reduces the landfills. Key features of NF composites grasped the global attention for sustainable markets are:

- Low density and high specific strength and stiffness
- Fibres are a renewable resource, for which production requires little energy, involves CO_2 absorption, whilst returning oxygen to the environment
- Fibres can be produced at lower cost than synthetic fibre
- Low hazard manufacturing processes
- Materials with enhanced acoustic insulation
- Low emission of toxic fumes when subjected to heat and during incineration
- Less abrasive damage to processing equipment in comparison with synthetic fibre composites
- Increased fuel efficiency
- Easy transport and implementation
- Zero waste upgradability
- Recyclability

The table below showed the comparison of material properties between commercially important natural fibres and manmade fibres. Jute is scientifically proven commercially viable natural fibres among the reinforcement materials available in the market.

Table-1: Comparison Between Commercially Important Natural Fibre and Man Made Fibres [2]

Properties	E-glass	Carbon	Kenaf	Flax	Hemp	Jute	Coir	Sisal	Cotton
Density (g/cm^2)	2.55	1.7	1.5	1.4	1.48	**1.46**	1.25	1.33	1.51
Tensile Strength (10E6 N/m^2)	2,400	3,400	350-600	800-1,500	550-900	**400-800**	220	600-700	400
E-modulus (GPa)	73	230	40	60-80	70	**10-30**	6	38	12
Specific (E/density)	29	-	27	26-46	47	**7-21**	5	29	8
Elongation at failure (%)	3	3.4	2.5-3.5	1.2-1.6	1.6	**1.8**	15-25	2-3	3-10
Moisture absorption (%)	-	-	-	7	8	**12**	10	11	8-25
Price($)/kg Raw (mat/fabric)	3.25 (1.7/3.8)	200	0.33-0.88	1.5 (2/4)	0.6-1.8 (2/4)	**0.71 (1.5/0.9-2)**	-	0.6-0.7	1.5-2.2

Commonly the matrix comprises a thermoplastic or thermoset polymer, as for instance, polyethylene and unsaturated polyester respectively. The manufacture of true bio-composites demands that the matrix be made predominantly from renewable resources, although the current state of biopolymer technology dictates that synthetic thermoplastics and thermosets dominate commercial bio-composite production. Thus polyethylene and polypropylene have found widespread use in wood–plastic composites (WPCs), a particular subset of bio-composites that are currently receiving a significant amount of attention and are in widespread commercial production, particularly in North America. By and large, such thermoplastic biopolymers that have been developed primarily for the packaging industry do not have the material properties to meet the matrix system requirements for other fibre composite materials.

The techniques used to manufacture bio-composite are based largely on existing techniques for processing composite materials. These include press moulding, hand lay-up, filament winding, pultrusion, extrusion, injection moulding, compression moulding, resin transfer moulding and sheet moulding compounding. However, the majority of current bio-composite materials based on thermoplastic polymers are processed by compounding and extrusion.

A.1 NFC Products in Automobile Sector

In the fields of automotive industries, reduction of energy consumption in production of motor vehicles and improvement of their day to day fuel economy are growing upwards due to accelerating use of natural fiber composites. Almost all the major car manufacturers in Germany use natural fibre composites. EU published the ‘end of life vehicle’ directive of 95% by weight of all vehicle component should be recyclable by 2015 [3]. Most of the renowned car manufacturing companies -Mercedes Benz & Daimler-Chrysler /Germany, Toyota/ Japan, Suzuki-Maruti/ India, Hyundai/ Korea and Proton/ Malaysia are using jute-composites in making different molded body structures in their automobiles.

In the United States, 10 million to 11 million vehicles come into use each year. By ending up their useful lives, the network of salvage and shredder facilities process about 96%

World Journal of Research and Review (WJRR)
ISSN:2455-3956, Volume-5, Issue-3, September 2017 Pages 35-42

old cars, about 25% of the vehicles by weight, including plastics, fibers, foams, glass and rubber, remains as waste. A car made of heated, treated and molded with bio-composite buried simply at its lifetime would be degraded naturally. Now a day, a generic vehicles use numbers of components made from the natural fibres.

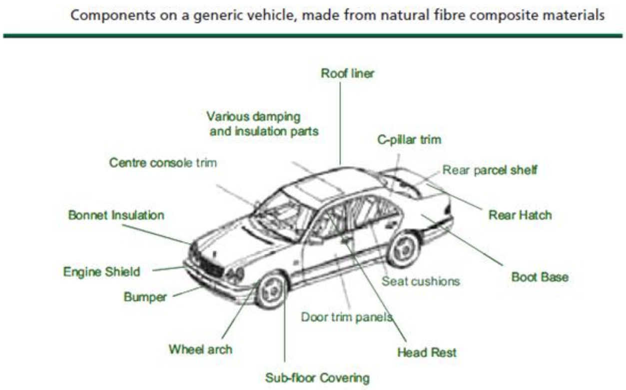


Fig-2: Components on a car, made from NFC material

The automotive manufacturers have been using kenaf, flax, abaca, hemp widely in the door panels, rear parcel shelf, seat backs, spare tyre covers, other interior trim and spare-wheel pan particularly.

A.2 NFC Products in Infrastructure Sector

As an ideal substitute of wood a range of products that are presently being produced from jute and kenaf composites are decks, housing panels, fencing, door, window frames, furniture, corrugated sheet, chequered board, wall panels, coffins and also sport equipments rackets, snow boards etc. At present, the natural fibres are being widely used in the following applications globally.

Jute thermoplastic board, which can be manufactured wastes of jute and plastic, have been found to be an effective material to produce sheets/boards, doors, window frames, furniture, fence, corrugated sheets and chequered boards etc. Jute based composites may be considered as a focused area of development as it holds the prospect of an entirely new application areas leading to future development and an increased market share for jute.

Table 2: Natural Fibres Usage per Component

Component	Weight (kg)
Front door liner	1.2-1.8
Rear door liner	0.8-1.5
Boot liners	1.5-2.5
Parcel shelves	<2
Seat backs	1.6-2
Soundproof shields	<0.4
Headrest	2.5

Dr. Mubarak Ahmed Khan, Current Director General and Famous Scientist of Bangladesh Atomic Energy Commission, patented a NFC for housing materials, Jutin, in 2010. Jutin mainly composite roofing material made from hessian cloth reinforced with unsaturated polyester resin is

Fig-3: House is made from NFC named 'Jutin' invented by the Scientist, Dr. Mubarak Ahmed Khan, in Bangladesh

prepared by simple hand lay-up technique. This jute-composite is an appropriate alternative to the conventional heavy and brittle building materials such as stones, bricks, mortar, granite etc especially in the temblor prone area as it tolerates and reduces high seismic waves. Jutin is 2.5 times stronger than conventional sheet, completely rust proof, heat, saline & water resistant and 50 years durable with normal conditions provided fixing accessories match with the quality of the sheets [4].

Table-3: NF Composite Applications in Construction Industry [5]

Type of fibre	Application in building, construction, and others
Hemp fiber	Construction products, textiles, cordage, geotextiles, paper & packaging, furniture, electrical, manufacture bank notes, and manufacture of pipes
Oil palm fiber	Building materials such as windows, door frames, structural insulated panel building systems, siding, fencing, roofing, decking, and other building materials
Wood fiber	Window frame, panels, door shutters, decking, railing systems, and fencing
Flax fiber	Window frame, panels, decking, railing systems, fencing, tennis racket, bicycle frame, fork, seat post, snowboarding, and laptop cases
Rice husk fiber	Building materials such as building panels, bricks, window frame, panels, decking, railing systems, and fencing
Bagasse fiber	Window frame, panels, decking, railing systems, and fencing
Sisal fiber	In construction industry such as panels, doors, shutting plate, and roofing sheets; also, manufacturing of paper and pulp
Stalk fiber	Building panel, furniture panels, bricks, and constructing drains and pipelines
Kenaf fiber	Packing material, mobile cases, bags, insulations, clothing-grade cloth, soilless potting mixes, animal bedding, and material that absorbs oil and liquids
Cotton fiber	Furniture industry, textile and yarn, goods, and cordage
Coir fibers	Building panels, flush door shutters, roofing sheets, storage tank, packing material, helmets and postboxes, mirror casing, paper weights, projector cover, voltage stabilizer cover, a filling material for the seat upholstery, brushes and brooms, ropes and yarns for nets, bags, and mats, as well as padding for mattresses, seat cushions
Ramie fiber	Use in products as industrial sewing thread, packing materials, fishing nets, and filter cloths. It is also made into fabrics for household furnishings (upholstery, canvas) and clothing, paper manufacture
Jute fiber	Building panels, roofing sheets, door frames, door shutters, transport, packaging, geotextiles, and chip boards.

B. Global Business of NF Composites

In the global value chain of sustainable world, ecological aspects rather than economic are the decisive factors for doing a business. Eco-friendly bio-composites from plant derived fibre would be the novel materials of the 21st century not only as an way out to the growing environmental threats but also as a solution to alleviating the uncertainty of the petroleum supply which is expected to decline between 2010 to 2020. Analysing the recent past data, the most promising sectors for natural fibre-reinforced composites are the automotive and infrastructure. The growth outlook for bio-composite is expected to increase by 54% per annum globally at a compound annual growth rate (CAGR) of 8.2% from 2015 to 2020[6].

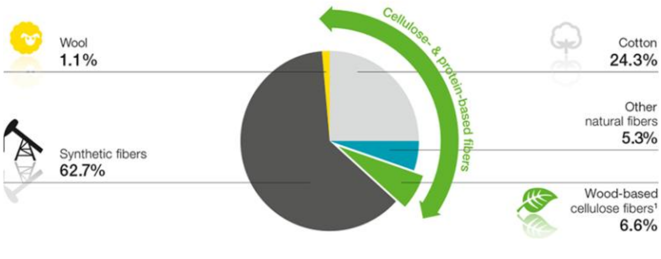


Fig-4: Global fiber consumption in 2016 by type of fiber in percent [7].

The modern era of composites did not begin until plastics are developed. In the early 1900s, plastics such as vinyl, polystyrene, phenolic and polyester were devised. However, only plastics found as less potential for structural applications in terms of strength and stiffness. In 1935, Owens Corning introduced the first glass fibre, fibreglass as the reinforcement agent for infrastructure. Fiberglass, when combined with a plastic polymer creates an outstanding strong structure which was also lightweight. This is the beginning of the Fibre Reinforced Polymers (FRP) industry. The versatile combination of raw materials, polymers and other natural or synthetic fibres, during the production and processing of FRP, as well as various different manufacturing techniques open up a variety of applications for fibre reinforced plastics. Since the 1990s, Natural Fibre Composites are emerging as realistic alternatives to synthetic fibre reinforced composites in many applications mainly in the automotive and infrastructure sectors.

B.1 Automobile Sector

The adoption of natural fibre composites in this FRP industry is led by the motives of a) price b) weight reduction and c) marketing (green resources). The fibre-based composites can contribute greatly to the automotive manufacturer's final goal constituting 30% weight reduction and cost reduction of 20%. According to a study completed by the US Environmental Protection Agency (EPA) and Bureau of Transportation Statistics, 75% of fuel consumption is directly related to vehicle weight, and EPA studies also have estimated that reducing vehicle weight by 10% saves 7% of fuel at the pump. Another study indicated that there is scope for about 20 kg of natural fibres to be used in each of approximately 60-70 million vehicles being produced globally each year. Even if 5-10 kg natural fibre is used per vehicle, 300 – 450 thousand tonnes of natural fibre would be required annually which will create additional demand in conjunction with the current world production of jute, kenaf and allied fibre 3.4 million tonnes. Jute, with average global annual production of 3.1 million tonnes, is the most suitable natural fibre to meet this demand. Renowned car manufacturing companies like Mercedes Benz, Daimler-Chrysler, Germany; Toyota, Japan; Ambassador Suzuki-Maruti, India; Hyundai, Korea and Proton, Malaysia etc. are widely using jute-composites in making different molded body structures in their automobiles.

The strength of the bio-composite in the automobile sector was 72,500 ton and 72 million USD in 2012 with 50% increasing prediction in 2015 of 162,000 ton and 162 million USD. This present figure also stated that globally natural fibre is being used in 3.6 million vehicles especially in private cars considering 20kg of natural fibres consumed per vehicle. The automotive company, Ford in Germany, is using kenaf fiber in their model "Ford Mondeo" which is importing kenaf from Bangladesh. The door panels of Ford Mondeo are manufactured by kenaf reinforced PP composites.

B.2 Infrastructure Sector

Infrastructure is another vibrant sector inter se other niche applications of the NF composites. The infrastructure i.e., the building and construction materials, are adopting green technology to opt a sustainable environment. Jute thermoplastic board, which can be manufactured utilizing wastes of jute and plastic, have been found to be an effective material to produce sheets/boards, doors, window frames, furniture, fence, corrugated sheets and chequered boards etc. Jute based composites may be considered as a focused area of development as it holds the prospect of an entirely new application areas leading to future development and an increased market share for jute. It also paves the way towards growth of an entirely new market where the raw material does not enter into traditional industrial production system through processing but finds direct industrial application at the stage of raw jute in the form of jute cuttings.

'Panasonic Electric Works Kenaf' in Malaysia consumes about 600 tonnes of kenaf fibre monthly to produce fibre board. More than 90% of its supply comes from Bangladesh with the remainder from Myanmar, Vietnam and local production [8]. According to the industry source, the factory currently produces 60,000 pieces of kenaf fibreboard per month to make wall panels and doors, all of which are exported to Japan for the housing and building materials industries [9].

C. The NFC Markets: Strengths and Opportunities

Global natural fiber composites market reached 2.1 billion USD in 2010, with compound annual growth rate of 15% in last five years further assuming 10% increase by 2016 [10]. Another ten years forecast by CFC and IJSG in 2006 showed jute in composites and plastic reinforcement will be stood at 30 -100 thousand tonnes in 2016. In 2010, only EU used bio-composites materials 362,000 tonne traversed the estimation of 2006 in four years. Rising prices of petroleum based products, strong government support to eco-friendly products, higher acceptance, positive growth of end use industries and new housing numbers will drive natural fiber composites growth to new horizon. Performance improvement in materials will also impel development for natural fiber composites in new application areas.

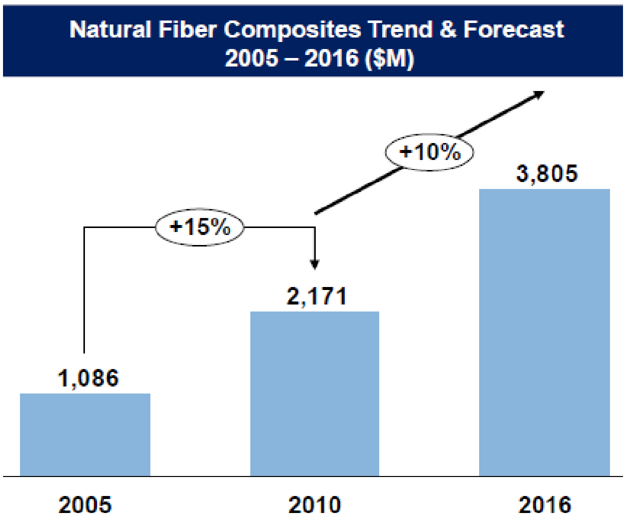


Fig-5: Natural Fibre Composites Trend & Forecast [10].

Rising prices of petroleum based products, strong government support to eco-friendly products, higher acceptance, positive growth of end use industries and new housing numbers will drive natural fiber composites growth to new horizon. The composite market report of EU 2012 for the first time considered Turkey, Saudi Arabia, Egypt and Iran as the composite consuming countries besides EU, USA and Japan. According to information provided by the Turkish Composites Association (TCMA), this market has now reached a size of nearly 200 kilo tonne. The main areas of application are construction sector (pipes and tanks). Transport is the second largest sector being manufactured for marine applications. The applications in Saudi Arabia, Egypt and Iran and Middle Eastern countries in general are similar. The construction of waste water treatment facilities and sewers, water tanks and other different construction applications (sanitation, roofs, masts, footpaths and plant construction) offer potential for the future in these regions. Taking into account of per capita income of people and consumption of different products, most potential markets for NFC in the coming years is likely to be USA and EU.

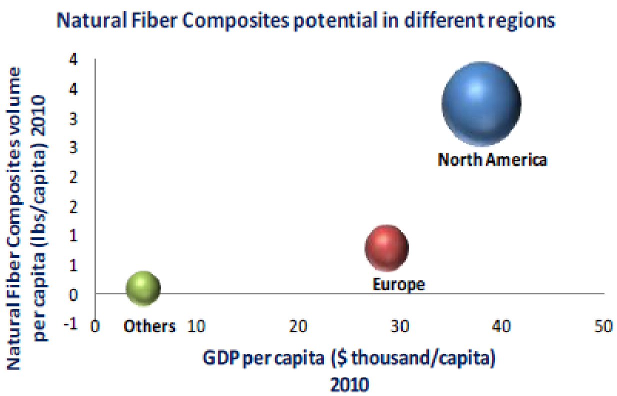


Fig-6: NFC Potential in different Regions [10].

Taking into account of per capita income of people and consumption of different products, most potential markets for NF composites in the coming years is likely to be USA and EU. NF composite has observed positive growth in each region and surpassed Gross Domestic Production growth. Natural Fiber Composites industry performed well compared to GDP during last 5 years, and it is expected to continue to grow at a higher rate than GDP over the next 5 years. North America is the leader in the natural fiber composites consumption followed by the European region. European region is potential due to increasing awareness and acceptance of natural fiber composites by automotive players. Asian region have significant potential for growth of composites as composites per capita is significantly lower than developed nations. In 2011, the per capita consumption of composites in India hovers around 0.25 kg compared to that of USA which is 10 kg. In this figure 'Others' include Asia and rest of the world and bubble size represents market size (million USD) [10].

D.Cost Comparison

Jute-composite, scientifically proved suitable alternative raw material, can be accounted for making more affordable houses in the disaster and saline prone regions like Japan, Indonesia, USA etc. The possible consumption of jute for building a house (cover side walls, partition, roof, angles, I-Beams, window frames & floor) is 463 kg. Estimation by Conenor Ltd. [11], specialized in applied development of natural fibre company in Finland, showed the cost of jute or NFC house is USD 9,000 whereas the wood-plastic composite (WPC) house costs about minimum USD 13,000.

Table-4: Cost-Benefits Ratio of a NFC House
(costs USD per ton)

	QTY (%)	$/TON	COST	SHARE
Natural Fibres	60	150	138	20.7 %
Recycled plastic	22	500	110	16.5 %
Virgin plastic	11	1,400	154	23.1 %
Additives incl. Minerals	7	2,300	161	24.1 %
Sub total			563	84.3 %
Labour (each 10.000 $/a)			35	5.2 %
Electricity (@ 60 $/mwh)			48	7.2 %
Maintenance & spares			12	1.8 %
Packaging & transport			10	1.5 %
Sub total			70	10.5 %
Total production cost			**668**	**$/TON**
Sales revenue			**900**	**$/TON**
Gross profit margin			**232**	**25.8 %**

Commercial production cost of jutin is also about BDT 35-40 per sq.ft. lesser than other corrugated sheets are available in Bangladesh.

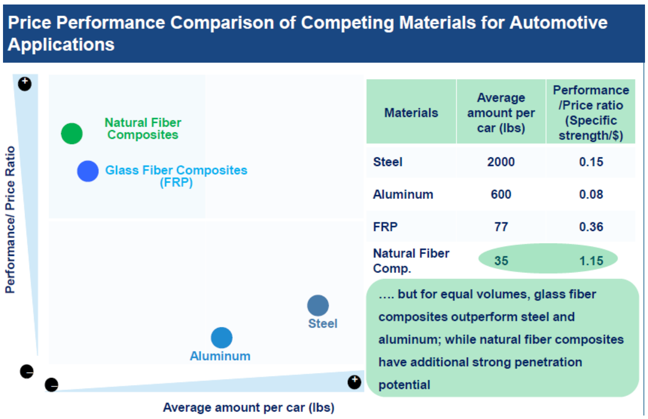
Table-5: Comparative Price of Commercial Corrugated Sheets and Jutin in Bangladesh (per square feet in BDT)

Metal	Metal color	GF 3mm, color	PVC/ PP* 2mm, color	Jutin 3mm, color
52-67	65-80	150-250	>90.00	**79.00****

*PVC- PolyVinyl Chloride, PP – Polypropylene.

**Cost will be BDT 35-40/sft in Industrial production

In the latest composite market analysis, the consulting firm Lucintel LLC also showed a price performance comparison of competing materials for automotive applications in the following figure [12] what clearly indicate the high performance potency of NF in the automobiles sector.



Materials	Average amount per car (lbs)	Performance /Price ratio (Specific strength/$)
Steel	2000	0.15
Aluminum	600	0.08
FRP	77	0.36
Natural Fiber Comp.	35	1.15

Fig-7: Price Performance Comparison of Competing Materials for Automobile Applications.

E. Environmental Facts

Natural fibres are scientifically approved bio-degradable, eco-friendly, recyclable and economic raw material sources for composite products. Reportedly 120 days of jute-growing period one hectare of jute plants can absorb about 15MT of CO_2 from atmosphere and liberate 11MT of O_2 [13]. Kenaf plant absorbs CO_2 from the atmosphere more than any other crop. About 1.5 tons of CO_2 is needed for a production of 1ton of dry matter of kenaf. It means that every hectare of kenaf consumes 30-40 tons of CO_2 for each growing cycle. During a single growing cycle, each hectare of kenaf consume the amount of CO_2 that exhaust from 20 cars in whole year. On an average of 60-65 million vehicles running in the roads all over the world emits about 306 – 332 million tonnes of CO_2 in the atmosphere. If new vehicles start utilizing the prescribed volume of NFC in the body parts, upto 21% of pump fuel will be saved per vehicle. Jute/ kenaf composites carry two remarkable features in reducing CO_2 emission in the end-applications.

- **Almost neutral CO_2 balance, because the fibre plants store CO_2 during its growth.**
- **NFC can save upto 21% fuel consumption of a vehicle that prevents millions of CO_2 emission in the atmosphere.**

NFC can play an important role is preserving the indigenous forests. The forests of most countries are rapidly being cut down for timber. Although extensive reforestation programmes are initiated, the balance existing in century old eco-systems remains disturbed, threatening the environment and the conservation of the biodiversity of plants and wildlife. NFC forms an important substitute for timber-wood, reducing the need to cut down trees. Compressed NFC panels and extruded profiles can substitute wooden board and beams as construction elements, but also single step manufactured constructions can replace their wooden counterpart.

Composites are hybrid materials made of a polymer resin reinforced by fibers, combining the high mechanical and physical characters of the fibers. Attention towards biodegradable polymers is increasing day by day due to severe concerns on managing carbon emissions in a sustainable manner, and the environmental requirements on safe and effective disposal of plastic polymers after use. There is increasing interest in replacing reinforcement materials (inorganic fillers and fibers) with renewable organic materials. NFs represent environmentally friendly alternatives to conventional reinforcing fibers (glass, carbon, Kevlar). Advantages of NF over traditional ones are low cost, high toughness, low density, and good specific strength properties, reduced tool wear (nonabrasive to processing equipment), enhanced energy recovery, CO_2 neutral when burned, biodegradability [14].

Another environmental issue is the output of the NFC industry in the form of sustainable products. A sustainable product fulfils the need of a current generation without compromising future generations to fulfill their needs. In concrete terms, a more sustainable design uses up less materials and/or energy during manufacturing, use and disposal, leaving more options over for future choices. Therefore, sustainability takes in account the entire product trajectory. The use of natural materials and mainly mechanical processes raises sustainability in the manufacturing stage and during disposal. The lightweight character of the products reduces fuel consumption during transport [15].

F. Standards of Bio-composites

International standardization, coding and marketing protocol of NFC are the issues being discoursed now a day. Following standards are available for fibre reinforced polymers/ plastics (FRP) so far.

USA: ASTM standards (D7031-04 & D7032-04) to assess performance of WPCs relative to building code requirements. Construction codes and assessment by International Code Council (ICC-ES).
EU: Technical Specifications for WPCs (CEN/TS 15534-1, 2 & 3).
Germany: Quality certificate by Qualitätsgemeinschaft Holzwerkstoffe e.V.
France: AFNOR certification for Marque NF514.
Japan: ECOMARK-label as per JIS A5741.
ISO/TC 61/SC 13 Composites and reinforcement fibres

From a technical standpoint, the need for specialized standards and codes for FRP or NFC materials arises from their substantially different mechanical and physical properties in comparison with conventional construction materials. The development of standards and codes for the use of FRP reinforcement with concrete structures is ongoing and is expected to shape up in the coming years.

IV. Conclusion

Composites will be manufactured widely through an integrated design process resulting in the optimum construction according to parameters such as shape, mass, strength, stiffness, durability, costs, etc. Along with the construction flexibility, the NFC from plant derived fiber and crop-derived plastics would be the novel materials of the 21st century not only as a solution to the growing environmental threat but also as a solution to alleviating the uncertainty of the petroleum supply which is expected to decline between 2010 to 2020. Natural fiber composites claim to offer environmental advantages such as reduced dependence on non-renewable energy/ material sources, lower pollutant emissions, lower greenhouse gas emissions, enhanced energy recovery, and end of life biodegradability of components.

This can be attributed to the growing concerns of global warming and the rising price of petroleum-based products. Considerable researches have been conducted and proven that natural fibres, an environmentally friendly substitute, have the potential to replace materials such as synthetic polymers, glass fibres and timber.

Much research and progress have completed in recent decades in the mechanical performance and applicability of NFCs. Remarkable improvements have been achieved due to modified fibre selection, extraction, treatment and interfacial engineering as well as composite processing. This paper has reviewed the potentiality of NFC to be expanded in the infrastructure and automobile markets worldwide. Overall, growth of NFC consumption continues at a rapid rate and there would appear to be a very positive future ahead for the diverse outdoor applications. NFC, at present, may not be the full alternative of synthetic fibres, but this is proven that NF composites can surely be an integral part of reinforced fibre products alongside the artificial fibres.

V. Acknowledgement

The publication gratefully recalls the organizations former International Jute Study Group (IJSG) and Bangladesh Jute Research Institute (BJRI) for their close cooperation and resources of developing this article.

References

[1] Avinash R. Pai, Ramanand N. Jagtap, "Surface Morphology & Mechanical properties of some unique Natural Fiber Reinforced Polymer Composites- A Review". J. Mater. Environ. Sci. 6 (4) (2015) 902-917 ISSN: 2028-2508 CODEN: JMESCN. https://www.jmaterenvironsci.com/Document/vol6/vol6_N4/106-JMES-869-2014-Pai.pdf

[2] Dr. Ziegler Lars et al, "WPC and Bio-Polymer Composites – State of the Art and Today´s Applications". BioStruct. Seventh Framework Programme (FP7-NMP-2007-LARGE-1) by the European Community.

[3] Directive 2000/53/EC on End of Life Vehicles. Guidance Document version-1 January 2005. www.ec.europa.eu/environment/waste/pdf/guidance_doc.pdf

[4] Mubarak A Khan and Jahangir Khan, "Opportunities of Jute Fibre Reinforced Polymer Composites and Its Challenges". Published in the roceedings of International R&D Seminar of JKAF by IJSG, 2011, pp 256-261. http://common-fund.org/fileadmin/user_upload/RF/R_D_Seminar_Proceedings.pdf

[5] Layth Mohammed, M. N. M. Ansari, Grace Pua, Jawaid Mohammad, and M. Saiful Islam, "A Review on Natural Fiber Reinforced Polymer Composite and Its Applications". International Journal of Polymer Science, vol. 2015, Article ID 243947, 15 pages, 2015. doi:10.1155/2015/243947

[6] "Global Natural Fiber Composite Market 2015-2020: Trends, Forecast, and Opportunity Analysis. " Published by Lucintel LLC, 2015. http://www.lucintel.com/ds/natural-fiber-composite-market-2020.aspx

[7] LENZING, 2017. ICAC, CIRFS, TFY, FEB, Lenzing estimates. http://www.lenzing.com/en/investors/equity-story/global-fiber-market.html

[8] World Jute Profile – Malaysia. http://www.jute.org/wjp/cp_malaysia.htm

[9] Abdul Rahman Khan, "Kenaf, a fibre for the future: the Harusmas experience". http://www.jeccomposites.com/knowledge/international-composites-news/kenaf-fibre-future-harusmas-experience

[10] "Opportunities in Natural Fiber Composites" by Lucintel LLC. Project Brief published in March 2011. http://www.lucintel.com/lucintelbrief/potentialofnaturalfibercomposites-final.pdf

[11] Markku Vilkki, "Extruded Natural Fibre Composites for House Construction Applications - Opportunities in Green Economy". Paper presented in the International Bio-composite Conference in August 2012.

[12] C. Kazmierski, "Growth Opportunities in Global Composites Industry". Paper presented in the Composite Exhibition and Convention on February 21-23, 2012. http://www.lucintel.com/lucintel-globalcompositemarketanalysis-acma2012-educationalsession.pdf

[13] "Environmental Impact of Jute Agriculture". http://jute.org/ecology.html

[14] N.ABILASH, M.SIVAPRAGASH, "Environmental Benefits Of Ecofriendly Natural Fiber Reinforced Polymeric Composite Materials". International Journal of Application or Innovation in Engineering & Management (IJAIEM), ISSN 2319 – 4847, Volume 2, Issue 1, January 2013, pp 55-59. http://www.ijaiem.org/volume2Issue1/IJAIEM-2012-01-06-008.pdf

[15] K. van Rijswijk et al, "Application of Natural Fibre Composites in the Development of Rural Societies". Paper published by Food and Agriculture Organization of the United Nations. http://www.fao.org/docrep/007/ad416e/ad416e00.htm

First Author:

Suriya Ferdous is a former research fellow of a 5-year project of USAID Bangladesh and an awardee of the Doctoral Research Fellowship from the Institute of Tropical Forestry and Forest Products of University Putra Malaysia for conducting the 'economic valuation of bio-composites in Malaysia'. She is a post-graduate in Environmental Sciences from a public university of Bangladesh known as Jahangirnagar University with all first classes in academic records; has six years of experiences in innovative research and methodologies, programme management and coordination, consultancy and documentation. Ms. Ferdous served as 'Project Officer (in Charge)' in International Jute Study Group for three years; has numbers of successful implementations with national and international research institutes, governments, UN agencies and renowned donor organizations in the sector of natural fibre commodity, resilient infrastructure, climate change adaptation, environmental sustainability and other development issues of Bangladesh.

Reinforcing her experiences and credentials are value additions that include 'PRINCE2®Foundation Certificate in Project Management' designation and certifications of 'Technology of Participation in Facilitations Methods'. The publications of Ms Ferdous are also available in the websites.

- Article: Strategic Action Plans on 'jute composites', 'jute shopping bag', 'food grade jute bags' and 'earning of carbon credit by jute', Compendium of Studies and SAPs by IJSG, January 2014.
- Article: '52.3b Food Grade Jute Bags are in Demand' published in E-jute matters in Volume 1, Issue 8, July 2013 by IJSG. http://www.unctad.info/upload/Infocomm/Docs/Jute/82013.pdf
- Article: 'Volatility in Raw Jute Price' published in E-jute matters in Volume 1, Issue 2, January 2013 by IJSG. http://www.eurojute.org/downloads/cms/Jute%20matters_%20Jan_2013.pdf
- Article: 'Natural Fibre Composites: A Gateway for Jute, Kenaf and Allied Fibres' published in E-jute matters in Volume 1, Issue 1, December 2012 by IJSG.
- Book: The Perceptions of Indigenous People of Climate Change in Kaptai National Park is published by USAID/Bangladesh in 2011. (ISBN: 978-0-86638-223-6). https://scholarspace.manoa.hawaii.edu/bitstream/10125/22219/1/ruralliv elihoods.pdf

Suriya Ferdous lives in Dhaka, Bangladesh; married for four years with an adorable son at cute age of three years. Her interest lies in making friendships, watching movies, facebooking and staying at home as longest as possible. She welcomes people to reach her at skype: suriya_ferdous.

Second Author:

Md Sarwar Hossain is a registered 'Surveyor' of Bangladesh, has acquired two post-graduations first in Geography & Environment from a public university of Bangladesh known as Jahangirnagar University and secondly, in Disaster Manager from another public university named Dhaka University; and completed two graduations in Geography & Environment from Jahangirnagar University and Bachelor of Laws (LLB) in Law and Justice in Bangladesh University of Business and Technology. He has 12 years of professional experience in GIS system, network infrastructure, site survey and acquisition, liaison with high officials of Government and effective communication. Vast work experiences in national and international platform with government, private sector and development partners have led Mr. Hossain to become a successful 'Consultant' in project management, law and justice, network infrastructure, environment and other technical and development issues of Bangladesh.

Mr. Hossain is also familiar in diverse surroundings by owning memberships of Bangladesh Association for Advancement of Science (BAAS), Bangladesh Geographical Society (BGS), Bangladesh National Geographical Association (BNGA), Bangladesh Society of Environmental Scientist (BSES), Bangladesh, Member of Earth Forum of Stamford University, GIS forum of Department of Geography and Environment, Jahangirnagar University and Jahangirnagar University Geographic Association.

His publication titled 'International and National Discourse of Business and Children's Right: Bangladesh Perspective (ISBN: 9783668317260)' notes a crucial issue of Bangladesh connecting child rights affected by different activities of non-formal businesses. Mr. Hossain is happily married for 8 years lives in Dhaka, Bangladesh. Her wife is a government service holder designated as 'Joint District Judge' of Bangladesh and he has bestowed with two beautiful young daughters. He finds his interest in undertaking research, achieving set goals in work and family and last but not the least, leading a peaceful life.