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Conversion of Jute Caddies (Jute Mill Waste) into Value Added Products: A Review

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ABSTRACT

Jute caddies (jute mill waste) can be used as a cellulosic raw material for production of biogas with the residual slurry for making manure. The non-wovens made out of jute caddies can replace glass fibre as reinforcing material in composites for making various utility items. It can be converted into biomass energy through briquetting and gasification after mixing with other agro-residues. Hand made paper for various applications can be prepared from jute caddies after scouring. The study reviews the potential application of jute caddies through different value addition techniques, highlighting the spectacular progress made in the research and development on this industrial biomass in recent years.

Key words: Biogas, composite, jute caddies, nonwoven, paper, products

INTRODUCTION

Jute fibre plays an important role in median economy. This fibre of commerce is extracted from the stem of two cultivated species of jute-tossa jute (*Corchorus olitorius* L.) and white jute (*C. capsularis* L.) (Mahapatra *et al*., 2009). The jute industry generates about 40,000 tonnes of processing waste as by-products, commonly known as jute caddies (Ganguly *et al*., 2004). The major constituent of this waste is unspinnable jute fibre. The other constituents are batching oil, machine oil and grease, barks of jute plant and in-organic dirts. Traditionally the jute industry used this waste along with coal as fuel for the boiler to generate steam, which was required to run the sizing and calendaring machines. This potential waste can find its application in many ways viz., biogas production, non-woven products, composites, biomass energy and hand made paper.

NON-WOVEN FABRICS FROM JUTE CADDIES

Non-woven technology is a forward one for production of fabrics without taking recourse to normal processes of spinning and weaving. This technology stands as a potential alternative to woven technology not only for cost advantage but also for recycling of caddies in a fruitful manner and to incorporate certain properties to the finished products, which are not achievable in conventional products. The nonwoven fabrics from caddies can be made by adhesive bonded and needle punched methods.

Adhesive bonded non-woven: The adhesive used is the key material in this process and may be applied in liquid or solid form depending on the type of adhesive and the final product to be made. Among the adhesives, the most important are rubber latex, polyvinyl acetate, polyvinyl chloride, dextrin, carboxymethyl cellulose, phenyl formaldehyde and acrylic resin (Sinha *et al.*, 1975). These are applied either alone or in admixture. The process in brief consists of the following steps: (1) Preparatory step (opening and blending) (2) Web formation (3) Impregnation with the binder (4) Drying and curing (5) Finishing.

Needle punched non-woven: Needle punching is a method of bonding fibrous fleeces mechanically without application of any binder or chemical (Mazumder *et al.*, 2000, 2001). A board containing a multiplicity of barbed needles is reciprocated at high speed as the fibrous fleece passes under the needles. Some of the needle-punched non-wovens are produced with a support layer known as scrimp cloth to improve the strength and stability of the final product. By the needle punching process fabrics from 27 to 3,000 gsm can be made by adjustment of machine parameters such as speed, feed rate, stroke frequency, needle density, punch density, etc. Both adhesive bonded and needle punched non-wovens fabrics from jute caddies are biodegradable and thus environment friendly.

Use of jute non-wovens: Non-wovens developed from jute caddies by above mentioned methods have potential applications in (i) air filters (vii) floor covering and carpets (ii) automotive cloth (viii) handicrafts (iii) blankets (ix) interlining in dress materials (iv) brattice cloth (x) plaiding cloth (v) disposable bags, disposable fabrics (xi) wall coverings and wipes (vi) felts (xii) window screens. However, the great scope for this material appears to be in the field of geotextiles and agrotextiles. Geotextiles from jute caddies non-wovens have the unique property of holding soil for a particular length of time after which it becomes a part of soil. It can also hold water largely (5 times of its weight) and release the water slowly when needed. All these properties have been utilized in civil engineering applications for controlling soil erosion, making canal linings, protection of riverbanks and construction of roads.

Jute caddies non-wovens can also be used as agro textiles in agricultural mulch. It has been found that by application of the agro textiles, weeds can be controlled largely and the plant growth and fruit bearing are improved obviously due to slow release of nutrients from the fabrics. The non-wovens also arrest essential nutrients from the soil to the benefit of vegetation coverage. Due to the same reason, horticultural pots made out of this showed better results because, on decomposition, the contents of the fabrics enriched the soil nutrition. It also keeps the seedlings in healthy condition by providing air and moisture during transport.

HAND MADE PAPER FROM JUTE CADDIES

Jute caddies received from the mill can be converted into handmade paper by a series of unit operations viz., pretreatment, mechanical pulping, beating, sheet making, drying, trimming and calendaring (Ganguly *et al.*, 2004). This study is suitable for making eco-friendly paper bags for grocery and shopping which could largely replace the non-biodegradable plastic (LDPE), carry-bags, a cause of ecological and environmental pollution in our habitat.

COMPOSITES PRODUCTS FROM JUTE CADDIES

Jute caddies based non-woven fabrics was found suitable as reinforcing material in making Fibre Reinforced Plastic (FRP), thereby replacing costlier glass fibre (Mitra *et al.*, 1998; Rana *et al.*, 1999). These FRPs were developed by reinforcing jute caddies based non-wovens in water-soluble thermosetting resin viz., urea formaldehyde while water-soluble phenolic resin was used for making exterior grade board, which can well substitute plywood. Besides the cost advantage of these composites, the wear and tear of machinery is supposed to be lower when natural fibres like jute caddies are used in place of glass fibre. The lower specific gravity and higher specific modules of jute plays a major role in these products applications. The products developed include corrugated sheet, cooling tower, fan blade, pipe, washbasin, serving tray, speaker box, automobile components, toolbox, traffic signal light case, chair, tabletop, country boat, etc.

BIOGAS FROM JUTE CADDIES

Biogas containing 55% or more by volume of methane can be produced from jute caddies by anaerobic fermentation in digesters using cattle dung as a source of inoculums. The lag period for production of the gas can be reduced by pretreatment of the caddies with mild caustic soda solution. Jute caddies are able to supply higher quantum of biogas due to their slow decomposing nature (Banik *et al*., 1993). The spent slurry left after biogas production is rich in mineral content and has high C:N ratio (about 100:1). The slurry can well be utilized as manure for increasing the yield of jute crop by about 50% through enrichment of rhizosphere soil (Banik and Nandi, 2000). The slurry can also be utilized to increase the yield of mushrooms when ad-mixture with rice straw in 1:1 proportion to improve the protein and mineral content of the edible fungi. Proper disinfection of straw and bio-manure with $KMnO_4$ and formalin ensures contamination free mushroom beds, smooth spawn run and eventually enhancement of yield. Biogas from jute caddies can provide gaseous fuel for use of common people and recycling of spent slurry for manuring and mushroom production can supply protein rich food to them.

BRIQUTTES PRODUCTION FROM JUTE CADDIES

Jute caddies in combination with other agro-residues viz., rice husk, saw dust, jute stick can be briquetted at optimum moisture condition of 10-15%. The gross calorific value of jute caddies briquettes was found to be is 3000-3200 kcal kg^{-1} (Anonymous, 2006). Considering the calorific value of coal as 5200 kcal kg^{-1} and mineral oil as 10,000 kcal kg^{-1}, 1 kg of jute caddies briquette is equivalent to 0.635 kg of coal or 0.33 kg of mineral oil (Nayak *et al*., 2011).

REDUCTION OF JUTE CADDIES FORMATION

Caddies formation may also depend on the quality of the jute fibre, type of retting process and morphology of retted jute fibre (Ahmed and Akhter, 2001; Shamsul Haque *et al*., 2001a). Shamsul Haque *et al*. (2001b) inferred that higher quality and quantity white fibre with fewer cuttings were obtained by retting from C-718 and OF-390 varieties than other varieties like *C. olitorius* (OM-1) and from *C. capsularis* (C-2035, C-2005 and C-2143) in all aspects. It indicated that selection of quality jute fibre might also lead to reduce the formation of jute caddies (Rafiqul Islam *et al*., 2002; Ali *et al*., 2002). Mahabubuzzaman *et al*. (2002) inferred that the quality of jute yarn i.e., 276 Tex is better in medium speed than any other speeds of breaker card cylinder, which also leads to reduction in formation of jute caddies.

FUTURE PERSPECTIVE ON DEVELOPMENT OF DIVERSIFIED PRODUCTS FROM JUTE CADDIES

Textile pretreatment like scouring, bleaching and grafting is used to improve the quality of jute material and so jute caddies might be pretreated for the product diversification and value addition (Shahidullah *et al*., 2007; Venkidusamy *et al*., 2002). Mondal *et al*. (2005) denoted that polymer grafting based on monomers like methacrylonitrile and ethyl methacrylate onto jute fibre could improve its dimensional stability and hydrophobicity with slight reduction of breaking load. The application of such polymer finishing on purified jute caddied may lead to development of jute based fiberboard and fibre reinforced plastics. The conversion of jute caddies into 100% jute based or jute/cotton based needle punched nonwoven fabrics followed by application of functional finishing to impart dimensional stability, flame retardant and water proof may leads to development of nonwoven house hold upholstery (Azad *et al.*, 2007; Kamal Uddin *et al.*, 2002). The basic properties such as Runkel ratio, slenderness ratio and flexibility ratio are considered for the suitability of bast fibres in pulp and papermaking (Olotuah, 2006). The fibre length from jute caddies is ranged from 2.0 to 3.0 mm and so it is a good source for pulp and papermaking. A pectinolytic fungus Aspergillus niger treated jute waste blended with good quality jute fibre could shown improvement in the mechanical properties of final composite product (Ahmed *et al.*, 2002). Wooden chips of high moisture holding capacity is used in the cooling pads for the sub-tropical condition (Nayak and Jha, 2010). Jute caddies being hygroscopic in nature, might also used in the cooling pads with replacement of conventional wooden chips (Nayak and Majumdar, 2011; Nayak and Roy, 2011). Traditionally bast fibres are spun into yarns in a partially mechanized spinning system (Das *et al.*, 2010). Being a bast fibre, it could be blended with other vegetable fibres for the decorative or craft products.

CONCLUSION

Jute caddies can be successfully utilized in making value added products for different sectors through application of advanced technologies. The conversion of this waste to wealth will play a key role in strengthening the economy of jute growers and entrepreneurship development.

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