International Journal of Applied Home Science ***REVIEW ARTICLE***
Volume 2 (11&12), Novemebr & December (2015) : 351-358 ISSN : 2394-1413
Received : 13.11.2015; Revised : 21.11.2015; Accepted : 27.11.2015

Agro- residues: Potential fibers for textile industry

PREETI KAUR SACHDEVA* AND BHAWANA CHANANA
Department of Fabric and Apparel Science, Lady Irwin College,
University of Delhi, New Delhi (India)
(Email : sachdevapreeti8@gmail.com)

ABSTRACT

Problem of managing agro- residues complicates the farming economies as well as creates a liability on the health of environment. Agro-residues are the most abundant and renewable source of cellulose on earth. Their wide- spread accumulation as landfills every year leads not only to deterioration of the environment, but also leads to loss of potentially valuable material which can be processed to yield valuable cellulosic fibers for textile industry. These agricultural residuals have the potential to be used in textile industry either as natural cellulosic fibers or as regenerated cellulosics. This paper attempts to address the alarming issue of climate change and India's stand on it. Possibility of inclusion of agro- residues in Indian textile industry is being discussed. Simultaneously, the paper also provides an overview of some of the easily accessible undervalued agro- residues.

Key Words : Agro- residues, Bagasse, Cane fibers, Cornhusk, Hemicellulose, Leaf fibers, Lignin

INTRODUCTION

Agriculture continues to be the backbone of Indian economy. In India, agriculture provides 54% employment to rural as well as urban masses. The total share of Agricultural output in terms of per cent age of Gross Domestic Product was 13.9% during 2013-2014 at 2004- 05 prices. Total estimated agricultural crop production for the same year was 264.77 Million Tonnes (*http://www.pib.nic.in*). After the isolation of the main agricultural product, abundant solid residue is generated. Worldwide, it is a common practice to dump the residue in garbage houses. The piled up residue starts to decompose by microbial activity and thus creates nuisance for the society. Industries use the agricultural residues for co- generation purpose, but these residues being low calorific value fuels generate smoke and pollute the surrounding environment.

Burning of the agricultural residues in the agricultural field itself has been a very common practice throughout the North Indian Agriculture sector. Burning of agricultural residues produces lethal smoke leading to respiratory diseases. Recently, National Green Tribunal (NGT) has banned such burning and declared such practice illegal and fineable (*http://www.ngt.nic.in*). In such a scenario, all the shareholders of the environment have to think of novel and sustainable methods for utilizing the idle lying underutilized resources of important economic value to India.

Rice, wheat, sugar cane, soybeans, corn, banana, pineapple, bamboo and okra are few examples of crops that generate considerable amount of residues annually. These residues constitute a major part of the total annual production of biomass residues and are an important source of long and short

Cite this Article: Sachdeva, Preeti Kaur and Chanana, Bhawana (2015). Agro- residues: Potential fibers for textile industry. *Internat. J. Appl. Home Sci.,* **2** (11&12) : 351-358

fibers rich in cellulosic content (*wgbis.ces.iisc.ernet.in*).

What are Agro- residues and why emphasize on them?:

The term agricultural residue or agro-residue is used to describe all the organic materials produced as by- products from harvesting and processing of agricultural crops.

Agro- residues are nonwood lignocellulosics and a rich source of cellulose along with lignin. Agro- residues may include stalk, cane, seed pod and leaves. Agro- residues are annually renewable and low cost source for natural cellulosic fibers. Agro- residues are of two types (*http://www.bioenergyconsult.com*).

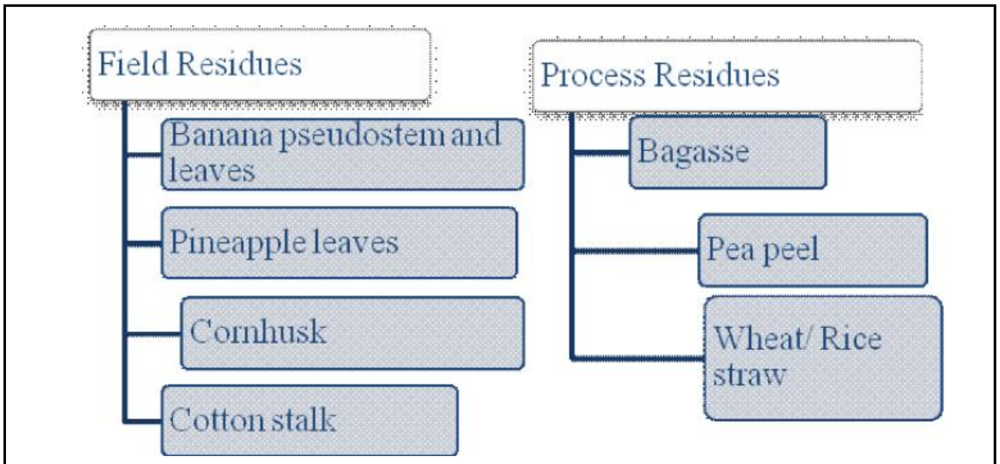

Fig. 1 : Classification of Agro- residues

One, the fields residues are materials left in agricultural field after the crop has harvested. Pineapple leaves, banana psuedostem and leaves, cornhusk, cotton seed pods, kapok seed pods, cotton stalks are field residues. The other ones, process residues are materials left after the crop is processed into a usable resource. After isolation of the main primary or main agricultural product, huge volume of residue is generated simultaneously in the process. Examples of process residues are bagasse, pea peel, wheat and rice straw (*http://www.bioenergyconsult.com*).

Worldwide leaders are discussing the alarming issue of climate change and its subsequent consequences. In order to promote sustainable living nations are striving to work primarily on climate change, affordable and clean energy alternatives, and efficient waste management.

The 193 countries of the UN General Assembly adopted the 2030 Development agenda titled Transforming our world-the 2030 agenda for sustainable development. All the 17 sustainable development goals with 169 proposed targets form the Sustainable development goals (SDGs) to be achieved by the abiding nations by 2030 w.e.f. 2015. India is one of the 193 countries to adopt the Sustainable Development Goals (SDG). The focus of Indian Authorities is to promote sustainable strategies in the field of climate change (goal no. 13), sustainable consumption and production patterns (goal no. 12), and effective waste management (*http://www.sustainabledevelopment.un.org*).

Availability of Agro- residues :

Quantifying the amounts and types of agricultural residues generated in each of the crop categories is extremely difficult, as it would require conducting comprehensive research throughout the state with continuous updates to the compiled data (*http://www.calrecycle.ca.gov*). As per the estimate by the Agricultural residue committee, the minimum worldwide availability of various agro-residues by 2000 A.D. will be as given in Table 2. The Ministry of New and Renewable Energy (MNRE, 2009), Government of India has estimated that about 500 Metric tonne of crop residues are generated every year. There is a wide variability in the generation of crop residues and their use across different regions of the country depending on the crops grown, cropping intensity and productivity of these crops. The generation of crop residues is highest in Uttar Pradesh (60 Mt) followed by Punjab (51 Mt) and Maharashtra (46 Mt) (*http://www.cgpl.iisc.ernet.in*).

Table 1: Proximate worldwide availability of agro- fibers in million tonnes

Agro- residue	Annual availability (MnTn)
Bagasse (Yang, 2005)	39
Bamboo (Yang, 2005)	36
Cornhusk (Reddy and Yang, 2006)	64
Banana Leaves (Anon, 2004)	233

Conventionally almost all agro- residues are burnt off for energy generation in boilers. But these residuals being low- calorific fuels generate air pollution due to which their use for energy generation is prohibited by Pollution Control Board (*http://www.cpcb.nic.in*). Currently, they are generally disposed off either by composting or by burning in the fields itself. Ina developing country like India every possible effort should be made for the proper utilization of these agro- residues as they are rich in cellulose and renewable in nature (Ramaswamy, 1997). As the stock is abundant, the price of agro-residues is cheaper than that of conventional cellulosic fibers like cotton, jute and linen (Wirawan *et al.*, 2009).

Conventional Uses of Agro-residues :

Conventionally agro- residues are used for many purposes and such uses often are site specific (Ramaswamy, 1997). Besides being used as Fuel, which can be considered as being one of the “6 F’s”, residues are also used as Fodder, Fertilizer, Fiber, Feedstock and Further uses. The latter “F” comprises for instance residues being used as a soil conditioner (e.g. coconut coir dust used to retain moisture in the soil, straw as a growing medium for mushroom, coconut husks as a growing medium for orchids, packing material). In some cases residues may even have a multipurpose use. Rice husk can be burned as Fuel with the ash being used by the steel industry as a source of carbon and as insulator (Feedstock, Further). Rice straw can be used as animal bedding (Fiber, Further) and subsequently as part of compost (Fertilizer), crop waste can be used as a Feedstock for biogas generation (Fuel), with the sludge being used as fertilizer (*http://en.wikipedia.org*). However, their use in textile industry is very limited. As it is a technically high end industry, hence sophisticated technology needs to be devised and made available for extraction and application of the cellulose rich fiber component of agro-residues in textile items.

Agro- residues: Alternative fibers for textile industry :

Upkeep of environment is of vital concern to Indian authorities these days. Agriculture industry is producing the agricultural waste in million tonnes annually. Successful waste management and utilization of these residues is the major challenge faced by the combatant authorities. Similar challenge is being acknowledged by the textile industry. It is the second major sector providing employment to total workforce in India. The Indian textile industry is primarily cotton based, for cotton accounting for 54% of total fiber consumption in Year 2014 (Cotton Council International, Colourage, June 2015). Cotton is one of the most economically and ecologically expensive commercial crops to produce.

Cotton production is the second largest agricultural use of pesticides in the world with five of the nastiest pesticides used. Cyanide, dicofol, naled, and propargite are mainly used in cotton cultivation and these chemicals are known to be cancer- causing apart from being environmentally sick (Mahapatra, 2010). Cotton still accounts for 60% of the total fiber production of the world, although man- made fibers have made significant inroads into cotton's share during the last three decades (Needles, 2001). Demand for cotton is rising exponentially with regard to booming population statistics of India and the World. China has emerged as a major buyer of cotton yarn from India. Business Standard reports that Indian cotton industry registered a record 142,297 tonnes export latest by June 2013. A billowing surge of 73% from last year in cotton export was recorded. This has left Indian's domestic cotton market hand- to- mouth (*http://www.business-standard.com*). This situation is aggravated and compounded with ever rising price of cultivating cotton and other natural cellulosic fibers like jute and linen; it's the need of the hour to look out for alternative cellulose resources. In order to address the critical situation, there is a requirement of substitutes to conventional cellulosic fibers, which are environmentally expensive to produce. Some of the undervalued but easily accessible agro- residues are being presented in this section.

The major constituents of all cellulosic fibers are α- cellulose, hemicellulose and lignin. High α-cellulose and low lignin content of a fiber are necessary for its textile application (Das *et al.*, 2010). The cellulose availability in agro- residues is in form of a complex where cellulose is encrusted in the layers of hemicellulose and lignin. Both cellulose and hemicellulose are carbohydrate polymers while lignin is an aromatic polymer. However, to obtain natural fibers with pure cellulose it is imperative to process the agro- residues for the maximum removal of hemicellulose and lignin. In utilization of cellulose present in agro- residues these two polymers (hemicellulose and lignin) act as impurities (Hu, 2008).

Besides the availability of pure cellulose other factors which influence the development and utilization of these lignocellulosics in textile industry are (Mahapatra, 2010).

a. The ability to be spun
b. The availability in sufficient quantity
c. The cost or economy of production
d. The desirability of their properties to consumers

The biochemical composition of agro- residues varies owing to the composition of the crop from which they are derived and the crop specific environmental conditions they are grown in. Han, 1998 has reported on how the chemical and physical properties of some nonwood fibers are influenced by fiber growth time (days after planting), botanical classification of fiber, stalk height, environmental conditions, rainfall, etc. (Han, 1998). The pure cellulose component of these agro- residues have the potential to be used in textile industry either as natural cellulosic fibers or as regenerated cellulosics. Though it is a well- acknowledged fact but hardly exploited owing to lack of dedicated research and technology in this direction.

Bagasse and Bamboo are two important stalk agro- residues, and cornhusk and banana leaves are the two important leaf agro- residues. The cellulose and lignin composition of the four residues testifies that bagasse holds the highest per cent of processable cellulose (57%) amongst all other residues (Table 2).

Table 2 : Proximate chemical analysis of some common agro- residues

Agro- residue	Fiber type	Cellulose (%)	Lignin (%)
Bagasse (Collier *et al.*, 1992)	Cane fibers	50~ 57	12~ 19
Bamboo (Phong *et al.*, 2012)		26~ 43	21~ 31
Cornhusk (Reddy and Yang, 2006)	Leaf fibers	39~ 42	8~13
Banana leaf (Mahapatra, 2010)		33~ 39	16~ 23

A brief review based on the recent literature centered on Bagasse and cornhusk is being presented in this section.

Bagasse :

One of the largest cellulosic agro-industrial by-products is sugarcane bagasse (or, 'bagasse' as it is generally called). It is a fibrous residue of cane stalks left over after the crushing and extraction of the juice from the sugar cane. The quality of bagasse is dependent on the variety of cane, age of cutting, agronomic and soil conditions and the extent of crushing and milling operations carried out. It is a lignocellulosic residue (by-product) of the sugar industry and used by the sugar factories themselves as fuel for the boilers (Pandey, 2000). India is a major producer of sugarcane bagasse which is an annual process residue of the sugar mills apart from cornhusk, wheat and rice straw (*http://www.unido.org*).

Bagasse is a multi- cellular and lignocellulosic cane fiber. Crude bagasse contains about 65- 70% useful fiber and about 30- 35% pith, dirt and other water soluble materials. Pith is an undesirable fraction because it contains non- fibrous cells, which are below 0.4mm in length. Further, pith consumes huge amount of chemicals leading to wastage and clogging. Hence, bagasse has to be depithed for any industrial application. The biochemical composition of depithed bagasse indicates that it contains about 57 per cent α-cellulose, 19 per cent lignin, 24 per cent hemicellulose, evincing its suitability for producing good quality natural cellulose fibers and pulp under controlled conditions (Kasiviswanathan, 1998). The chemical composition of bagasse varies with sugar-cane varieties, plant maturity, and soil properties (Pandey, 2000).

For each 10 tonnes of sugarcane crushed, a sugar factory produces nearly 3 tones of wet bagasse. Since bagasse is a byproduct of sugar industry, the quantity of production of bagasse is in line with the quantity of sugarcane produced (*http://en.wikipedia.org*/wiki/Bagasse).Studies reveal that about 54 million tonnes of dry bagasse is produced annually throughout the world. In general, sugar mills generate approximately 270 kg of bagasse (50% moisture) per metric ton of sugarcane (Xu *et al.*, 2006).

Bagasse is considered as a rich natural resource when compared to other agricultural residues because of its high yield and annual regeneration capacity (Xun *et al.*, 2010). The biochemical composition represents bagasse as a potential and abundant cellulose resource. To put bagasse to some useful industrial applications it is imperative to extract pure cellulosic fibers free off hemicellulose and lignin which act as impurities.

Though, bagasse has not been the subject of much research worldwide. Some, of the research studies were taken up by researchers specifically at Louisiana State University. An important research effort in previous work was extraction of sugarcane rind fiber for textile applications (Collier *et al.*, 1994). The extraction of fibers was done by alkalization. Collected bagasse was subjected to sodium hydroxide under specific pressure. The extracted sugarcane rind fiber was used for making geotextile mats for soil erosion control (Collier *et al.*, 1995). It was reported that the sugarcane fiber mats had higher water resistance, lower light penetration, and were less flammable than the commercial geotextile products (Collier *et al.*, 1994). Similarly, in various other studies bagasse fibers have been reported to be used for nonwovens but there is no literature on the spinning of bagasse fibers.

Cornhusk :

Corn is a member of the grass family of plants and the most widely distributed crop in the world. It is the largest food crop in the world and the United States produces about 40% of the world corn production. Based on the annual world production of corn, about 45 million tonnes of cornhusks are available every year. More than 9 million tonnes of natural cellulose fibers suitable for textile applications can be extracted from cornhusks available every year. This makes cornhusk fibers second only to cotton in terms of natural cellulosic fibers (Hu, 2008). Cornhusks, one of the byproducts of corn production contains about 39- 42% cellulose which can be extracted in fibrous form for various industrial applications including textiles. Although textile applications offer a relatively high value addition and a huge market for cornhusk fibers, they require fibers of high quality. Reddy (2005) has for the first time attempted to extract natural cellulosic fibers with strength and elongation between cotton and linen from cornhusks. Fibers were extracted manually due to lack of any suitable mechanical process. Researchers state that the extracted fibers from cornhusk have the potential to be the cheapest available natural cellulosic fibers for textile applications and would be the second only to cotton in terms of availability. Hydrolysis alkalization was done to obtain fibers from cornhusk. Fibers were cooked at varying concentrations of sodium hydroxide to obtain long cellulosic fibers free of lignin and hemicellulose. In further investigation the same research group has examined the compatibility of cornhusk fibers with cotton and polyester on ring and rotor spinning machines. Cornhusk fiber blends with cotton were developed in the weight ratio of 80/20, 70/30 and 50/50 and with polyester in the weight ratio of 65/35 (Reddy and Yang, 2006).

Socio- economic perspective :

There are regions where these abundant agro- residues are still a waste in look of any institutional bias. These valuable agricultural residuals are being burnt in lack of any alternative commercial use of them. In these regions the farmers are losing additional income at least to the extent of the gain to their counterparts in the region where the small and medium scale handloom industries exist and significantly contribute in income generation (*http://www.inpaper.com*).

Exploring a feasible application of agro- residues will lead to environmental as well as most sought after socio- economic benefits to the farmer community of India. These agro- residues can be instrumental in increasing the farm income to some extent. The prices received by the farmers may help them in strengthening their economics at least to the extent of their livelihood status. Devising technology for efficient utilization of these agro- residues will not only support the rural community by adding value to their products, but also will protect the environment by prevention of burning these process and field residues, which is otherwise a common practice (Yilmaz, 2013). This cause is in a look for a robust nexus between industrialists and research groups with consistent efforts and genuine concern for the development of agro- residues.

Conclusion:

Although textile applications offer a relatively high value addition and a huge market for consumption of fibers from agro- residues, they require fibers of high quality. Versatile application of agro- residues in textile industry depends upon the fineness and the strength of fibers produced. Extraction of quality fibers depends a lot upon the extraction techniques employed. Therefore, existing extraction methods need to be supplemented with robust techniques and machineries to provide the agro- residues like Bagasse and cornhusk with value worth advocating. It is sometimes assumed that residues are wastes and therefore by definition more or less ‘free’. However, in practice it is unwise to assume so. In a monetized economy, even where residues are at present freely available, everything which has a use will rather sooner than later acquire a monetary value.

REFERENCES

Anonymous (2004). Banana Stem an emerging fiber source, *Snippers* **8**(4) : 1.

Collier, B.J., Collier, J.R., Agarwal, P. and Lu, Y.W. (2001). Extraction and Evaluation of Fibres from Sugar Cane, *Textile Res. J.*, **62**(12) : 741-748.

Collier, B.J. and Arora, M.S. (1994). Water pretreatment and alkaline treatment for extraction of fibers from Sugar cane rind. *Clothing & Textiles Res. J.,* **14**(1) :1-6.

Collier, J.R., Collier, B.J., Thames, J.L. and Elsunni, M.M. (1995).. Production and evaluation of sugar cane fiber geotextiles. Report 1: Production and Laboratory Testing, Louisiana Transportation Research Center, Baton Rouge, LA, 1995.

Das, P.K., Nag, D., Debnath, S. and Nyak, L.K. (2010). Machinery for extraction and traditional spinning of plant fibers. *Indian J. Traditional Knowledge,* **9**(2) : 386- 393.

Han, J.S. (1998). *'Fiber Property Comparison'* Presented at North American Nonwood Symposium, Atlanta, ISSN 1225- 6811, 3- 12.

Hu, Q.T. (2008). *Characterization of Lignocellulosic Materials* (Wiley- Blackwell).

Kasiviswanathan, K.S. (1998). Utilization of bagasse for paper making- An Overview. *Indian Paper & Pulp Technical Association,* **10**(3) : 9-13.

Mahapatra, D. (2010). Processing of Banana fibre in Textile Industries, *Colourage,* **57**(3).

Needles, H.L. (2001). *Textile Fibers, Dyes, Finishes & Processes*, Cellulosic Fibers, (Standard Publishers Delhi, India), 2001 Edition, 34.

Pandey, A., Soccol, C.R., Nigam, P. and Socco, V.T. (2000). Biotechnological Potential of Agro- Industrial Residues: Sugarcane Bagasse, *Bioresource Technol.,* **74**(2) :69-80.

Phong, N.T., Fujii, T., Chuong, B. and Okubo, K. (2012). How to effectively extract bamboo fibers from raw bamboo & waste water treatment. *J. Materials Sci. Res.,* **1**(1) : 144-155.

Ramaswamy, R. (1997). Growth of Paper Industry based on Non-Woody Fibrous Raw Materials, Proceedings of Paperex, 47-51 pp.

Reddy, N. and Yang, Y. (2006). Processability and properties of yarns produced from cornhusk fibers and their blends with other fibers, *Indian J. Fiber & Textile Res.,* **31**(4) : 537- 542.

Special report, Cotton Council International, Colourage, June 2015, Page 87, 88.

Wirawan, R., Sapuan, M.S., Robiah, Y. and Khalina, A. (2009). '*Flexural Properties of Sugarcane Pith and Rind Reinforced Poly (Vinyl Chloride)*', Proceedings of 9th National Symposium on Polymeric Materials, Malaysia, 2009, 1-4.

Xu, F., Zhong, X.C., Sun, R.C. and Lu, Q. (2006). Anatomy, ultrastructure, and lignin distribution in cell wall of Sugarcane Bagasse. *Industrial Crops & Products,* **24**(2006) : 186-193.

Xun, Y., Wun, Q., Lei, Y. and Yao, F. (2010). Creep behavior of bagasse fibre reinforced polymer composites. *Bioresource Technol.,* **101** (9) : 3280- 3286.

Yang, Y. (2005). *Natural Cellulose Fibers from HOP Stems for Textiles and Composites*, Polymer, **47**: 5494.

Yilmaz, M.D. (2013). Effect of chemical extraction parameters on corn husk fibers characteristics, *Indian J. Fibre & Textile Res.,* **38**(1) : 29- 34.

http://www.cpcb.nic.in (28/09/13)

http://www.pib.nic.in (13/12/15)

http://www.ngt.nic.in (14/12/15)

http://www.bioenergyconsult.com (13/12/15)

http://www.sustainabledevelopment.un.org (14/12/15)

http://www.calrecycle.ca.gov/Organics/Conversion/AgForestRpt/Agricultur (15/09/13)

http://www.cgpl.iisc.ernet.in (13/12/15) http://en.wikipedia.org/wiki/Textile_industry_in_India (10/09/13)

http://www.business-standard.com/article/markets/cotton-yarn-export-registrations-jump-55-on-huge-chinese-demand-113082100247_1.html (15/09/13)

http://www.unido.org/fileadmin/user_media/Services/AgroIndustries/FPPCs/AgroSupport/AGRO.pdf (11/09/13)

http://en.wikipedia.org/wiki/Bagasse (09/09/13)

http://www.inpaper.com/Indian Agro_AD3.pdf (11/09/13)

wgbis.ces.iisc.ernet.in/energy/HC270799/RWEDP/acrobat/p_residues.pdf (10/09/13)

****