# Environmental Preservation through use of Cotton Stalks for Industrial Purpose*

*S.K.Tandon** & C.Sundaramoorthy****

***Introduction:***

Climate change resulting from excessive accumulation of Green House Gases (GHG) in atmosphere is one of the most significant challenges facing international community. The presence of GHGs ($CO_2$, $CH_4$, $N_2O$, Ozone and HFC) in the atmosphere can be ought to both natural as well as anthropogenic factors. During the pre industrial period their concentration was relatively constant, but the industrialization process necessitating burning of fossil fuels and clearing of forest cover has increased the concentration of the GHGs. The increase in the global average temperature in mid 20$^{th}$ century can be attributed to this increase in concentration of GHGs.

In order to mitigate the anthropogenic emission of GHGs and stabilize global warming an international environment treaty “United Nations Framework Convention on Climate Change” (UNFCC) was produced during the Earth Summit held at Rio de Janeiro in 1992. Under the UNFCC, a protocol necessitating legally binding commitment among the member nations on GHG reduction was initiated in 1997 at Kyoto, Japan (popularly called as Kyoto protocol). Under the protocol 37 developed nations were categorized as “Annex I” countries and the developing nations were categorized as “Annex II” countries. Under the Protocol, Annex I countries committed themselves to a reduction of GHGs and agreed to reduce their collective GHG emissions. The target agreed upon was an average reduction of 5.2% from 1990 levels by the year 2012.

The Protocol allows for flexible mechanisms such as emissions trading, the clean development mechanism (CDM) and joint implementation to allow Annex I countries to meet their reduction targets. The commitment can also be complied by purchasing GHG emission reductions credits from financial exchanges or projects that reduce emissions in non-Annex I countries or from other Annex I countries or from Annex I countries with excess allowances. The protocol has adopted principle of “Common but Differentiated Responsibility” giving more responsibility to developed nations in mitigating green house gas emission. India signed and ratified the Protocol in August, 2002. Since, India is exempted from any reduction commitments as per the framework of the treaty, it is expected to gain from the protocol in terms of transfer of technology and related foreign investments that may result from clean development mechanism or joint implementation.

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In India the major sectors that contribute to the emission of GHG are the energy sector, industrial process, agriculture, land use and land use planning change and waste. Among the above Indian agriculture contributes to around 20% of total green house gas emission from the country as given in Table 1 below:

**Table 1. Emission of Green House Gases – 2004 Estimates (million MT, $CO_2$ e)**

| Particulars | $CO_2$ | $CH_4$ | $N_2O$ | Others | Total |
|---|---|---|---|---|---|
| World | 28485 | 6408 | 3286 | 549 | 38726 |
| India | 1222 | 548 | 71 | 13 | 1853 |
| Indian Agriculture | 0 | 317 | 58 | 0 | 375 |

Note: Others include HFC, PFC and $SF_6$

Source: World Resource Institute (2009)

Emission from the agricultural sector covers enteric fermentation ($CH_4$), Manure management ($CH_4$ & $N_2O$), Rice cultivation ($CH_4$), Field burning of agricultural residues (Non-$CO_2$ gases) and agricultural soils ($N_2O$). In case of the field burning of the crop residues the non-$CO_2$ gas that is released into the atmosphere includes $CH_4$, $N_2O$, $NO_x$ and CO.

Cotton is one of the major commercial crops grown in India covering an area of around 9.3 million hectares and producing an output of 4930 million kg of raw cotton (2008-09). Cotton fibre is the economic part for which the crop is cultivated and the rest of the biomass which includes cotton stalks, leaves and rinds *etc* are the waste that are produced from the cotton field. On an average around 3.0 tonnes of stalks are produced per hectare of the cotton field in India. Cotton is a woody plant and the stalks are used as fuel wood in small farm households. In some places the labourers who pick cotton uproot and take away the cotton sticks for their household needs, instead of wages. These stalks are susceptible and harbour large number of pest and diseases and hence after the harvest season the stalks apart from the household fuel consumption are burned in the field itself. The total availability of the stalks in the major cotton producing states during the period of 2007 is given in Table2 below:

**Table 2. Availability of Cotton Stalks in major cotton producing states of India (2007)**

| States | Area* (M.ha) | Availability of Stalks** (M.Tonnes) |
|---|---|---|
| Maharashtra | 3.124 | 6.24 |
| Gujarat | 2.39 | 7.17 |

| | | |
|---|---|---|
| Andhra Pradesh | 0.962 | 2.40 |
| Madhya Pradesh | 0.63 | 1.26 |
| Punjab | 0.588 | 1.76 |
| Haryana | 0.533 | 1.60 |
| Others | 0.948 | 1.90 |
| Total | 9.175 | 22.33 |

*CAB Estimates ** Cleaned stalks availability

Cotton stalks can be put to various industrial applications like particle board manufacture, bio energy, paper & pulp and corrugated boxes *etc*. Burning of the biomass in the field in wide area will create a serious environmental problem as it releases large amount of GHGs viz carbon-di-oxide, carbon monoxide, methane, nitrous oxide and hydrocarbons, which are responsible for global warming. This paper describes exclusively the environmental problem that results from burning of the cotton stalks in the field and how the environment can be preserved by effective utilization of the cotton stalks for different industrial purposes.

***Emission of Green House gases from Cotton stalk burning:***

The present practice of burning the cotton stalk in the field results in emission of GHGs. The emission of green house gas is measured using the methodology developed by the IPCC (Inter Governmental Panel on Climate Change). In case of the Biomass burning the emission is estimated for the non $CO_2$ gases as it is assumed that the $CO_2$ released into the atmosphere during the burning is re-absorbed during the next growing season.

The amount of stalks burnt is estimated using the fraction of stalks burnt in the field, yield of the crop and the crop to residue ratio. The emission of green house gases is the product of crop residue burnt and the emission factor. The emission factor can be obtained by burning the biomass in the experimental setup and the quantity of different gasses that are released during the burning.

The general equation for emissions estimates is

$$E = A \times EF$$

where

E = emissions

A = activity data (e.g., fuel consumed, material input, throughput, or production output)

EF = emission factor (usually the weight of the pollutant or the unit weight, or the volume or duration of the activity, e.g., tons $CO_2$ or tons of coal)

***Table 3. Emission of green house gas per million tonnes of Cotton Stalks Burned in Field***

| Green House Gas | Emission Factor (g. $Kg^{-1}$) | Total Emission (Mn MT) | Total Emission (Mn MT CO2 e) |
|---|---|---|---|
| $NO_x$ | 2.68 | 0.00265 | 0.7898 |
| $CH_4$ | 2.7 | 0.0027 | 0.0675 |

In order to estimate the amount of green house emission from the burning of the biomass the emission factor estimated for the cotton stalk (Guo Liang *et.al*, 2008) has been used and the total GHG emission from burning one million tonnes of cotton stalks is estimated (Table3.). In order to estimate the total emission by burning cotton stalk in the field the total cotton stalk burnt in the field after the retention for annual household fuel consumption by small and marginal farmers has to be taken into account. Large farmers generally burn the entire stalk in the field immediately after the harvest. On an average around 23 million tonnes of the cotton stalk are available in India.

The emission of $CO_2$ from the burning of the biomass is not taken into account as it is assumed that the $CO_2$ released during burning is absorbed by the crop raised during the successive cropping season. On an average we can see that around 0.85 million metric tonnes of $CO_2$ equivalent is released into the atmosphere per million tonne of cotton stalks burnt. The $CO_2$ equivalent of the methane and nitrous oxide is obtained by using the global warming potential of the gases which are 25 and 298, respectively. In order to avoid such a consistent environmental degradation by burning of the cotton stalks every year after harvest, an effective utilization of the cotton stalks will save the environmental degradation and also provide an additional remuneration to the farmers for the stalks.

***Utilization of the Cotton stalks:***

The yield of biomass from cotton crop varies from species to species, it is highest in the case of hybrids and lowest in the case of *G. arboreum* species. However, on an average about 3 tonnes of cotton plant stalks are obtained from one hectare of land. Most of the stalk produced is treated as waste though a small part of it is used as domestic fuel. The cotton plant stalk contains about 68% holocellulose, 26% lignin and 7% ash. Cotton stalks are an exception compared to other agricultural crop residues as it possesses properties comparable to commonly available species of wood. The calorific value of cotton stalks is equivalent to 17.40

(MJ/kg) at 12% moisture level basis (IPCC guidelines, 2006). Considering these properties the cotton stalks can be put into number of industrial uses.

### *Cotton Stalk for Particle Board*

Presently, boards especially particle boards are mainly made from wood and saw dust particles. The increase in demand for sawn wood and panel materials in the country will result in exhaustion of the existing forest resources. The regeneration of forest takes considerable time and therefore it is unlikely that timber alone can serve as the raw material required by the wood product industries. Removal of forest trees also has a direct impact on the GHG concentration in the atmosphere. At this juncture use of cotton stalks as a substitute for wood in particle board industry will provide two fold benefits. On the one hand it can partially reduce the increasing demand for the wood, thereby saving forest resources and on the other it provides an avenue for effective utilization of the cotton stalks, which at present are treated as waste and disposed of in the field by burning and creating environmental problem.

Depending upon the variety and the crop condition the stalks are 1 to 1.75 m long and their diameter just above the ground may vary from 1 to 2.5 cm. The properties of the particle board are comparable to those made from wood particles and meeting the Bureau of Indian Standards (BIS). Utilization of cotton stalks for particle board manufacture will provide additional remuneration to the farmers for supply of raw material to the particle board industry and in addition help in mitigation of the green house gas emission from burning them in open air and indirectly by reducing the demand on forest resources.

The particle board made from cotton stalks can be used for making furniture's, wall paneling, roof paneling, floor and ceiling tiles, window panel inserts, table tops, insulating material and for partitioning. Commercial utilization of the cotton stalks as the raw material for particle board industry need to be promoted. Efforts have been made in this regard by Central Institute for Research on Cotton Technology (CIRCOT) under the Common Fund for Commodities (CFC) funded project on "Utilization of Cotton plant by-produce for value added products", through which a pilot plant of one tonne per day capacity has been established at CIRCOT Ginning Training Centre at Nagpur. The logistics of collection and transportation system has also been established through the project so as to ensure proper supply chain of cotton stalks as raw material to the particle board industry. Based on the transportation logistics it was shown that it is feasible to set up a factory that can cover an area of around 50 km. The cotton stalks collected from the field has to be cleaned, dried to optimum moisture content and chipped into small chips to economize on the transportation cost of raw material to factory site. The industry may find it difficult to utilize the stalks as raw material unless they get the stalks in usable form with appropriate moisture content. So it's essential to develop entrepreneurs in the rural areas to ensure that the supply chain of cleaned cotton stalk chips as readily usable raw material is made available to the factories at their site. This initiative may help in effective utilization of cotton stalks, preserve the environment and also create entrepreneurship in the rural areas. The government may think of appropriate incentives to promote the initiative.

### *Cotton Stalk for Bio energy*

Biomass burning has a significant impact on global atmospheric chemistry since it provides large sources of carbon monoxide, nitrogen oxides, and hydrocarbons, primarily in the tropics [*Crutzen et al.*, 1979, *Logan et al.*, 1981]. The idea of the cotton-stalks biomass as source of energy could be an efficient, holistic approach because the environment as well as the renewable energy system will be positively affected. The use of cotton stalks for generation of energy will address the following problems, (1) Need for energy and its gradual expansion (2) Emissions of dangerous greenhouse gases like $CO_2$ by present practices (3) Parasite sources in cotton fields after the seed cotton collection.

The main problem with cotton stalks lies in its high transportation and storage cost due to the stalks are highly branchy and bulky. This could be solved through the briquetting (densification) process. The optimum moisture content for agricultural residues to be briquetted is in the range 8-15% which fresh cotton stalks attain after one week storing in open air. This implies that these residues can be briquetted one week after harvest operation without any additional costs for drying. The calorific value of cotton stalks is equivalent to 17.40 MJ/kg at 12% moisture level basis. The cotton stalk briquettes can serve as raw material for generation of Bio energy. The condensed briquettes will also enable cost effective transportation. According to the study by IISc Bangalore, one kt/year of cotton stalks residue will provide scope for at least 5 power plants of (100 kW each). Efforts have been taken under the renewable energy to make briquettes from agricultural wastes. Under the National Agricultural Innovation Project (NAIP) funded project "Value chain on Biomass based decentralized power generation for Agro Enterprises" it is proposed to set up three 100 KW power generation plant. These plants will use briquettes made out of cotton stalks, pigeon pea and soybean stalks.

### *Other Industrial uses:*

It is interesting to note that in contrast to other agricultural crop residues, cotton stalks possess fibre dimension comparable to most commonly available species of hardwood. It can therefore be used for other industrial purposes such as Preparation of pulp and paper, Hard board and Corrugated boards and boxes.

CIRCOT has standardized a biological anaerobic treatment for preparation of paper grade Kraft Pulp from cotton plant stalks. The technology developed and patented indicate that the process of anaerobic digestion is technically feasible and economically viable as evidenced by the significant saving in chemical and electrical energy and that the quality of the paper produced by this new process was on par with that from conventional process. For processing 100 kg of cotton plant stalks by anaerobic process the thermal energy saving was about 106 Mj and the electrical energy saving was about 10 KWh while the chemical saving was about 11 kg/day in comparison with the cost involved in conventional chemical process. The process was also found to be eco friendly as the effluents were less toxic with low BOD and COD values.

Cotton plant stalk an abundantly available agro-waste material can be a substitute for wood in the manufacture of corrugated fibre board boxes for packaging of fruits. A process was standardised to prepare good quality kraft paper suitable for manufacture of CFB boxes from cotton plant stalks. Uniform chipping of stalks and kraft liquor concentration of 18 per cent produced kraft paper with desired properties. The techno-economic feasibility worked out by conducting large-scale trial in a mill indicated that the box prepared from cotton plant stalk kraft would be cheaper than that of commercially available box. Corrugated boxes were lighter in weight than wooden boxes and hence more CFB boxes could be transported thus reducing freight per box. CFB boxes prepared from cotton plant stalk kraft paper possessed desirable bursting and compressive strength. Lamination of CPS box with polypropylene film from outer side further improved strength and ability of these boxes to withstand moisture during prolonged cool storage under high humidity conditions.

***Carbon Credit:***

The concept of carbon credits came into existence as a result of increasing awareness of the need for controlling emissions. A credit can be an emissions allowance which was originally allocated or it can be an offset of emissions. Such offsetting and mitigating activities can occur in any developing country which has ratified the Kyoto Protocol, and has a national agreement in place to validate its carbon project through one of the UNFCCC's approved mechanisms. Once approved, these units are termed Certified Emission Reductions, or CERs.

The Kyoto Protocol provides for three mechanisms that enable countries or operators in developed countries to acquire greenhouse gas reduction credits

- Under Joint Implementation (JI) a developed country with relatively high costs of domestic greenhouse reduction would set up a project in another developed country.
- Under the Clean Development Mechanism (CDM) a developed country can 'sponsor' a greenhouse gas reduction project in a developing country where the cost of greenhouse

gas reduction project activities is usually much lower, but the atmospheric effect is globally equivalent. The developed country would be given credits for meeting its emission reduction targets, while the developing country would receive the capital investment and clean technology or beneficial change in land use.

- Under International Emissions Trading (IET) countries can trade in the international carbon credit market to cover their shortfall in allowances. Countries with surplus credits can sell them to countries with capped emission commitments under the Kyoto Protocol.

One allowance or CER is considered equivalent to one metric tonne of $CO_2$ emissions. Industrial application of cotton stalks will result in considerable amount of decrease in the emission of green house gases by the existing practice of burning the cotton stalks in the field. A project to utilize the available cotton stalks as raw material for the manufacture industrial output rather than burning it in the field may end up earning carbon credits which is additional revenue to the project as such and additional remuneration to farmers for the supply of raw materials for the industry.

***Conclusion:***

The cotton stalks produced in the field has the potential to be the raw material for production of particle boards, bio energy generation, paper grade pulp and corrugated boxes etc.. The present practice of burning the stalks in the field results in persistent environmental problem. Efforts to divert these stalks for effective utilization can preserve the environment as well as provide additional revenue to the farmers for supply of raw material. By effectively utilizing one million tonne of the cotton stalks for industrial application we can prevent approximately 0.8 million metric tonnes of $CO_2$ equivalent from being released into the atmosphere. Creation of an effective supply chain system for provision of the cotton stalk as a raw material usable for the industry will enable the industrial utilization of cotton stalks. The development of entrepreneurship in the supply chain of the cotton stalks as industrially usable raw material will play a crucial role in nurturing this venture. Use of cotton stalk for industrial purposes instead of burning may help in obtaining carbon credits also and would thus help the farmer in obtaining additional income.

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# Environmental Preservation through use of Cotton Stalks for Industrial Purpose

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## Introduction

- **Cotton grown in an area of around 9.3 million hectares**
  - **512 kg/ha of raw cotton (2008-09)-4390 million kg of raw cotton**
  - **3 tonnes/ha of cotton stalks (on an average)**
- **Cotton – used in Textile Industry**
- **Cotton Stalks**
  - **Fuel wood in small farm house holds**
  - **Wage for labourers in some places who uproot the stalk**
  - **Burnt in the field after harvest season-environmental problems**
  - **Harbour Pests & Diseases**

## Availability of Cotton Stalks in Major Cotton Producing States of India (2007)

| States | Area* (M.ha) | Availability of Stalks** (M. Tonnes) |
|---|---|---|
| Maharashtra | 3.124 | 6.24 |
| Gujarat | 2.39 | 7.17 |
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| Punjab | 0.588 | 1.76 |
| Haryana | 0.533 | 1.60 |
| Others | 0.948 | 1.90 |
| ***Total*** | ***9.175*** | ***22.33*** |

*CAB Estimates ** Cleaned stalks availability

## Contd…

- Climate change due to Green House Gases (GHG) - challenges
- GHGs – $CO_2$, $CH_4$, $N_2O$, Ozone, HFC
- Industrialization process & burning of fossil fuels & forest covers - increased the concentration of the GHG
- Rise in the global average temperature in mid 20th century - increase in conc. of GHGs
- To Mitigate Anthropogenic Emission of GHGs & stabilize Global Warming-Inter. Environment Treaty – UNFCCC – Earth Summit at Rio de Janeiro (1992)

## UNFCCC - International Environment Treaty

- Kyoto Protocol – concluded in 1997- Binding Commitment to reduce GHGs initiated.
  - Annex I – Developed Countries -37
  - Annex II – Developing Nations
- Legally Binding reduction commitments for Annex I Countries to reduce GHGs
  - Committed to reduce GHGs (Av. Red. 5.2% from 1990 level by 2012)
- Mechanism For Mitigation of GHG
  - Clean Development Mechanism
  - Joint Implementation to allow Annex-I countries to meet their reduction targets
  - Emission Trading

  India signed and ratified the protocol-2002

## India – GHG Emission

- Annex II Country – Exempt from reduction commitment
- Gain from the protocol
  - Transfer of Technology
  - Foreign Investments (CDM or joint implementation)
- Major Sectors Contribute for GHG
  - Energy sector
  - Industrial process
  - Agriculture
  - Land use and land use planning change
  - Waste

## Indian Agriculture – GHG Emission

- Contributes 20% of GHG Emission
- Emission from Agricultural Sector Covers
  - Enteric Fermentation ($CH_4$),
  - Manure Management ($CH_4$ & $N_2O$),
  - Rice Cultivation ($CH_4$),
  - Field Burning of Agricultural Residues (Non-$CO_2$ gases)
  - Agricultural soils ($N_2O$)

## Emission of Green House Gases – 2004 Estimates (million MT, $CO_2$ equivalent)

| Particulars | $CO_2$ | $CH_4$ | $N_2O$ | Others | Total |
|---|---|---|---|---|---|
| World | 28485 | 6408 | 3286 | 549 | 38726 |
| India | 1222 | 548 | 71 | 13 | 1853 |
| Indian Agriculture | 0 | 317 | 58 | 0 | 375 |

Note: Others include HFC, PFC and $SF_6$

Source: World Resource Institute (2009)

## Emission of GHG from Cotton Stalk Burning

- Burning of the Biomass
  - Releases – $CO_2$, $CH_4$, CO, $N_2O$, hydrocarbons
- Emission of GHG - measured by IPCC Methodology
  - Non- CO2 gases estimated ( biomass burning)
  - Assumed that CO2 released is reabsorbed in subsequent crop season
- Emission of GHG (E) is product of amount of Crop residue burnt and the Emission Factor(EF) i.e. E = A x EF
  - Amount of Crop Residue = fraction of stalk burnt* Yield of Crop* Crop to residue ratio
  - Emission Factor = quantity of different gases released during burning (estimated in experimental setup)

## Emission of green house gas per million tonnes of Cotton Stalks Burned in Field

| Green House Gas | Emission Factor* (g. $Kg^{-1}$) | Total Emission (Mn MT) | Total Emission (Mn MT $CO_2$ e) |
|---|---|---|---|
| $NO_x$ | 2.68 | 0.00265 | 0.7898 |
| $CH_4$ | 2.7 | 0.0027 | 0.0675 |

*Emission Factor estimated for the cotton stalk (Guo Liang *et.al*, 2008)

Global warming potential of $CH_4$ and $NO_x$ are 25 and 298 times that of $CO_2$

**On an average around 0.85 million metric tonnes of $CO_2$ equivalent is released per million tonne of cotton stalks burnt**

## Cotton Stalk – Properties

- On an average about 3 tonnes of cotton plant stalks are obtained from one hectare of land
- Most of the stalk produced is treated as waste though a small part of it is used as domestic fuel
- Industrially Usable Properties
  - Cotton plant stalk contains about 68% holocellulose, 26% lignin and 7% ash
  - Calorific value of cotton stalks is equivalent to 17.40 (Mj/kg) at 12% moisture level basis
  - Cotton stalks possess fibre dimension comparable to most commonly available species of hardwood

## Industrial Application of Cotton Stalks

- Particle Board Manufacture
- Generation of Bio Energy
- Paper and Pulp Making
- Corrugated Fibre Board Boxes

## Cotton Stalk Particle Board

- Stalks are 1 to 1.75 m long and their diameter vary from 1 to 2.5 cm
- CIRCOT established technology for Particle board Manufacture.
- The properties of cotton stalk board comparable to those made from wood particles.
- Compliant with Bureau of Indian Standards (BIS)
- Pilot plant of one ton per day capacity for demonstration is installed at GTC Nagpur.

## Contd...

- Logistics of supply chain ( collection and transportation) established.
- Benefits:
  - Additional remuneration to the farmers
  - Environmental preservation by using the otherwise burnt cotton stalks
  - Reduce the pressure on forest resource

***Need to nurture rural entrepreneurship to develop a sustainable supply chain of raw material to the industries***

## Uses of Cotton Stalk Particle Board

- ***Making furniture***
- ***Wall panelling /Roof panelling***
- ***Floor and ceiling tiles***
- ***Window panel inserts***
- ***Table tops***
- ***Insulating material***
- ***Partitioning***

- **Briquetting machine was operated on soybean stalk and pigeon pea straw.**
- **Output: 350-370 kg/h**
- **Diameter of briquettes produced: 20mm, 30 mm, 60 mm**
- **Power consumption: 13 kW**

**SPRERI open core DD gasifier Cap. 60 kg/h biomass**

**M/s Suman Food Products, Udaipur**

**Under regular use for the last 6 months**

## Use of Cotton Stalk for Bio Energy

- Calorific value of cotton stalks is equivalent to 17.40 MJ/kg at 12% moisture level basis
- Gasifier -Updraft and Downdraft
- Briquettes from cotton stalk + crop residue
- Screw type or piston type presses
- Screw type-Large amount of wear and tear and problem of supply of parts
- Dryer for cotton stalk (8-15% m.c.)
- Transportation logistics met through Briquetting process
- One kt/year of cotton stalks residue will provide scope for at least 5 power plants of (100 kW each)-IISc., Bangalore
- NAIP-Value chain on biomass based decentralised power generation for Agro –Enterprises" – one 100 kW plant to run on cotton stalk to be established in MP ( 2 more plants – soybean and pigeon pea)

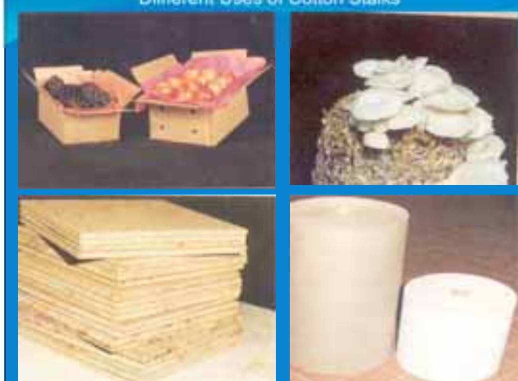
## Other Industrial Uses of Cotton Stalk

- ***Paper grade Kraft pulp*** through biological anaerobic treatment
- Processing 100 kg of stalks by the process saves
  - 106 MJ of Thermal Energy
  - 10 kWh of electrical energy
  - 11 kg/day of chemicals
- Quality of paper produced on par with that of conventional process
- Tech. patented - econ. & technically viable
- Process eco friendly as effluents are less toxic
- Technology in the process of transfer to Industry

Contd...

- Cotton Plant Stalk – substituted for wood in manufacture of corrugated boxes-fruits & vegetables
- Process standardised for preparing good quality kraft paper-CFB Boxes
- Uniform chipping of stalk & kraft liquor concentration of 18 % - produce kraft paper of desirable properties.
- Boxes –cheaper than commercially available boxes
  - lighter in weight than wooden boxes
  - so more boxes can be transported
  - have desirable bursting & compressive strength
  - lamination –improved strength & ability to withstand moisture during prolong cool storage under high humidity

## Different Uses of Cotton Stalks



## Carbon Credits

- Industrial application of Cotton stalks adds value to the waste in multiple dimension.
  - **Additional remuneration to farmers**
  - **Protect the environment**
  - **Emission of GHG due to burning**
  - **Reduce the pressure on forest resource by substituting wood in certain applications.**
- Mitigation of the GHG will provide ample scope for claiming carbon credits
- Carbon credits came into existence as a result of increasing awareness of the need for controlling emissions of GHGs.
- Industrial application of cotton stalks – decrease the emission of GHG and earn carbon credits which is additional revenue to the project

## Conclusion

- Cotton stalk is potential raw material for varied industrial applications – particle board, bio energy , boxes etc
- Diverting the stalks from present practice to effective utilization
  - Additional revenue to farmers
  - Preserve the environment
- Use of one million tonne of stalks for industrial use will mitigate emission of 0.8 million metric tonnes of $CO_2$ equivalent
- Industrial utilization of stalks depend on effective supply chain system
- Development of rural entrepreneurship for supply chain of cotton stalks will play crucial role in nurturing the venture.

**Why destroy when you can create**

*Thank you...*