EXECUTIVE SUMMARY

The evolution of packaging material has been incremental and gravitated towards more durability. The Industrial Revolution that was born almost 250 years ago adopted the concept of packaging from nature to ensure that the goods produced reach customers without mutilation in quality. The importance of the art of wrapping grew with the proliferation of goods and packaging became sibling to the goods that the industries produced. For, the goods would loose their value, if they didn't reach in the condition they were expected to be. This benign symbiotic relationship catalyzed the evolution of packaging to meet the rising expectation of consumer and the spread of distribution chain of products.

Recently, ICPE (Indian Centre for Plastic in the Environment, New Delhi) decided to carry out Life Cycle Analysis (LCA) of commodity packaging materials such as materials used in packaging of milk, atta and lube oil. In this volume 'Atta' packaging materials (jute bags and plastic film bags) with a packaging capacity of 5 Kg has been considered for life cycle analysis. It was thus particularly necessary to discover the "Cradle to Grave" input of these packaging materials. This report documents the journey of these packaging materials from the time they are born to the end of their utility in the hope that environmental safe guards could be incorporated without hampering Plastic's progressive role that it has been playing in sustainable development.

Life cycle analysis is an effective tool to measure the impact of a product or process on the environment. This study covers the environmental and resource impact of plastic film bags vis-à-vis jute bags used for packaging 'Atta' from the stage of raw material extraction, production, use and disposal, taking into account all the inputs such as materials, energy, capital equipment, man-hours, etc.) and the outputs like products, by-products, waste materials, emissions at every stage.

The basis of this study has been considered as one lakh metric ton of 'Atta' in keeping with the view of the consumption in order of magnitude.

THE TOTAL IMPACT ASSESSMENT

The study discloses that for producing packaging with plastic film bags for one lakh ton of 'Atta', the raw material required for packaging is only 680 Mt. But for the same quantity of packaging with jute bags require 1960 Mt of packaging material. The results of this analysis are organized in two categories: resource utilization, water and atmospheric emission.

Energy Consumption

The analysis by steps identifies the production of jute (Table – I) and subsequently manufacture of bags (Phase I and Phase II) as being responsible for the higher consumption of energy (~68.69 thousand GJ per one lakh metric ton of packed 'Atta') as compared to plastic film bags (~62.58 GJ per one lakh metric ton of packed 'Atta'). Energy consumption related to transportation (Phase III) of 'Atta' shows that transportation in jute bags requires significantly excess amount of energy, being about ~261 GJ per one lakh metric ton of packed 'Atta', more than that in plastic film bags.

Table I: Life Cycle data for Different Materials used for Packaging One lakh ton of 'Atta'

	Jute Bags		Plastic Film Bag	
Material Required (Mt)	**1960**		**680**	
	Energy (thousand GJ)	**Water (Thousand Tons)**	**Energy (thousand GJ)**	**Water (Thousand Tons)**
Phase I: Production of Raw Material	**21.50**	**1677**	**38.36**	**264**
Phase II: Production of Bags & Liners	**47.19**	**1506**	**24.22**	**296**
Total	**68.69**	**3183**	**62.58**	**560**

Phase III: Distribution	Jute Bags		Plastic Film Bag	
	Fuel (Tons)	**Energy (GJ)**	**Fuel**	**Energy**
	4663	**261.29**	**Taken as Basis**	

Phase IV: Waste Management	Jute	**Plastic Film Bags**
Recycling Percent	**Energy Savings**	**Energy Savings (thousand GJ/680ton)**
100%	**Not Applicable**	**17.20**
80%		**13.76**
Incineration	**Energy Recovered**	**Energy Recovered (thousand GJ/680ton)**
100%	**Not Applicable**	**35.24**
80%		**28.12**

Table II: Emissions during Phase I and Phase II for Packaging One Lakh ton of 'Atta'

For 1 Lakh ton of 'Atta'		Jute	LDPE
Air Emissions			
CO	kg	**54.3**	**0.6**
CO_2	kg	**6610.2**	**760.0**
SO_x	kg	**134.8**	**5.2**
NO_x	kg	**68.1**	**4.8**
CH_4	kg	**39.5**	**3.2**
HCl	kg	**5.3**	**0.0**
Dust	kg	**67.6**	**1.4**
Water Emission			
Suspended Solids	kg	**352.3**	**0.2**
Chlorides	kg	**4535.5**	**0.1**

Table III: Emissions during Phase III for Packaging One Lakh ton of 'Atta'

Emission	gm/km	Excess Emission for Jute Bags (kg)	Plastic Bags
CO_2	781.0	**11107.3**	Taken as Basis
CO	4.5	**64.0**	Taken as Basis
HC	1.1	**15.6**	Taken as Basis
NO_x	8	**113.8**	Taken as Basis
$HC+NO_x$	9.1	**129.4**	Taken as Basis
Particulates	0.36	**5.1**	Taken as Basis
Total Regulated Tail Pipe Emission	13.96	**198.5**	Taken as Basis

Atmospheric Emission: About ten components dominate the category of atmospheric emission for jute bags and plastic film bags: CO, CO_2, SO_x, NO_x, CH_4, HCl, dust, heavy metals, suspended solids and chlorides. For all of these, the plastic pouch produces less of each emission than the jute bag. Tables II and III list atmospheric emissions.

Another major resource utilization is being demonstrated in terms of consumption of water. The manufacture of jute bags is found to be responsible for the overall greatest consumption of water; ~3183 (thousand tons/lakh ton of packed 'Atta') in case of jute bags production. This is about 6 times higher than that for plastic film bags for same amount of packed 'Atta'.

Reuse of jute bags has also been considered as one of the option to reduce waste. It has been found that even for 95% reuse of jute bags the energy consumption is double than that consumed in making new plastic film bags. Also the water consumption in case of 95% reuse of jute bags is 20 times of that used in new plastic film bags. More importantly attention is also given to two end-of-life cases i.e., 100% incineration (waste to energy, energy recovery) and/or 100%-50% recycling (energy usage). According to this phase energy recovery due to incineration is about 35.24 thousand GJ/680ton (for 100% incineration) and 28.12 thousand GJ/680ton (for 80% incineration) for plastic film bags, while there is no incineration for waste jute. Similarly energy savings during to recycling is found to be ~17.20 GJ/680ton (for 100% recycling) and ~13.76 GJ/680ton (for 100% incineration) for plastic film bags while there is no recycling for jute bags. It should also be noted that in case of recycling of plastics the waste enters into a new life and if this waste management technique is considered the life cycle analysis of plastics/jute bags can be termed as *"Cradle to Cradle"* approach instead of "Cradle to Grave".

Emission to Air

Phase I of jute involves absorption of CO_2 from the atmosphere but phase II involves emission of CO_2. This benefit of phase I is lost during the transportation phase, where because of excess weight it leads to consumption of excess fuel resulting in severe atmospheric pollution. The emission of CO_2 for plastic film bags are higher is phase I but leads to overall less CO_2 emission because of its light weight during the transportation phase. The analysis of input effects indicates remarkably high emission of CH_4 emission in case of production of jute. The comparative study on emission during transportation also shows significantly excess generation of CO, CO_2 and NO_x in case of jute bags as compared to that in case of plastic film bags.

Emission to Water

As shown in the different tables, BOD and COD to water are unmistakably of highest amount in case of production of jute bags. While these values are negligible for plastic film bags. The COD and BOD values are atleast 15-20 times larger in the case of jute bags leading to dangerous environmental impact apart from health hazards.

CONCLUSIONS

Though plastics are relatively newcomers, their use in packaging of 'Atta' commodities adhere to the basic tenets of sustainable development more than jute, if one considers the consumption of energy, emission of gases and the use of chemicals. An analysis of the comparable life cycle of plastics with jute clearly brings the fact to the fore that plastics are economically affordable, socially acceptable and environmentally effective. Health hazards for workers in jute are worse than those employed in plastics.

The recording of the stages of production of jute bags and plastic film bags give a complete picture of the consumption of energy, water and gases in these materials and remove the prevailing notion that jute bags are more environment- friendly than plastic film bags.

Efficient management of waste not only reduces pollution and landfilling but also helps in producing more from fewer resources. The measures to reduce the amount of solid waste produced, either as industrial, commercial or domestic waste, in essence are improvements in efficiency. Jute as 'Atta' packaging material cause more stress on waste management than plastic film bags. It has been estimated that the residual plastics at less than 10 per cent by weight of Municipal Solid Waste can provide 20 per cent of the fuel value for a local WTE plant.

From this study we can claim that the overall negative impact on environment due to plastic film bags is less that that of jute bags and the difference seems significant. The choice of product end-of-life (work) management even strengthens this assessment.

Another sensitivity in the study results in discovering the effects of the weight of the jute vis-à-vis plastic film bags on the overall negative impact on environment through transport of packed 'Atta' in first use. Jute leads to more burden on the environment. Recycling of the plastic film bags also decreases the burden on environmental due to the use of lesser energy and water as compared to making the products from virgin plastics.

Instead of banning its production, the need of the hour is educating the public on what to do with such waste bags and where to throw them for recycle. After all, these polymers perform dutifully the role of a carrier effectively from the doors of producer to consumer.

PREAMBLE

Packaging may be defined as 'a means of ensuring the safe delivery of product to the ultimate consumer in sound condition at the minimum overall cost. Packaging represents one of the most widespread activities of modern society. Packaging has become an integral part of the processing, preservation, marketing and even the cooking of the foods. In the early days of emergence of food industry, packaging was mainly done to reduce spoilage and to facilitate transportation. In contrast, packaging has today become essentially a convenience based to make it fancier and more fascinating. In food industry, packaging plays the dominant role in marketing and in the total manufacturing activity. Food packaging is a growing activity the world over and is the fastest growing in the developing countries like India. Some of the very important packaging considerations are product protection, shelf life, strength of package, packaging machinery, material availability, convenience, sales appeal, package decoration, product-package compatibility, package sealing efficiency, statutory requirement and cost. The criteria by which a package is judged are usually the following:

1. It must protect and preserve the commodity from the time it is packed to the point of consumption.
2. It must be suitable for the chosen selling and distribution system.
3. It must be attractive to the consumer, easy to open, store and dispose.
4. It must cost no more than the market can bear.

Functions

Package has a three fold functions of containing, protecting and merchandising:

a. **To contain the product**
   Package should be large one with proper constructional features so as to avoid leakage and spoilage. It should be as compatible as possible with the product and finally it should have enough strength to withstand handling, transportation and storage hazards.

b. **To protect the product**
   Protection of the product against contamination or loss and damage or degradation due to microbial action, exposure to heat, light, moisture and oxygen, evaporation etc.

c. **To help in selling the product**
   The shape of the package should be favourable to dispensation and reclosure, and to its disposal and reuse.

The packaging must be:

- Most economical
- Easily chilled, heated or micro-waved
- Environmentally friendly
- Priced correctly

Packaging is both a symbol of society's consumption habits and reflection of its progress. The user expects it to have easier handling, to be lighter, more aesthetic or safer from a hygiene point of view, etc. The factors governing the choice of an appropriate material for a given dairy product are:

- The specific sensitivities of the contents (Moisture and Oxygen)
- Factors changing the content (Temperature, Relative humidity etc.)
- Weight and shape of the container
- Effect on filling and scaling speed
- Contamination of food by constituents of packaging materials
- Storage condition and for how long the product needs to be protected
- Biodegradability and recycling potential

The most suitable packaging size for 'Atta' in India is currently 5 kg and 10 kg. The types of bags generally used for packaging of 'Atta' are:

- Jute Bags with LDPE liner
- Plastic Film Bags with LDPE liner

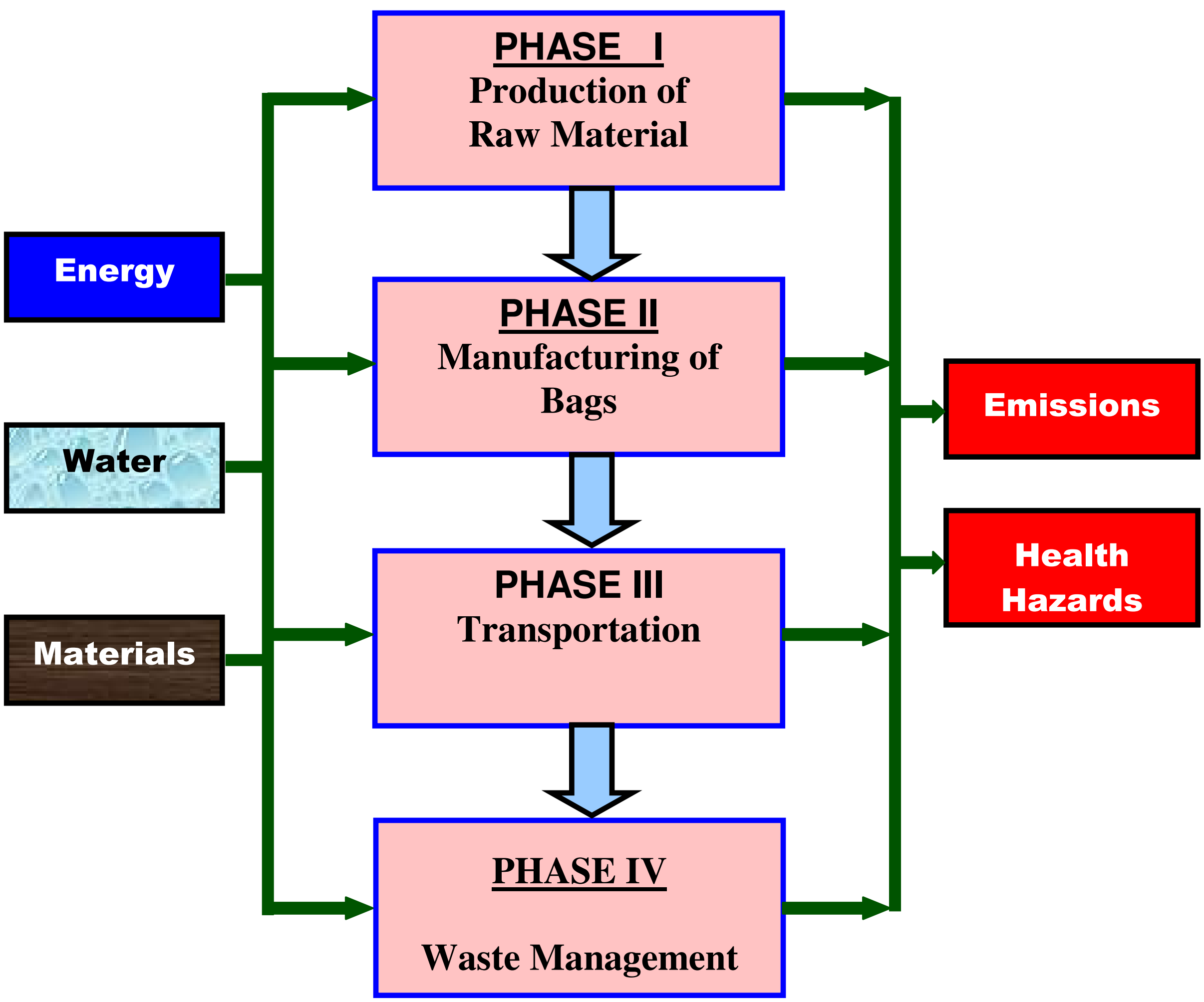
Environmental packaging considerations now seem to be as important as brand image. Matters relating to the environment and especially those concerned with disposal and recycling of 'Atta' bags, appear to have become as important as the containers themselves.

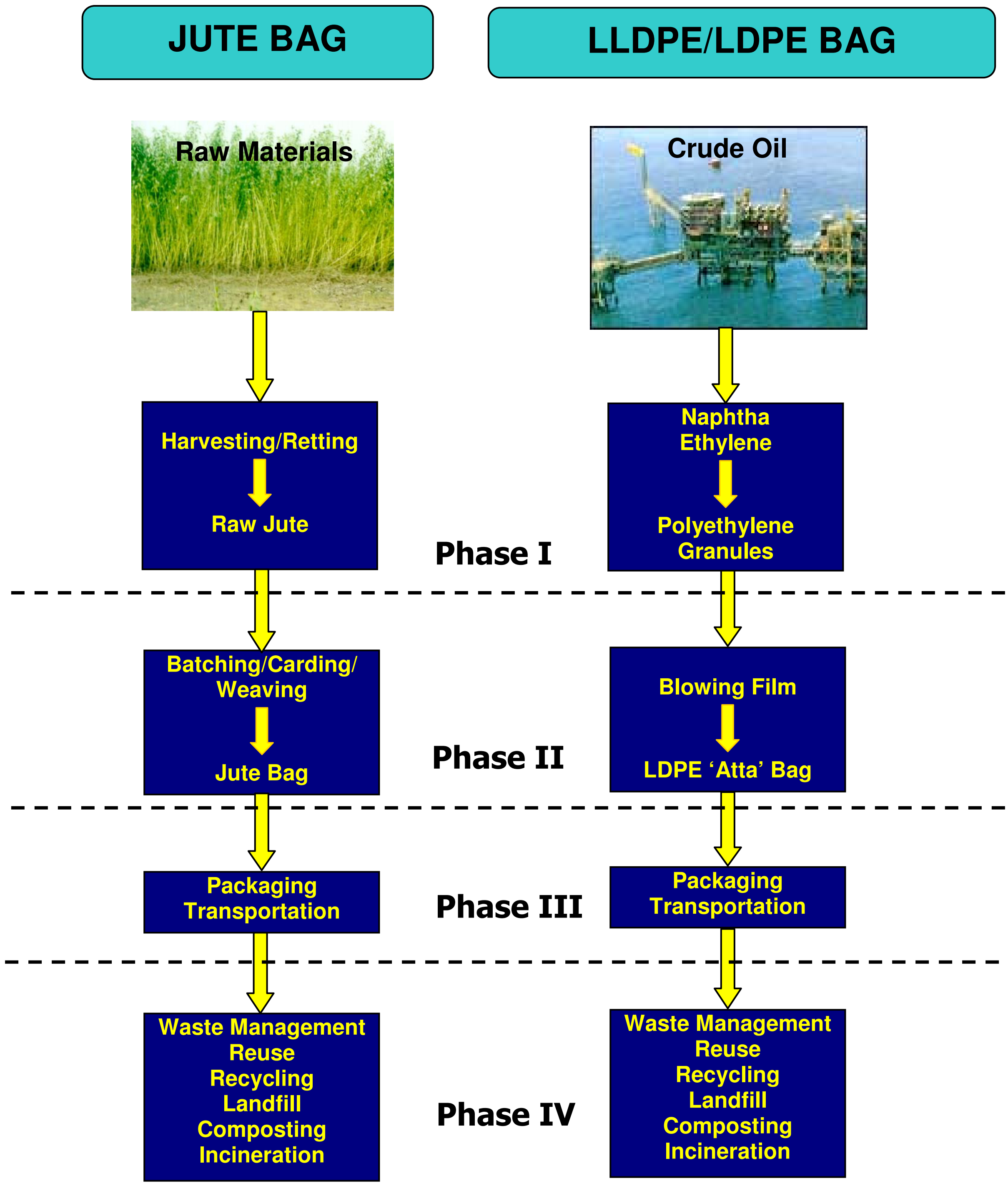
Table 1.4: Comparison of different packaging material in terms of their strengths and weaknesses

Packaging Material	Strengths	Weaknesses
Jute Sacks	• Sustainable raw materials • Good repairability • Good sampling convenience for inspection	• Pollution risks in effluents from retting, bleaching, and other chemical treatments • Frequent use of a laminated material • Susceptible to bacterial and fungal attack • High water absorption • High co-efficient of friction; not suitable for loading and unloading • Degradable • Hygenic Risk
LDPE Film Bags	• The most versatile and diverse family of packaging materials • Efficient and economic use of material for individual packs • Hygienic packaging for foods and beverages • Excellent protection from physical damage provided by low mass of expanded materials • High energy recovery from incineration • Efficient in-plant industrial scrap reuse • Non-degradable perceived as a weakness for plastics • Moisture resistant, suitable for packing hygroscopic commodities (urea, sugar, etc.) • Fully reusable and amenable to recycling	• Raw material derived from non-sustainable resources of fossil fuels, though only 4% of the world's oil consumption used in total plastic products.

Goal and Scope

This project aims to provide a comprehensive environmental model for domestic packaging and waste management using a life cycle assessment methodology. The main focus of the project would involve producing lifecycle inventory data for plastic packaging during manufacturing, usage (both primary and secondary) and disposal and comparing the same in case of jute. As a case packaging of 1 lakh ton 'Atta' in bags (5kg capacity) made of plastic and jute has been considered in this report. The study has been divided in four phases as shown below:





Flow chart of jute bag and LDPE/LLDPE bag during the life cycle analysis

PACKAGING ASPECTS

The first forms of packaging were made from leaves, animal skins, bamboo, reeds, wicker and gourds and used by ancient hunter-gatherer communities. Later, as people continued to live near the source of their food, packaging was simply a means of containment. Various simple containers were used to store fresh products, which had been preserved by drying, salting or smoking. But despite such efforts at preservation, it was often attacked by animals, insects and microorganisms. By the eighteenth century, most of the goods sold in shops at that time were wrapped in parcels or wooden boxes and displayed around the shop walls.

The history of packaging is intimately connected with foodstuffs. Until the nineteenth century packaging was mainly used to transport goods from their place of production to the customer. Further, as people gravitated away from living near their sources of food to the rapidly expanding towns during the period of early industrial growth, the role of packaging expanded from one of essentially containing products to one of protecting them as well. With the onset of industrialization, the search began for better methods of preserving foodstuffs and packaging became a key ingredient for the successful development of enhanced shelf life preserved foods.

There are several myths and public perception of packaging:

- **It fills the dustbin and the amount of waste is growing.**
- **It is disposed of by methods that harm the environment.**
- **It wastes scarce materials and energy.**
- **It is not recycled or reused.**
- **It should be returnable for reuse.**
- **It is a cause of litter.**
- **It should be biodegradable.**
- **It contributes to pollution.**

Unfortunately, the misconceptions, frequently get more attention than the service and essential benefits that packaging provides.

One needs to be sustainable in packaging the bulk commodities. Sustainability has been defined as 'development, which meets the needs of the present without compromising the ability of future generation to meet their own needs'. This identifies the synergy between economic development, social equity and the environment. Therefore, sustainable packaging must be:

- Economically affordable
- Socially acceptable (Human Health)
- Environmentally effective

Equal consideration of each is necessary, otherwise the whole system will be become unbalanced. There is need to produce more value from goods

and services with less raw material and energy consumption and less waste and emission production.

Functions of Packaging

Containment and protection:

Protecting the product from spoilage is the most important function of packaging. It must create a barrier between the product and the hazards of the environment. Packaging protects products from light, dirt, bacteria, fungi, insects and animals, and is a major factor in determining the shelf life of the product.

Preservation:

By acting as a protective barrier to foodstuffs, packaging slows their rate of deterioration. As consumers demand more natural foods, so the packaging takes on the role of the preservative previously added to the food itself. An example of this is 'modified atmosphere packaging' where the ratio of gases in the air-space inside the pack is modified to produce conditions which are not conductive to enzymatic changes or microbial growth.

Communication:

Packaging also serves as means of communications between the manufacturer and the consumer. Self-service retailing has led to lower prices through economies of scale and reductions in labour, but the product now has to sell itself, often against competition from other similar products.

Packaging Reflects a Changing Lifestyle

Today, typical supermarket stocks in excess of 15000 different product types, six times more than it did in 1960. Consumer choice has never been greater. The rising affluence has made consumers more adventurous in the foods, they eat and in the way, they spend their leisure. Consumers can only choose from the products available to them, but with the vast amount of choice today, the power of consumer to influence what is stocked by retailers has also increased for market research to understand, what customers actually want.

Packaging plays a vital role in the world today; without it much food would become unavailable to the consuming public or would be spoilt, many non-food products would become damaged and wasted and the distribution of goods would be much more expensive and difficult to carry out. There are not likely to be too many major changes in the way that packaging performs its role in the future; packaging designers and technologists will continue to develop more resource-efficient, more economical, more convenient and more environmentally responsible packaging.

The function of containment, protection and preservation in packaging are paramount, and many of the communication functions will always be necessary. However, the relative amount of resource and effort that is put into the development of the convenience, service and presentation and selling functions of packaging may well change, but the overall costs of delivering such packaging products to consumers will be the major criterion for dictating change.

Finally, there is a growing demand for the products, which are seen as environment-friendly, and here the packaging is often challenged, sometimes above the product itself. It is important that, consumer are made aware of all these functions.

Types of Packaging

The early uses of packaging were concerned with survival and this highlights basic principles that are just as important today. Around two-thirds of packaging is used for food grains and sugar. Many non-food products, as well as food products, require protection during their distribution from factory to customer, and none more so than the enormous range of pharmaceutical, toiletries and household products that are now a necessary part of modern life.

The choice of suitable packaging involves a number of considerations would the pack provide the optimum protection for the contents throughout their distribution and shelf life, will it contain the product adequately, keeping harmful outside influences out and will it adequately describe and market the product?

Primary, secondary and tertiary packaging:

The primary packaging of a product is the first and main line of protection, the material, which is in direct contact with the product. It represents the barrier between the product and the hazards of the external environment. Although it is convenient to consider the different types of primary packaging as distinct material sectors (metals, glass, plastics, paper and board), they are seldom used singly. Glass containers need closures of cork, metal or plastic and usually at least one paper or plastics label. Paper or thin board is often used in combination with plastics and/or foil to provide sufficient product protection to ensure 'fitness for use' with the minimum use of resources.

Primary or sales packs are often delivered in some forms of secondary packaging. Secondary packaging utilizes the primary packaging providing both the retailer and the consumer with a more convenient means of handling the product. It also helps in protecting the primary packages and thus the product.

Transport or tertiary packaging must ensure the safe and efficient delivery of products from their point of manufacture to the next point in their distribution chain. Integrated design of tertiary packaging, together with products' primary and secondary packaging, can reduce transport costs and the environmental impact of transport. Today many of the wooden and metal systems have been replaced by lighter and often more durable plastic ones, which reduce the total amount of energy, in transformation.

Returnable, non-returnable and recoverable packaging:

The role of packaging in protecting products and helping to make them readily available to consumers can be served by both returnable and non-returnable packaging. Returnable has come to mean, refillable and reusable 'multi-trip' packaging, while non-returnable usually means disposable 'one way' packaging. Recoverable packaging is now widely acknowledged as any packaging for which the raw material can be recycled and reused for the original purpose or other purposes, composted, regenerated or for which the energy value can be utilized as a source of energy generation.

Commodity packaging:

The roles of packaging are many and varied and the amount and complexity of the packaging used in a product depends to a large extent on the type of product being packed. Therefore, a further categorization of primary packaging type is as commodity, convenience and functional and luxury packaging. Commodity packaging for staple foodstuffs and household goods, such as flour, sugar, butter and detergents, is usually kept as simple as possible, whilst still providing safe delivery of the product, in prime condition, from the manufacturer, through the distribution and retail chain, to the consumer. Each layer of packaging fulfils a different function, protecting against various hazards such as moisture, light, oxygen, pests or crushing.

Convenience and functional packaging:

Convenience and functional packaging for products, such as pre-packaged fresh foods, ready-to-eat meals, portion packs and multi packs, is usually more complex and sophisticated than that used for staple products. It reflects the needs of our changing lifestyles, where we spend less time shopping and preparing meals. These packs may be required to do more than simply provide basic protection for the product. They may for example:

- Extend the shelf life of perishable products through the use of modified atmosphere packaging;
- Be designed to be oven, microwave and/or table ready;
- Be tamper evident;
- Need to be child resistant, easy to open for the elderly, or to dispense measured amounts of the product.

The design of this type of packaging has to be a compromise between fulfilling specific consumer needs and minimizing the use of resources.

Environmentally Responsible Packaging Manufacture

There is a need for packaging and to concentrate on how best to satisfy that need whilst, at the same time, controlling and minimizing the resulting environmental impacts. Impacts arising from any product system can be simplistically divided into three broad categories of environmental burden:

- Consumption of resources
- Pollution
- Solids waste

To be meaningful, any environmental assessment must consider these three effects at each stage in the lifecycle.

Packaging Design

For most design considerations, there is a fortunate coincidence of performance, cost and environmental virtue. Requirements for protecting the environment, such as minimizing use of materials, i.e. lightweighting, efficient manufacturing and handling processes which restrict energy consumption, and avoiding waste through good product protection in storage and distribution, are now routinely practiced by the packaging industry. They represent efficient, cost-effective packaging systems and therefore, make good business sense.

The benefits achieved from the redesign and improvements of packaging, in reducing weight alone, are most impressive. Even the sophistication of convenience in packaging design have their environmental merits and justifications. While some additional packaging resource may be incorporated into a design, producing a specification, which exceeds the minimum required for simple product protection and delivery, contributes significantly in environmental gain.

Convenience foods, for example, are, by their very nature, products that require little, if any, preparation in the home: for hot foods, re-heating in a microwave oven is highly energy efficient. The combination of bulk production by the food manufacturer, with minimal waste in the home, compensates for the increase in packaging.

There are nevertheless, aspects of packaging design, which now receive much attention on purely environmental grounds. The almost universal acceptance of the need to maximize recycling and reuse of materials has placed new demands on the packaging designer. The importance and difficulties of post-consumer packaging material recovery, or reclamation, is a first step to recycling. Thought given to this requirement at the design stage, the 'cradle' or start of the lifecycle can facilitate reclamation and reuse at the end of the cycle, thereby avoiding the 'grave'. Correct design may tip the scales between economically and environmentally viable recycling and recycling that would be pointless due to more resource being used than was saved through the recycling.

Packaging of 'Atta'

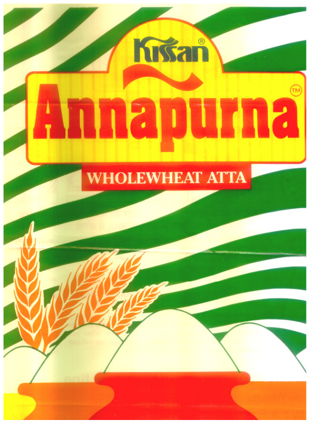
In the recent years multinational companies like Cargill Foods, ITC, HLL, General Mills, etc. have entered atta market and are positioning atta as branded commodity with a stress on purity and packaging under hygienic conditions. Although local regional atta manufacturers are using printed PE bags, MNCs are using six to eight colour printed PET / PE laminates for higher shelf appeal. "Shakti Bhog" is the market leader in the branded atta market and leads the pack with an annual turnover estimated to be close to Rs. 200 Crores (Source ET). Pearl Packaging, Veebro Plastic, Shanker Plastics and Shiva Plastics – all four are Delhi based monolayer film manufacturers. These are the predominant atta bag suppliers to Northern India based atta manufacturers. Atta bags are predominantly supplied by monolayer blown film manufactures because they can use smaller dies of 4 to 6 inches and are able to make tubing of said lay flat width. Tubing is bottom sealed to manufacture pre-formed bags.

Important Characteristics of 'Atta' Bags: Local atta manufacturers lack proper infrastructure to test film quality in terms of properties like sealing strength, dart strength, puncture resistance, etc. Dropping a filled atta bag from a height of 5 – 6 feet is the most common quality test conducted by all the atta manufacturers as well as the film manufacturers. Few monolayer film manufacturers also fill the preformed bag with air and try to burst it by hitting it against ground or wall. In view of tough handling conditions like loading / unloading at wholesalers and retailers' end, atta manufacturers are always demanding bags with superior dart strength. It is also expected that atta bags should have high sealing strength to undergo all the vigorous transit operations and maintain its integrity before consumers finally use the bag.

5 Kg. Pack Size: Generally industry average thickness of PE film is 82 microns in case of outer printed bag, Recently M/s Shakti Bhog Foods, major player in Northern India have down-gauged the film to 63 – 68 microns. Inner liners are used in case of PE bags while in case of laminates, liners are used on need basis only.

10 Kg. Pack Size: Industry average is generally 94 microns thick PE film for outer printed bag. However, Shakti Bhog is using the PE bags of thickness in the range 65 –70 microns only.

Liners: Inner liners are used in case of PE bags. Film manufacturers are supplying liners in the range of 37 – 50 microns for 5 Kg and 10 Kg pack size.



Atta Manufacturing and Packging Industries

Ahaar International, Delhi has their branded 'Atta' in the brand name of "Ahaar". They consume around 20 MTM of PE bags for packing atta in 5Kg and 10Kg pack size. Secondary packaging is done in woven sacks. 5 bags of 10 Kg each or 10 bags of 5Kg each are placed in a woven sack. Shakti Bhog Foods, Delhi has their branded 'Atta' in the brand name of Shakti Bhog and had a turnover of around Rs. 200 Cr. in 2001-02. Atta is packed in 5 Kg and 10 Kg consumer packs. Shakti Bhog enjoys the highest market share in atta segment followed by HLL's Annapurna and Cargill's Nature Fresh. HDPE Raffia Bags are used for packing individual consumer bags of 5Kg and 10 Kg. Master bag is of 50 Kg. Five bags of 10 Kg or ten bags of 5 Kg are placed in the master bag.

'Atta' Consumer Packs of 5Kg. in PE Bags

No	Brand Name	Name of Manufacturer	PE (micron)	Length (cm)	Breadth (cm)	Pouch Weight (gram)
1	Gauri Shanker	Alka Flour Mills, Bhiwadi	87	44.5	33	23.5
2	Rose Brand Atta	Ashoka Flour Mills, Delhi	88	45	32.5	23.7
5	Kisan Annapurna	HLL, (S.R. Chemicals, Kanpur)	60	44.7	32.7	16.1
7	Mayoor	Mahalakshmi Flour Mills, Chandigarh	65	45.3	30.3	16.4
8	Shakti Bhog Atta	Shakti Bhog Foods Ltd., Delhi	63	45	34	17.7
9	Rajdhani	Victoria Foods P. Ltd,Delhi	78	45	33	21.3
Liners						
1	Shakti Bhog Atta	Shakti Bhog Foods Ltd., Delhi	32	43.5	35	9.0

Average Specifications

Length of a pouch, cm	46.0
Breadth of a pouch, cm	33.0
PE film thickness, cm	82
Weight of a pouch, g	23.3

Tirupati Food Products, Delhi has its branded 'Atta' in the brand name of "Mohanji". Mohanji Atta is weighed 10 Kg on a weigh scale manually and liner is sealed using a local make Band Sealing machine. Similarly, printed PE bag is sealed manually using the same band sealer. Victoria Foods (Rajdhani Group), New Delhi, has their branded 'Atta' in the brand name of "Rajdhani" with annual turnover of around Rs. 150 Crores. Atta is packed on local make band sealing machines. Rajdhani Group is consuming around 8 – 10 MMT of PE bags for atta packaging. Cargill Foods, Gurgaon has their branded 'Atta' in the brand name of "Nature Fresh". Their pack sizes are 5 Kg and 10 Kg with majority of volume sales in 10 Kg pack size. Atta is being packed at various co-packers located in the country. Co-packer based in Indore is catering Western India market like Mumbai. Cargill also has their own unit at Noida equipped with imported Innotech German make FFS machines while other co-packers in country have Winpack, Nichrome, Samarpan, etc. make FFS machines.

Packaging Material Selection

In theory a choice can always be made from any one of the three main groups of packaging materials used in packaging bulk commodities:

- Jute Bags
- LDPE Film Bags

Table 1.1: Comparative Properties of LDPE Film Bags and Jute Bags

Property	Jute Bags	LDPE Film Bags
Seam Strength	Strong	Strong
Surface Texture	Rough	Smooth
Operational Convenience	Good but abrasive	Good
Capacity Utilization	Excellent	Excellent
Stack Stability	Good	Good
Resistance to Hooking	Fair	Fair
Drop Test Performance	Fair	Very Good
End-Use Performance (W.R.T. Bursting, Damage, Spillage, Replacement)	Good	Excellent
Grain Preservation Efficiency	Good	Good
Resistance to Moisture Dampening	Poor	Excellent
Organoleptic Deterioration	Very High	Poor
Chemical Resistance	Poor	Excellent
Air Borne Pollution	Very High	None
Microbial Attack	Very High	Nil

Table 1.2: Functional performance of Jute Bags and LDPE Film Bags

Parameter	Jute bags	LDPE Film Bags
Seepage	Relatively Higher	Low
Moisture resistance	Nil	Excellent
Aesthetics	Poor	Good
Performance in Humid conditions	Poor	Good
Availability	Seasonal	Abundant & Easy
Cost	High	Low

Table 1.3: Other Characteristics of Jute Bags and LDPE Film Bags

Property	Jute Bags	LDPE Film Bags
Hygienic Issue	High potential	Nil
Sustainable Raw Material	High	Low
Pollution Risk	Higher	Low
Energy Recovery	Low	High
Degradability	Yes	No
Moisture Absorption	High	Low
Reusability	Good	Good
Recyclability	Poor	Best
Contamination	High	Nil
Initial Infestation by Insects	High	Low
Reparability	Good	Fair
Sampling convenience for inspection	Good	Good

Jute: Jute is an agricultural product. Jute and mesta, the two rainfed crops are used for manufacture of jute bags. The fibre is obtained from the stems of C. Capsularies (white) and C. Olitorius (tossa/daisee) species of jute, commercial fibre consists of strands of overlapping fibre cells that are held together by natural plant gums. These strands surround the woody central part of the stem and are found just under the bark embedded in non fibrous tissues. Jute is used in packaging bulk commodities from olden days. On a world basis, about 80% of all the jute manufactured find its way into packing of one sort or another. In certain cases, the contents of the jute bag must be protected against contamination by jute itself, by other products stored nearby, or by the atmosphere. For such uses, the bag may be lined with paper or polythene bonded to jute. Jute is also used in woven carpets as weft, warp, or pile, in tufted carpets as the backing material, in linoleum as backing, and in carpet underlays and felts.

Plastics: Compared to other materials, plastics are the relative newcomers. Although thermosetting resins, whose molecular structure is cross-linked, have been used since the last century and are still extensively used in coating formulations for packaging, contemporary use of plastics for primary, secondary and tertiary packaging is almost entirely based on thermoplastic materials. Today, about one third of all plastic manufactured are used in packaging.

The breakthrough for thermoplastic was the discovery and development of polyethylene by Imperial Chemical Industries in 1935. Significant use of polyolefins, and of vinylpolymers, was being made to support the war efforts by 1945 and, with the onset of peace, alternatives uses for the materials, as packaging, were rapidly developed. The same happened in non-packing markets, e.g. nylon parachutes to nylon stockings. The term plastics cover a very broad family of different polymeric materials. Those commonly used for packaging include the polyolefins, principally polyethylene and polypropylene; PVC, (polyvinyl chloride); polystyrene and PET, (polyethylene terephthalate). About two thirds of this use is for foods and beverages, with much of the perishable foods in modern supermarkets being portion-packed in some form of plastics.

Manufacturing processes entail taking-in the plastic material as granules or powder, heating it (temperatures vary widely between the different polymers but are typically in the 150 to 300^0C range) and forming into shape. The forming can be blowing or injecting into a chilled mould or by pre-extruding sheet and then forming this into a mould. Sheet is also supplied direct to packers for use on form fill-seal machines. The process is reversible so that all unadulterated industrial scrap is collected by the packaging manufacturer, regranulated and reused in-plant, representing a significant cost saving, Many blown bottles and moulded tubs are also printed prior to delivery to the packer.

Foamed materials, where a blowing agent is incorporated in the polymer, are another variant of plastics. The resulting light, rigid, cellular structure makes efficient use of very little material and is ideal for heat insulation or for the physical protection of fragile goods. The ozone-layer endangering CFC blowing agents, once used for these expanded materials, have now been replaced. Environmental effects, specifically associated with plastics packaging manufacturer, are relatively benign. Impacts common to all manufacturing operations, such as nuisance for local communities, have to be controlled but apart from these, energy consumption, atmospheric emissions and incidence of solid waste are readily controlled.

Environmental effects from these processes principally relate to the coating and printing operations. Storage, use and disposal of waste inks and coating must be controlled. Use of the actual paper and board is very efficient and scrap is collected and returned for recycling, often back into paper packaging itself. General processes to obtain different packaging materials are shown in the figure 1.4.

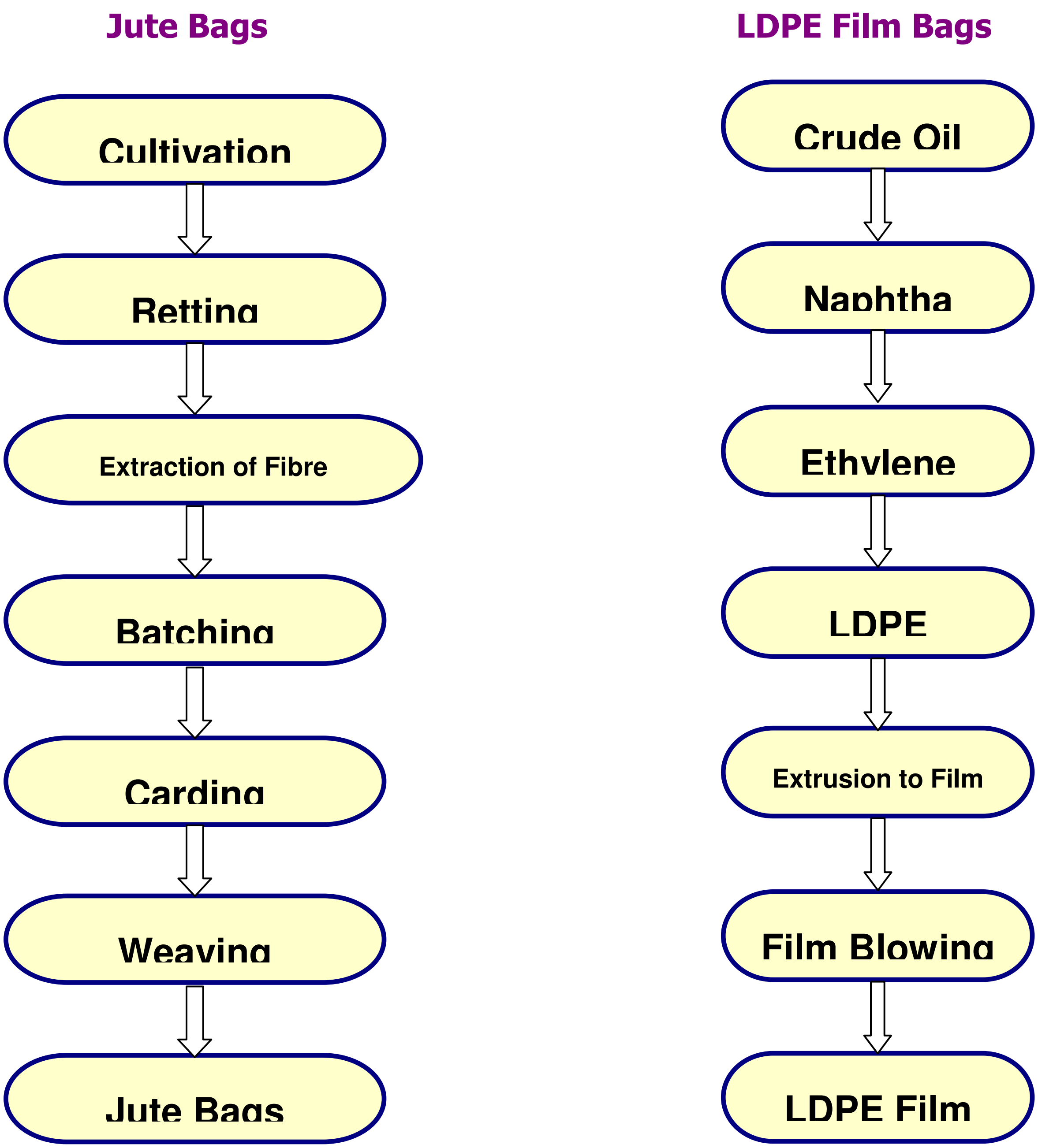


Figure 1.1 : General process to obtain the two packaging materials.

Health Aspects in Production of Packaging Materials

Health hazards with Jute

Health Hazards in Jute Cultivation

Perhaps more than any other occupational group, agricultural workers are exposed to a tremendous variety of environmental hazards that are potentially harmful to their health and well-being. Farmers and farm workers suffer from increased rates of respiratory diseases, noise-induced hearing loss, skin disorders, certain cancers, chemical toxicity, and heat-related illnesses.

Farming situations present several respiratory hazards to farm workers. Exposure to these hazards has been linked to excessive coughing and respiratory congestion of farm workers and families. A variety of disabling gases, including nitrogen dioxide (NO_2), hydrogen sulfide (H_2S), ammonia (NH_3), carbon dioxide (CO_2), and methane (CH_4), are produced during many routine operations. Exposure to low levels of NO_2, H_2S, or NH_3 will produce lung and eye irritations, dizziness, drowsiness, and headaches. High levels of H_2S particularly, and NO_2 secondarily, will quickly render a worker unconscious and may eventually lead to death.

Contact dermatitis is a skin disorder that occurs among agricultural workers. There are two general categories: irritant and allergic. Irritants act directly on the skin at the place of contact. Allergic sensitizers, however, cause changes in the immune system so that subsequent contact produces a reaction. Phototoxic or photoallergic reactions occur when light, in combination with certain substances, causes skin disease. Other types of agricultural dermatitis include heat rash, origin infections, and insect and plant irritants. Many agricultural workers are exposed to chemicals on a daily basis. If they do not observe proper precautions, illness or even death may occur. Pesticides can enter the body through many routes, but the most common ways are through the skin and by inhaling. To prevent dermal (skin) contact and inhalation of pesticides, applicators should wear personal protective clothing and equipment. Noise is another common health hazard.

Health Hazards during Retting

Retting of jute, stems or ribbons, gives rise to various microbes, organic acids, and gases in the retting waters some of which have unpleasant smell. Extraction of the fibres is done standing right in the retting water with heavy organic load or sitting on the bank of the retting ditch or pond, which is injurious to health. A lot of broken woody cores (jute sticks) are left in the retting water or around retting site spoiling aesthetics and contributing to siltation. The extracted fibres are washed in the retting water. The washings further add to the partially decomposed organic matters. During and immediately after retting, the dissolved oxygen levels in the water especially in the vicinity of rets (6 m from rets) are too low for most of the biota, except for the air-breathing fish, to survive. With increased intensity and frequency of retting, the situation becomes more acute. Water pollution becomes more apparent, water turns darker and frothy, becomes more acidic and foul smelling and the water body becomes a mosquito breeding centre. Some growers have also complained of athlete foot, itching skin diseases, and of leaches establishing on submerged portions of the workers body.

The retting workers are required to remain for 6 to10 hours in waist-deep water in the tank on the day they are engaged in retting. The retting operation continues for 4-6 weeks. The quality of the water in the tank deteriorates considerably due to retting. The workers are in physical contact with this water for considerable period of time. The job is also physically strenuous. Table 1.4 gives an idea about the health status in respect of certain parameters amongst retting workers.

Table 1.4: Health status in respect of certain parameters amongst the retting Workers

Abnormality	Number of Retting Workers affected	
	Just after Retting Period	5 months after Retting Period
Condition of skin	8	0
Condition of nail	8	23
G.I. diseases	8	8
Eye infection	15	8
Nasal discharge	8	0
Respiratory infection	0	8

Methane Emissions To The Atmosphere

It is reported that 60-65 per cent of the gases emitted during microbial retting in natural waters is methane (CH_4). Other gases present are CO_2, CO, H_2, O_2,N_2, etc. Gaseous composition is similar to that of biogas. Optimum temperatures and pH requirement of retting and biogas production processes are also similar. Methane is much more harmful as ozone depleting agent than CO_2. By utilizing methane in cooking stoves, it can be transformed into less harmful form, thereby protecting the environment. The average production of methane is reported to be 1.4 kg/kg of jute fibre.

Health Hazards of Jute Batching Oil (JBO)

For as long as we remember, edible items like coarse foodgrains (wheat, rice, cereals, etc.) and sugar are packaged and distributed in jute sacks. To a common man, the usage of jute packaging inspires trust that the items they use in their daily lives are safe for consumption and would not harm their health. The real truth is poles apart from this myth.

The very processing of jute involves a softening process wherein raw jute (an agri-product) after retting is softened by soaking the same in jute batching oil (JBO), a mineral oil obtained from refinery industry. The dried jute fibres are softened by adding jute batching oil, an emulsifying agent and water. This stage of operation is called batching. A part of this softening medium (mineral oil) is retained even in the final jute sacks. In the absence of any protective barrier between the body of the jute sacks and the food grains and other edible items they are holding, the contained jute batching oil tends to migrate into the foodstuff.

Sources in the petroleum industry have stated that JBO is nothing but a suitable fraction of high speed diesel (HSD). An oil industry document called *material data sheet* indicated the following health hazards related to HSD:

Routes of entry: Inhalation, Ingestion, Skin, Eye

Effects of Exposure/ Symptoms:

- **Inhalation**
  Dizziness, headache
- **Ingestion**
  Nausea and vomiting. Irritation of mouth and gastro-intestinal tract may follow. Rapidly developing, potentially fatal chemical pneumonities.
- **Skin and eye contact**
  Irritation will remove natural fat from skin. Prolonged and repeated contact should be avoided; otherwise skin chapping, cracking, or possible dermatitis may result. Dry skin, erythema, oil acne, and oil folliculitis and warty growth may occur, which may become skin cancer subsequently on excessive, repeated exposure.

Thus, all of us are constantly and inadvertently consuming such mineral oils without any knowledge. Further, the workers in various FCI (Food Corporation of India) and other godowns, who have to carry the filled sacks on their backs (for stacking, etc.) are also constantly in touch with JBO and live under the threat of various skin ailments as listed above.

Jute sacks and cloth processed in India under the Indian Jute Industry Research Association (IJIRA) licensing scheme courtesy the RBO technology forms the best and the safest packaging material for food products in general. Significantly, the sacks and cloth processed under this technology fully conform to the international specifications, IJO Standard 98/O1 and that set by IOCCC.

Indian Jute Industries' Research Association (IJIRA) and Surveillance General Superintendent (SGS) India Ltd., under Memorandum of Understanding (MOU) with IJIRA are jointly engaged in food grade jute product certification. All such certified Indian food grade jute products carry this logo as a mark of quality. The user should insist on this certificate and verify the logo to ensure quality supply.

Background themes:

- 1990 findings…..
  Swiss Food Laboratory reported traces of hydrocarbon in cocoa and coffee beans in 1990. Contamination of these products became a matter of concern with the European food industry and the public at large. The presence of hydrocarbon was traced to the use of mineral oil in the manufacture of jute sacks. An appropriate hydrocarbon-free fibre lubricant had to be identified.

- Creation of food grade sacks
  Indian Jute Industries' Research Association (IJIRA) and Indian Jute Mills Association (IJMA) initiated research to identify a suitable alternative oil. IJIRA soon developed and patented a special technology based on Rice Bran Oil (RBO II) to manufacture food grade jute sacks.
- Salient features of the new batching oil (RBO II)
  Nontoxic vegetable oil.
  Stable and resistant to rancidity helps storage.
  Biodegradable, eco-friendly, abundantly available in India.
- The specification for jute packages of food grade material as prescribed in IJO 98/01 have become effective from 1st October 1999. The specification has been accepted by ICCO and recommended by IOCCC.

IJO 98/01 has three criteria

- **Analytical criteria** for food grade jute sacks for the packing of cocoa, coffee
  and shelled nuts:
  The ingredients used as batching oils shall be non-toxic and approved for use in packaging materials that will come in contact with food materials. Batching oils shall not contain compounds that could produce off-flavours or off-tastes in food materials packed in jute sacks.

- **Chemical Criteria**
  The amount of unsaponifiable compounds shall be less than 125O mg/kg. The recommended methods shall follow British Standard 3845 : 1990 on methods for the determination of added oil content of jute yarn, rove, and fabric. Subsequent saponification shall be done according to the methodology described in IUPAC 2.401 (ref. 1 and 2) of the International Union of Pure and Applied Chemistry (IUPAC).

- **Organoleptic Criteria**
  Jute sacks shall be analysed for their olfactory qualities. No undesirable odours or odours untypical of jute shall be present. No unacceptable odours shall develop after artificial ageing of the sacks. The ageing procedure to be followed shall be the one described in the European Standard EN 766 on sacks for the transport of food aid.

Of around seventy three major jute mills across India, only nine mills have adopted this new technology developed by IJIRA, for export purposes. However, in the absence of any enabling legislation in India , jute sacks destined for home consumption continue to use JBO (a mineral oil), thereby threatening the health of all Indians. The Government of India has, however, restricted the use of JBO. to a maximum of 3 per cent vide its Notification of 14th August 2001..

Health Hazards in Jute Mill

There is a clear indication of the presence of symptoms of byssinosis in jute mill workers. Byssinosis is an occupational disease characterized by chest tightness and breathlessness at work after the weekend break or other absences. The diagnosis of byssinosis is made on the characteristic symptoms of chest tightness, which in early stages of the disease is always at the beginning of the week. These symptoms are usually associated with a marked fall in ventilatory capacity during the work shift.

Bacterial endotoxins, which are thought to be associated with byssinosis in cotton workers, may play a similar role in jute workers. Retting of jute is a process by which the embedded fibre is separated from the stem through partial rotting by immersion in water. Heavy bacterial contamination during retting may lead to high levels of bacterial endotoxins. Besides this, one step in jute processing may cause micro-organism contamination in jute fibre. In the softening process, oil and water are added to the jute fibre, which is then kept in a warm house (25^0C) for forty-eight hours. Bacteria and endotoxins may be produced in jute fibre during this time.

The hot and humid Indian climate is quite favourable for bacterial growth. Levels of bacterial endotoxins in the airborne dust in jute mills are found to be comparable to those reported in the card room and blow room of cotton textile mills. Observations of significantly higher prevalence of byssinotic symptoms in high dust- exposed workers with a high endotoxin level support the assumption of the relationship between dust exposure and occurrence of byssinosis in jute mill workers.

The finding of chronic effects in jute mill workers is attributed to exposure to jute dust. The chronic effect of jute dust was observed more in smokers than in non-smokers with a similar type of dust exposure. Nevertheless, the observation of a higher prevalence of ventilatory function abnormalities in non-smoking jute mill workers exposed to high concentrations of dust than in smokers exposed to low dust concentrations indicates the greater effect of jute dust on non-smokers in a high-dust zone. It is, therefore, concluded that byssinosis does exist in jute mill workers, particularly those who are exposed to high concentrations of dust for a long time.

Generation of Dust in the Jute Industry

Large amount of dust is generated in jute industry during different processes involved in jute bag manufacture [Table 1.5(a)]. Workers in jute mill have been found to suffer from specific respiratory morbidity and byssinosis (a lung disease caused by prolonged inhalation of textile fibre dust), [Tables 1.5 (b)]. This is also observed in cotton, flax, and hemp mill workers.

Table 1.5(a): Dust level and prevalence of byssinosis in jute mill environment.

Dust Zone	Dust Levels (mg/m^3)		Prevalence of Byssinosis (%)
	Total	<10 μm	
High Dust Zone	6.58	4.21	18.75
Low Dust Zone	1.39	1.29	2.36

Table 1.5(b): Prevalence of byssinosis-like symptoms in jute mill workers

Clinical symptoms	High dust (n = 77)	Low dust (n =119)	Total (n =196)
Byssinosis-like symptoms present on Monday (chest tightness, cough, sputum, breathlessness on first working day of the week, i.e. Monday)	15 (19.5)	3 (2.5)	18 (9.2)
Byssinosislike symptoms present on days other than Monday (same symptoms but not on the first working day)	16 (20.8)	7 (5.9)	23 (11.7)
No byssinosis symptoms	46 (59.7)	109 (91.6)	155 (79.1)
Total	77 (100)	119 (100)	196 (100)

n = number of subjects; figures in parentheses are percentage

Occurrence of Byssinosis in Jute Mill Workers

Byssinosis is an occupational disease characterized by chest tightness and breathlessness at work after the weekend break or other absences. The diagnosis of byssinosis is made on the characteristic symptoms of chest tightness, which in early stages of the disease is always at the beginning of the week. These symptoms are usually associated with a marked fall in ventilatory capacity during the work shift.

Production of Raw Jute

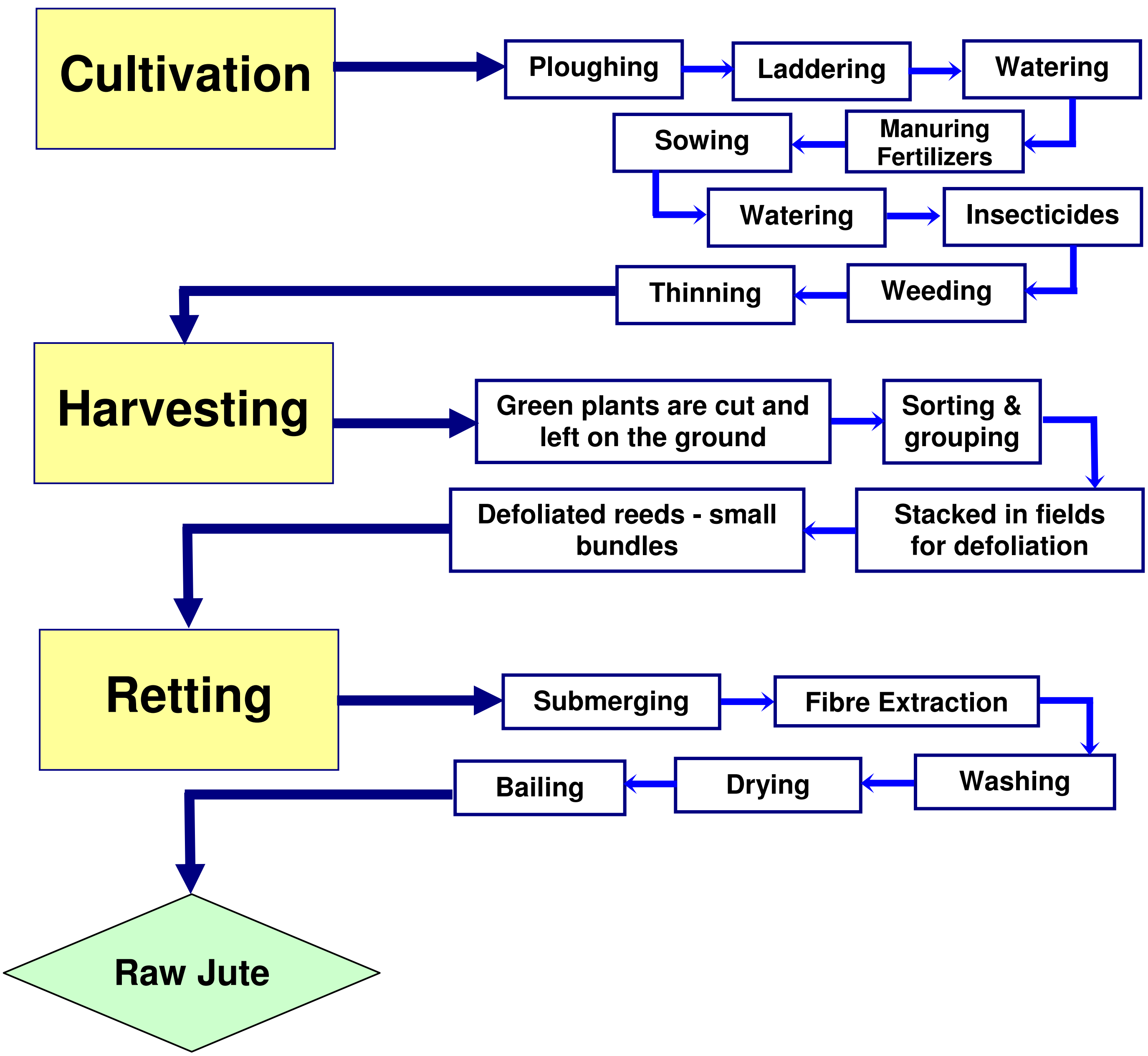


Figure 2.1: Flow Chart for Production of Raw Jute.

CULTIVATION

The flow chart to produce raw jute is given in figure 2.1.

Land preparation

Ploughing and Laddering:

Preparatory tillage of land starts in the latter part of February or the beginning of March. Jute seeds are very small. Therefore, the soil should be thoroughly pulverized and a seed-bed with a fine tilth prepared before sowing. In general, the soil is ploughed and cross-ploughed five to six times, sometimes even more, until a fine seed-bed is obtained. After each ploughing, a log of wood or ladder made of bamboo, about seven to eight feet long and weighted down by the cultivator standing on it, is drawn over the ploughed surface. This process of 'laddering' levels the land, breaks up the clods of soil, loosens and collects the weeds and compresses the soil slightly.

Manuring/Fertiliser:

For the manuring of jute lands, if required, cow-dung, ashes and composted house sweepings are usually used. Cow dung is applied at the rate of 50 to 100 maunds, i.e. about two to four tons per acre. Chemical manures and inorganic fertilizers are also used. Ammonium sulphate among the inorganic nitrogenous fertilizers is used for top dressing, when the crop is 1-1.5 months old after the first weeding and thinning operations is over.

Fertilizers:

The production of chemical fertilizers requires a variety of raw materials and intermediates, viz., feedstock (coal, gas etc.) ammonia, carbon dioxide, nitric acid, sulphur, sulphuric acid, phosphoric acid and rock phosphate. A variety of feedstocks are used for producing fertilizers. They are lignite, coal, coke, oven gas, electrolysis of water, natural gas, associated gas, naphtha, fuel oil, etc. 52 % of the fertilizers for plants are using natural gas as raw material, 24% are using naphtha, 13% are using fuel oil, 4% are using coal, 6% are using imported ammonia.

Consumption of fertilizers 40 kg /ha in India for jute production for a yield of 1.8 ton/ha of jute fibre

Source: Plant production and protection paper FAO, UN, The retting of jute FAO, UN, IIT, Kharagpur report

Since the production of Jute requires fertilizers, a weighted fraction for energy and emission from fertilizer industry will be counted for the total energy required and emission generated during production of Jute fibre.

Consequently, the fertilizer industries are emitting variety of wastes as well as pollutants in gaseous, aqueous and solid forms depending on the nature of raw materials, feedstock used, type of product produced and location of industry. Even these synthetic inorganic nutrients are not directly toxic to human and other life forms but they are bound to upset the fragile ecological balance.

On applying to soil, fertilizers are oxidized to ammonium and nitrate ions by soil micro-organisms. This results in higher concentration of nitrate in the ground water.

Permissible level of nitrate: 11.3 mg/l of nitrate- N ***A nation wide survey of 3000 well revealed 20% in excess of 50 mg/l and 3% over 100 mg/l***

Source: Suri, R.K. Maini, P. and Mehrotra, A. (1995). 'Environment: Fertilizers, Manures and Biofertilizers'. Society of Forest and Environmental Managers in association with Society of Economic Botanists and Phytochemists. P. 23

***Health hazard due to nitrate*:**

- The reaction of nitrate with haemoglobin prevents the blood from transporting oxygen and giving skins a blue colour.
- Risk of gastric cancer is increased by high intake of nitrate in drinking water.
- Transmission of heavy metals to food and feed are harmful to all living beings.

Emissions

Conversion of fertilizer N to gaseous forms leads to atmospheric pollution. Nitrous oxide evolved from agricultural land may enter the stratosphere in quantities sufficient to diminish the concentration of ozone, which absorbs much ultraviolet radiation.

In sulfuric acid plant: sulphur dioxide in the order of 2000-3000 ppm.
Dust content from urea plant in the escaping air varies from 40 to 1100 mg/m^3

Source: Suri, R.K. Maini, P. and Mehrotra, A. (1995). 'Environment: Fertilizers, Manures and Biofertilizers'. Society of Forest and Environmental Managers in association with Society of Economic Botanists and Phytochemists. P. 31

Liquid effluents

- **The major waste water from ammonia plant producing 900 ton/day ammonia is around 50 m^3/hr.**
- **Around 450-480 kg of effluent is generated for each metric ton of urea produced.**
- **Composition of effluent is 4 - 5% ammonia, 1.5 – 2% CO_2 and 0.5 – 1% urea.**

Source: Suri, R.K. Maini, P. and Mehrotra, A. (1995). 'Environment: Fertilizers, Manures and Biofertilizers'. Society of Forest and Environmental Managers in association with Society of Economic Botanists and Phytochemists. P. 33

Sowing:

The sowing is carried out cross-wise first from north to south and then from east to west in order to ensure a fairly even distribution of the seed. After sowing, the land is horrowed and then laddered so that seed is covered and is in close contact with the moist soil, which hastens germination. To ensure uniform germination, the seeds should remain 1 to 1.5 inches below the surface of soil.

Insecticides

Fertilizers and pesticides are used as inputs. The extent of use of chemical fertilizers varies 6-53 nutrient/hectare. Excessive use can cause soil salinity and acidity.

Pesticide: 0.5 kg / hectare ~ 400 gm of pesticide per ton of product

Source: IIT, Kharagpur report, P. 47, (Groenewegen and Overbeeke, 1994)

Common pests:

Semilooper, indigo caterpillar, jute hairy caterpillar, jute stem weevil and jute stem girdler.

Common insecticides:

- BHC, endosulfan, metasystox, kelthane
- BHC, endosulfan, kelthane are chlorinated hydrocarbons and metasystox is organophosphate.
- Other insecticides include Quinalphos, phenthoate, delnav, toxaphene etc.

Amount used:

- Endosulfan : 150-525 ml/ha
- Metasystox : 200 ml/ha
- Kelthane : 1100 ml/ha

Insecticides are used in production of Jute, therefore, a weighted fraction for energy and emission from insecticide industry as well as hazards of their use will be counted for the total energy required and emission generated in course of cultivation of jute.

Weeding and thinning:

During the first two months of crop, a large amount of plants has to be thinned out gradually. When the plants are about three to nine inches high, a hand or bullock-drawn rake is drawn over the land to thin out the plants and loosen the soil slightly. These operations may be repeated twice at an interval of about a fortnight. Weeding is important in jute cultivation. After the initial thinning with a rake, the crop is weeded with a hand-hoe (khurpi) twice or thrice; weeding is accompanied by thinning.

Harvesting:

Jute plants may be cut at any time before they are dead ripe, but harvesting is not usually done before the flowering stages. The ideal stage of harvest is when the plants are in small pods. In most places, except in the flooded areas, jute is harvested at this stage, when both the yield and quality are found to be good. The plants are cut close to the ground with a sickle. In many places, harvested plants are immediately made into bundles and are laid on the ground in long narrow lines so that the leafy tops of one set of bundles cover the bare lower portions of another. After two to four days, the leaves shed, and the bundles are then taken for steeping in water. Within two to four days, the tissues shrink and cells rupture. This facilitates the entry of micro- organisms into stems. The defoliated leaves are used as fertilizer (table 3.1).

Table 2.1: Use of leaves of Jute plant

Uses	Percentage (%)
Fertiliser	25.0
Other use	3.7
Waste	70.4

Source: CPCB report, 1994 (Retting of Jute fibre: Its impact on Environment P. 13)

Retting

Retting is a process by which the embedded fibre is separated from the stem through partial rotting by keeping them immersed in water. The conventional practice consists of two distinct phases viz (i) the physical phase and (ii) the biological phase. Structural changes, which occur during the retting operation, are due to disintegration of tissues caused by the micro-organisms. First the soft tissues are attacked, which disintegrate and the fibre bundles are separated. The retting is complete at this stage. But if the stems are left in the retting water, the fibres are damaged.

While the jute stems are kept in water, the bark of the stem swells resulting in cracks and crevices in the cortex. This is the physical phase of the retting. Retting microbes enter then through these cracks and crevices initiating the biological phase of retting. Though aerobic and anaerobic micro-organisms under respective favourable conditions are responsible for retting, the anaerobic decomposition is predominantly practiced in the field. It is observed that anaerobic bacteria of the Clostridium group are most effective.

The factors that affect retting primarily are:

(a) characteristic of water
(b) pH
(c) nutrients – macro and micro
(d) temperature and
(e) light.

Of these, water characteristics are most important. The state of movement of water, such as stagnant, slow-moving and fast moving, chemical quality and depth of retting water and thickness of the heap of stack immersed have bearing on the quality of fibre.

Harvesting, retting and extraction of jute is very labour intensive process, requiring about 50 man-days per hectare for harvesting and pre-retting operation and another 50 man-days per hectare for retting and extraction. About 50% of total labour is used in its cultivation.

Chemical Retting – Jute can be chemically retted using ammonium oxalate (0.5% solution) at 80-85^{o}C in 4 hours at ribbon (Dry) to liquor ratio of 1:10. However, the fibre obtained is rough though strong.

Microbial Retting – This is the most practised method for retting of jute. It involves soaking or steeping the stems or ribbons in water. If whole stems are steeped, it is called 'Stem-retting' and if ribbons are steeped, then it is termed as 'Ribbon-retting'. Ribbons can be green or dry. Steeping too early may lead to under retting, thereby causing defective fibre, which will require cutting subsequently and quantitative loss. Steeping too late, causes over-retting, which reduces the strength of the fibre. Depending upon the crop, the retting method used, temperature, pH, the microbes present and the use of activators (if any), microbial retting may take 7-30 days. After stem retting, the fibre is extracted manually (Stripping) and washed. Washing alone is sufficient for ribbon retting.

Selection of retting tanks

- Shallow ponds/ditches are used for retting of jute.
- Several families work in each of the retting tank.
- The tank water during and after retting operation is not used for any domestic purpose.

In the following Tables (Tables 2.2 and 2.3), the average data related to selection of water tanks and depth of the water tanks is given.

Table 2.2: Criteria for selection of Water tanks for retting

Nature of water tank	Percentage (%)
Sunny tank	20.0
Clean water	42.0
Sufficient water	8.0
Vicinity to field	12.0
Flowing stream	-
Nothing specific	18.0

Table 2.3: Water depth of retting water tanks

Depth of water tank	Percentage (%)
Up to 1.2m	29.6
1.5m	7.4
1.8m	40.7
2.1m	-
2.4m	3.7
Nothing Specific	18.6

Source: CPCB report, 1994 (Retting of Jute fibre: Its impact on Environment P. 12)

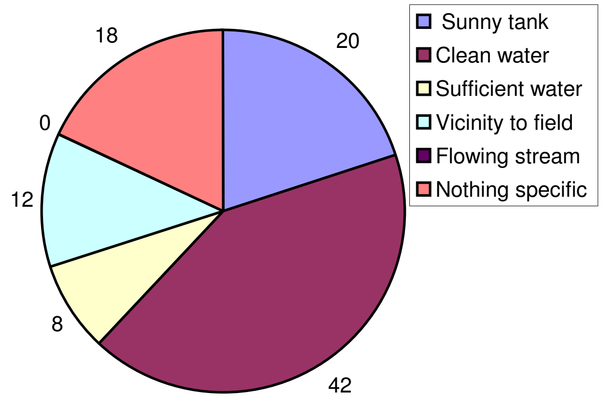


Fig: 2.2: Criteria for selection of Water tanks for retting

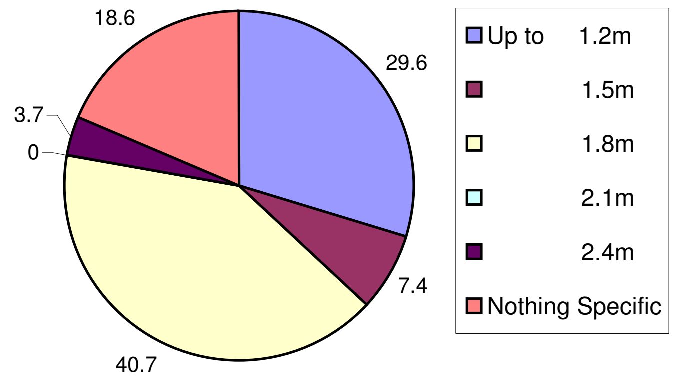


Fig: 2.3: Water depth of retting water tanks (Figure in %)

Retting Problems:

Main problems of retting and extraction associated with jute are:

1. Slow speed of retting
2. Excessive water requirement
3. Paucity of retting waters
4. Loss of fibre quality
    - Loss of characteristic colour
    - Excessive cuttings or root content
    - Loss of strength/lustre
    - Fineness of fibre
    - Presence of specks and entangled sticks
    - Reduced fibre length
    - Runners due to under – retting
    - Shifting in fibre alignment
5. Negative impact of retting on environment
6. Very labour intensive, adding to the unit cost
7. Poor waste and by-product utilisation

Activities associated with retting:

Preparation of 'Jak': The defoliated bundles are then laid in the retting water body. The bundles are placed side by side with their top (thicker edge) facing one direction. Generally, two or three layers are placed one above the other. Each of the bundled top is in the opposite direction compared to those of the adjacent layers. Two pieces of bamboos are placed on the top and the bottom of the stacks and tied to prevent the mass from drifting away. The compact mass thus produced is known as 'jak'.

Submerging: The 'Jak' usually tends to float on the water and the portion of the 'jak' projecting out above the water surface will not ret properly. It is therefore, necessary to place just sufficient weight over the 'jak' to keep it fully submerged in water. It has been observed that by maintaining the top surface of the 'jak' approximately 10 cm below the water surface yield good results.

Since seasoned wooden logs are not readily available, apart from being costly, lumps of puddle clay and banana tree trunks are used frequently to provide the dead weight.

Duration of Retting: Retting is considered to be complete when it is found that most of the fibres in the bundle have loosened enough for smooth extraction. Usually a 'jak' is kept in retting water for a period ranging from 2 to 3 weeks.

Fibre Extraction: Fibre extraction is the process by which the retted fibres are removed from the reeds. Two processes are used by the cultivators for the extraction of fibre:

(a) Beat – Break – Jerk Process: Standing waist-deep in retting water, the worker beats the bottom end of each bundle by a wooden mallet to loose the fibre. The bundle is then broken and twisted at the middle. The worker then holds the fibre where the bundle has to be broken and shakes the bundle vigorously to and fro in water to remove the broken sticks. The wet strips of fibre are then washed in water to remove pieces of broken sticks adhering to the strips. The strips are then coiled and placed on the bank for further washing.

(b) Single-reed process: In this process, the retted bundles are taken out of the 'jak' and placed on the bank of water body. A few reeds are taken out of the bundle and extraction of fibre is done from the bottom. Approximately 10-12 cm of fibre are made free from stick. The fibre is gripped firmly and pulled out slowly from the rest of the stick. The extracted wet strips are then coiled and kept ready for further washing.

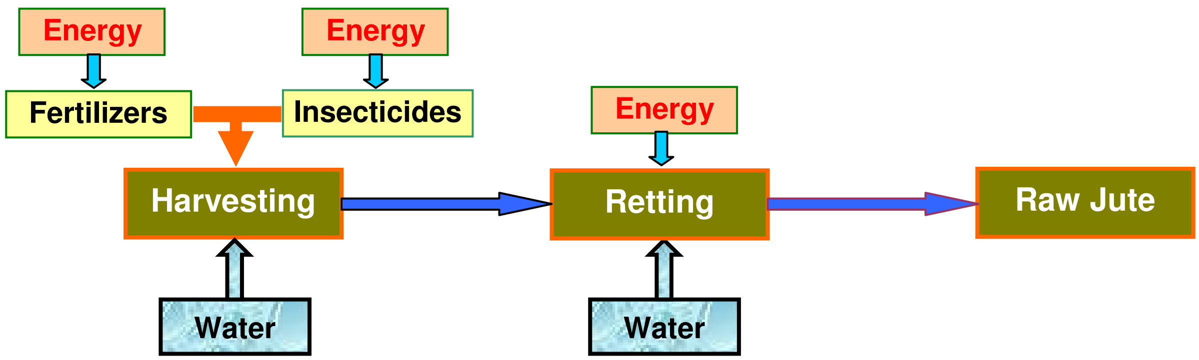
In beat-break-jerk process, the fibre sometimes get entangled and may contain broken sticks whereas in single-reed process straight untangled fibres which are free from broken sticks are obtained.

Final Washing: Final washing of the wet strips of fibre is done in clean water to remove the retting residues sticking to the fibre and to improve the quality. Due to non-availability of sufficient quantity of clean water in close proximity of the retting site, the process of washing in clean water is skipped in majority of the retting centres. In most cases, the final washing of the jute strips are accomplished in the retting water itself.

Drying: Washed wet strips are next spread over an elevation platform made of bamboo, or hung on bamboo frames for drying. Drying under mild sun is preferred as drying under strong sun yields rough fibres. Spreading of wet fibre on the ground for drying is usually avoided, as the wet fibre would gather dust in the process.

***Bailing**:* The dried jute fibres are made into bales for storage and subsequent dispatch.

LIFE CYCLE INVENTORY FOR PRODUCTION OF RAW JUTE



Energy Consumption

- Energy consumed: 10.4 MJ / kg of Jute fibre
- Weighted average energy consumed by Fertilizer Industry: 1.5 MJ / kg of Jute fibre
- Weighted average energy consumed by Insecticide Industry: 0.6 MJ / kg of Jute fibre

Total Energy Consumption in Production of Jute Fibre: 12.5 MJ/kg of Jute

Water Consumption

- Water consumption/Requirement: 96.75L/kg of Jute fibre
- Weighted average water consumed by Fertilizer Industry: 0.5 L/kg of Jute fibre
- Weighted average water consumed by Insecticide Industry: 0.2L/kg of Jute fibre

Total Water Consumption in Production of Jute Fibre: 97.5 L/kg of Jute

Source: CPCB report, 1992, Alam, A. 1993, IIT, Kharagpur report, P. 53

Air Emission

CO_2 absorbed - 1.2 kg of CO_2 removed from the atmosphere for each kg of fibre

Source: IIT, Kharagpur report, P. 51, (Alam, A. 1993)

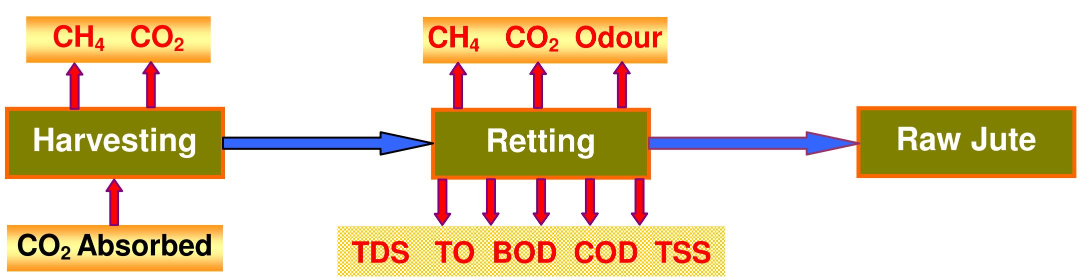


Table 2.4.: Emissions during production of 1 kg of Jute and corresponding amount required of LDPE film (liner)

Emission (gm)	Jute	LDPE film for liner*
CO_2	69	232.65
CH_4	0.491	0.735
NO_x	0.145	1.175
SO_x	0.3	1.592
Dust	0.071	0.184
HC	0.087	0.218

** Explained in the next section on LDPE production and processing*

Methane Emissions to the Atmosphere:

Problem of methane emission is very severe which is a prime cause for ozone layer depletion. The quantitative data is not readily available as jute cultivation is scattered over a large area.

It is reported that 60-65% of the gases emitted during microbial retting in natural waters is methane (CH_4)

Other gases present are CO_2, CO, H_2, O_2, etc. Gaseous composition is similar to that of bio-gas. Optimum temperatures and pH requirement of retting and biogas production processes are similar**.** The average production of biogas is reported approximately 1 m^3/kg (1000L/kg) of total volatile solids from livestock wastes. If this data is considered, the emission of methane during retting is 0.6 m^3/kg (600L/kg). This accounts to approximately 400gm/kg of methane.

Methane is much more harmful (11times than that of CO_2) as ozone depleting agent than CO_2

Source: IIT, Kharagpur report, P. 49, (Groenewegen and Van Overbeeke, 1994)

Biogas production from jute stems and ribbons can be expected of the same order, may be slightly less due to unfavourable C:N ratio.

Fish Culture in Retting Waters:

Natural surface waters contain dissolved oxygen which meets the requirements of fish. Plankton and submerged aquatic vegetation. It requires only 2-3 days of retting for dissolved oxygen to be depleted to a level at which captive gill breathing fish are put at risk.

Fertilizer Industry and Use of Fertilizers:

Use of nitrogeneous fertilizers by microorganisms in the soil, leads to generation of nitrogen and nitrous oxide as gases that diminishes the concentration of ozone (Ozone depletion). The hazards envisaged from an increase in the radiation reaching the earth's surface are responsible for increase in skin cancer of fair skinned people much exposed to sunshine and a possible a change in our climates.

Water Emission:

Jute is an agricultural product and not much attention have been paid to scientifically determine the level of other pollutants in the water. Therefore, available data is very limited. The water emissions and larval density during retting are presented in Tables 2.5 and 2.6 respectively.

Table 2.5: Water Emissions during retting of jute

Property	Days								
	0	7	12	18	100	130	170	244	285
pH	6.8	6.7	6.6	6.6	6.6	6.8	6.9	7.0	6.9
Odour	Normal	Odourous	Highly Pungent	Highly Pungent	Highly Pungent	Odourous	Less odourous	Less odourous	No odourous
TSS	55	175	345	295	295	175	150	97	41
TVS	35	130	255	227	227	95	72	59	19
TDS	85	205	305	285	285	272	245	258	64
BOD	40	699	1469	4014	1491	594	155	75	35
COD	100	1499	3338	8857	3125	1285	375	212	95
Phen.	4	40	75	60	60	29	11	2	Nil
O.N	25	250	355	325	325	195	140	89	12
T.N.	45	375	405	380	380	232	171	132	31
Phos.	7	45	81	68	68	52	45	25	Nil
TO	130	2490	5860	14931	5970	1944	485	364	146

Note: All the units (except pH are in mg/L)
(TSS – Total Suspended Solids; TVS – Total Volatile Solids; TDS – Total Dissolved Solids; BOD – Biological Oxygen Demand; COD – Chemical Oxygen Demand; ON – Organic Nitrogen; TN – Total Nitrogen; Phen. – Phenolics; Phos. – Phosphates, TO – Total Organic)
Source: CPCB report, 1994 and Alam ICAR Seminar

- Weighted average contribution to BOD by Fertilizer Industry: 1.2 mg/L to produce 1 kg of raw Jute
- Weighted average contribution to COD by Fertilizer Industry: 8.3 mg/L to produce 1 kg of raw Jute
- Nitrates in water due to use of Fertilizers: 50 mg/L to produce 1 kg of raw Jute
- Weighted average contribution to BOD by Insecticide Industry: 1.4 mg/L to produce 1 kg of raw Jute
- Weighted average contribution to COD by Insecticide Industry: 9 mg/L to produce 1 kg of raw Jute

Effects on Mosquito Population:

Anopheles prefers reasonably clean water, the Culex favours moderately polluted water. Both the varieties may exist side by side in a water body but the predominance of one variety over the other is an indication of the degree of organic pollution in the water body.

Table 2.6: Larval density in the retting water

Dates of Sampling (Days)	Density
0	80
45	266
55	445
65	233
75	293
105	135

Source: CPCB report, 1994

Solid Waste:

The solid waste emission data is not available for production of Jute fibre. However, the jute sticks that are left behind after extraction of fibre are used for different purposes as given in the table 2.7.

Table 2.7: Use of jute sticks (solid residue)

Residual Uses of Jute	Percentage (%)
Household use	74.8
Use for other purpose	3.0
Not used	-
Nothing specific	22.2

Source: CPCB report, 1994

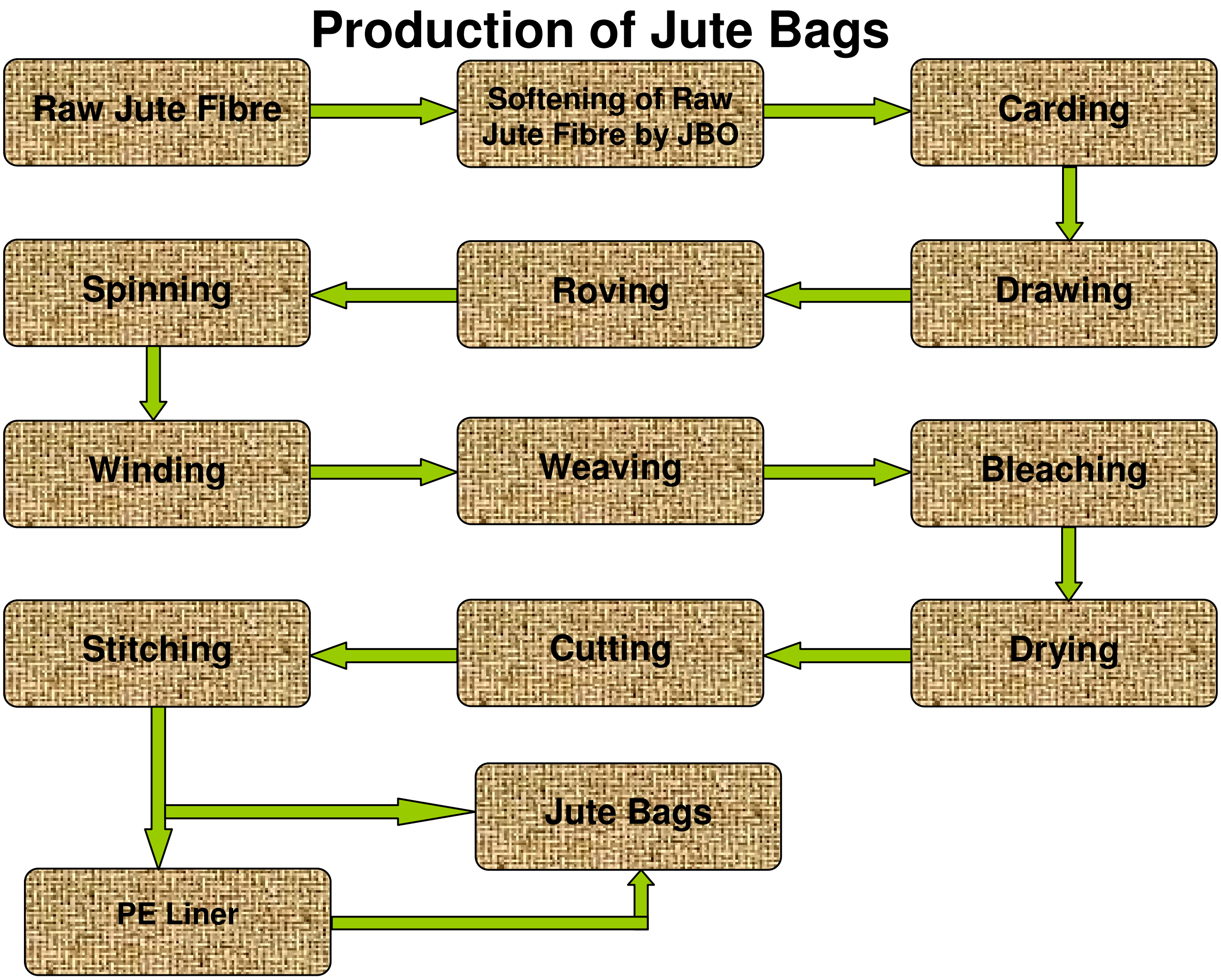


Figure 2.4: Flow chart for the manufacturing of jute bags from the raw jute fibre

PROCESS FOR PRODUCTION OF JUTE BAGS

The flow chart for manufacturing of jute bags has been given in figure 2.4.

Processing of Jute Fibres

The dried jute fibres are then put to softening by adding (5 – 6)% of jute batching oil and water. This operation is called batching. Batching involves softening of hard raw fabric. The ingredients used for batching are emulsion of jute batching oil (a mineral oil derived from petroleum products), surfactants and water. Part of this softening medium is retained even in the final jute bags.

Jute fibres after batching is also subjected to a process of compression called Carding. After this, the compacted fibres go for the process of spinning. The yarns thus obtained are coarse and abrasive in nature with a tenacity ranging from 3-4 g/d. Jute yarn are fed to the circular/flat looms and woven into tubular/flat fabric.

The fabric thus produced is cut and the bottom parts stitched. Then it is printed as per requirement of the customer.

Jute has several drawbacks, which are both product and processing related. Inherent disadvantage of moisture absorption (about 12%) allows the moisture to get transmitted to packed products especially sugar and fertiliser, which are hygroscopic in nature. Contamination of products by migration of jute batching oil and subsequent organoleptic deterioration of the product are quite common in jute packaging.

Jute Batching Oil

Jute is a lignocellulosic fibre. The fibre of jute obtained by a natural microbiological process known as "Retting" from the bark of two cultivated species of corchorus, namely, C. capsularis. L. (white jute) and C. olitorius L. (Tossa jute). Jute contains small amount of natural fats and waxes (0.25-0.5%). Deficiencies in fats and waxes are the reason for the application of batching oil. Technically, 3 % oil is sufficient for hessian and 5 % for sacking fabrics for lubrication purposes.
(Consumption: 90,000 tonnes around Calcutta.)

Composition of Jute Batching Oil

It is obtained from crude petroleum. JBO is a gas oil fraction distilling just after kerosene, it is normally associated with a slight kerosene fraction. It is composed of hydrocarbons with 15-20 carbon atoms per molecule. In addition to open type hydrocarbons, it contains varying amount of cycloparaffins known as naphthenes and wide variety of aromatic substances. Poly nuclear aromatics (some of which are toxic and carcinogenic ex. Pyrene, chrysene, benzopyrene) are also present in small amount. The oxygenated compounds are present in very small amounts.

Sulfur: 0.1-3%

Odour: JBO has a characteristics odour (of petroleum products) which is imparted to processed jute goods. The objectionable odour may also be caused by sulfur compounds and cracked petroleum products which are likely to be introduced into JBO during distillation process.

Types of JBO: Two types of JBO - One for processing jute goods for the American market (FDA quality) and other for the Russian and East European market (Pre-FDA quality).

Characteristics of JBO

JBO is pale yellowish brown but turns distinctly brown on exposure to light. The colour intensified to some extent on long storage.

Physical Characteristics of JBO

- Density: 0.865-0.880
- Flash point: 130^0-145^0C
- Initial boiling point: 285^0-300^0C
- Final boiling point: 385^0-400^0C

- It is free from kerosenic fraction and contains about 18 % of heavier gas oil fraction above 371^{0}C

Chemical characteristics
JBO contains small amounts of unsaturated compounds and only traces of acidic substances and saponifiable matters.

- Iodine value: 15-25
- Acid value: 0.02-0.1
- Saponification value: 0.5-1.0

JBO is emulsified in water with soap in which 12-33 % oil, 0.2-1.5 % emulsifier and 65-87 % water is used. Photochemical oxidation of oil forms peroxides and hydroperoxides as toxic intermediates. Although saturated hydrocarbons have little toxicity but aromatic are toxic in range between 0.1-0.5 ppm. It appears that both additives and hydrocarbons in oil contribute to toxicity, although in low level.

JBO has been found to be carcinogenic and therefore its use is barred in western countries for packaging of food items that come in direct contact with jute bag.

Carding

The primary function of the cards is to convert reeds of jute into a uniform supply of fibrous material which can then be drafted and finally twisted into yarn. It is perhaps at the card that the most dramatic change in the appearance of the jute is seen, when it is passing into the breaker card the reeds from the stems of the pant can easily be identified and the whole feed is coarse and uneven but by the time of jute has passed through the breaker and finisher card it has been transformed into a thin web to separate fibres emerging as a fleece which is then condensed into a sliver. Besides this essential task, the cards begin the work of weight reduction by drafting and weight levelling by doubling. This process consumes 5% of the total power used in the manufacture of jute bag.

Drawing

The functions of the drawing stages are (i) Drafting the finisher card sliver to a count suitable for feeding the spinning frames (ii) Reduction of weight irregularities by doubling (iii) straightening the fibres and laying them along the sliver axis so that when they come to be spun on the spinning frame they will be evenly drafted and twisted to form an acceptable yarn. This process consumes 3.4% of the total energy used in the manufacture of jute bag.

Roving

The roving frame is essentially a drawing frame fitted with an attachment for inserting twist into the drafted stand and winding it up on to a bobbin. It is used to produce heavy count 'rove' yarns in the range 70 – 200 lb/sp or to provide another drawing stage to reduce the sliver count to a level suitable for spinning fine yarns of 3.5 – 5 lb/sp.

Spinning & Winding:

The essential features of the spinning process are drafting, twisting and winding-on. Spinning frame are made in several different sizes, designated by the distance between adjacent spindle, i.e., the pitch only a small part of the entire count range is produced on a given pitch of frame but no matter what the size of the frame, the mechanism for twisting and winding-on function in the same manner although some differences exist in the methods adopted for controlling fibre motion drafting. This process consumes 40% of the total energy used in the manufacture of jute bag.

Weaving:

The yarns so obtained by above step are fed to circular looms/flat loom and woven into tubular or flat fabric respectively.

Jute Bleaching

In jute fibre, Cellulose component is surrounded by hemicellulose and lignin. During bleaching a part of lignin is expected to undergo modification or subjected to removal and at the same time the hemicellulosic portion of jute is required to remain unaffected for retaining the quality of fibre.

The objectives of jute bleaching are:

1. To remove the coloring matter present in the fibre.
2. To improve its whiteness.
3. To retain the whiteness for a longer period.
4. To achieve the maximum whiteness with minimum loss in strength.
5. To keep the cellulosic and hemicellulosic constituents of jute unimpaired but at the same time, at least a portion of lignin constituents needs to be modified or removed.
6. To minimize the weight loss during bleaching.

The bleaching of jute can be done by using the reductive and oxidative bleaching agents.

Reductive bleaching agents are:

- Sulfur dioxide
- Sodium hydrosulphite

Oxidative bleaching agents can be classified into two categories:

Chlorine based compounds

- Calcium hypochlorite
- Sodium hypochlorite
- Sodium chlorite
- Carbon tetrachloride

Non chlorine compounds

- Hydrogen peroxide
- Potassium permanganate
- Potassium dichromate
- Peracetic acid

Among these Hydrogen peroxide is considered to be the best bleaching agent for jute, inspite of its high cost as compared to sodium hypochlorite or calcium hypochlorite.

In jute bleaching process, generation of free chlorine, chloro carbons, SO_x takes place that are major pollutants in terms of ozone depletion. Also lot of effluent goes into water stream that causes severe harm to ecosystem of water.

Jute Industry

Some silent features of jute industry are:

- ***Majority of the mills set up the machines ignoring the basic design of the factory building construction with anti-pollution environment viz. proper layout of sewerage and provision for effluent treatment.***
- ***Drainage of effluents from mill premises is generally affected through a number of drain lines.***
- ***Industrial activities release gaseous, solid and liquid pollutants, which pollute the environment.***

The sources of water pollution (Table 2.8) with regard to chemical processing of jute are as follows:

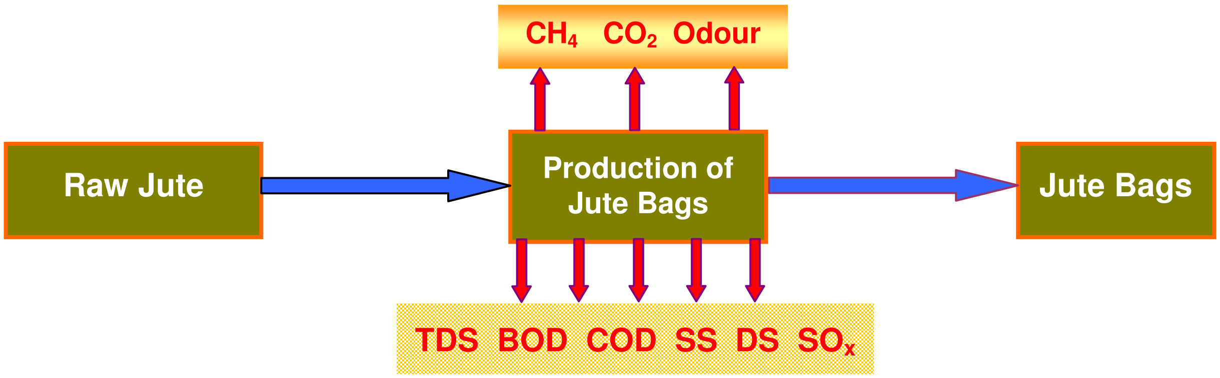
1. ***Spillage of mineral oil used in batching.***
2. ***Process waste from sizing***
3. ***Wet processing such as scouring, bleaching, dyeing / printing and finishing.***
4. ***Waste water from rinsing after each step of chemical processing.***

Table 2.8: Sources of water pollution in the jute industry

Chemical process	Chemicals/products	Pollution category	Difficulty of treatment
Fibre preparation	Mineral oil (JBO) Non-ionic emulsifier (Short chain EO adducts)	Most harmful Harmful	Difficult to biodegrade /moderate BOD Readily bio-degradable /moderate to high BOD
Sizing	Tamarind Kernal Powder Sodium silico-fluoride	Harmful Harmful	Inorganic contaminants
Scouring	Anionic detergent (linear alkyl anionics) Non-ionic detergent (short chain EO adducts)	Harmful Harmful	Biodegradable but moderate to high BOD
Bleaching	Bleaching powder/Sodium hypochlorite Hydrogen peroxide Sodium silicate Sodium phosphate Sodium hydroxide	Harmful	Inorganic pollutants.

Source: Guha Roy, T. K. (1996). The problem of water pollution related to jute industry and its control, Textile trends,31.

LIFE CYCLE INVENTORY DATA FOR PRODUCTION OF JUTE BAGS



Energy Consumption

- Energy consumption in Carding: 0.6 MJ/kg of Jute Bags
- Energy consumption in Drawing: 0.5 MJ/kg of Jute Bag
- Energy consumption in Spinning: 6.2 MJ/kg of Jute Bags
- Energy consumption others: 16.9 MJ/kg of Jute Bags
  (processing/humidification/bleaching/weaving etc.)
- Energy consumption in production of JBO (5% JBO): 2.5 MJ/kg of Jute Bags
  (Weighted fraction of JBO to manufacture Jute Bags)

Total Energy Required to Produce 1kg of Jute Bag: 26.7 MJ

Source: Energy conservation, The Indian Textile journal, 1998

Water Consumption

- Water Consumption in Bleaching: 60kg/ kg of Jute Bag
- Water Consumption others (cooling etc): 8kg/ kg of Jute Bag
- Water consumption in production of JBO: 0.65 kg/kg of Jute Bag
  (Weighted fraction of JBO to manufacture Jute Bags)
- Water consumption in production Chemicals: 20 kg/kg of Jute Bag
  (Weighted fraction of chemical manufacturing used in Jute industry to manufacture Jute Bags)

Total Water Consumption to Produce 1kg of Jute Bag: 78.65 kg

Emission to water due to Bleaching

pH: 5.5; BOD: 78mg/L; COD: 350mg/L

Generation of Dust in the Jute Industry

Large amount of dust is generated in Jute industry during different processes involved in Jute Bag manufacture (Table 3.7). Dust in jute mill has been found to suffer from specific respiratory morbidity, 'Byssinosis' (A lung disease caused by prolonged inhalation of textile fibre dust), also observed in cotton, flax and hemp mill workers. Direct emissions of different metals from the jute industry are listed in Table 3.8.

Table 2.9: Dust Level and prevalence of 'Byssinosis' in Jute Mill environment.

Dust Zone	Dust Levels (mg/m^3)		Prevalence of 'Byssinosis' (%)
	Total	<10 μm	
High Dust Zone	6.58	4.21	18.75
Low Dust Zone	1.39	1.29	2.36

Table 2.10: Direct Emissions of different metals from Jute Industry

Metals	Conc. mg/kg fibre
Mercury	0.04
lead	125.00
cadmium	0.02
Chromium	35.00
Copper	1770.00
Zinc	1030.00

For other effluents going into water stream scientific data is not available.

Table 2.11: Emissions during production of 1 kg of Bags (Jute and LDPE film(liner))

Emission (gms)	Jute	LDPE film*
CO_2	147	4.7
CH_4	1.043	0
NO_x	1.37	0.019
SO_x	0.66	0.157
Dust	0.035	0.055
HC	0.185	0

* *Explained in the next section on LDPE production and processing*

Table 2.12: Energy and Resource Consumption during production of Jute Bags and Liner used for Packaging One lakh ton of 'Atta'

	Jute Bags	
Material Required (Mt)	**1960**	
	Energy (thousand GJ)	**Water (Thousand Tons)**
Phase I: Production of Raw Material	**21.50**	**1677**
Phase II: Production of Bags & Liners	**47.19**	**1506**
Total	**68.69**	**3183**

Table 2.13: Total Emission during Production of Raw materials (Jute and Liner) for packaging of 1 lakh tonne of 'Atta'

Emission (Kg)	Jute	LDPE film liner
CO_2	118680#	456000*
CH_4	844.52	1440
NO_x	249.4	2304
SO_x	516	3120
Dust	122.12	360
HC	149.64	552

** Explained in the next section on Life Cycle Inventory of LDPE production and processing #Without taking into account the CO_2 absorbed*

Table 2.14: Total Emission during Production of Jute Bags (Jute and Liner) for packaging of 1 lakh tonne of 'Atta'

Emission (Kg)	Jute	LDPE film liner
CO_2	252840#	1128*
CH_4	1793.96	0
NO_x	2356.4	4.56
SO_x	1135.2	37.68
Dust	0.455	13.2
HC	318.2	0

** Explained in the next section on Life Cycle Inventory of LDPE production and processing #Without taking into account the CO_2 absorbed*

Production of LDPE/LLDPE Granules

The process of manufacturing involves following steps:

- Extraction of crude oil
- Production of naphtha by fractionation from crude oil
- Cracking of naphtha to produce ethylene/propylene
- Polymerization of ethylene to produce LDPE/LLDPE
- Manufacturing of tapes from LDPE/LLDPE granules

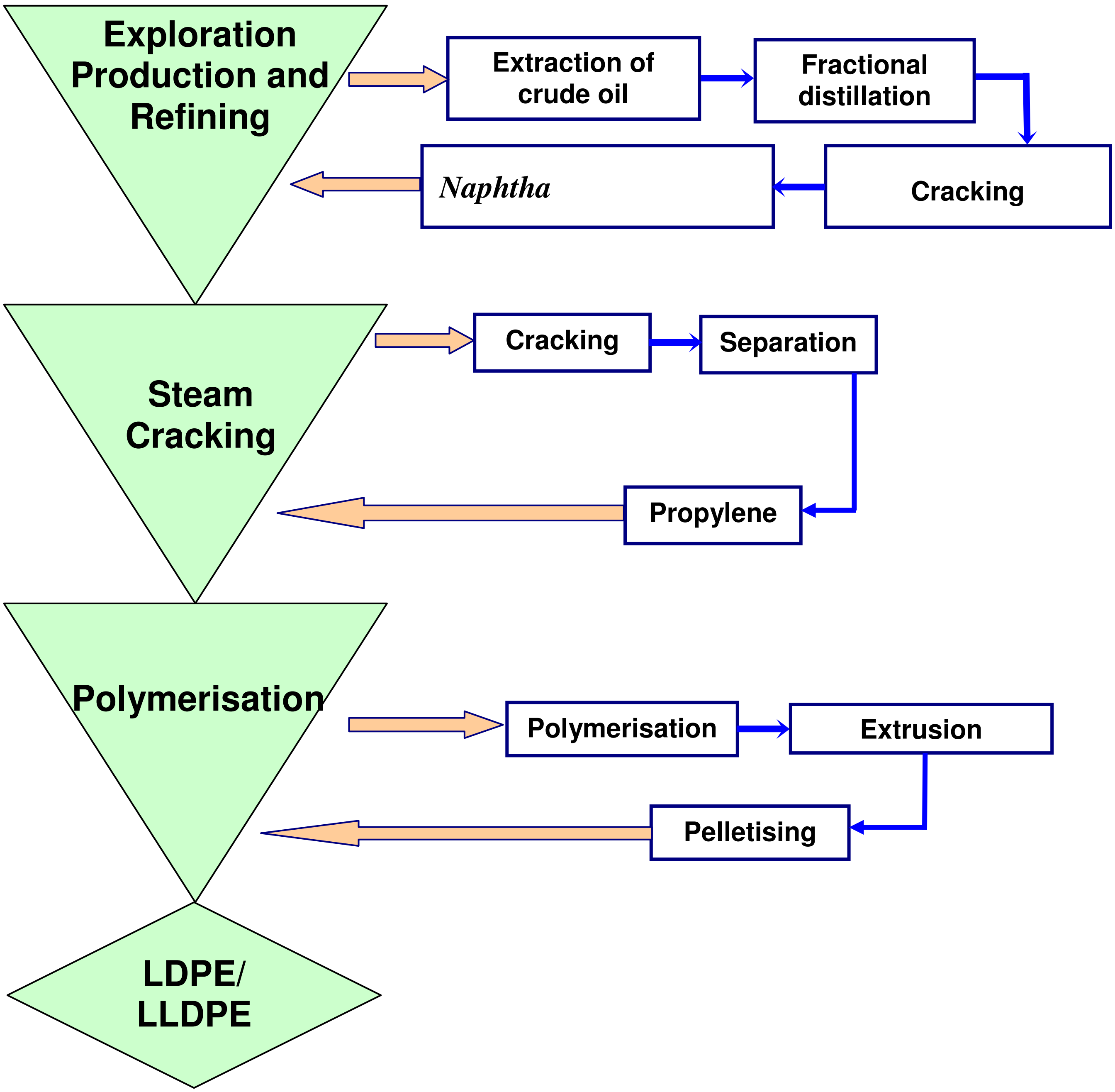
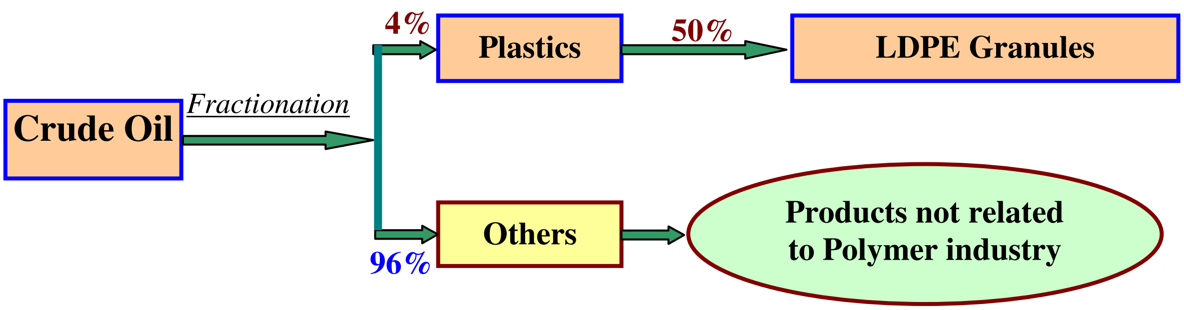


Figure 2.5: Flow Chart for Production of LDPE/LLDPE Granules.



Extraction of Crude oil

The first step for production of LDPE/LLDPE is to extract crude oil. This industry has long presence and the extraction of crude oil is mainly carried out to meet the need of transportation and electricity sector. Only a small fraction (4%) of world's total oil consumption is used in plastic industry (Figure 3.6). Out of this 4%, 57% is used to make PP and PE, that amounts to ~2% of world's total oil consumption.

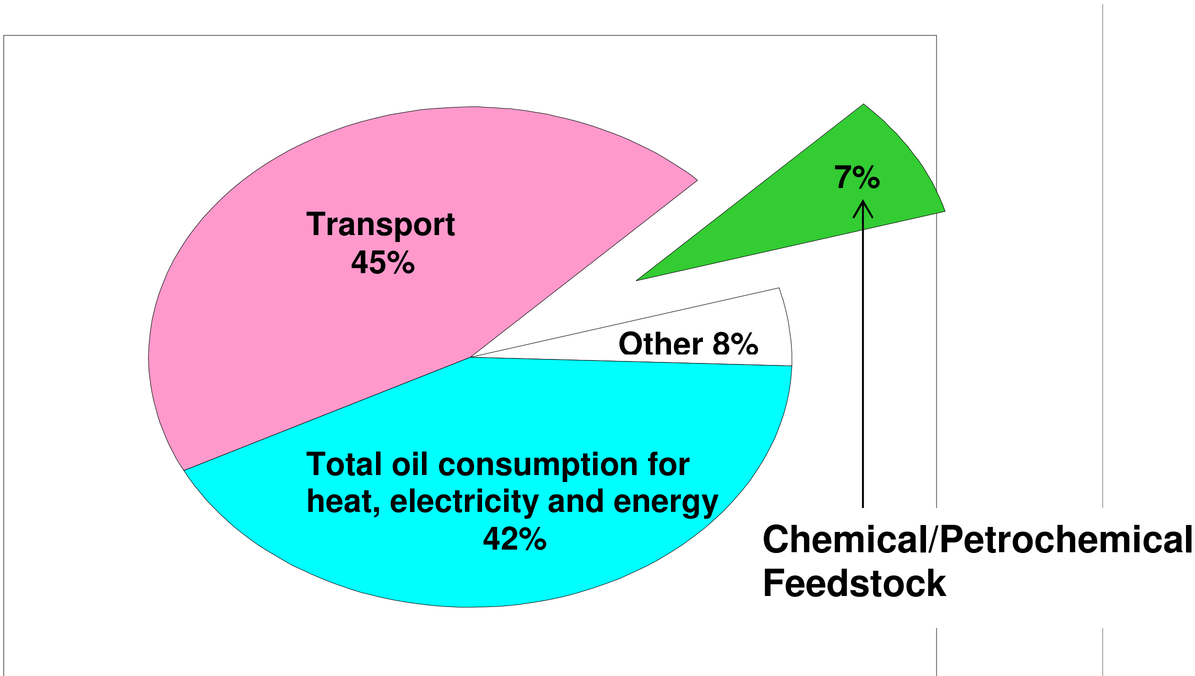
Production of Naphtha by fractionation from crude oil

The crude unit functions simply to separate the crude oil physically, by fractional distillation, into components of such boiling range that they can be processed approximately in subsequent equipment to make specified products. A crude unit will resolve the crude into the following fractions:

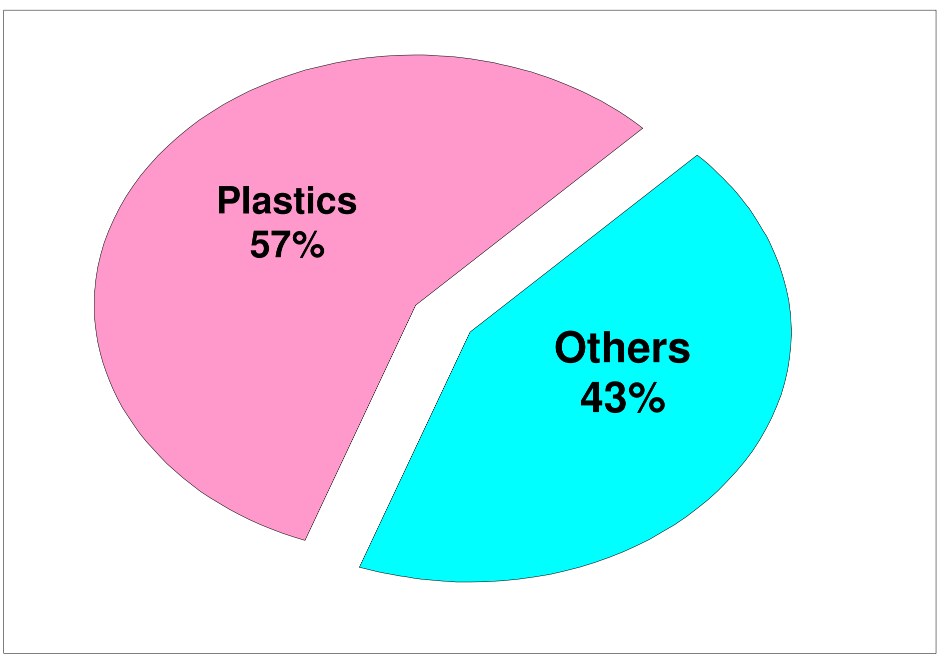
(i) A light straight-run function, consisting primarily of C_5 and C_6 hydrocarbons.
(ii) A naphtha fraction having a nominal boiling range of 200-400^{0}F
(iii) A light distillate with boiling range of 400-650^{0}F

Wastes resulting from the production and handling of crude oil, include drilling mud, oil field brines, free and emulsified oil and tank bottom sludge.

World's Oil Consumption



World's Chemical and Petrochemical Feedstock



Total 4% of the World's Oil Consumption used in Plastic Products

Figure 2.6: Consumption of world's total oil in making plastic products

Products from Refinery

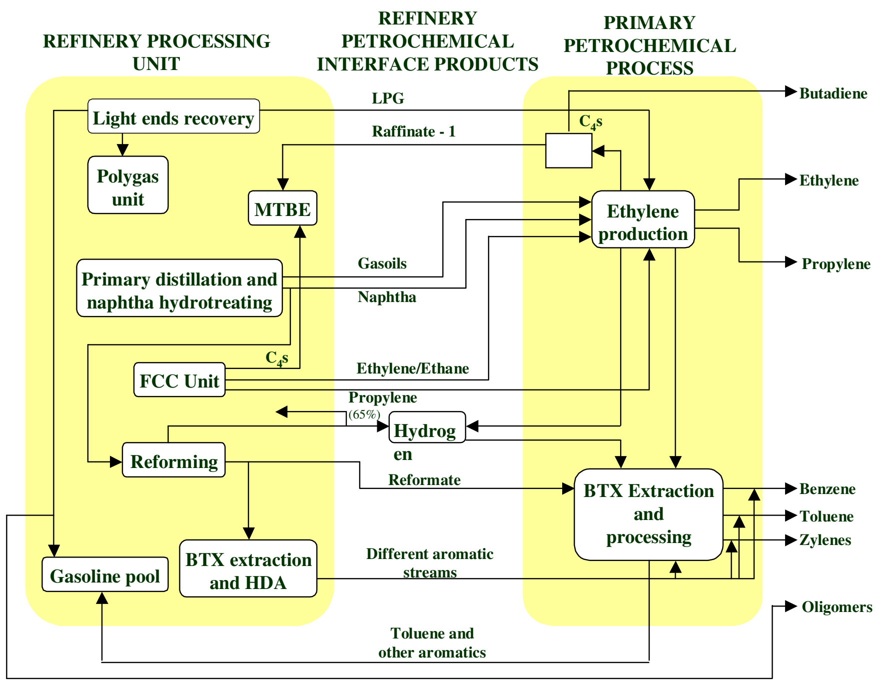


Figure 2.7: Different products obtained during different process

> ***However, it is important to note that extraction of crude oil is carried out mainly to supply the needs of transport and other sectors. Plastics only consume a small fraction - four percent - of the world's oil. This fraction is used so effectively that fossil fuel reserves last longer as a result. In fact, it is estimated that the use of plastics as a whole actually saves more oil than needed for their manufacture.***
>
> *(Source: APC: Environmental Protection Agency)*

Cracking of Naphtha to Produce Ethylene

Cracking is used in petroleum industry to reduce the molecular weight of hydrocarbon by breaking molecular bonds. Cracking is carried out by thermal, catalytic or hydro cracking. Thermal cracking depends on a free radical mechanism to cause scission of hydrocarbon carbon-carbon bonds and a reduction in molecular size, with the formation of olefins, paraffin and some aromatics. Side reaction such as radical saturation and polymerisation are controlled by regulating reaction conditions. In catalytic cracking, carbonium ions are formed on a catalyst surface, where bond scissions, isomerisations, hydrocarbon exchange and so on, yield lower olefins, paraffin, iso-olefins and aromatics.

Petroleum refining is a very developed process and every emission from refinery is highly controlled, so that it never exceeds the standard limits. Different types of emissions and their monitoring to guard emissions are given below.

Combustion related emission:

- *Nitrogen oxides control:* Nitrogen oxides from refineries are generated in the combustion process. A number of methods are there to reduce NO_x emissions, such as reducing the nitrogen in the feed, reducing the oxygen supply, but such an approach run the risks of increasing PM (Particulate Material) emissions- and reducing the combustion temperature. The most common method is by reducing the residence time, which, however, is the design feature of the burner.

- *Carbon dioxide control:* There is at present no treatment method for reducing CO_2 emissions.

- *Particulate control:* Particulate emissions from refineries come mainly from fuel combustion. Particulate emissions can be reduced by suitable changes to the burner or to fuel technology, or primary low cost techniques.

- *Process emission:* Particulate can be major emission from refinery process units. The main sources are catalytic cracking and cokers. In catalytic cracking, use of cyclones and electrostatic precipitators, and careful catalyst selection help to minimize the particulate emission. In coker process, the coke is maintained in a damp condition to minimize the condition of these fine particles.

- *Flare related emission:* Flares in refineries contribute to SO_x, NO_x and particulate emissions. These can be reduced by minimizing the hydrocarbons entering the flare at source and avoiding unnecessary flaring.

- *Fugitive emission:* These are volatile organic compounds that escape mainly from the process and off-site areas, such as tankage and oily water effluent treatment systems. Reduction in VOC emission can be achieved by using the technologies such as vapour recovery or internal floating decks in fixed roof tanks etc.

- *Control of aqueous emissions:* Refinery effluents can cause pollution of water by the release of contaminants, which are damaging to aquatic life. The major sources are process water, ballast water, rain water run-off and cooling water. The minimum treatment is to remove the free oil from the water.

Polymerization of Ethylene to produce LDPE/LLDPE

The polymerisation of ethylene is carried out using Zeiglar-Natta Catalyst or Metallocence catalysts. The reaction involved can be given as:

$$n\ CH_2{=}CH_2 \xrightarrow[\text{Heat}]{\text{Catalyst}} \left[CH_2 - CH_2 \right]_n$$

Ethylene Polyethylene

Ethylene + Co-monomers → LDPE or LLDPE

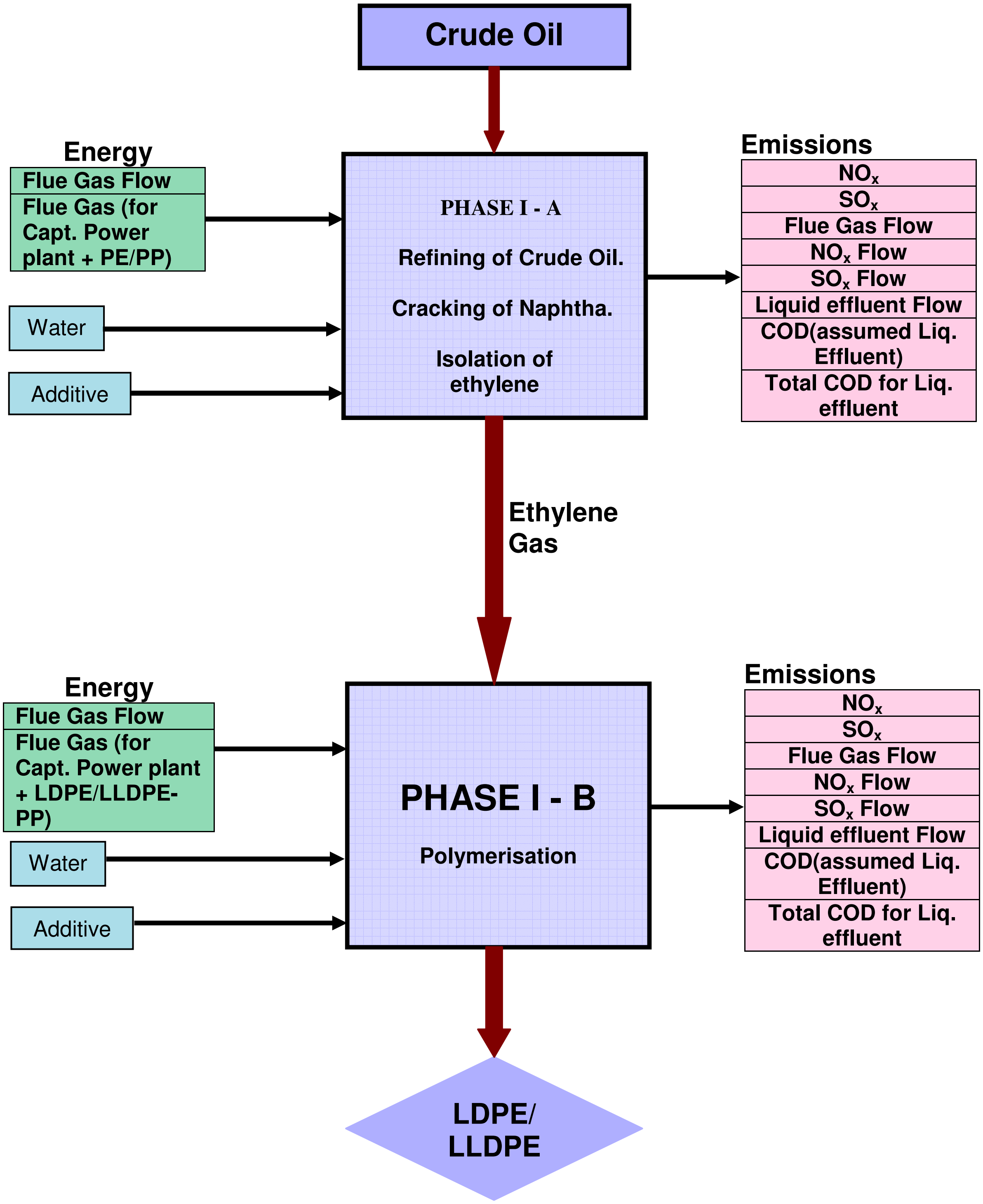
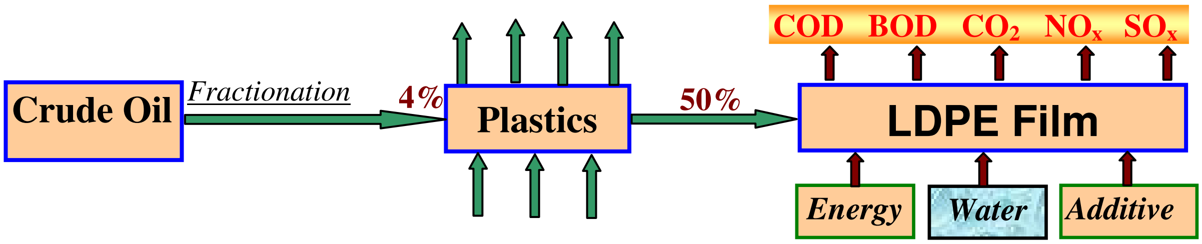


Figure 2.8: Flow Chart of input and output during Production of LDPE/LLDPEPellets.



Production of Plastic bags

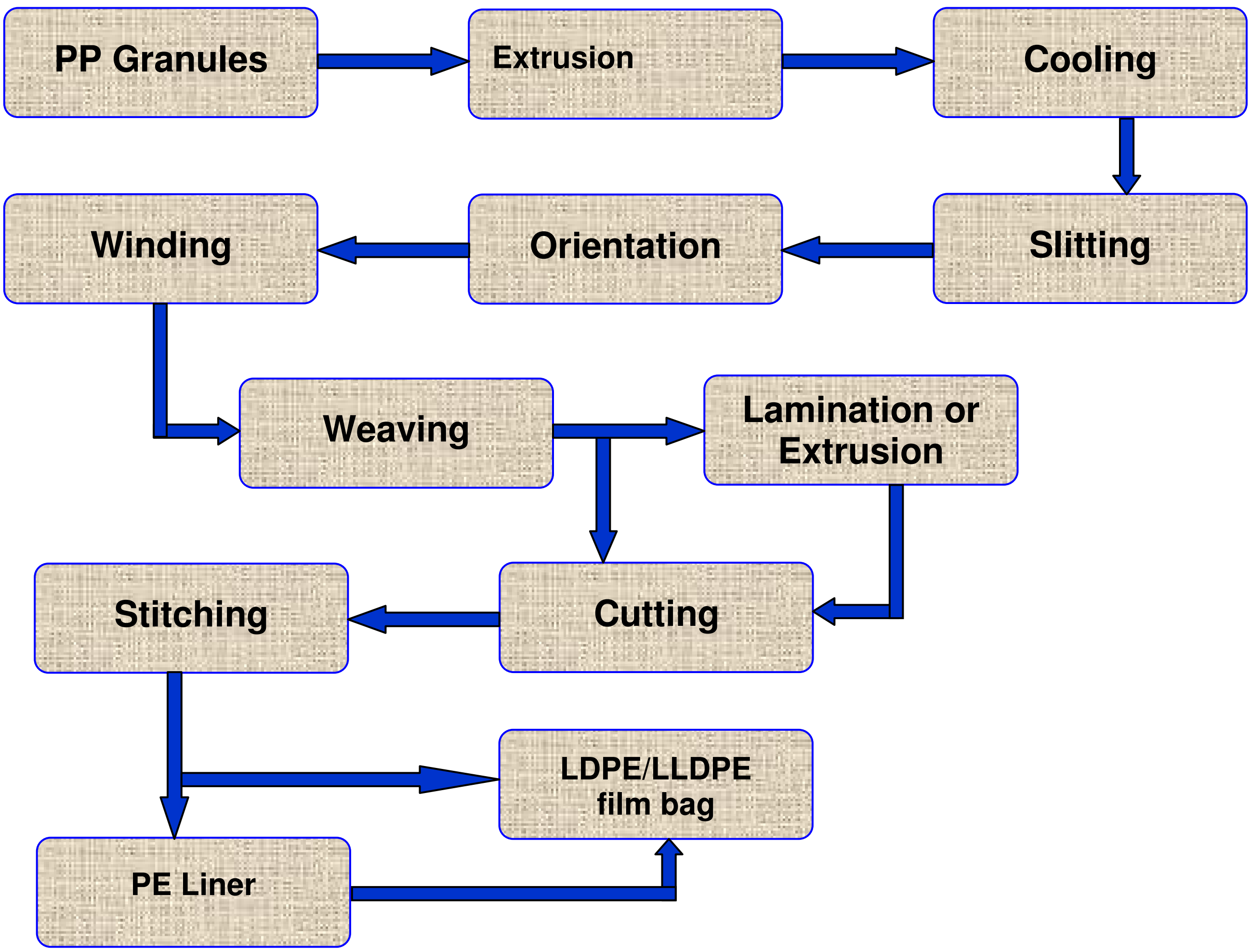


Figure 2.9: Flow Chart for Production of Plastic bags.

PROCESS FOR PRODUCTION OF PLASTIC BAGS

Manufacturing of Film

The granules of LDPE/LLDPE are fed to the extruder hopper, where they are plasticized and the melt is passed through a blown film die. Films are wound on cheese winders.

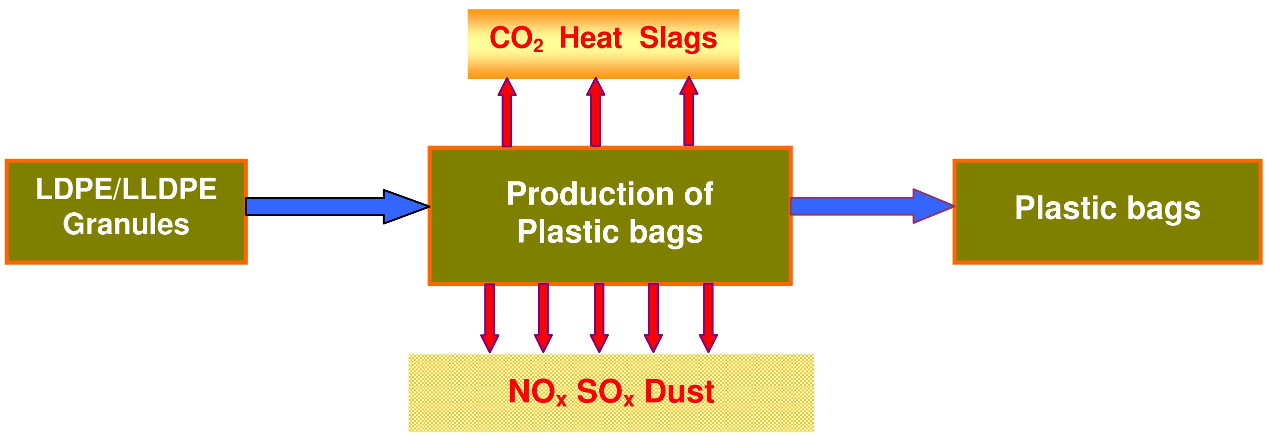
Blown Film Process: In this process the extruded materials flows through a tubular die, which is like a combination of an offset die and a pipe die in that the materials turns as it flows into the die thus providing access to the back of the die and allowing the extrudate to travel upwards. The upward motion is preferred because it makes the gravity uniform over the entire part. Downward extrusion would also accomplish this purpose but most extrusion operations have much more room overhead than below for the additional downstream equipment. The melt flows around a mandrel and exits the die as a tube. A cooling ring is placed at the exit of the die to give the tube some dimensional stability since the material is air-cooled rather than cooled in a water tank.

The treatment of the tube after it has exited the die is the critical part of the blown film process. Air is introduced through the back of the die and flows upward inside the middle of the tube of material. This flow pushes the tube outward. The tube, which is sometimes called the bubble, continues to expand, cool, and crystallize until the radial (tensile) strength of the plastic equals the pressure of the air inside or until some outer mechanical limit is reached. The cooling and crystallization increase the radial strength so that the bubble size is limited. The bubble continues upward with approximately the same shape (sometimes through basket of rollers or an external air chamber to ensure that the shape is constant). The bubble is then forced into a flat sheet by the collapsing guides (also called the tent frame) and moved into the nip roles. These rolls pinch the material together so that the bubble is maintained. The nip rolls also pull on the plastic in the same way that a puller system works with a traditional extrusion line. After the nip rollers, the material travels down over some rollers and enters the take-off equipment. The material can be perforated so that wind-up is still easy to accomplish. The high speed and continuous nature of this process often dictates that a two-station windup system be used for take-off. A depiction of a blown film line is given in the figure above.

The stretching and cooling of the tube causes the molecules to be oriented. The push of the internal air orients the molecules in the radial direction while the simultaneous pulling by the nip rolls orients the molecules in the machine direction. Blown films are, therefore, biaxially oriented. This orientation often causes some crystallization in the film. The amount of expansion of the bubble is important in controlling the process and predicting mechanical properties. Therefore, a parameter that measures the amount of expansion of the tube has been developed. This parameter is the blow-up ratio and is the ratio of the final tube diameter after blow-up to the diameter of the orifice of the die. Blow-up ratios of 3:1 are common. Most mechanical properties are increased as the blow-up ratio increases because orientation increases.

The cooling of the tube can be followed by the change in crystallinity that occurs with cooling or stretching. The material exiting the die is amorphous and clear. As it cools and stretches the molecules become more oriented and develop a closer-packed configuration, similar to crystalline structures. These close-packed structures reflect light and therefore become less transparent. The line on the bubble that marks the onset of this close-packed molecular arrangement can be identified by a loss of clarity (haziness). Because it looks like frost or freezing has occurred at that point, the line is called the frost line or the freeze line.

LIFE CYCLE INVENTORY DATA FOR PRODUCTION OF PLASTIC BAGS



Primary Properties of PP/LDPE/LLDPE used in producing Film bags are their chemical inertness and inertness to metabolic processes.

PP and LDPE/LLDPE used in producing Film bags are also the raw materials used for extremely critical and life saving medical applications e.g.,

- *Various bone joints like knee joints/caps, hip joints, heart valves etc;*
- *Syringes, blood pouches, IV fluid dispenser, sutures, medicine bottles, tablet packs and a whole lot of medical accessories;*
- *Packaging of milk products, vegetable oils, ghee, butter and many items of daily human consumptions;*
- *Newborn babies and infants (most susceptible to adverse environment) are fed in bottles made of PP as a daily routine.*

LDPE/LLDPE used for the manufacture of Film bags:

- *Meets the requirement stipulated in BIS standard IS:10146 on "Specification of Polyethylene and its copolymers for safe use in contact with foodstuff, pharmaceuticals and drinking water"*
- *Additives incorporated in LDPE/LLDPE conform to the positive list of constituents as prescribed in BIS standard IS:10141.*
- *The grade of additives incorporated in LDPE/LLDPE also comply with the FDA:CFR Title 21, 177.1520 Olefin Polymers.*

LIFE CYCLE INVENTORY DATA FOR PRODUCTION OF LDPE GRANULES AND FILM

The values given in the inventory data are obtained for production of LDPE granules starting from the extraction of crude oil.

Energy Required

Energy Requirement for making LLDPE film can be considered in the following headings:

- (i) Energy required to produce and deliver raw materials
- (ii) Energy required to produce LDPE/LLDPE resin
- (iii) Energy required to produce LDPE/LLDPE film

Energy required to produce/deliver raw materials (crude oil) = 48.30 MJ
Energy required to produce 1 kg LDPE/LLDPE resin = 32.27 MJ
Energy required to produce 1 kg LDPE/LLDPE film = 11.41 MJ

Gross energy required to produce 1 kg of LDPE/LLDPE Film: 91.98 MJ

Table 2.15: Gross energy in MJ required to produce 1 kg of low density polyethylene.

(Totals may not agree because of rounding)

Fuel type	Fuel production and delivery energy (MJ)	Energy content of delivered fuel (MJ)	Energy used in transport (MJ)	Feedstock energy (MJ)	Total energy (MJ)
Electricity	10.83	5.77	0.05	<0.01	16.65
Oil fuels	0.77	9.36	0.21	22.47	32.81
Other fuels	1.97	7.90	0.09	32.56	42.52
Totals	13.57	23.03	0.35	55.03	91.98

Water Required

Water required to produce/deliver raw materials (crude oil) = 00.34 L
Water required to produce 1 kg LDPE/LLDPE resin = 45.66 L
Water required to produce 1 kg LDPE/LLDPE film = 18.20 L

Total water required to produce 1 kg of LDPE/LLDPE Film: 64.20 L

Table 3.16: Gross primary fuels and feedstocks in MJ required to produce 1 kg of low density polyethylene.

Fuel type	Fuel production and delivery energy (MJ)	Energy content of delivered fuel (MJ)	Fuel used in transport (MJ)	Feedstock energy (MJ)	Total energy (MJ)
Coal	3.50	2.02	0.01	<0.01	5.53
Oil	1.14	9.62	0.27	22.47	33.50
Gas	4.23	9.93	0.07	30.21	44.43
Hydro	0.66	0.79	<0.01	-	1.45
Nuclear	3.83	1.94	<0.01	-	5.77
Lignite	0.07	0.05	<0.01	-	0.12
Wood	-	-	-	2.35	2.35
Sulfur	-	<0.01	<0.01	<0.01	<0.01
Biomass	0.05	0.04	<0.01	<0.01	0.09
Hydrogen	<0.01	0.11	<0.01	-	0.11
Recovered energy	-	-1.53	<0.01	-	-1.53
Unspecified	0.06	0.03	<0.01	-	0.09
Peat	0.04	0.03	<0.01	-	0.07
Totals	13.57	23.03	0.35	55.03	91.98

Table 2.17: Gross primary fuels and feedstocks in mg to produce 1 kg of low density Polethylene.

Fuel type	Input in mg
Crude oil	740,000
Gas/Condensate	840,000
Coal	200,000
Metallurgical coal	1,000
Lignite	7,900
Peat	7,400
Wood	530,000
Biomass	10,000

Raw Materials Required

Table 2.18: Gross raw materials in mg required to produce 1 kg of low density polyethylene.

Raw material	Input in mg
Air	110,000
Barytes	<1
Bauxite	920
Bentonite	48
Calcium sulfate	5
Clay	76
Dolomite	32
Feldspar	<1
Ferromanganese	2
Fluorspar	5
Granite	<1
Gravel	10
Iron	2,700
Lead	3
Limestone	2,000
Nitrogen	17,000
Olivine	24
Oxygen	74
Phosphate as P_2O_5	<1
Potassium chloride	1
Sand	230
Shale	13
Sodium chloride	1,400
Sulfur (bonded)	25
Sulfur (elemental)	56

Table 2.19: Gross water resources in mg required to produce 1 kg of low density polyethylene.

Source	Used for processing (mg)	Used for cooling (mg)	Totals (mg)
Public supply	5,100,000	-	5,100,000
River canal	2,000	130,000	130,000
Sea	74,000	25,000,000	25,000,000
Unspecified	440,000	33,000,000	33,000,000
Well	57	2,000	2,100
Totals	5,600,000	58,000,000	64,000,000

Emission:

Table 2.20: Gross air emissions in mg arising from the production of 1 kg of low density polyethylene.

Emission	From fuel production (mg)	From fuel use (mg)	From transport operations (mg)	From process operations (mg)	From biomass use (mg)	Totals (mg)
Dust	3,100	220	11	86	-	3,400
CO	610	730	130	72	-500,000	1,600
CO_2	1,300,000	1,100,000	18,000	7,000	-	1,900,000
SO_x	7,400	4,900	120	180	-	13,000
NO_x	7,700	4,000	180	58	-	12,000
N_2O	<1	<1	-	-	-	<1
Hydrocarbons	520	410	50	6,200	-	7,200
Methane	6,200	410	-	1,500	-	8,100
H_2S	-	-	-	3	-	3
HCl	110	1	-	1	-	110
Cl_2	-	-	-	<1	-	<1
HF	6	<1	-	<1	-	6
Lead (Pb)	-	<1	-	<1	-	<1
Metals	1	3	-	<1	-	4
F_2	-	-	-	<1	-	<1
Mertcaptans	-	<1	-	<1	-	<1
Organo-Cl	-	-	-	<1	-	<1
Aromatic HC	-	-	-	30	-	30
Polycyclic-HC	-	-	-	<1	-	<1
Other organics	-	-	-	19	-	19
CFC/HCFC	-	-	-	7	-	7
Aldehydes (CHO)	-	-	-	8	-	8
Hydrogen (H_2)	-	-	-	73	-	73
Mercury (Hg)	-	-	-	<1	-	<1
Ammonia (NH_3)	-	-	-	<1	-	<1

Table 2.21: Gross solid waste in mg arising from the production of 1 kg of low density polyethylene.

Type	From fuel production (mg)	From fuel use (mg)	From process operations (mg)	Totals (mg)
Mineral	37,000	-	5,600	43,000
Mixed industrial	410	-	1,700	2,100
Slags/ash	12,000	150	1,300	13,000
Inert chemical	1	-	530	530
Regulated chemical	25	-	1,500	1,600
Unspecified	<1	-	45,000	45,000
Construction	-	-	8	8
Metals	-		2,100	2,100
To incinerator	-	-	120	120
To recycling	-	-	6	6
Plastics	-	-	270	270
Wood waste	-	-	4,100	4,100

Table 2.22: Gross water pollution in mg arising from the production of 1 kg of low density polyethylene.

Emission	From fuel production (mg)	From fuel use (mg)	From transport operations (mg)	From process operations (mg)	Totals (mg)
COD	5	-	-	780	790
BOD	4	-	-	160	160
Acid (H^+)	1	-	-	63	65
Dissolved solids	74	-	-	91	160
Hydrocarbons	9	3	-	36	48
NH_4	1	-	-	7	9
Suspended solids	55	-	-	470	520
Phenol	4	-	-	1	4
Ca^{++}	-	-	-	1	1
Na^+	-	-	-	190	190
Metals-unspecified	<1	-	-	120	120
NO_3^-	-	-	-	5	5
Other nitrogen	<1	-	-	7	7
Cl^-	-	-	-	300	300
SO_4^{--}	-	-	-	89	89
CO_3^{--}	-	-	-	43	43
Phosphate as P_2O_5	-	-	-	5	5
Detergent/oil	-	-	-	180	180
Dissolved organics	-	-	-	38	38
Other organics	-	-	-	7	7
Sulfur/Sulfide	-	-	-	10	10

Table 2.23: Energy and Resource Consumption during production of Plastic Film Bags and Liner used for Packaging One lakh ton of 'Atta'

	Plastic Film Bag	
Material Required (Mt)	**680**	
	Energy (thousand GJ)	**Water (Thousand Tons)**
Phase I: Production of Raw Material	**38.36**	**264**
Phase II: Production of Bags & Liners	**24.22**	**296**
Total	**62.58**	**560**

Table 2.24: Emissions during Phase I and Phase II for production of Plastic Film Bags and Liner used for Packaging One lakh ton of 'Atta'

For 1 Lakh ton of 'Atta'		**LDPE Bag and Liner**
CO	kg	**0.6**
CO_2	kg	**760.0**
SO_x	kg	**5.2**
NO_x	kg	**4.8**
CH_4	kg	**3.2**
HCl	kg	**0.0**
Dust	kg	**1.4**
Suspended Solids	kg	**0.2**
Chlorides	kg	**0.1**

Usage (Packaging and Transportation)

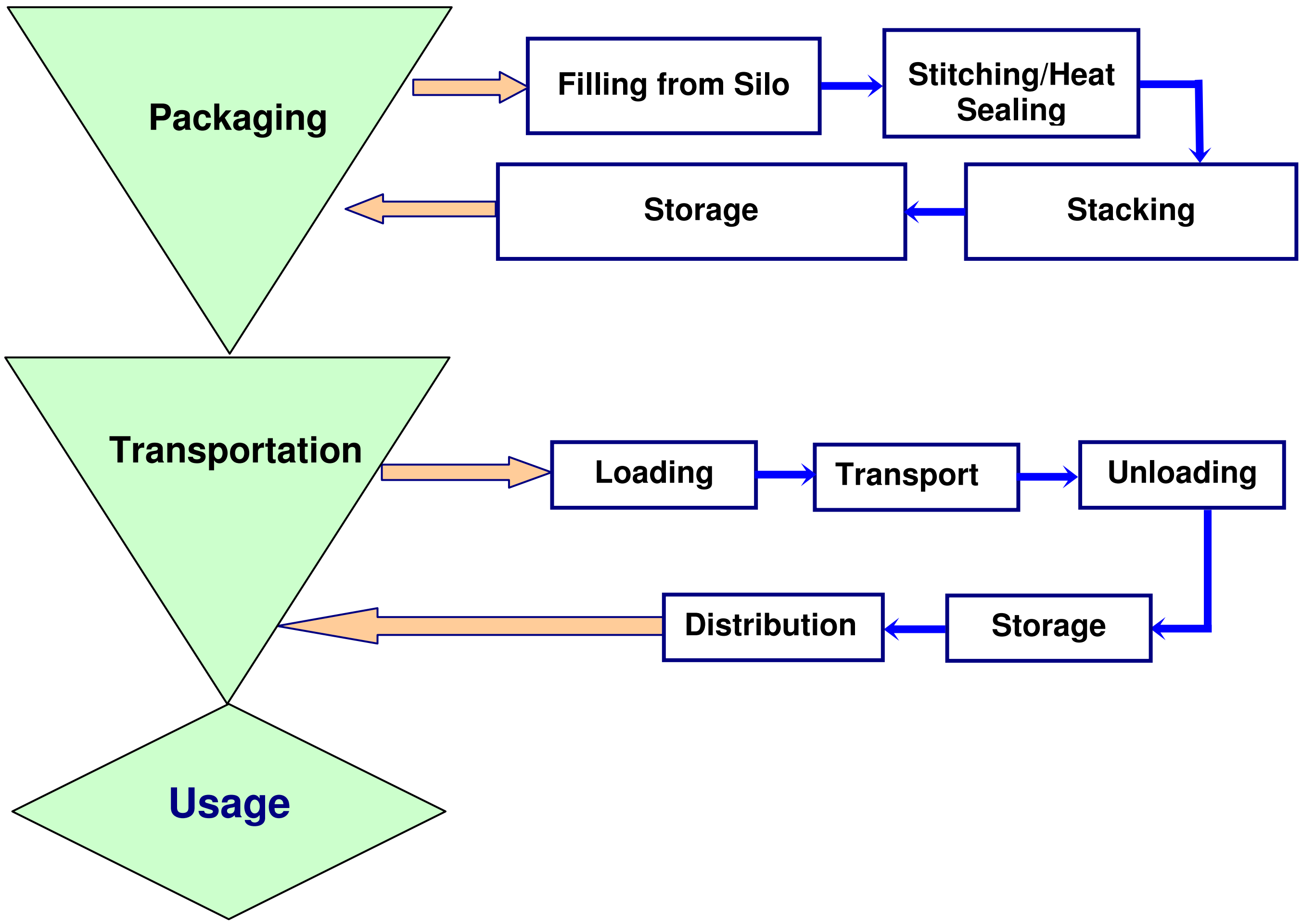


Figure 3.1: Flow Chart for Usage (Packaging & Transportation)

In this part of the report, initially brief description is given for production of different commodities in India and the calculation are carried out for packaging of packed Atta produced/manufactured per annum. The case studies involve packaging Atta in jute bag with liner and plastic film bags. Comparison has been made in terms of total truckload (trips) required to transport packed Atta in different packaging materials. The total fuel, energy required and total emissions generated are compared.

PACKAGING

In case of food products, the basic requirement for packaging material should be

- To prevent contamination of the packed edible items from the packaging material (or its constituents)
- Moisture resistance
- Rot resistance
- Good shelf life even under exposed or covered storage.
- Breathability

Other factors deciding the choice of the packaging materials are

- Better cost economics
- Easy availability of the packaging material
- Reusability to improve overall cost economics
- Subsidy borne by the Government.

Jute was a choice, when alternative packaging options did not exist. Plastic bags on the other hand provide the most cost effective and functionally superior alternative to traditional packaging alternatives.

Life Cycle Inventory Data for Packaging of 'Atta'

Table 3.1: Amount of Packaging Material required

Atta 1 lakh metric tonne	Wt. of Packaging Material Required	Total weight to be carried (Wt of Food grains + Wt of Bags)
In case if the total packaging is carried out in Jute Bags		
5 Kg Atta 98 gm Bag (Jute + Liner)	1960 ton (1720+240)	101960 ton
In case if the total packaging is carried out in Plastic		
5 Kg Atta 34 gm Bag (Plastic + Liner)	680 ton (480+200)	100680 ton

TRANSPORTATION

Road is a major mode of bulk commodity transport. Besides truck for long distances, local distribution is done in a variety of sizes ranging from small petrol driven pick-up to large diesel powered vehicles. Not surprisingly, the energy requirements of these vehicles vary considerably. The energy requirements for road transport can be considered as the sum of the fuel directly consumed by the vehicle on its journey with two other sub systems responsible - (a) the construction and maintenance of the vehicle and (b) the construction and maintenance of the roads. The energy requirement associated with the fuel consumption comprise some 70% of the total, construction and maintenance of the vehicle has been estimated as a further 22% and construction and maintenance of routes as 7%. As the inclusion of vehicle-road construction and maintenance energy had been much debated, its contribution has been excluded from the calculation in this report.

In this report, a truck with average fuel efficiency of 3.05 km/lit, has been considered as the standard vehicle for transportation of bulk commodities. The truck runs on diesel fuel and can carry 9MT of load.

The truck causes pollution while the fuel burns in the engine and from evaporation of the fuel itself. The main pollutants contributed by the trucks are carbon monoxide (CO), unburned hydrocarbons (HC), oxides of nitrogen (NOx), lead and particulate matter (PM) etc. Diesel fuels, without any additives, are mixtures of hydrocarbon compounds, which contain hydrogen and carbon atoms. In a perfect combustion process, where time of combustion is not a factor, oxygen in the air would convert all the hydrogen in the fuel to water and all the carbon in the fuel to carbon dioxide. The nitrogen in the air would remain unaffected.

However, the state of ideal thermodynamic equilibrium is never achieved in an automobile engine. The use of additives like sulphur in the fuel, short combustion time for chemical oxidation processes, lack of homogeneity and heterogeneity and rapid variation in temperature leads to the formation of some unwanted compounds. Added to these incomplete combustion products are oxides of nitrogen formed due to high temperature oxidation of the nitrogen present in the air fuel mixture. In simple terms, the combustion process in an automobile is never 'perfect' and thus leads to emissions of several types of pollutants. Emissions from a typical truck can be classified according to the sources of emission. The amount of emissions from a truck is presented in Figure 4.2 and health hazards are presented in Table 4.2.

Hydrocarbons

Hydrocarbon emissions result when fuel molecules in the engine do not burn or burn only partially. Hydrocarbons include a wide variety of compounds with varying impact on human health and with different reactivities in the tropospheric chemical conversions. In particular, unburnt hydrocarbon contains a large proportion of methane, which is inert in human health respect. Added to these are the oxygenated compounds, aldehydes, ketones, phenol, alcohol, nitromethane, esters etc., all of which are more reactive then methane. A number of these exhaust hydrocarbons are also toxic, with a potential to cause cancer. Hydrocarbon reacts in the presence of nitrogen oxides and sunlight to form ground-level ozone, a major component of smog. Ozone irritates the eyes, damages the lungs, and aggravates respiratory problems. It is one of the most widespread and intractable urban air pollution problem.

Nitrogen Oxides (NO_x)

Under high pressure and temperature conditions in an engine, nitrogen and oxygen atoms in the air react to form various nitrogen oxides. Nitric oxide (NO) and nitrogen dioxide (NO_2) are the main oxides formed during this reaction and are collectively grouped together as NO_x, in which NO largely predominates. The main source of NO is molecular nitrogen in the air used as a comburent feeding the engine. Diesel fuels contain too little nitrogen for their contribution to NO formation to be significant. Like hydrocarbons, NO_x are precursor to the formation of ozone. They also contribute to the formation of acid rain.

Carbon Monoxide:

Carbon monoxide (CO) is a product of incomplete combustion and occurs when carbon in the fuel is partially oxidised rather than fully oxidised to carbon dioxide (CO_2). The main parameter governing CO emissions is the fuel-air ratio. In a rich mixture, the CO concentration increases steadily with the fuel-air ratio and the lack of oxygen causes incomplete combustion. Carbon monoxide reduces the flow of oxygen in the bloodstream and is particularly dangerous to persons with a history of heart disease.

Carbon Dioxide:

In recent years carbon dioxide a product of 'perfect' combustion, is becoming a major pollution concern. Carbon dioxide does not directly impair human health but it is a 'green house gas' that traps the earth's heat and contributes to the global warming.

Suspended Particulate Matter (SPM)

Particulates are present in exhaust emission of CI engines (diesel engines) only and they are virtually absent in SI engines. Diesel particulates are composed of carbonaceous material (soot) generated during combustion. SPM is emerging as one of the most serious problem in India with regard to air pollution. There is a growing concern all over the world about particulate matter of size 10 micron and 2.5 micron or less. WHO has classified these as thoracic particles because these are respirable and lodged into the respiratory tracts.

Evaporative Emissions

Hydrocarbon pollutants also escape into the air through fuel evaporation. With today's exhaust emission controls and fuel formulation, evaporative losses can account for a substantial amount of the total hydrocarbon pollution from the vehicles on hot days. Evaporative emissions account for 15 to 25 % of total hydrocarbon emission from a fuel engine. The two main sources of evaporative emissions are the fuel tank and the carburettor. These occur in several ways:

Diurnal: Fuel evaporation increases as the temperature rises during the days, heating the fuel tank and venting fuel vapours.

Running Losses: The hot engine and exhaust system can vaporize fuel when the truck is running.

Hot Soak: The engine remains hot for a period of time after the truck is parked and fuel evaporating continues.

Refuelling: Fuel vapours are always present in fuel tanks. These vapours are forced out when the tank is being filled with liquid fuel.

The following graph shows the amount of different pollutants generated from a Truck:

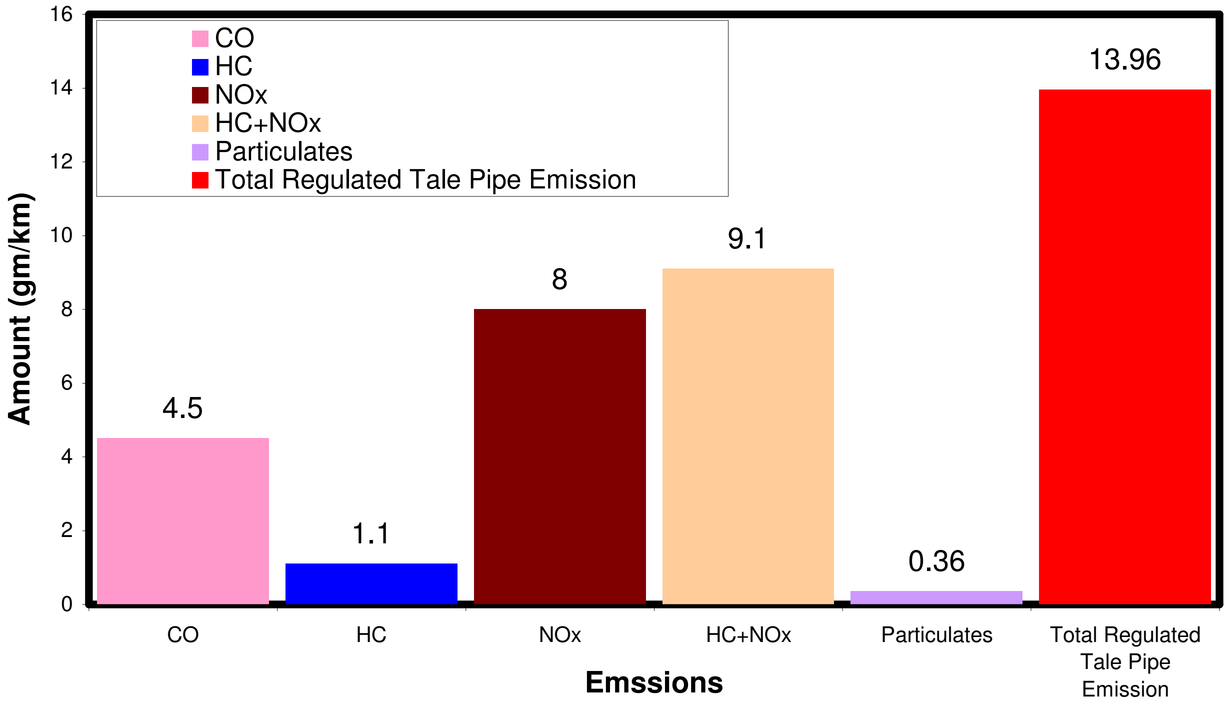


Figure 3.2: Different emissions from a truck

Table 3.2: Health Implications Of Automobile Pollution

Agent	Health/environmental implications
Oxides of Nitrogen	Respiratory tract irritation, bronchial hyperactivity, impairing lung defenses
Hydrocarbons	Lung cancer
Ozone	Cough, substantial discomfort, bronchoconstriction, decreased exercise performance, respiratory tract irritation
Sulphur dioxide	Exacerbation of asthma and COPD, respiratory tract irritation, hospitalisation may be necessary and death may result in cases of severe exposure
Lead	Impaired mental growth in children. Lead can affect mental development, blood chemistry, kidneys, nervous, reproductive and cardiovascular systems.
Particulates	The World Health Organization has concluded that, on a worldwide basis, suspended particulate matter is the most serious air pollutant which is resulting in a total excess mortality per year of about 4,60,000 additional deaths every year of which 1,35,000 are because of chronic obstructive pulmonary disease (COPD) or chronic asthma and about 90,000 due to cardiovascular diseases (CVD). Scientists also point out that it is not all particles that are equally dangerous. It is particles that are respirable (that is, less than 10 microns in size), that cause the major damage. Diesel vehicles are the biggest contributor to the particulate pollution.
Source: Dieter Schwela 1996, Health Effects of and Pollution Exposure to Air Pollutant: Global Aspects, Keynote Speech, World Congress on Air Pollution in Developing Countries, San Jose, 21-26 October, 1996, mimeo	

Life Cycle Inventory Data for Transportation of Bulk Commodities

Table 3.3: Number of truckloads (trips) required, excess fuel and energy consumption during transportation of 'Atta'

Atta 1Mt	Wt. of Packaging Material Required	Total weight to be carried (Wt of Food grains + Wt of Bags)	Total number of Trucks (truckloads) required
In case if the total packaging is carried out in Jute Bags			
5 Kg Atta 98 gm Bag (Jute + Liner)	1960 ton (1720+240)	101960 ton	11329
In case if the total packaging is carried out in Plastic			
5 Kg Atta 34 gm Bag (Plastic + Liner)	680 ton (480+200)	100680 ton	11187

Energy Required:

The total energy requirement for transportation of all the bulk commodities in different packaging materials is given in the following table. It can be seen from table the total loss of energy because of packaging in jute bags comes to **261129 MJ** in excess than compared to that of Plastic bags.

Table 3.4: Excess Energy and Fuel Required for Transportation

'Atta' 1 lakh tonne	Total number of Truckloads required	Excess Fuel Required* (litres)	Excess Energy Required* (MJ)
Jute Bags	**11329**	**4663**	**261129**
Plastic bags	**11187**	**Taken as Basis**	**Taken as Basis**

*per 100 km distance

Excess Environmental Burden

Excess fuel required in the case of packaging of all the bulk commodities in jute bags will cause sever environmental problem in the transportation as the amount of emissions generated per annum will be very high. Figure 5.16 presents the excess burden on the environment because of use of jute bags.

Table 3.5: Excess Emissions during Transportation of 1lakh metric ton of 'Atta'

Emissions	Amount* gm/km	Total* (kg/lakhtonne)	
		Jute Bags	Plastic Bags
CO_2	781	**11107.4**	Taken as basis
CO	4.5	**63.9**	Taken as basis
HC	1.1	**15.6**	Taken as basis
NO_x	8	**113.8**	Taken as basis
$HC+NO_x$	9.1	**129.4**	Taken as basis
Particulates	0.36	**5.2**	Taken as basis
Total Regulated Tail Pipe Emission	13.96	**198.5**	Taken as basis

**Only because of excess fuel used during the transportation phase.(Does not include emissions during fuel production phase and the emissions during the maintenance of roads (40% additional)*

WASTE MANAGEMENT

Waste is an inevitable product of society. Solid waste management practices were initially developed to avoid the adverse affects on public health that were being caused by the increasing amount of solid waste being discarded without appropriate collection or disposal. Managing this waste more effectively is now a need that society has to address. In dealing with the waste, there are two fundamental requirements: less waste and an effective system for managing the waste produced.

The Organization for Economic Cooperation and Development (OECD) defines waste in general terms as: 'Unavoidable material for which there is currently or no near future economic demand and for which treatment and/or disposal may be required'. The United Nation Environment Program (UNEP) defines waste as: 'objects which the owner does not want, need or use any longer, which required treatment and/or disposal'. The European Community broadly defines waste as: 'any substance or object which the holder disposes of or is required to dispose of pursuant to the provisions of the national law in force'.

Waste management in case of bulk commodity packaging materials involves four different techniques:

- Reuse
- Recycle
- Landfill
- Waste to energy

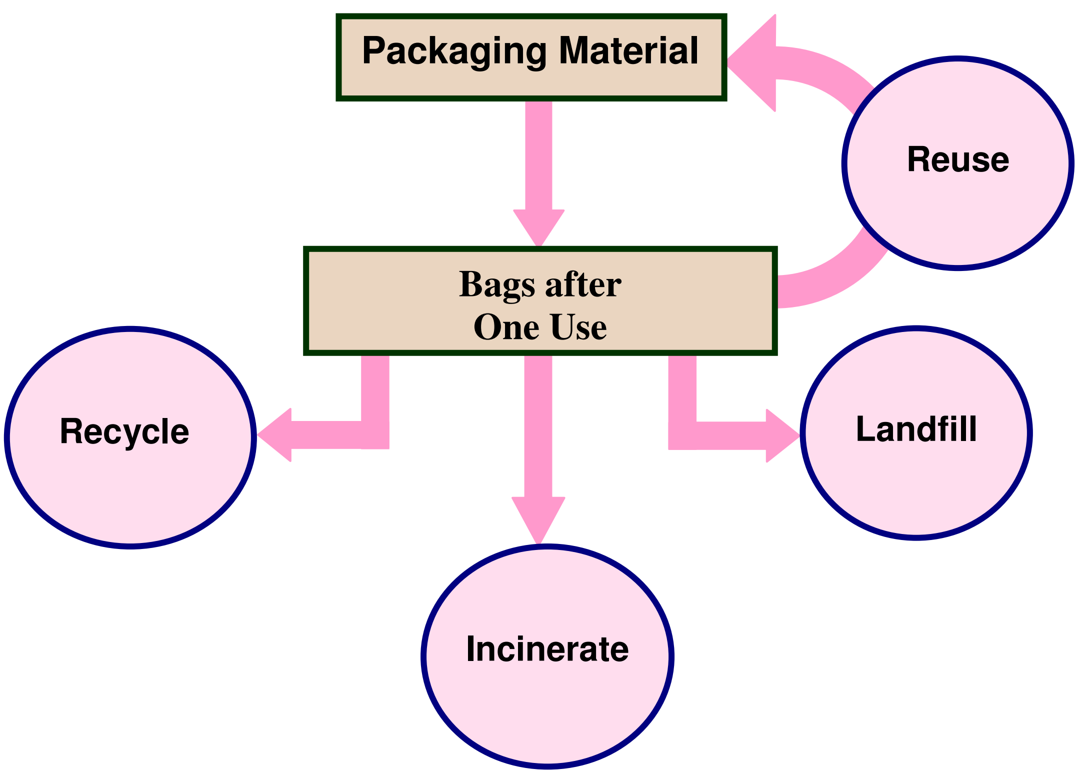


Figure 4.1: Different Techniques of Managing Waste

In case of packaging material used in bulk commodities, the waste generated after one packaging does not go to the mainstream of general waste. The bags are reused, recycled or can be made to go for landfilling or incineration.

Generation of Less Waste: Concept of 'More with Less'

The Brundtland report of the United Nations, Our Common Future (WCED, 1987), clearly explained how sustainable development could only be achieved if society in general and industry in particular, learn to produce 'more from less'; more goods and services from less of the resources, while generating less pollution and waste.

In this era of 'green consumerism' (Elkington and Hailes, 1988; Elkington, 1997), this concept of 'more from less' has been taken up by industry. This has resulted in a range of concentrated products, light-weighted packaging, reduction of transport packaging and other innovations (Hindle et al, 1993; IGD, 1994; EPU, 1998). Production as well as product changes have been introduced, with many companies using internal recycling of materials as part of solid waste minimization schemes.

All of these measures help to reduce the amount of solid waste produced, either as industrial, commercial or domestic waste. In essence, they are improvements in efficiency, i.e., 'eco-efficiency', whether in terms of materials or energy consumption. The cost of the raw materials and energy and rising disposal costs for commercial and industrial waste will ensure that waste reduction continues to be pursued in industry for economic as well as environmental reasons.

'Waste minimization', 'waste reduction' or 'source reduction' is usually placed at the top of the conventional waste management hierarchy. In reality, however, source reduction is a necessary precursor of effective waste management rather than part of it. Source reduction will affect the volume and to some extent the nature of the waste, but there will still be waste for disposal

As shown in the figure 4.2, the amount of packaging material required per MMT of commodities will be much higher in case of use of jute bags than compared to LDPE/LLDPE film bag. This extra amount of material used will put extra burden on the waste management at the end of the life of packaging material. The use of Jute/Paper bags goes against the concept of 'More with Less', as one is required to use more packaging material packed with lesser commodities.

REUSE

Jute Bags ✗ **Plastic Bags** ✗

Jute bags and Plastic bags after first use, cannot be reused to pack edible commodities, as they will result in a significant contamination by the wheat flour (residue). These bags are smaller in size than that used in packaging bulk commodities therefore are not reused in packaging of non-critical foodstuff such as, groundnut etc. Same problems are there for the reuse of Plastic bags.

Waste Disposal Techniques

The three principal disposal methods - recycling, incineration and landfill - are not so much alternative options, dealing with the totality of the waste arising, as complementary techniques, each being most effective with a specific part of the total waste. Hence, to employ the techniques in parallel is to produce the most effective economic and environmentally sensitive solution to the specific needs industry and society at large. This is the basis of an integrated waste strategy.

Recycling

Jute Bags ✗ **Plastic Bags** ✓

There is no practice to recycle jute bags. However plastic bags can be recycled and various industries are making useful domestic products from these bags. In fact, the new life starts for plastic bags after recycling.

The availability of long-term outlets for the sale of recycled material is prime requirement for the adoption of this technique. Materials collected for recycling into new products is often of relatively low bulk density, when collected, and transportation costs can be prohibitive if the reception points are not suitably located. The quantity of material to be sold is very relevant and this is best achieved by the collection of community source separated waste in order to avoid contamination. The materials to be recycled are best handled and processed in a central plant catering for communities of between 250000 and 500000 people. Only at this level can effective tonnages of each material be brought together and scale benefit be obtained from mechanization of the sorting processes. Depending on the market for paper and cardboard, the recycled materials could amount to between 20% and 40% of the total waste arisings.

Recycling of Plastic Bags

There are two types of plastics recycling systems

Primary recycling:

It involves using uniform, uncontaminated plastics waste to manufacture plastic products of same or similar types. Much fabricator scrap, commonly blended with virgin resin in various ratios, is used in primary recycling but sometimes used alone.

Secondary Recycling:

Postconsumer plastic bags are used for this type of recycling. This involves granulation, cleaning and sometimes recompounding and palletizing to form different products such as small packaging, brushes, scrubbers and twines (Figure 6.2). Other useful products that can be made from recycling of plastic bags are toys, detergent bottles etc.

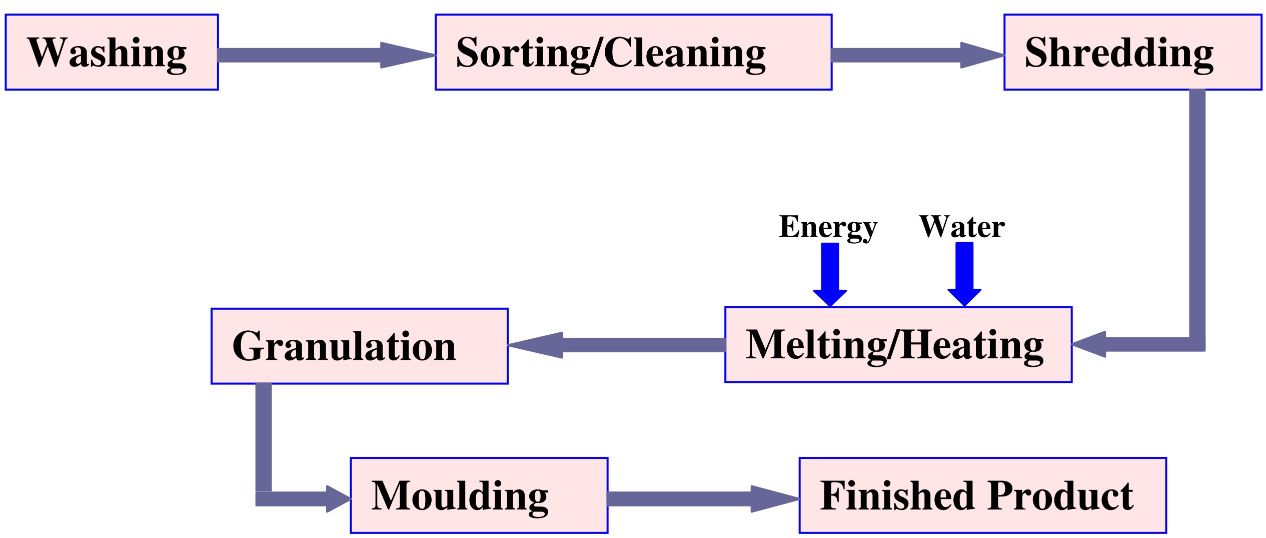


Figure 4.2: Different operations involved during Recycling of Plastic Bags

Incentives for using recycled plastics include ecological reasons, consumer demand, recycle content legislation and lower cost. Until recently, these incentives have had to be weighted against variable material composition, possibility of contamination, loss of mechanical properties due to degradation, lack of standards and variations in the supply. Now many of these problems have been solved through such measures as the use of sophisticated automated sorting, restabilization, implementation of recyclate quality standards and integrated collection networks. The three essential elements of plastics recycling are: (i) a stable supply source which involves reliable collection and sortation; (ii) an economical, proven and environmentally sound recycling process; and (iii) end-use applications for the recycled plastics which yield economic market values and capture consumer confidence. ***For all recycled products, a separate life cycle starts and therefore new cradle to plastic bags. The correct term to describe the life cycle analysis of plastic bags can be "cradle to cradle" as there is no grave for the bags.***

Table 4.1: Recycling of 1 kg of Packaging Material

	Recycled LDPE/kg produced
Energy Saving* (MJ)	**25.3**
Emissions (g)	
CO_2	353
NO_x	0.98
SO_x	2.00
Solid waste (kg)	0.13
BOD	2.36
COD	4.62
Suspended Solid	-
Total Organic Compounds	-

** Compared to making the product by Virgin Material*

Table 4.2: Energy Savings in Recycling of Plastic Bags used for Packaging of One Lakh Ton of 'Atta'

Phase IV: Waste Management	**Jute**	**Plastic Film Bags**
Recycling Percent	**Energy Savings**	**Energy Savings** (thousand GJ/680ton)
100%	**Not Done**	**17.20**
80%		**13.76**

Total Energy Savings for 100% Recycling: 17.20 thousand GJ/680tonne
Total Energy Savings for 80% Recycling: 13.76 thousand GJ/680tonne

Incineration (Waste-to-Energy)

Jute Bags ✗

Plastic Bags ✓

The techniques for burning refuse have been improved immeasurably over recent years from the crude fixed cell incinerators of the 1930s. Incineration without energy recovery is not an environmentally acceptable solution since the material resources are simply destroyed without any effective recovery.

Incineration with heat and power generation overcomes this weakness and may be the most effective method of disposal for our major conurbations in the future. However, such a plant is not economic below an annual input of 0.25 million tonnes. This quantity of waste represent the arisings from a population of nearly one million people and only in our major centres of population does this concentration of development exist within an effective transportation distance of the chosen site.

As already mentioned, emission standards for flue gases are going to be very stringent in the European Community countries, and these will only be met by a high capital investment in flue gas scrubbing equipment. Incineration will continue to be the most expensive of all the techniques.

Plastics and Waste-to-Energy

Plastics for the most part are derived from petroleum and natural gas and have heating values measured in British thermal units (BTUs) competitive with coal and heating oil and superior to wood, paper, and other biomass fuels. Because of their high heating value, the residual plastics in MSW provide an excellent fuel for modern waste-to-energy plants. Residual plastics mean those plastics that remain in MSW after some plastic is diverted from MSW for environmentally and economically sound material recovery. Even in communities with extensive recycling, residual plastics at less than 10 percent by weight of MSW can provide over 20 percent of the fuel value for a local WTE plant.

A detailed European study has recently documented the ability of plastics to improve combustion in a modern WTE plant. The study also looked at the contribution of plastics to air emissions. This was done by intentionally adding plastics to the regular MSW feed to the plant and carefully monitoring the release of pollutants. Plastics were shown to have no negative effect on air pollution loads to the environment. The study included a specific examination of dioxin and furan emissions.

Table 4.3: Incineration of 1 kg of Packaging Material as waste

	Jute Bags	Plastic Bags
Energy Generated (MJ)	-	51.83

Table 4.4: Energy generated during Incineration of Packaging Material as waste used for Packaging One Lakh Ton of 'Atta'

Phase IV: Waste Management	Jute	Plastic Film Bags
Incineration	Energy Recovered	Energy Recovered (thousand GJ/680ton)
100%	Not Done	35.24
80%		28.12

Total Energy Savings for 100% Incineration: 35.24 thousand GJ/680tonne
Total Energy Savings for 80% Incineration: 28.12 thousand GJ/680tonne

Landfill

Jute Bags ✗ **Plastic Bags** ✗

Commodity packaging waste generally does not go for landfilling and therefore this technique of waste disposal has no significant meaning in context with the packaging material used in commodities like 'Atta' packaging. Modern techniques for landfill require the cell to receive the waste, to be lined with a leachate barrier formed of puddled clay and high-density polyethylene (LDPE/LLDPE). The technology is expensive but is not the main obstacle to the establishment of future landfill sites.

Crude tipping practices of the recent past have deserved a hostile reception from the local communities. A 'not in my back yard' (NIMBY) syndrome in addition to the environmental damage foreseen by local residents from increased vehicle usage results in the major obstacle to future creation of landfill sites. However, new sites will have to be created, because without them organic as well as inorganic waste will have no effective disposal outlet. Landfill disposal costs will, in many countries, probably double or treble in the future.

The concerns over waste

The old concern – the conservation of resources

In 1972, the best-selling book "Limits To Growth" was published. It argued that the usage rates of the earth's finite material and energy resources could not continue indefinitely. The sequel, beyond the limits told the same story, but with increased urgency; raw materials are being used at a faster rate than they are being replaced or alternatives are being found. The result of such reports was the development of the concept of Sustainable Development. Sustainability requires that the natural resources be efficiently managed, and where possible conserved, but not to the detriment of the individuals quality of life.

The original concerns of Meadows et. Al., about the imminent depletion of natural resources has proved to be incorrect. For each raw material, the proven reserves in 1989 were greater than proven reserves in 1970. This is because 'proven reserves' are defined as reserves that could be extracted with today's technology and price structures. Technology and innovation have resulted in most resources being more available, at a lower extraction cost today than 20 years ago. Consumption has changed in favour of less material-intensive products and services-'eco-efficiency'. Energy efficiency has improved with technological advances and the recycling of many raw materials have increased the efficiency of material used. These factors have led to slow use of material than many economies. The per capita use of basic materials such as steel, timber and copper has stabilized in most OECD countries – and even declined in some countries for some products. This is not to argue that resources can never be depleted to unacceptable levels but in most cases, the time period required for this to happen is extremely long, allowing time for the implementation of technological developments.

The new concerns – pollution and the deterioration of renewables

The depletion of non-renewables is now not the urgent problem but two other concerns have become critical with respect to the 'need of future generations'. These are:

- The generation of pollution and wastes that exceed the ability of the planet's natural sinks to absorb and convert them into harmless compounds and
- The increased deterioration of renewables such as water, soil, forests, fish stock and biodiversity.

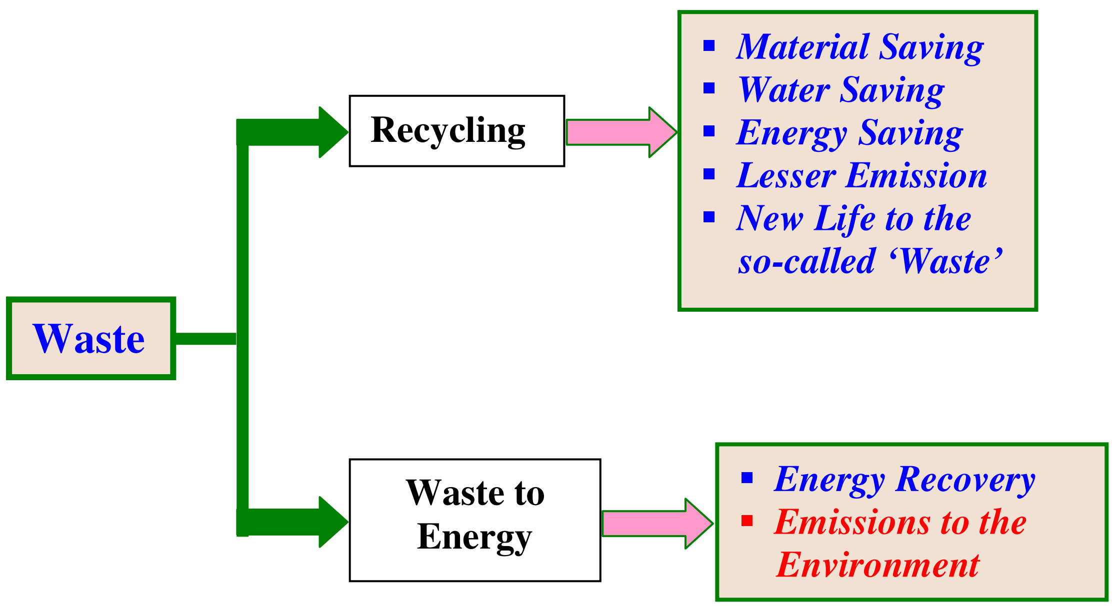
A Life Cycle Inventory Model for Integrated Waste Management:

The model's most obvious uses are waste management scenario optimization and comparisons. The actual data needs of the model are small, as wherever possible default data are provided. Although it must be emphasized that more data that can be supplied by the user to describe the waste management system under study, the more accurate the result will be. The model requires data on the number of inhabitant and household the study area and the amount of waste generated per person per year. It would tell waste characterization of the area under study. The goal of this model is to be able to predict the environmental burdens and economic cost of this specific waste management system. The scope of this model is to enable a Life Cycle Inventory of a specific waste management system to be carried out. The unit processes included within the model are waste generation, waste collection, sorting processes, biological treatment, thermal treatment, landfill and energy generation.

The calculations for life cycle inventory data were made using the IWM-2 model and then the values were averaged on per kg basis for different bulk packaging materials.

Table 4.5: Life Cycle Inventory table for Waste Management

	Reuse	Recycling	Incineration	Landfilling
Jute Bags	✗	✗	✗	✗
Plastic Bags	✗	✓	✓	✗



Conclusions

Detailed scenario of use of Jute Bags and Plastic Film Bags as packaging materials for 'Atta' using life cycle analysis as the principal methodology has been covered in this study. Life cycle analysis using cradle to grave approach has been used to assess and compare the benefits for different packaging material by identifying inputs and outputs in the different phases of the life cycle. In this study analysis has been carried out by dividing the total life cycle in four different phases and the energy consumed or recovered and emissions released or absorbed are considered in totality as much as possible.

It is to be noted a priori that a comparison of this nature can only be of real importance when contribution for each sector involved in the birth to death of a material is considered fully and without any bias. Hence the following issues become very-very pertinent:

- Crude oil which is the basic input to the Plastic Pouches is not processed only for making LDPE/LLDPE, it has to be fractionated anyway in order for the generation of various fuels and feedstocks for the interest of consumers mostly for transportation and energy generation. Moreover only 2% of the total crude oil processing is required for the generation of feedstock for Plastic Pouches.

- Although jute is a natural product, its cultivation requires fertilizers, insecticides and chemicals which involve a number of other energy intensive processes and related health hazards.

- Jute being biodegradable may offer some benefits when goes to landfilling but this will result in overall burden on the environment because of need of more jute bags will result in more energy consumption in raw material production, bag manufacture and usage phases. Moreover, landfilling will take up land that can be utilised for agriculture, industrial purposes.

- The basis of this study has been considered as one lakh tonne of Atta in keeping with the view of the consumption in order of magnitude.

Keeping above facts in view, the conclusion arising out of the study can be listed as follows:

1. It can be seen that production of Jute bags requires more energy than plastic film bags for packing equal amount of Atta. This is due to the more weight of jute bags required to pack the same amount of Atta. **The relative weight of only packaging material itself amounts to 1960 Mt for jute when compared with 680 Mt of Plastic for packing one lakh tonne of Atta.**

2. **Energy consumption in the case of plastic film bags in Phase I (production of raw material) is greater than that for the jute bags.** This is due to high feedstock energy values of the polyethylene used to make plastic film bags. Water consumption is huge in case of production of jute than that of plastic film bags.

	Jute Bags	Plastic Film Bag
Material Required (Mt)	**1960**	**680**
Phases of Life Cycle Analysis	**Energy** (Thousand GJ)	**Energy** (Thousand GJ)
Phase I: Production of Raw Material	**21.50**	**38.36**
Phase II: Production of Bags & Liners	**47.19**	**24.22**
Total	**68.69**	**62.58**

3. **Phase – II of the life cycle analysis shows that the production of jute bags is energy intensive and in this respect, Plastic film bags consume less energy.** This is again due to the more material required to be processed in case of manufacture of jute bags than that in case of plastic film bags. It is to be noted that the water requirement for manufacturing glass bottles is significantly high as compared to that for plastic pouches.

Phases of Life Cycle Analysis	Jute Bags	Plastic Film Bag
	Water (Thousand Tons)	**Water** (Thousand Tons)
Phase I: Production of Raw Material	**1677**	**264**
Phase II: Production of Bags & Liners	**1506**	**296**
Total	**3183**	**560**

4. Considering Phase – I and Phase – II together for packaging of onelakh tonne of Atta the energy required to produce bottles/pouches can be assessed as:

$$\textbf{Energy}_{\textbf{Jute Bags}} > \textbf{Energy}_{\textbf{LDPE/LLDPE}} \textbf{ (6000GJ more for Jute Bags)}$$
$$\textbf{Water}_{\textbf{Jute Bags}} > \textbf{Water}_{\textbf{LDPE/LLDPE}} \textbf{ (}\sim\textbf{6 times more for Jute Bags)}$$

5. The pollution of water during the production of Plastic film bags is negligible while it is very high in case jute bags.

6. **The release of chemicals into water is very high for the production of jute bags as indicated by the high value of COD. Also the BOD attains**

very high values during the time of retting leading to bad odour and also make difficult for the fishes to survive. The COD and BOD values are found to be low in case of production of plastic film bags.

7. **On the energy front during transportation there is considerable saving in the use of plastic film bags for Atta packaging** as these are lighter in weight than jute bags and the vehicles transporting them have to make lesser number of trips for moving the same amount of material, thereby reducing fuel consumption. The pollution associated with movement of transport vehicle is also reduced correspondingly.

8. **Reuse of Jute bags and plastic film bags is not the viable option** as this will lead to mixing of Atta particles with the repacked material. Also being small in size it is not the common practice to reuse them.

9. Recycling of jute bags is not carried out, however, some use in the filling of furniture (cushioning) etc. has been found. **There is a considerable amount of energy savings in case of recycling of plastic film bags being about ~14000 GJ for 80% recycling compared to making the same product using virgin material.**

Phase IV: Waste Management	Jute	Plastic Film Bags
Recycling Percent	**Energy Savings**	**Energy Savings** (thousand GJ/680ton)
100%	**Not Done**	**17.20**
80%		**13.76**

10. **Incineration of plastic film bags leads to considerable energy generation.** This is again due to very high calorific value of the LDPE/LLDPE used to manufacture plastic film bags. The amount of energy generated is in the tune of 35000 GJ for 100 % incineration. Recalculating the energy consumption in plastic film bags, taking into account the energy generated during incineration, it can be said that plastic bags consume half the energy consumed by the jute bags.

Phase IV: Waste Management	Jute	Plastic Film Bags
Incineration	**Energy Recovered**	**Energy Recovered** (thousand GJ/680ton)
100%	**Not Done**	**35.24**
80%		**28.12**

One issue that need to be highlighted is the protection of Atta from the external atmosphere. Plastic bags are hygienic, strong, attractive, convenient, easily available and easy to handle. The protection is very effective in case of plastic film bags and packaging in jute bags requires same plastic film to make it protected.

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