CHAPTER I

GENERAL INTRODUCTION

1.1. History of paper production

The tradition of paper making started in China around the year 105 AD, using cellulose fibre from flax, cotton and other vegetable sources. Over the centuries, different raw materials have been used and industrial revolution has facilitated laborious manual operation from one sheet at a time to continuous production in large scale using computerized processing control. The essential principle of paper and paper board manufacturing has however remained the same. Worldwide, the pulp and paper industry is huge and technically diverse operating a wide variety of manufacture processes on a range of fibre types from tropical hardwoods to straw. The annual global paper and paperboard production is more than 382 million tons. It is expected to increase 490 million tons by 2020 (Pulp and Paper International, 2005). The global pulp and paper industry consists of about 5000 industrial pulp and paper mills and an equal number of very small mills.

India, due to its burgeoning population, is under tremendous pressure to meet the ever-growing multifarious demands for pulp and paper products. There are 6666 pulp and paper mills manufacturing paper and paper boards in India, of which 632 units are agro-residue and recycled fibre based units (Central Pulp and Paper Research Institute, 2005). Pulp and paper mills constitute the largest manufacturing sector in the country, providing thousands of high-paid jobs.

1.2 Paper and paperboard manufacturing

The primary raw material in paper manufacture is cellulose fibre. Wood consists of approximately 50 per cent cellulose, 30 per cent lignin (a resinous adhesive which holds the fibres together) and 20 per cent aromatic hydrocarbons and hemicellulose, carbohydrates. In order to obtain cellulose in usable form for paper manufacture, the wood or plant material must be pulped to separate the fibres and remove impurities. The higher cellulose content of the pulp and longer fibres make better quality of paper. Hardwoods generally contain a higher proportion of cellulose but shorter fibre length than softwoods,
which are more resinous. Hardwood species like Eucalyptus, Poplar, Acacia, Subabul, Casuarina, and soft woods like Pine are used for manufacturing of paper and paperboard. Generally, the manufacturing of paper and paperboard from the wood involves both chemical and mechanical pulping.

**Wood based Paper and paperboard manufacturing**

**Chemical Pulping**

Kraft or sulphate pulping is the dominant method of pulp production in the world by virtue of its versatility and the high strength, long fibre, very low lignin content pulp it produces. The process involves boiling wood chips in a sodium hydroxide (caustic soda) and sodium liquor. This separates the lignin and wood resins from the cellulose fibre pulp, which is then washed and if necessary, bleached. The majority of Kraft mills operate in closed loop system whereby 95 - 98 per cent of the chemicals used in the process are recovered and reused. This means that in comparison with other processes, small amounts of chemicals are needed to produce large amounts of pulp. About 20 kg of sodium sulphate and 75 kg of calcium carbonate are required per ton of pulp. The waste products from the process are generally burned to provide energy (Kroesa, 1990). Each ton of wood chips used yields about 0.5 ton of pulp (compared to 0.9 - 0.95 ton for mechanical pulp). Another major disadvantage of Kraft pulp is that, due to its dark colour, it requires strong bleaching agents if it is destined to become white paper.

Sulphite pulping is another chemical method which uses similar equipment to Kraft but involves a different chemical process. The resulting pulp is characteristically strong, soft and lighter in colour than Kraft pulp thus requiring less bleaching its major end use being tissue products. Sulphuric acid or hydrogen sulphite is used to 'cook' the raw material in a liquor with a reactive metal base (usually calcium, magnesium or sodium) or ammonium to produce an acid sulphite or bisulphite pulp. Whilst, closed loop systems can be applied to sulphite processes, they are dependent on the base metal used. In general terms, chemical recovery rates for sulphite pulping are not as high as for Kraft although in terms of energy use sulphite has the slight edge with roughly equivalent pulp yields. Water consumption for both chemical pulping methods is high (Pulp and Paper International, 2005)
**Mechanical Pulping**

This is the most basic form of pulping and simply involves the grinding of debarked logs or chips to separate the fibres. The quality of the pulp is low as the fibres produced are broken by the grinding and still surrounded by lignin. Mechanical pulp is largely used for newsprint and paper products which require little tear strength. Whilst, the pulp yield per ton of wood is much higher than chemical pulping, the amount of imported energy required is approximately double that required by the chemical process water consumption however, is roughly one third of the amount required by chemical pulpmills (UNEP, 1982).

**Paper and paperboard from non-wood fibre**

In addition to wood-based fibres, a wide variety of non-wood material is used worldwide in the manufacture of paper. Whilst, worldwide production of non-wood pulp is estimated at 5 - 11 per cent of total fibre produced, its use is very regionalized, being concentrated almost exclusively in less developed countries which have few forest resources and whose paper consumption is comparatively low (IIED, 1996).

Essentially three categories of plants are used in non-wood fibre production, although in theory almost any fibrous plant can be used.

1. Annual fibre crops: Hemp, Kenaf, Flax and Jute
2. Agricultural residue: Wheat, Corn or Rice Straw, Bagasse and Sisal
3. Wild plants: Grasses, Bamboo and Seaweed

The physical characteristics of non-wood fibres are significant when the conventional chemical pulping process is used, particularly the higher silica and hemicellulose content and thinner fibres. Lower lignin levels in non-wood fibres are an advantage in mechanical and Chemo-Thermomechanical pulping, as less energy is required to remove it. However, with mechanical pulping the lignin is the primary 'fuel' in the black liquor combustion so, as such, less energy will be recovered. Lower lignin levels also have the advantage that correspondingly less bleach and energy will be required if the pulp is brightened, dependent upon the pulping process used. Chemical and energy recovery are fundamental to modern closed-loop chemical plants. In non-wood fibre pulping, the so-called 'black liquor' comprising pulping chemicals, lignin and other
residues becomes contaminated by silica, which significantly reduces efficiency. Without chemical recovery, the organic residues cannot be incinerated to provide energy, more chemicals are needed, and effluent loads are very much higher. Other important characteristics of non-wood fibres include higher hemicellulose content which combined with longer fibre lengths and the high silica content, causes black liquor to be more viscous, leading to poor drainage of the pulp. Reported pulp yields of non-wood fibre are highly variable and dependent upon fibre type, process etc. Mechanical pulping yields upto of 90 per cent compared to wood pulp and chemically pulped kenaf which yields 44 - 70 per cent and similar to the equivalent in Eucalyptus yield of 53 per cent (www.foe.co.uk).

**Paper and paperboard from recycled fibre**

The use of waste paper as an input for pulp and paper began as an environmental friendly initiative and gained acceptance world-wide. Globally wastepaper is the second largest source of fibre for papermaking after wood. Waste paper currently constitutes about 35 per cent of the global fibre furnish. Global trends in the last decade point to a steady rise in the consumption of wastepaper. According to the FAO’s Global Forest Products outlook study, wastepaper will become the single largest source of fibre in the global fibre furnish by 2011, overtaking wood fibres. According to FAO’s estimates, the contribution of wastepaper to the global fibre furnish by 2020 will be 46 per cent 2.5 per cent higher than wood. Different types of wastepaper required to produce different grades of paper and boards are given in table 1.1.

**Table 1.1. Different types of wastepaper are required to produce different grades of paper and board (Anon, 1996)**

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Grade of Wastepaper</th>
<th>Type of product</th>
<th>End-use of pulp</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mixed domestic wastepaper</td>
<td>Coarse, only modestly clean pulp</td>
<td>Corrugated medium</td>
</tr>
<tr>
<td>2</td>
<td>Commercial wastepaper and Magazine</td>
<td>High quality pulp, type depends on waste</td>
<td>Printing and writing grades, special packaging boards</td>
</tr>
<tr>
<td>3</td>
<td>Old newspapers</td>
<td>Clean, modestly bright pulp</td>
<td>Newsprint and low grade printing papers</td>
</tr>
<tr>
<td>4</td>
<td>Old corrugated containers</td>
<td>Strong brown pulp</td>
<td>Corrugated medium and linerboard</td>
</tr>
<tr>
<td>5</td>
<td>Selected wood free wastepaper</td>
<td>Strong bright and clean pulp</td>
<td>High quality papers</td>
</tr>
</tbody>
</table>
Asia is currently the leader in utilizing waste paper for paper and paperboard production. Wastepaper utilization rate (total wastepaper utilized/total paper and paperboard consumed) is more than 55 per cent. Western Europe is slowly catching up with Asia. Its wastepaper utilization rate was 52 per cent in 2001. In 2002, the wastepaper utilization rate in producing newsprint in Western Europe was 73.2 per cent. This is, of the total newsprint consumed during previous year, 73.2 percent was recovered and utilized in producing newsprints. The wastepaper utilization rate for case material production in Western Europe in 2002 was whooping 91.4 percent. Therefore, wastepaper has completely replaced the virgin fibre pulp in the production of case material. The development has continued all through the 1980s and 1990s and will continue in the future (CSE, 2004a).

Another area where wastepaper has pushed chemical pulp out is in tissue paper production. In 2002, the wastepaper utilization rate for household and sanitary paper production in Western Europe was as high as 60.6 per cent. The only area where wastepaper is not seen as a major threat to virgin pulp is in writing and printing paper segment. In 2002, the wastepaper utilization rate for graphics paper production in Western Europe was just 8.6 per cent. The low utilization of waste paper in the production of writing and printing paper production is primarily because of its inferior fibre quality (CSE, 2004b).

1.3. Indian Pulp and Paper Industry

Indian Mills consume a variety of raw materials; from forest based raw materials like wood and bamboo, to grasses, agro-residues like bagasse, rice straw, wheat straw and jute, recyclables like wastepaper and sawmill waste to imported market pulp. In fact, everything that can be pulped is used by the Indian paper industries. Mills in India are likely to use at least a combination of two or more types of raw materials. This is one of the greatest strengths of the Indian Paper industry.

Mills using wood in India use multiple wood species unlike the use of a single species in European and US Mills. There is large variety in the species of wood that are used. Hardwoods like Eucalyptus, Poplar, Acacia, Subabul, Casuarina and soft woods like
Pine are used by the Indian Paper Industry. The multitude of raw materials used by the Indian paper industry can be clubbed into three major categories:

**Forest-based raw materials:** Mainly include mixed hard-wood and bamboo from government forests (including wood from joint forest management), government plantations and farm and social forestry. The farm and social forestry sector, in which trees are grown by farmers on farmland and the produce is sold to the pulp and paper industry, is slowly becoming the major source of wood for the industry.

**Agricultural residues:** Agricultural residues are an importation alternative raw material. Currently about 1.3 to 1.5 million tons of agro residues are used annually by the industry. The main agricultural residues utilized include bagasse, wheat and rice straws. After meeting all other requirements India has the potential to produce 14 million tons of pulp from agro–residues annually.

**Wastepaper:** Imported as well as domestic wastepaper is slowly catching up with forest-based raw materials and is likely to become the single-largest fibre source for the Indian paper industry in the future. Wastepaper based mills currently account for about one third of the Indian paper capacity. The domestic recovery of wastepaper has increased from 0.65 million ton in 1995 to 0.85 million ton in 2000 (CSC, 2004c). Most of the paper is recovered, but due to alternative uses, the recovery rate for the paper industry is still only about 20 per cent, which is very low by international standards. Multiple use of wastepaper (wrapping papers, packaging and other applications) is common in India, and often these end users pay a better price for wastepaper than the paper industry. Wastepaper recovery and trading is unorganized in India. The collection is done by individual dealers. As a result recovery does not keep pace with recycled paper utilization, resulting in massive in imports (FAO(a)).

The amount of wastepaper products we use in our daily lives can be assessed from the fact that more than one-third of the total raw materials used in paper production. More than two-third of Indian paper mills use wastepaper as primary fibre for paper and paperboard production. The logic for using wastepaper is very simple – paper fibre can
safely be recycled at least four to five times; to let it get into landfills after using it only once is an extravagance.

1.4. Major pulp and paper industries in India

Total numbers of pulp and paper mills 706 numbers
Wood based mills 33 numbers
Agro based mills 165 numbers
Recycled paper based mills 508 numbers
Installed capacity of mills 8.3 Million ton
Production of paper and paper board 6.0 Million ton
Production of News sprint 0.8 Million ton

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Wood Based Paper Mills</th>
<th>Agro based</th>
<th>Recycled fibre based mills</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ITC</td>
<td>Shreyans Industries</td>
<td>Khanna Paper Mill</td>
</tr>
<tr>
<td>2</td>
<td>Bilt</td>
<td>Abhishek Paper Division</td>
<td>Bilt Graphics, Bhigwan</td>
</tr>
<tr>
<td>4</td>
<td>JK Paper Ltd (Rayagada)</td>
<td>Satia Papers</td>
<td>Amaravati Sri Venkatesh</td>
</tr>
<tr>
<td>5</td>
<td>Orient Paper mllls</td>
<td>A.B.C Paper</td>
<td>Pudumjee P&amp; P Mill</td>
</tr>
<tr>
<td>6</td>
<td>Andhra Pradesh Paper Mill</td>
<td>Delta Paper Mill</td>
<td>Ruby Macons</td>
</tr>
<tr>
<td>7</td>
<td>Sirpur Paper Mills</td>
<td>Chadha Papers</td>
<td>Nepa Paper</td>
</tr>
<tr>
<td>8</td>
<td>Star Paper Mills</td>
<td>Sainsons Papers</td>
<td>Bilt APR Packaging (Ashti)</td>
</tr>
<tr>
<td>9</td>
<td>West Coast Paper Mills</td>
<td>Ruchira Papers</td>
<td>Khatema Fibres</td>
</tr>
<tr>
<td>10</td>
<td>Mysore Paper Mills</td>
<td>Mukerian Papers</td>
<td>RCF Based Mills</td>
</tr>
<tr>
<td>11</td>
<td>Tamilnadu Newsprint &amp; Papers Ltd</td>
<td>Pudumjee Agro</td>
<td>Balkrishna Paper Mill</td>
</tr>
<tr>
<td>12</td>
<td>Hindustan News Print Ltd</td>
<td>Emami Papers</td>
<td>Gayatri Shakti</td>
</tr>
<tr>
<td>13</td>
<td>Century Paper Mills</td>
<td>-</td>
<td>ITC PSPD, Kovai</td>
</tr>
<tr>
<td>14</td>
<td>Seshasayee Paper &amp; Boards Limited</td>
<td>-</td>
<td>Sun Paper</td>
</tr>
<tr>
<td>15</td>
<td>-</td>
<td>-</td>
<td>GVG Paper</td>
</tr>
<tr>
<td>16</td>
<td>-</td>
<td>-</td>
<td>Khanna Paper Mill</td>
</tr>
</tbody>
</table>

(Source: Central Pulp and Paper Research Institute, 2005)
1.5. Indian Scenario of waste paper

In 1970, only about 40,000 tons of wastepaper was used for papermaking in India. In 2002, the industry used more than 2.1 million tons, an increase of over 50 times (FAO(b)). Wastepaper in India is used mainly to manufacture paperboards, Kraft paper and newsprint. The bulk of recycled paper is used for packaging. In 2001, 70 per cent of the mills in India depended on wastepaper to meet their fibre requirement and they together produced 37 per cent of the paper and board produced in the country. With less energy consumption and waste generation than wood based mills, a high ratio of production and little chemical consumption, recycling mills make good business and environmental sense. Historically large-scale Indian mills have depended on forest-based raw materials to meet their requirements. However, in the last 20 years there is a slow shift towards capacity addition based on wastepaper. Wastepaper use in the large scale segment has increased over the years (CSE, 2004d). In 2002, only about 20 per cent of the total paper and paperboard consumed was recovered and utilized for papermaking. This did not even meet 40 per cent of the total wastepaper demand in the country and therefore most wastepaper mills in India are heavily dependent on imports (CSE, 2004e).

Waste paper imports have increased in leaps and bounds in the last 20 years. From importing just 17,000 tons wastepaper in 1981, imports have increased to 1.32 million tons is 2002; more than 76 times in the last two decades. In India there is no organized effort to collect wastepaper. One of the serious drawbacks of the wastepaper recovery system in India is that the wastepaper is not segregated at source, largely because of the unorganized nature of collection and segregation. Domestic wastepaper therefore lacks quality control and is highly contaminated. This seriously jeopardizes the possibility of utilizing it as feedstock for making good quality paper. Industry is not keen to get into wastepaper collection and sorting operations because of its de-centralized nature. It would rather buy imported wastepaper than to invest in formal wastepaper collection and sorting. But considering the social and economic benefits, it is in the interest of companies to work towards downstream integration (CSE, 2004f). There are 12 large-scale mills in India that use wastepaper. Only four of these mills are completely dependent on wastepaper.
1.6. Major pollution from the pulp and paper manufacturing industry

It was in the 1990’s that the industry sector witnessed a quantum jump in growth due to certain liberal industrial policies, but this came unbridled pollution which grew at a rate faster than industrial growth. The most common organic pollutants in effluents are cellulose fibre, carbohydrate, starch and hemi-cellulose. The levels of these pollutants are measured by the Biological Oxygen Demand (BOD) or Chemical Oxygen Demand (COD). COD discharge can range from 25 - 125 kg/ton of pulp (IIED, 1995). This depletes oxygen available to fauna and flora. High levels of suspended solids also cause problems of both water opacity and blanketing of river or lake beds. Severe blanketing may also result in anaerobic decomposition under the blanket releasing hydrogen sulphide into the aquatic ecosystem. These problems are reasonably localized. However, organic solids can also absorb many of the toxins present in mill effluents, such as resin and fatty acids and heavy metals. This can have long-term effects over a wider area as a result of bioaccumulation and transportation through the food chain.

Emissions from recycling plants are much more limited than those for virgin pulp and paper mills and have less environmental impact. Pre-treatment levels of suspended solids and Biological Oxygen Demand (BOD) are likely to be higher in de-inked recycled effluents than virgin pulp effluents but, more significantly, Chemical Oxygen Demand (COD) and Adsorbable Organic Halogens (AOX) are likely to be lower. Non de-inked recycled fibre effluents show significantly lower Total Suspended Solids (TSS), BOD and COD than de-inked effluent. Hence BOD and TSS levels will be higher when the lower grades of paper used. However, technology is available to remove most of these pollutants from effluent streams. Heavy metals in recycling mill effluents are also a cause for concern. Metals such as copper, chromium, lead, zinc, nickel and cadmium are commonly used in printing inks and are discharged not only to wastewater but also to waste sludges and some remain in the final paper product. Dioxins and Furans do occur in re-pulped effluent, although little is known about their precise source recycling reduces dioxin emissions by reducing demand for bleached wood pulp.

Air emissions from chemical pulp mills are primarily made up of particulates, hydrogen sulphide, oxides of sulphur and oxides of nitrogen. Micro-pollutants include
chloroform, dioxins and furans, other organochlorines and other volatile organics. Gaseous and particulate emissions to air from the recycled paper making process primarily come from the incineration of de-inking sludges and fuel combustion. Direct emissions from the process itself are minimal and considered to be relatively insignificant (www.foe.co.uk).

Solid waste from paper manufacture ranges from 10-250 kg/ton (dry equivalent). Disposal is usually to landfill, although incineration is becoming increasingly widespread. Other experimental disposal techniques include using the waste as a soil improver but, as with all disposal options; there is some concern about possible dioxin and heavy metal contamination (IIED, 1996).

Relatively large amounts of solid waste result from the production of recycled paper although, obviously, overall recycling reduces waste volume. This waste comes in the form of bale wrappers and wire, sorting rejects and, more significantly, pulping and de-inking sludge, comprising water, cellulose fibre, fillers and ink. The amount of waste is dependent upon paper source and product type but is typically 15-100 kg solid waste and 90 kg (newsprint) to 520 kg (tissues) sludge per ton of de-inked recycled paper. Traditionally, this waste has been consigned to landfill. Incineration is becoming more widespread but is an unsatisfactory solution as burning sludge produces a relatively high proportion of ash and gaseous emissions. Other disposal options in the initial stages of development include composting and techniques to remove clay and other fillers for reuse are also being developed (CSE, 2004g).

**Objectives of the present study**

Recycling paper decreases the demand for virgin pulp and thus reduces the overall amount of air and water pollution associated with paper manufacture. Although, waste paper recycling emerged as viable alternative for virgin paper production, by-products released during paper recycling process such as effluent, sludge, gaseous and particulate air pollutants also causes environmental pollution to certain extent. However, information on inventory of recycled paper production, environmental impact and its management are dismally modest in India. In this context, the present work focused on inventory analysis, impact assessment and various environmental management initiatives related to recycled
paper board manufacturing at ITC Limited, PSPD, Unit: Kovai, Tamil Nadu, India with the following objectives,

- To conduct inventory analysis for paper boards production
- To investigate environmental impacts of paper boards production
- To find out the suitable environmental management practices.