BACKGROUND & TECHNOLOGICAL TRENDS IN INDIAN PAPER INDUSTRY

(VOL-II)

PREPARED FOR

DEVELOPMENT COUNCIL FOR
PAPER, PULP & ALLIED INDUSTRIES

BY

CENTRAL PULP & PAPER RESEARCH INSTITUTE
P.O. BOX-174, SAHARANPUR (U.P.) - 247001

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JAN.'1996

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CHAPTER- 1

BACKGROUND OF PAPER INDUSTRY IN INDIA

1.0 INTRODUCTION :

Paper manufacture in India started in the beginning of 20th century, and today we have nearly 380 paper and paper board mills with an aggregate capacity of nearly 3.96 million tonnes. There are 7 large Newsprint mills and 16 other mills registered with Registrar, Newsprint producing around 4,00,000 tonnes of newsprint annually. Our per capita paper consumption is still very low at 3.2 Kg/annum against a world average of 44 Kgs.

There are three distinct segments of the industry namely, forest based, agro based and 'others' primarily based on waste paper & secondary fibres. Presently, forest based units constitute 38% of capacity, agro-based units 36% and others 26%.

India's demand of paper and board is projected to grow from the present level of 2.6 million tonnes to 4.2 million tonnes by the turn of century and 6.0 million tonnes by the year 2010 A.D. Pattern of consumption comprising of nearly 45% as cultural varieties & 55% as industrial & packaging varieties has started undergoing a shift towards the latter in tune with the structural changes in our economy. (Source:Paper Asia,May'95)

With the shortage of forest based raw materials their use is declining sharply. From 84% share in 1970, the forest based production is currently at 38%. Indian paper mills were originally designed for processing bamboo. As the supplies dwindled, mills were forced to use hardwoods. This compelled them to go in for modifications and modernisation of processing facilities. Over the years, Indian Paper Industry has resorted to short term planning specially in augmenting the sustained raw material supply and organised efforts by Industry has not been made before the actual raw material crisis began in early 70's.

On account of constraints regarding the availability of forest based raw materials, large scale use of bagasse and other agricultural cellulosic materials are being encouraged. Besides, raw material Indian Paper industries till recently has perforce adopted process techniques & process equipments which are not ideal in processing of type of raw materials used by paper industry.

Today,the industrial outlook has focussed on two imporant areas -

- The quality consciousness and
- Improved environmental standards.

The environmental pressure are mounting day by day with new environmental legislations coming in to force. Looking to the environmental legislation & also the social aspect, industry has to make consorted efforts to create high quality environmental standards.

Today, we need environment friendly industry and improvement in process technology and equipment has to be ensured for reduction of pollution at source.

2.0 EARLY DEVELOPMENTS:

Paper industry is one of the oldest industries established in India. Before the advent of machine made paper a sizeable hand made paper manufacture flourished in India. The earliest efforts at mechanizing this industry in our country dates back to the beginning of 19th century. First paper mill was set up at Sorampur, West Bengal in the year 1812. The first fourdrinier type machine was introduced in 1832.

At the beginning of 20th century, India's production of paper was estimated at 19,000 tonnes. By 1913, as many as seven mills were in production with a total output of about 25,000 tonnes. The raw materials in common use were sabai-grass, hemp, rags and jute. Wood pulp was also imported for use in these mills. Production of paper from 1924 onwards was largely based on bamboo as raw material.

By 1930-31, annual capacity for paper production increased to 45,000 tonnes. The share of indigenous productions in the national consumption of paper increased to 71% in that year. Important varieties of paper in production were:

- Printing Paper
- Writing Paper
- Badami Paper and
- Wrapping Paper

In the course of next 15-16 years, additional varieties of paper that came into production included kraft paper, blotting papers & bank papers. Also imported

wood pulp had been almost wholly substituted by pulp made from bamboo, sabai-grass, waste paper, old rags, cloth cuttings and hemp.

Gradual rise in the output of paper from the level of 25,000 tonnes in 1913 to about 100,000 tonnes in 1943 is shown below:

1931	—	40,000 tonnes
1941	—	95,000 tonnes
1943	—	102,000 tonnes

Rapid developments of capacity for the manufacture of paper, in fact, started taking place from these years onward when the country's economic and industrial development was taken up on a planned basis. This industry has today secured for itself an important place in the industrial structure of the economy and now is one of the core industries (Paperex'93).

3.0 PRESENT STATUS OF INDIAN PAPER INDUSTRY:

3.1 Growth of Paper & Paper Board:

Capacity & production of paper and paper boards during the past four decades is shown in Fig -1.1 & 1.2.

A bigger increase in the installed capacity (6.7% per annum) compared to demand (5.5% per annum) led to a gradual decline in capacity utilisation of the Industry. Over all by 1994-95,due to faster growth in capacity (7% per annum) vis-a-vis demand the average capacity utilisation declined to 63% from a peak of 99% in 1970-71.

Shortage of raw material, the absence of adequate modernisation programmes and environmental legislation led to the closure of number of small & large mills.

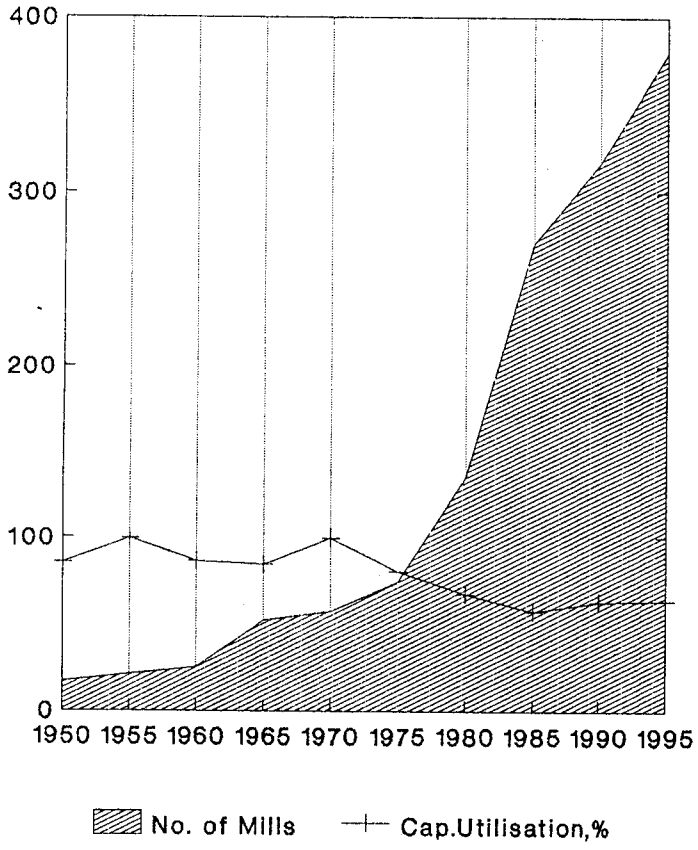
A substantial portion of the capacity increase came from agro and waste paper based units. This was the result of Govt.'s efforts to save the dwindling forest resources and subsequently to meet the growing paper demand. However, most of the units that were set up had very old machinery and in most cases the wood based machinery was modified for using agro residues.

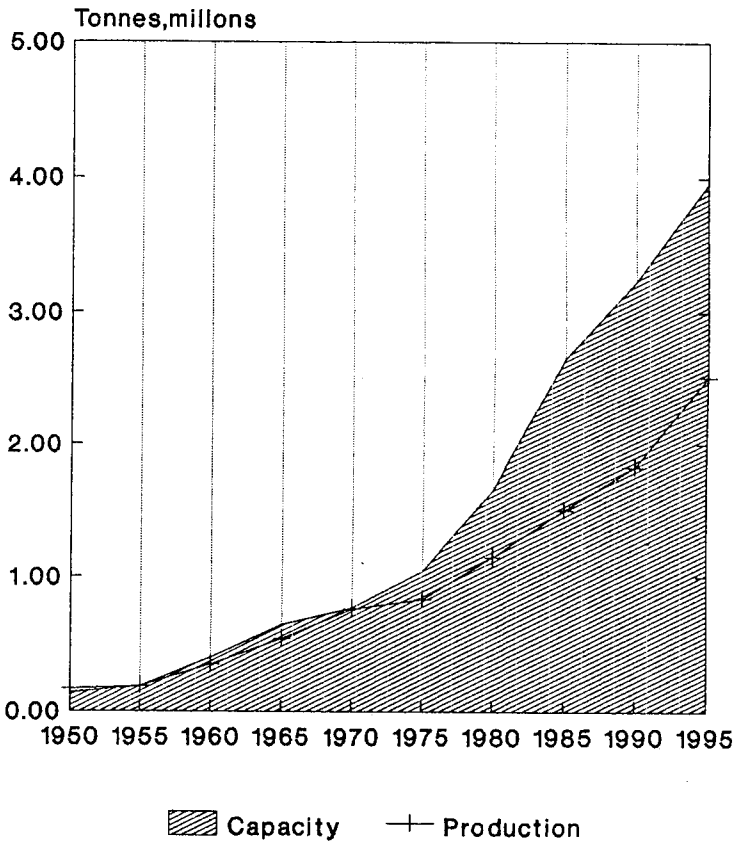
3.2 Categorisation of Mills :

Large paper mills in India, are invariably based on bamboo, wood and other forest raw materials, although there are some wood based mills which have a

FIG.1.1 CAPACITY AND PRODUCTION OF PAPER & PAPER BOARD

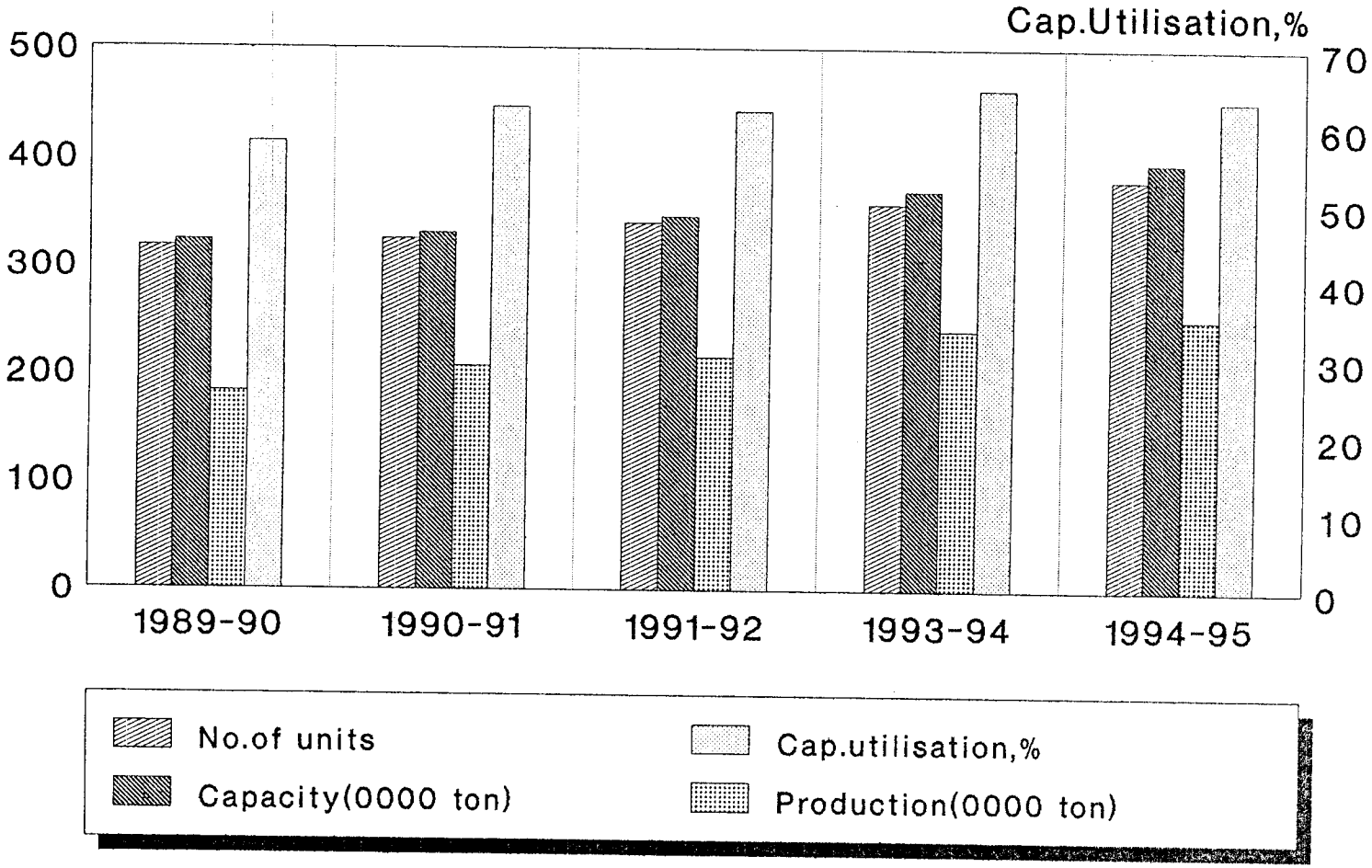
(YEAR WISE)





SOURCE:
MARKET RESEARCH DEPARTMENT,ICICI
INDIAN AGRO PAPER MILLS ASSOCIATION
DEVELOPMENT COUNCIL IN PULP,PAPER & ALLIED PRODUCTS

FIG.1.2 CAPACITY AND PRODUCTION OF PAPER & PAPER BOARD



capacity of less than 33,000 tpa. Also in recent years, large agro based mills are being set up and several of the small agro based mills are gradually expanding their capacities to 33,000 tpa and above. As raw materials are classified as forest based , agro based etc.. Paper mills may be categorised into:

(i) Forest based
(ii) Agro based, and
(iii) Others - principally based on waste paper secondary fibres,bast fibres and market pulp.

Units mostly using waste paper and imported pulp are classified as 'other' units and these are mainly small capacity mills. However, most agro based and forest based units also use varying amounts of waste paper and/or market pulp in their furnish.

The category-wise split-up of the production capacity within three groups, their respective capacity utilization and contribution to the total production are presented in Table-1.1 (Fig.1.3)

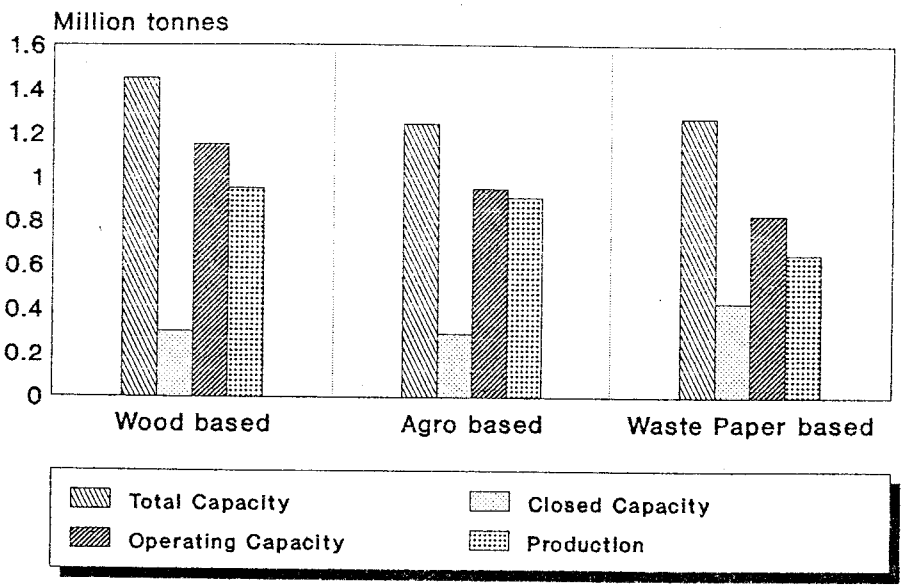
TABLE - 1.1

CAPACITY & PRODUCTION OF PAPER & PAPER BOARD
(Million Tonnes) 1994-95

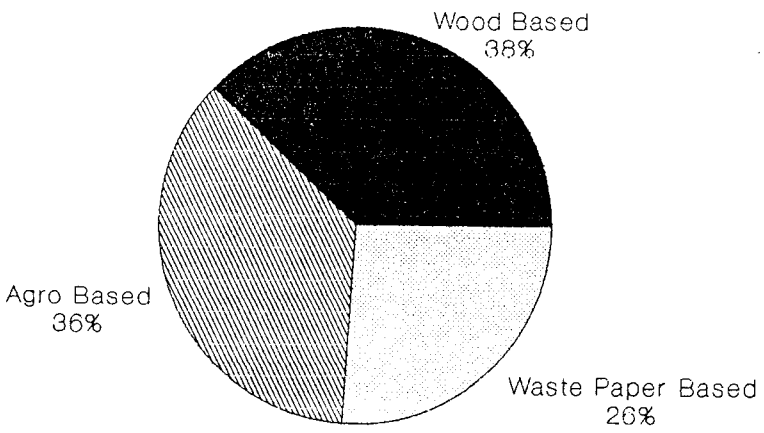
	Total Capacity	**Closed capacity**	**Operating capacity**	**Produc-tion**	**% of Prod.**
Wood based	1.45	0.30	1.15	0.95	38
Agro based	1.24	0.29	0.95	0.91	36
Waste Paper based	1.27	0.43	0.83	0.65	26
	3.96	**1.02**	**2.93**	**2.51**	**100**

Source: Development Council for Pulp, Paper & Allied Industries.

FIG.1.3 CAPACITY AND PRODUCTION OF PAPER & PAPER BOARD (1994-95)



PERCENT DISTRIBUTION OF PRODUCTION



Source: Development Council for Pulp,Paper & Allied Products

The installed capacity of the 'Forest based' mills is highest in the East Zone followed by the South while 'Agro based' and 'others' are mainly concentrated in the North and Western Zones as shown in Fig-1.4.

3.3 News Print Industry in India :

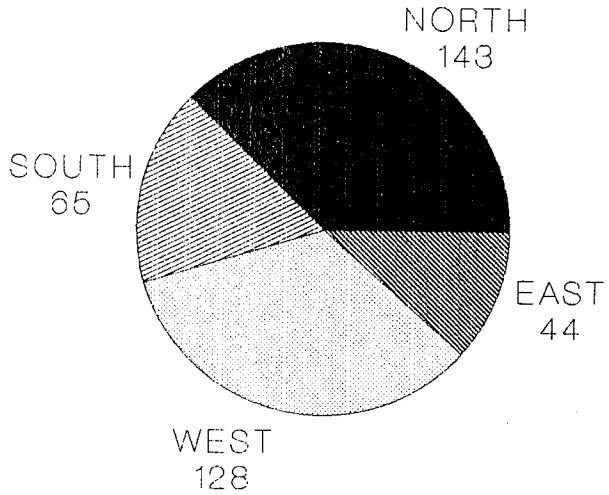
The Newsprint paper industry was set up in the country in the public sector in the year 1955 by M/s National Newsprint and Paper Mills, Nepa Nagar, Madhya Pradesh. Till 1981 there was only one unit manufacturing newsprint with installed capacity of 75,000 tonnes per annum. During 1982, two more units i.e M/s Mysore Paper Mills- a state sector unit and M/s Hindustan Newsprint Ltd., Kerala-Public sector unit with installed capacity of 75,000 tonnes and 80,000 tonnes per annum respectively were set up. In 1985, M/s Tamilnadu Newsprints Ltd., a state owned unit became operational with an installed capacity of 90000 tonnes per annum, out of which 50000 tpa is the newsprint production and 40000 tpa is the writing and printing production.
Unlike paper and paper board, demand for newsprint continues to outstrip supply. Despite the setting up of three large newsprint plants namely TNPL (50000 tpy), HNL (80000 tpy) and MPM (80000 tpy),. during the early 80's nearly 40 to 45% of consumption needs had to be imported. With demand of newsprint likely to touch about one million tonnes by 2000 and the supply standing at only 0.55 million tpy, the short fall of about 0.45 million requires to be managed through imports. At present following seven large newsprint units as shown in Table-1.2, are manufacturing newsprint paper in the country with a total installed capacity of 4.53 lakh tonnes. Rama Newsprint is presently producing around 50,000 tonnes/annum of newsprint and is likely to go for full production by the end of year 1997.

TABLE-1.2
NEWSPRINT UNITS & PRODUCTION

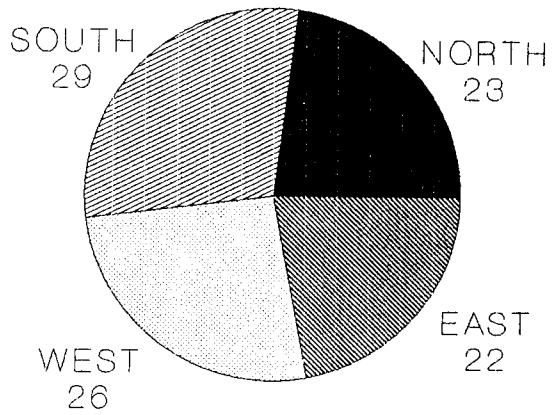
	Mills	Installed Capacity,TPA
I)	NEPA Ltd., MP	88,000
ii)	The Mysore Paper Mills Ltd,Karnataka	75,000
iii)	Hindustan Newsprint Ltd.,Kerala	1,00,000
iv)	Tamil Nadu Newsprint & Papers Ltd,	50,000
v)	HPC,Ltd., Nagaon,Assam	20,000
vi)	HPC,Ltd., Cachar Assam	20,000
vii)	Rama Newsprint	1,00,000
	Total :	**4,53,000**

Source: Ippta Directory and Paper Asia:May'95.

FIG. 1.4 ZONEWISE DISTRIBUTION OF MILLS AND PRODUCTION



No.of Mil s



Production,%

Capacity and production indicating the growth of industry since the last three decades is shown in Fig- 1.5.

4.0 STATUS OF TECHNOLOGY - AN OVERVIEW

Since the inception of large scale mechanised paper production in our country, the paper industry to a large extent has been depending upon imported technology & process equipments. The industry has not kept pace with the technology trends in other parts of the world. Notable achievements have been made in developed countries & even in some third world countries like Thailand, Indonesia & Malaysia, etc which have inducted new technologies keeping in view of the open market competitions & also mounting environmental pressures. In India, only the mills which have come up in 1980's & 90's have inducted to some extent modern process & equipments. It is generally observed that even in these mills, the modern technologies is prevalent exclusively in the transparent section of the paper industry, i.e the paper making section and serious concern has not been shown in other parts of the industry as even a modern mill still consume higher quantities of water and energy. The modernisation programme in paper industry calls for a total investment of Rs.1700 Crores. (Source:ICICI)

4.1 Basic Inputs :

Performance of paper mills in comparison to the units in developed countries is rather poor in terms of size, material,energy & waste consumption and environmental management. Table - 1.3 shows the comparative figures of basic items used in India & in developed countries.

FIG. 1.5 CAPACITY AND PRODUCTION OF NEWSPRINT IN INDIA

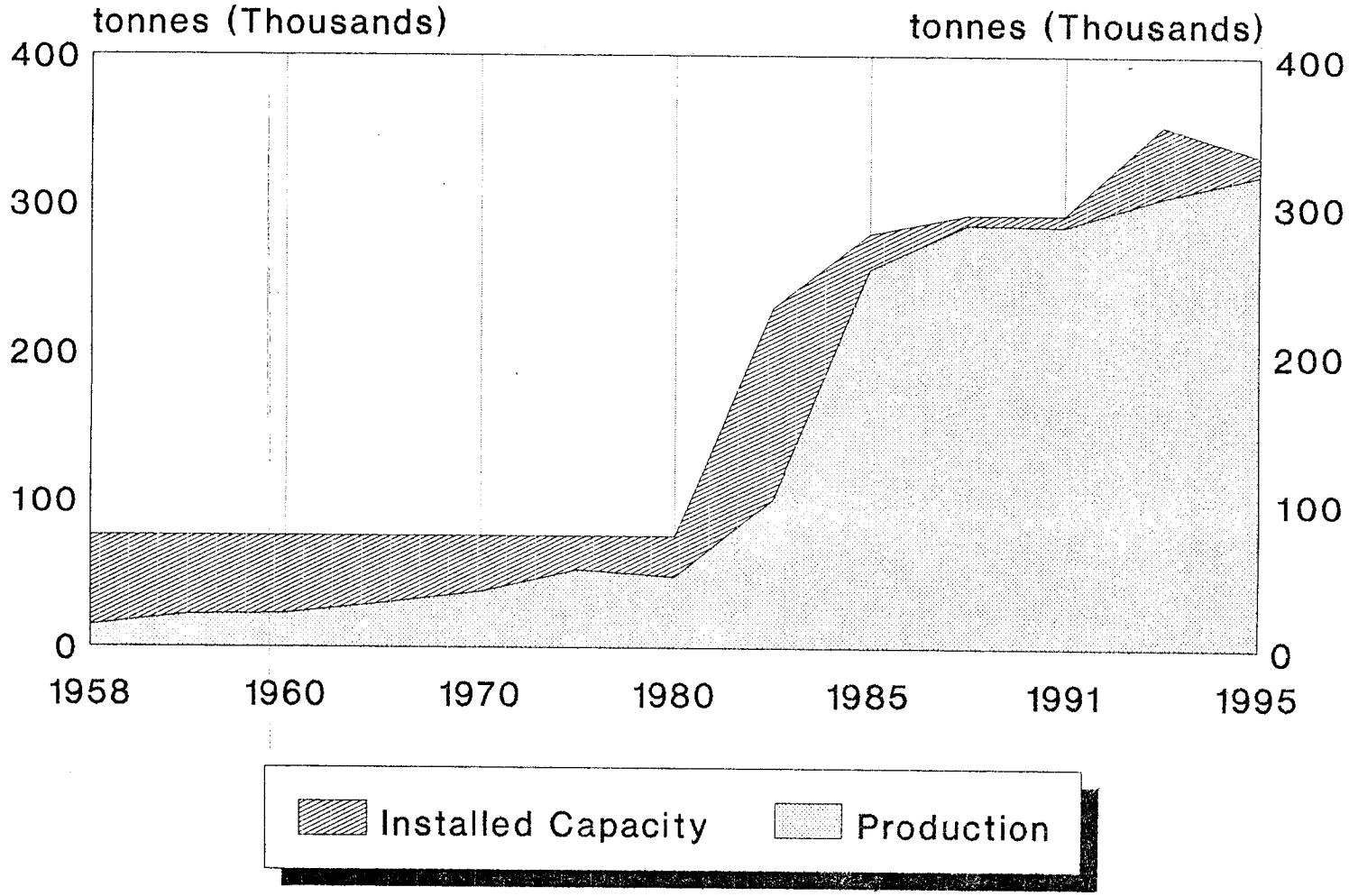


TABLE-1.3

COMPARISON OF ENERGY AND WATER CONSUMPTION FIGURES IN DEVELOPED COUNTRIES AND INDIA

Particulars	Developed Countries	India
Energy Consumption Figures		
Specific Steam Consumption, t/t	**6.5-8.5**	**10-16**
Digester	1.9-2.3	2.7-3.9
Evaporator	1.5-2.2	2.5-4.0
Paper Machines	1.9-2.0	3.0-4.0
S/R Plant	0.3-0.5	0.5-1.1
Bleach Plant	0.2-0.25	0.3-0.4
Steam Generation/tonne of Black Liquor solids	3.0-3.5	1.5-2.5
Electrical Energy Consumption kWh/tonne of paper		
Total Consumption	**1150-1250**	**1200-1700**
Chipper	92-98	112-128
Digester	43-4	58-62
Washing & Screening	116-122	145-155
Bleach Plant	67-69	88-92
Stock Preparation	164-172	275-286
Paper Machine	410-415	465-475
S/R Plant	127-135	170-190
Utilities & Others	160-165	246-252
Total Specific Energy, GJ/t	4.14-4.5	4.32-6.12
Water Consumption Figures		
Water Consumption, m^3/t of paper	50-70	200-350

Source:IDS Report prepared by CPPRI-Dec'93 for Asia Development Bank.

4.2 Raw Material Situation :

The raw material scenario presents a rather gloomy picture. The country no longer has fibre resources and forest based raw materials supply on sustainable basis is questionable. The non-wood raw materials while being available to a certain extent pose many constraints in their use due to their characteristics like seasonal availability, high bulk, inferior fibre and poor paper quality in comparison to wood or bamboo. Added to these difficulties, cost of any type of raw material is too high to withstand international competition.

On the basis of prudent raw material furnishes for the production of estimated quantities of the products, the cellulosis raw material requirements for main items work out as in Table-1.4.

TABLE-1.4
PROJECTED RAW MATERIAL & MARKET PULP REQUIREMENTS.

S.No.	Item of Raw Material	Quantities in million tonnes in the year		
		Actuals of 1990-91	Actual of 1994-95	2000-01
1.	Bamboo/Ochlandra reed	1.36	1.67	2.56
2.	Hardwood including Eucalyptus	1.77	2.01	3.18
3.	Cereal straws & bagasse	1.42	1.84	3.35
4.	Waste paper	0.87	1.14	1.78
5.	Others including grasses etc.	0.11	0.38	0.61
6.	Market pulp	0.32	0.41	0.68

Source: Paperex'95 Proceedings.

4.3 Processing :

The pulping, bleaching and paper making technology level in most mills is not comparable with their counterparts in developed countries, primarily due to raw material mix and scale of operation.

4.4 Status of Machinery & Equipments :

The Paper industry in India has been established for just over a century and since then the paper industry has undergone a lot of changes by way of equipment & process development. Hundred years ago the machinery and equipment available for pulping, bleaching & paper making limited the use of the mills to about 50 tpd. Apart from the constraints like sustained availability of raw material and other inputs, one reason for low capacity utilisation is the fact that productive assets are often not at an optimum level of efficiency owing to lack of modernisation and renovation of old equipment. Further, the Indian Paper Industry has perforce adopted equipments primarily designed for use of softwoods for processing of indigenous raw material like bamboo, hardwoods. As a consequence, operating efficiencies are not what they should be, requiring modernisation of technologies to ensure better yield thereby reducing cost.

In view of increasing paper demand and shortage of forest based raw material, Govt. of India has come with a policy to promote Non-conventional fibrous raw materials like bagasse, straws etc. However due to difficult transportation & storage problem the size of the mill has to be restricted. The large integrated pulp & paper mills mainly producing writing & printing grade of papers are equipped with full fledged chemical recovery system and effluent treatment plants. On the other hand, agro based paper mills produce almost all kinds of paper right from writing & printing to boards etc. These mills in absence of chemical recovery system and high cost of alkali use low chemicals at the cooking stage which results in excess Cl_2 consumption, which is a major source of pollution in terms of toxic, TOCl discharge. Secondly, the pollution problem also assumes gigantic proportion. Second hand paper machine are being employed for paper making by the mills which are energy deficient.

The development in the field of pulp & paper making has been gradual. The advanced knowledge of morphology and structure of fibres, chemical reactions of wood components e.g. Carbohydrate and lignin during pulping and bleaching has led to several technological innovations in the field of pulping. The spectrum of fibrous raw materials which in the beginning had been limited to wood has widened from wood to non-wood fibrous raw materials.

5.0 ENVIRONMENTAL ISSUES & PRACTICES :

The Indian pulp and paper industry is no exception to the other polluting industry and paper industry in India is still considered a smoke stack industry, environmentally hazardous, lacking glamourous high technology compared to

developed world. The complex strucutre of the industry with size varying from 2-600 t/d, the magnitude of pollution is still a challanging problem before industry. With emergence of environmental legislations, new technologies like sulfur free pulping process to reduce odour, chlorine free bleaching process,increased utilization of waste paper and the hygiene aspect are coming in way of environmental protection.

The generation of pollutants and discharge of effluents from many paper mills in India is far above the level prevalent in most mills in the developed world. Fig.1.6 shows the general flowsheet of waste sources during pulping and papermaking process.

If we take an overview of the environmental practices adopted in paper industry ;

1. The performance is far from satisfactory as the industry with few exceptions still continue to consume large quantities of water i.e 200-400 m^3 of water per ton of paper.
2. There appears to be very few mills which have taken up programmes like ; at source reduction of pollutants.
3. There are number of pulp and paper mills with open or partially closed, brown stock washing and paper making process.
4. The effluent treatment plants are designed on the basis of improper sampling.
5. Lack of adequate training to the people operating effluent treatment plants.

These issue leave enormous scope to improve the overall environmental situation in pulp and paper industry.

The agro based mills in particular with capacity less than 40 tons per day and small mills equipped with pulping will be facing an enormous challenge to control the pollution problem. The major environmental issues to be addressed in next 5-10 years are ;

1. The adoption of total recycling concept through better water management.
2. Improved management practices to reduce pollution at source.
3. Elimination or partial reduction of elemental chlorine based bleaching chemicals.
4. Setting up of chemical recovery in agro based paper mill.
5. Identification & adoption of common effluent treatment system for cluster of small pulp mills.
6. Adequate modernisation of processes and equipments in all areas of manufacturing process.
7. Last, but not the least, creating awareness of the better environment management at all levels including shop floor people which indirectly implies

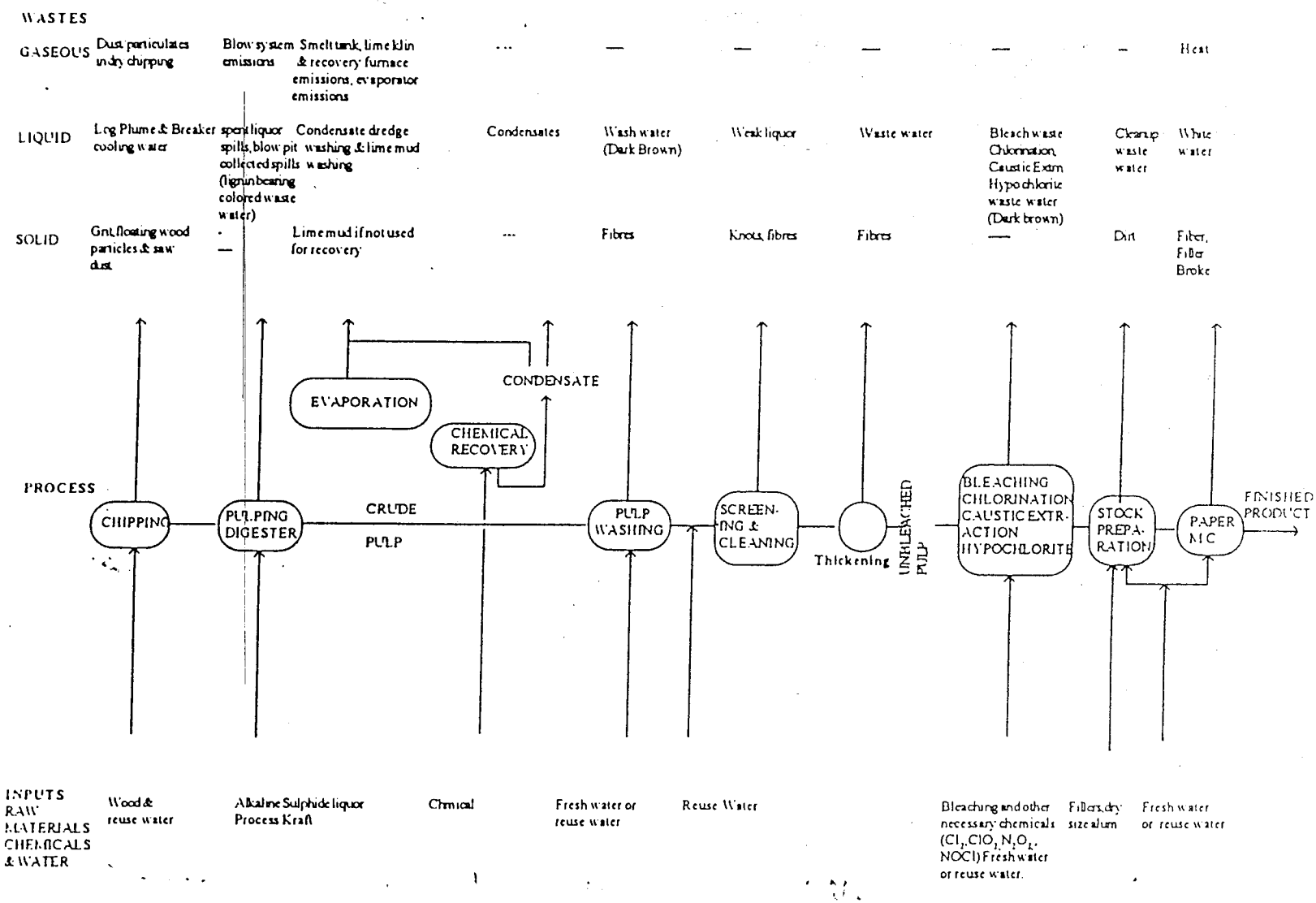


FIG. 1.6 GENERAL FLOW SHEET FOR PULPING AND PAPER MAKING AND SOURCES OF WASTE

that in the years to come the increased responsibility rests with the industry and not with the controlling and regulatory bodies. .

6.0 CURRENT MODERNISATION TRENDS:

Being one of the oldest industry in India and with many of its operational efficiencies below industry standards, coupled with short term planning, growth and recessionary trends in the early 80's, any form of modernisation in the industry has been greatly hindered.

The differences coupled with high cost of production, greater environmental consciousness and the new industrial policy of globalisation pose an immense challenge before the industry. The industry as well as policy makers are required to make greater possible efforts in making suitable changes so that the industry can meet the challenges of globalisation and become a truly sustainable industry adopting improved mill management practices, environment friendly production processes.

The investment in modernisation in individual section is illustrated in Fig.1.7, which only few units carried out. The break down of investment for modernisation in various sections is shown in Table-1.5

TABLE - 1.5
INVESTMENT IN MODERNISATION

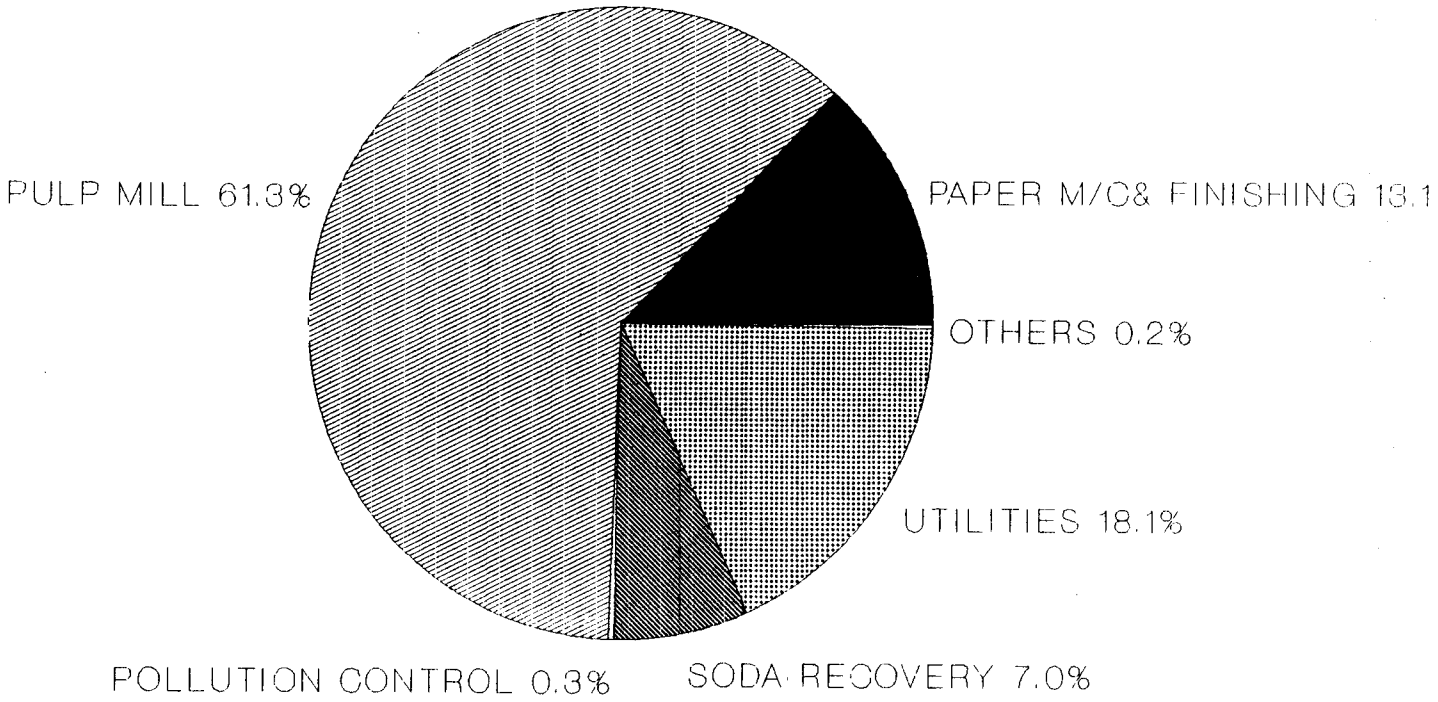
Investment Type	Investment %
Paper machine & finishing	13.0
Pulp Mill	61.0
Soda Recovery	7.0
Pollution Control	0.3
Utilities	18.0
Others	0.2

Source : Paper Asia, May 95.

It can be seen from the table that most of the investments were in the modernisation of the pulping section and paper machine, followed by utilities. Some objectives in the programme include :-

* Conserving energy
* Improving process efficiency

FIG. 1.7 INVESTMENT IN MODERNISATION



* Upgrading quality of the final product
* Product development
* Controlling Pollution

7.0 R & D INPUTS :

The developed countries have evolved and commercialised cleaner technologies to contain the pollution problems. This evolution of technology was essentially a vigorous R & D effort and joint participation by the industry. However, R & D specifically addressed to pollution problems appears to be lacking , National Environment Engineering Research Institute (NEERI) is a premier Research organisation, but it has its own priorities, despite its initial efforts in pulp & paper sector, not much of the R&D was oriented towards cleaner technologies. Besides NEERI, some academic institutions are also engaged in pollution related R & D activities but have confined to long term projects, rather than a specific programme. Keeping in view of the present requirements, it has become essential to pool up the R & D efforts going in different institution including Central Pulp & Paper Research Institute, so that the more meaningful programmes can be formulated for effective utilization of R & D sector in better environmental management.

8.0 SENSITIVITY OF INDUSTRY TOWARDS GOVT.POLICIES VIS-A-VIS POLLUTION ISSUES :

Govt. in early 70's to augment the raw material situation encouraged setting up of large number of mills based on agricultural residues and due to various problems, the size of the mills had to be restricted. This short term planning of encouraging the small mills which are not in a position to afford for chemical recovery systems for recovery of cooking chemicals, generation of energy & elimination of pollution problems resulted in severe pollution problems in smaller sectors. All these small mills were based on imported and obsolete second hand machinery. The pollution problems were further aggravated with Govt.'s policy to exempt excise duty for using more than 75% of the unconventional raw materials which prompted large number of enterpreneurs to set up such small mills to avail the fiscal incentives and consequently, by the end of 1995 nearly 300 mills were created in the country which have become major source of pollution today. With this infrastructure of 1.25 million tonnes capacity, it becomes difficult to close down such infrastructure for non compliance of the environmental regulations . Pollution Control Board had set pH, S.S. and BOD limits in mid eighties and mills were supposed to comply in

phase wise with these MINAS standards. With available information till today, not many mills are complying with the regulations set by CPCB (IEPA), primarily, due to technical problems and problems relating to non-availability of techno-economically viable chemical recovery/treatment systems. Govt. has taken adequate steps in encouraging the industry to take necessary measures to contain pollution problems and the policies like 100% depreciation on equipments related to pollution control has been allowed. Raja Chelliah committee has come with number of recommendations and some of the recommendations like soft loans envisaged in Raja Chelliah Committee can be brought into force .

Further , Govt. should explore the possibilities of liberalised financing and encourage financing through Institutions like IDBI,ICICI, etc. in the form of soft loans and grants for modernization & updating the technology aimed towards pollution control .

CHAPTER - 2

THE LARGE PULP PAPER & NEWSPRINT MILLS BASED ON FOREST PRODUCE

1.0 RAW MATERIAL SITUATION

From the raw material situation as stands today and various sources indicating the projection for the year ending 2000 there is going to be a decline in availability of forest produce. Serious efforts are required to ensure that the required quantity of raw materials is available to the existing mills based on the forest based raw materials.

The raw material consumption pattern has significant implications on the pollution loads and the type of raw material being used.

1.1 Bamboo :

The large scale mechanised pulp and paper manufacturing in India started in early 30's with the advent of bamboo as a main raw material for pulp and paper making. Bamboo continued to be the main raw material till late 60's and today bamboo represents 23% in total raw material furnish and continues to be major source in the raw material furnish. There are some mills in north eastern part of India and western part of India which are almost based on 100% bamboo.

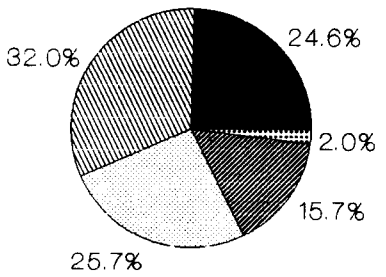
1.2 Raw Material from Natural Forests:

With depleting availability of bamboo in early 70's, some of the mills resorted to use of the lops and tops from natural forest in the form of mixed hard wood after the main stem was used for timber quality. However, the mills started facing problem with these mixed hardwoods as there was lot of variations in the type of raw material entering the digester thus affecting the process and equipment efficiency.

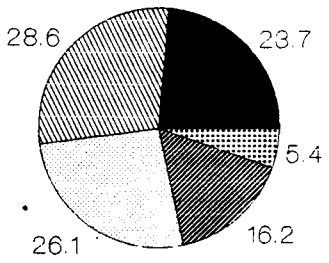
1.3 Eucalyptus & Other Plantation Hardwoods:

To avoid too much of raw material, mills decided to restrict raw material furnish to not more than three and subsequently eucalyptus which is considered to be a fast growing and with its ability to grow in almost all parts of the country became another major raw material for the paper industry. From the Figure -2.1 it is clear that nearly 28 % of the raw material today is from

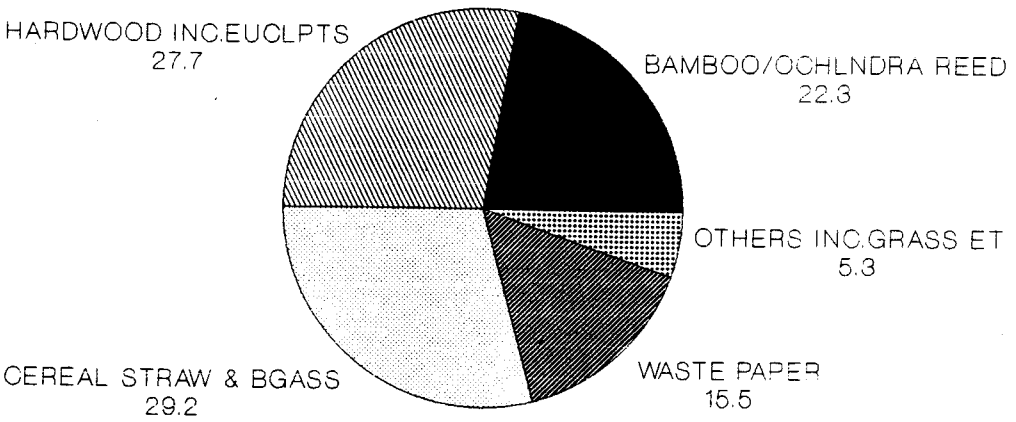
FIG 2.1 PAST,PRESENT & FUTURE RAW MATERIAL REQUIREMENT



(1990-91)



(1994-95)



PROJECTED(2000-01)

hardwood which constitutes mainly eucalyptus in most of the mills and only selected mills are using hardwoods like casuarina and poplar.

1.4 Waste Paper:

Waste paper is an environmentally friendly raw material substitute for paper manufacturing. However, the utilisation of waste paper is limited to specific varieties of the paper and waste paper can not be a substitute for virgin pulp in value added high quality papers. Nevertheless, efforts are required for increased use of waste paper to suit the requirement of the end products. Further systematic collection, segregation and upgradation of the indigenous waste paper should also be encouraged. Maximum use of waste paper in newsprint sector should be undertaken as the newsprint sector uses 100% of the forest based raw materials for manufacture of mechanical as well as chemical components for newsprint manufacture.

Following are some of the recommendations made at various stages for existing pulp, paper and newsprint sector mills.

i) Large scale captive plantation on degraded forest land

ii) Economic exploitation of bamboo in north eastern regions.

iii) Encouraged social and agro forestry programmes

iv) Induction of new plantation techniques to obtain high fibre yielding crops with more yield per unit hectare.

1.5 Raw Material vis-a-vis Pollution:

The magnitude of pollution is very much linked with the types of fibrous raw materials used for paper making process. Table-2.1 indicates the inter-linkage between pollution problems and raw materials.

TABLE- 2.1

RAW MATERIAL AND ITS ASSOCIATED POLLUTION PROBLEMS

Raw material		Pollution Problems
Bamboo & Reed	-	Solid waste pollution due to inability to reburn silica rich lime sludge.
	-	Higher chlorine requirement for bleaching.
	-	More suspended solids in effluents.
Eucalyptus	-	High viscosity of black liquor.
	-	High Caustic demand
	-	Less Cl_2 demand.
	-	Emissions in recovery.
	-	Foaming in washing & more soda losses going to effluent.

2.0 THE BASIC INPUTS:

Cooking chemicals, energy and water are three primary inputs other than fibrous raw materials going in the paper manufacturing process. The quantum of these inputs varies with raw material to raw material and has a direct bearing on the over all pollution in paper industry. The average consumption of these primary inputs is as in Table-2.2

TABLE- 2.2

OPERATIONAL EFFICIENCY WITH RESPECT TO PRIMARY INPUTS & THEIR RANGES

Parameters	Targetted Norm	Range under which most of the units fall
Bleached pulp yield,%	45	38-44
Chemical consumption, TTA,Kg/T of unbleached pulp	330-350	340-355
Chlorine consumption, as available Cl_2 Kg/T	80-110	90-130
Washing loss, Kg/T	10-12	20-30
Fibre loss, Kg/T	2.5-3.0	3.0-7.0
Furnishing loss, %	4.0-5.0	6.0-10.0
Power consumption, Kwh/T	1200	1500-1900
Steam T/T paper	9.0	10.0-14.0
Water consumption,M^3/T	175	225-475
Machine down time,%	10.0	15.0-25.0

Source: ICICI Report, 1994

Above figures clearly indicate higher percentage of yield loss during pulping, bleaching and paper making process. Also higher percentage of chemical consumption and chemical losses and the high proportion of electric and heat energy consumed. There is enormous scope for resource recovery and resource conservation in Indian Paper Industry. Resource consumption by closing of the cycle will reduce the pollution problem to a maximum extent and this is one area where concerted efforts are required to be made.

3.0 MANUFACTURING PROCESS : TRENDS & PRACTICES

3.1 Raw Material Preparation and Handling:

Wood and bamboo are felled at forest. Wood is either debarked at felling site or mill site. The practice of raw material preparation and handling with few exceptions are not satisfactory. In some mills, even for bamboo still inefficient disc chippers are used and the performance of disc chippers for bamboo are not satisfactory. As a result significant shives are produced which have to be recycled in chippers and lot of dust is formed. Only recently, some mills have switched over to efficient drum chippers for bamboo. The dust generated during chipping of wood and bamboo sometimes goes to the extent of 5% and generally it is mixed with effluent treatment sludge and disposed off. With appropriate chipping technology valuable portion of fibre instead of converting it into dust can be used as source of pulp.

3.2 Cleaning :

Wood debarking is often carried at forest. Bamboo and wood often carry significant proportion of grit and sand. During storage and transportation, these inerts often enter the pulping loop increasing the load on mechanical cleaning system. Some mills are practicing bamboo cleaning using special rafts and also by train water during transportation to chipper but these mills appeared to have stopped this practice with increased water consumption.

3.3 Storage of Raw Material

The storage of raw material needs to be well designed as some of the reported figure indicates that as much as 5-20% of the raw material is lost through pest attack. So appropriate storage and chemical application may have to be practiced to preserve the raw material.

3.4 Transportation:

With depleting forest resources, the availability of raw material within an econimic distance has become problem and there are instances of transportation of bamboo all the way from Assam to Kerala which becomes an energy intensive process.

3.5 Chip Collection:

The pneumatic transportation of chips is energy intensive process and mills are slowly switching over to belt conveying system.

3.6 Pulping Process:

Indian mills predominantly use alkaline pulping process. Mills based on forest raw material use kraft process, where as agro based mills use soda process and newsprint mill use mechanical, chemical, chemi-mechanical and CTMP process.

3.7 Digestion :

The predominant practice is the use of batch digesters. Two large mills have continuous digesters for bamboo and wood where as some of the large mills based on bagasse use Pandya digesters. Reasons for not using continuous digesters are:-

- Higher capital outlays for machinery replacement in the existing units.
- Lack of flexibility of the continuous digester process system to accept varying raw material mix.

Among the batch digesters,indirect steaming is more efficient in terms of energy consumption, uniform cooking and easier operation but still some mills continue to practice direct steaming which ultimately results in black liquor of lower concentration increasing the load on evaporation system.

3.7.1 Kappa Number

Some of the mills not withstanding the fuel value of lignin still continue to produce pulp of higher kappa number to compromise in the cost of cooking chemicals and they have preferential practice to remove the lignin in the bleaching process as the cost of bleaching chemicals are lower than the cost of cooking chemicals. Table-2.3 depicts the role of pulping conditions on discharge of halogenated compounds and energy recovery.

TABLE -2.3

PULPING CONDITIONS AND ITS INFLUECE ON ORGANIC HALIDES FORMATION

Kappa No.	NaOH Kg/t	Cl_2 required Kg/t	AOX Kg/t	Energy Recovery 100 tpd
20	484	50	5.O	300
30	375	75	7.5	290
Differential Cost 100 tpd Basis, Rupees	**17000 *Expenditure**	**15000 Saving**	**-**	**5000 *Saving**

This High Kappa pulping practice results in increased pollution loads particularly from bleach plant effluents.

3.8. Blow Heat Recovery:

Hot water is one of the essential requirements for pulp washing and mills generally prepare the required hot water by employing the steam but if the mills adopt blow heat recovery , 0.5 to 0.7 tonnes of steam per ton product can be saved. Only few mills are practicing blow heat recovery. The blow heat recovery in addition to heat recovery will be of immense help in controlling malodorous gaseous emissions from the digesters.

3.9 Bleaching

Most of the Indian mills use chlorine based bleaching chemicals with barometric drop leg or displacement type of washers. Common bleaching sequences are CEHH, CEH, CHHH. Most common sequence of bleaching to achieve brightness level over 75% is CEHH. Some large mills have started using chlorine dioxide and peroxide partially i.e. $CE_{(P)}HD$. Many large paper mills are in way to go for oxygen bleaching to combat the problem of adsorbable organic halides/TOCl. including newsprint sector, paper industry is producing about 0.8 million tonnes of bleached pulp and nearly 60% of the bleaching is accomplished employing 11 tonnes chlorine based bleaching chemicals everyday which comes to about 30,000 tonnes of chlorine every

year. Now with globalisation of paper industry and brightness level requirement of more than 82% and above, it is heartening to know that at least some of the mills are switching over to chlorine dioxide bleaching and oxidative extraction. In the process, it is likely to improve the quality of effluents from bleaching section.

3.9.1 Water Consumption and Recycling in Bleaching :

Nearly 60 M^3 of water is consumed in bleaching operation as some of these steps like chlorination and extraction are carried at low consistency levels. Except hypochlorite stage, the rest of the water is not recycled and directly enters the effluent stream. The maximum level of pollution comes from chlorination and extraction stage and accounts to about 80% of total pollution load from bleaching section and 60% of the pollution load of the entire mill.

3.10 Pulp Washing :

Drum washers and three stage counter current washing are the most common systems used in these mills. In some mills displament washers are also used. Washing systems determines following important parameters :

I. Carry over of the organics in the unbleached pulp requires high bleach chemical demand.

ii. Sodium losses occuring lead to high concentration of NaCl in the effluent and

iii. Efficiency of extraction of black liquor determines the steam demand.

The washing efficiency varies widely from mill to mill primarily depending upon the raw material used. The washing efficiency can be graded as below:

- Bamboo pulp > Hardwood pulp > Bagasse pulp

The bagasse pulp is very difficult to wash and large mills using bagasse invariably produce black liquor with lower solid concentration. Significant carry over of the black liquor to the bleaching section results as certain amount of compromise is required between dilution factor and black liquor solid concentration as shown in Table-2.4

TABLE-2.4

INFLUENCE OF DILUTION ON WASHING EFFICIENCY*

Dilution factor	2.0	2.5	3.0
Washing loss, kg/t Na_2SO_4	17.0	12.0	10.0
COD (Dissolved), Kg/t pulp	120	85	71

* **Calculated under standard conditions.**

Now the recent trend has been to utilise efficient washing system rather than using more dilution factors.

Increased COD loads in pulp mill will call for increased bleached chemical requirement and increased pollution load.

3.11 Stock Preparation

Stock preparation is one section of the Paper Industry irrespective whether it is a small or big mill ought to happen a completely closed one and today a number of mill are still consuming higher proportion of water primarily due to low consistency operations in stock preparation equipments like conical refiners, wide angle refiners but mills which have come up recently and also mills which have gone to modernisation have slowly switched over to equipments which can handle high consistency stock capable of reducing water consumption.

3.12 Paper Machine

Majority of mills use fourdrinier former and only the mills which are producing newsprints and only few mills which are producing common variety of papers are employing twin wire formers. The fourdrinier former tend to use more water compared to twin wire former and the number of breakages are more frequent in these formers compared to twin wire formers resulting in excess fibre losses and at times difficult to control the white water generated in paper making section.

3.13 Fibre Recovery in White Water :

Most of the paper machine systems are more or less closed systems, however, the fibre recovery installations in some of the mills are not efficient and fibre losses are reported to be as high as 10%. This problem is most commonly observed in newsprint units which are producing pulp containing significant proportion of fines. The efficient recovery system should provide better closure of paper machine back water.

4.0 CHEMICAL RECOVERY SYSTEM :

All forest based paper mills have chemical recovery system, because of this,the pollution problems in these mills is atleast 2-3 time lesser than mills without chemical recovery system. However, the efficiency attained in our recovery units are below 90%. Impressive developments have been made in evaporation and combustion of spent liquor in Chemical Recovery Section. Spent liquor from most of our raw material exhibit very high viscosities restricting the evaporator outlet concentration to just 40-45% solids. Scaling tendency and colloidal instability of spent liquors are the common problems faced in evaporator units. Mills have either STV/LTV type evaporators. The older evaporators are of short tube variety and the evaporators installed between mid 60's and 80's are of long tube variety. Recently, the trend is towards Falling Film type Forced Circulation Evaporators. Experience with these evaporators have shown clearly the benefits like high end concentration, maximum steam economy and improved condensate quality.

In case of bamboo liquors, silica in black liquor causes scaling, thereby reduces effective surface area for evaporation. CPPRI has made breakthrough in desilication of black liquor, which will help in improving the performance of recovery units using silica rich raw materials and also making possibilities of lime sludge reburning/ recycling which is a major concern of solid wastes.

The major areas in chemical recovery requiring energy and environmental attention are -

- Improved evaporation system by indirect methods
- Entrainment of condensate with black liquor to be avoided.
- High solids firing in chemical recovery furnace.
- Retrofitting and modernisation of existing boilers to a high pressure boiler for improved co-generation.

- Improved causticising system to achieve concentrated white liquor and low moisture containing lime sludge.
- Gaseous emissions control in recovery boilers.

Two major sources of gaseous pollution are direct contact. evaporators and absence of electrostatic precipitators in some of the mills.

With modern generation of evaporation system, the elimination of direct contact evaporation has become possible and it should become mandatory for all mills to introduce ESP for chemical recovery as well as power boilers.

5.0 UTILITY :

The boilers are coal fired types. 11% of the total installed capacity has been installed during the past five years. These are mainly fluidised bed boilers. Prior to 1975,the capacity was 20 tph of steam generation at 20-30 kg/cm^2 pressure and 380°C to 400°C temperature and thermal efficiency was between 50% to 60%. After 1975,the steam generation capacity increased to 25-27 tph at 40 kg/cm^2 pressure and 400°C to 480°C temperature. The thermal efficiency has gone upto 70-80%.

The improvement in the steam generation capacity at higher pressure will reduce the burden on fossil fuels through fuels flexibility employing unconventional fuels like rice husk, pith, bark etc. in fluid bed boiler which will substantially reduce the solid waste pollution.

6.0 MACHINERY & EQUIPMENT :

Manufacture of paper, requires utilization of wide range of plant and equipment from raw material storage/transportation to packing and handling of the finished product apart from the actual process machinery for paper making. In addition various auxiliary items such as steam boilers, power generation equipment, effluent treatment equipment etc. are also required. India has now developed capability to manufacture and supply of almost entire range of equipment for paper industry including pulping plant, stock preparation, paper machine, steam and power generation equipment, chemical recovery equipment etc. The estimated share of equipment in a project is 60-70% and extent of in-digenisation is about 70% . Almost all the manufactures have collaboration with reputed international firms.

6.1 Process Optimisation and Control :A Step Towards Cleaner Environment:

Considerable improvements in Environmental situation through process optimization and advanced control have been reported. These savings may include results from minor process modifications, better control of the existing processes and operations. Mills with frequent product grade change and changes in operating parameters usually have attractive savings. Magnitude of benefits through process optimization and control, energy savings are likely to be as below :-

-	Digester	10-20%
-	Bleachin	5-10%
-	Evaporator	3-5%
-	Recovery boiler	20-50%
-	Paper Machine	10-20%

6.2 Introduction of On-Line Measurement and Control System :

On-line measurement and control system for basis weight, moisture and caliper are the modern measure which has been introduced in Indian paper machines recently. Tribeni,CPM and HNL have already introduced on-line measurement and control systems where as mills like Bhadrachalam and West Coast, TNPL etc. are going for it.

7.0 DISCHARGE CHARACTERISITICS & MAGNITUDE OF POLLUTION :

Most of the mills are using raw material mix and at the same time with different kinds of washing system, bleaching process and variations in the end products,there is a wide variation in effluent discharge characteristics .

The waste water generated in the mill can be categorised in to two groups :

- Colored stream due to presence of lignin comprising of waste water from pulp washing.
- Caustic extraction & spillages from chemical recovery.
- Less colored stream comprising of waste waters from chipper house, bleaching section and paper machine.

The range of pollutants is given in Table-2.5

TABLE- 2.5

CHARACTERISTICS OF COMBINED WASTE WATERS FROM LARGE PULP & PAPER MILLS

Parameter	Large Paper Mills (RangeAv)	Newsprint Mills
Flow, m^3/t pap	167-281 (220)	213
pH	6.6-10	6.5-10
S.S., mg/l	620-1120(764)	-
BOD_5,20°C,mg/l	240-380(295)	-
COD, mg/l	840-1660(1118)	-
COD/BOD	2.95-4.37(3.8)	-
Colour Pt-CO unit	300-655	-
SAR	2.0-5.3(3.5)	-
Pollution Load Kg/t Paper		
SS	188	160
BOD	150	107
COD	313	213

7.1 Pulp Bleaching vis-a-vis Pollution :

In large pulp & paper mills, bleaching is one of the section discharging highly polluting substances, primarily because these effuents are loaded with lignin and carbohydrate degraded products. Specially mills which are using chlorine, which still continues to be a major bleaching chemical are discharging effluents with chlorinated toxic substances. The high charges of chlorine causes the formation of persistent toxic polychlorniated compounds that can bioaccumulate & has adverse effect on human & aquatic life. Generally, the amount of discharge of chlorinated discharge can be calculated by the following formula.

$$\text{TOCl, Kg/a.d.t pulp} = k\,(C+D/5+H/2)\,.$$

where,C,D & H are doses of chlorine,chlorine dioxide and hypochlorite.

Since, most of the mills are still using conventional sequences like CEHH, the discharge of chlorinated compounds continues to be major concern.

The routine environmental audit with standard methods right from sampling to the analysis needs to be evaluated in each mill and it should be made mandatory for all mills, which ultimately helps in controlling the pollution.

7.2 Solid Waste :

Solid waste constitutes a complex problem in the industry due to the varying nature and enormity of the wastes generated. The main sources of solid wastes are :

- The raw material handling/preparation.
- The effluent sludge from the combined mills effluent treatment plant.
- Fly ash from coal fired boilers and fines in the coal.
- Coal cinders from coal fired boilers.
- Lime sludge from the chemical recovery plant.
- Hypo mud from the hypo plant.
- Pith generation from depithing plant.

Table 2.6 gives the magnitude of solid waste in wood, bamboo and bagasse based mills employed in paper and in newsprint sector.

TABLE -2.6
SOLID WASTE GENERATION IN LARGE PAPER MILLS

Waste source	Solid waste from Large paper mills kg.dry solids/t paper		
Raw Material	**Bamboo**	**Wood**	**Bagasse**
Raw material handling/preparation	45	350*	550
Chemical Recovery section	650	50	650
Hypochlorite preparation grit	20	Other parameters being	
Power plant/boiler ash**	656	similar to bagasse.	
Waste water treatment plant***			
1. Primary sludge	159		
2. Secondary sludge	34		
Total	507		
% inorganic solids	84		
% organic solids	16		

** Ash generation depends on % ash in coal and the amount of power/steam generation.
*** Estimated assuming 0.5 kg mixed liquor suspended solids (MLSS) produced/kg BOD removed in activated sludge treatment plant.

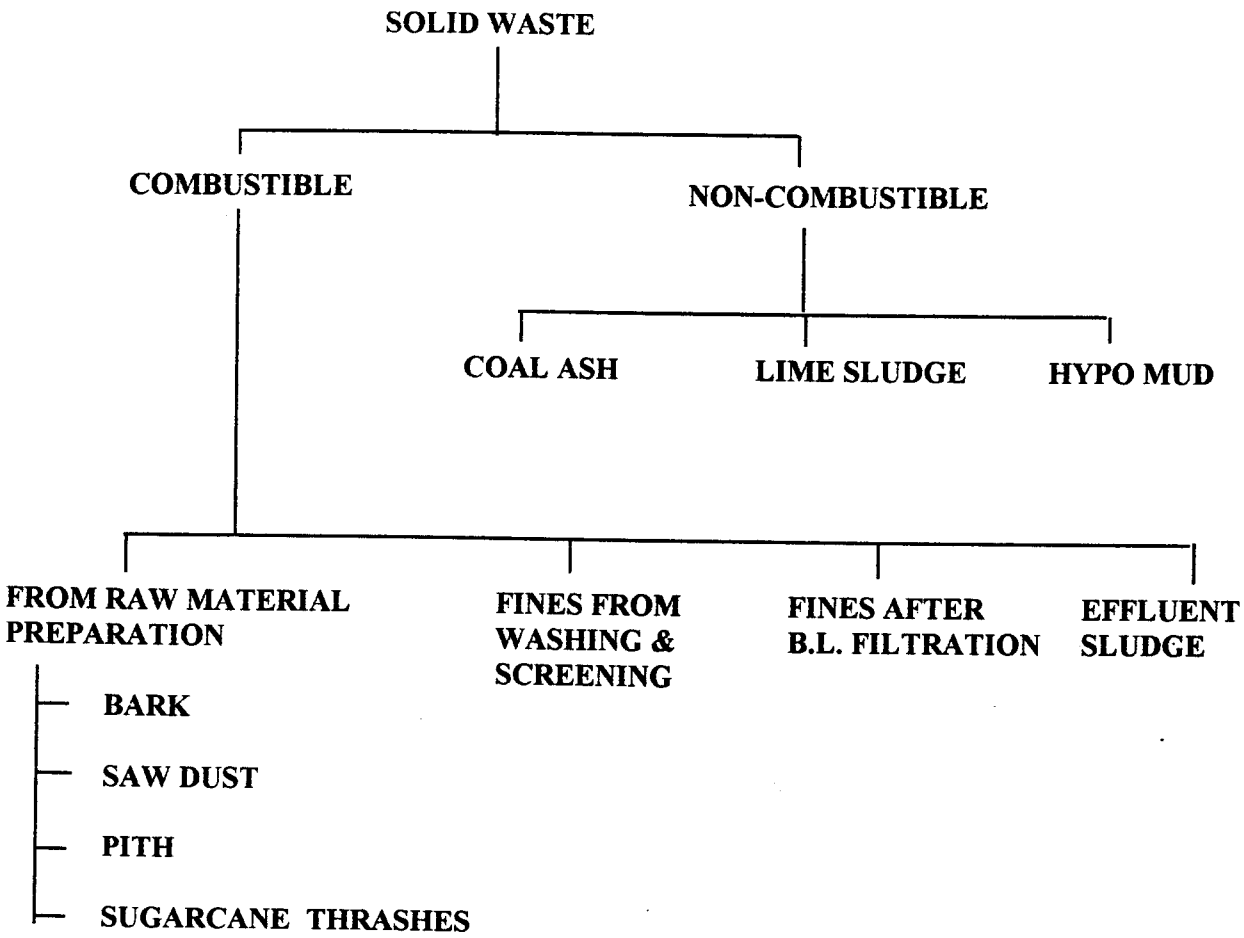
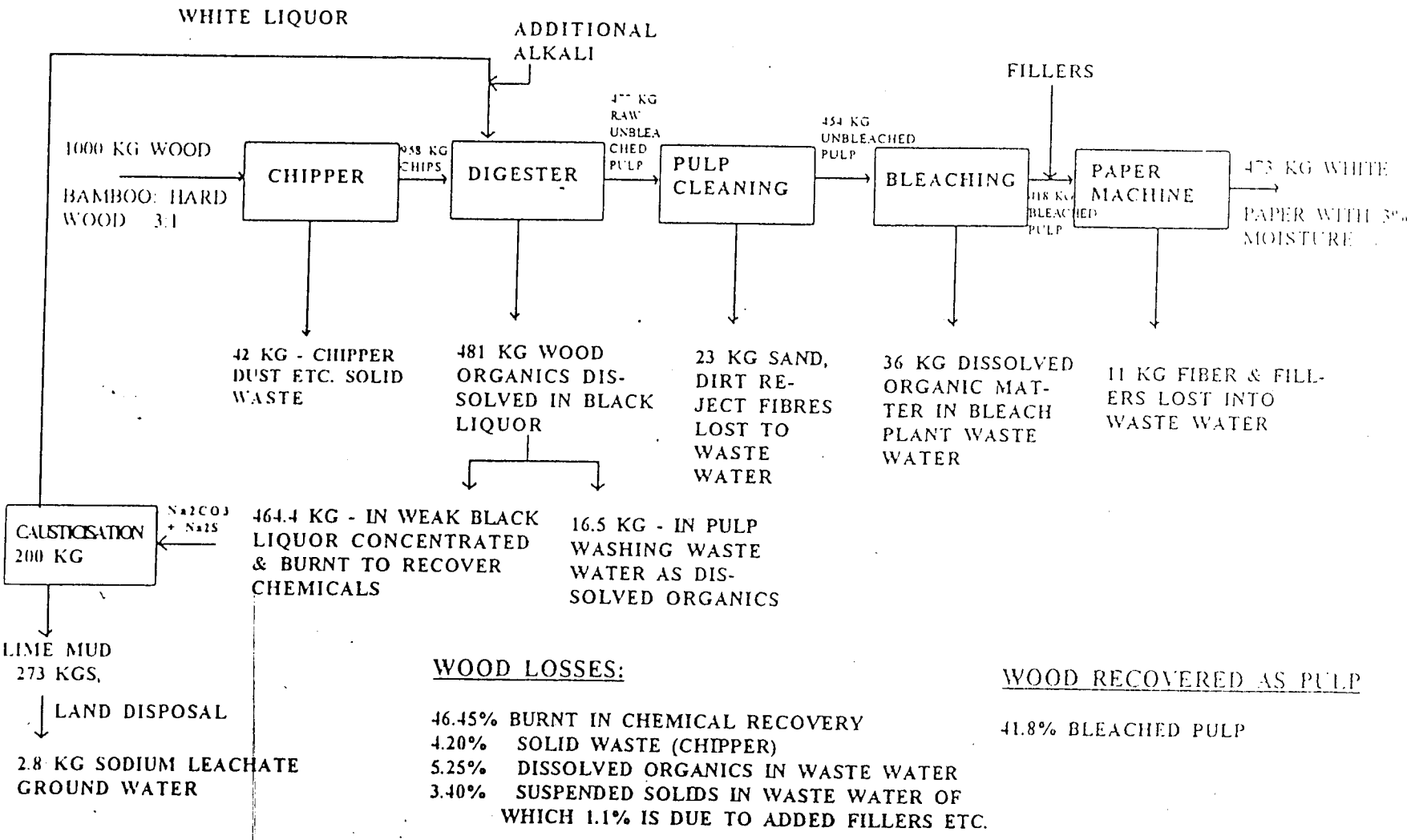


FIG. 2.2 SOURCES OF COMBUSTIBLE AND NON-COMBUSTIBLE WASTES

FIG. 2.3 MATERIAL BALANCE OF WOOD IN PAPER MAKING KRAFT PROCESS



WOOD LOSSES:

46.45% BURNT IN CHEMICAL RECOVERY
4.20% SOLID WASTE (CHIPPER)
5.25% DISSOLVED ORGANICS IN WASTE WATER
3.40% SUSPENDED SOLIDS IN WASTE WATER OF WHICH 1.1% IS DUE TO ADDED FILLERS ETC.

WOOD RECOVERED AS PULP

41.8% BLEACHED PULP

7.2.1 Type of Solid Wastes :

It is estimated that the magnitude of solid waste generation in totality is almost closer to the total paper produced in the country. The entire solid waste can be broadly categorised as

i) Combustible
ii) Non-combustible waste .

The source of solid waste is illustrated in Fig 2.2 and 2.3.

The combustibile waste include ;

I) Bark
ii) Wood dust
iii) Coal powder
iv) Effluent sludge.

Only few mills recycle the combustible waste as fuel and majority of the mills do not recycle and dispose it as land fill. The magnitude of non-combustible waste is primarily due to fly ash from the boiler and lime sludge in mills which are not reburning the lime sludge due to silica problems.

The mills which are based on major portion of woods, like rayon grade pulp mills, newsprint mills are reburning the lime sludge but mills which are using bamboo along with wood /entirely based on bamboo, still continue to dispose off lime sludge as a land fill.

7.2.2 The Effect of Lime Sludge on Ground Water Contamination :

The lime sludge disposed carry significant proportion of Na which gets leached during rainy season and gets contaminated with the ground water & subsequently increases the salinity of the surrounding soil. (Fig.2.3).

7.3 Air Pollution :

The major sources of air emissions are through discharge of gaseous and particulate emissions.

Particulates :

a) Fly ash from coal fired boiler
b) Chemical particles primarily sodium and calcium based
c) Char from bark burners.

Gases:

a) Malodorous sulphur gases such as mercaptans and hydrogen sulphide released from various stages in Kraft pulping and recovery processes.

b) Oxides of Sulphur from power plants, Kraft Recovery Furnace and Lime Kiln.

c) Steam, since it can be hazardous when visibility is impaired.

The air emissions, particularly from kraft mill lead to obnoxious odour problem because of the presence of Reduced Sulphur Compounds.

Table 2.7 shows the main emission of reduced sulphur compounds from sulphate pulping process,which are the major sources of odor problem.

TABLE -2.7

MAIN EMISSIONS OF REDUCED SULPHUR COMPOUNDS FROM SULPHATE PULPING PROCESS

Emission Source	Emission rate, kgs/t90			
	H_2S	*MM CH_3SH	*DMS CH_3SCH_3	*DMDS CH_3SSCH_3
Digester,batch	0-0.15	0 -1.3	0.05-3.3	0.05-2.0
Digester,continuous	0-0.10	0.5-1	0.05-0.5	0.05-0.4
Washing	0-0.10	0.05-1	0.1-1.0	0.1-0.08
Evaporation	0.05-1.5	0.05-0.8	0.05-1.0	0.05-1.0
Recovery furnace (with DCE)	0-2.5	0-2	0-1	0.03
Smelt dissolving tank	0-1.0	0-0.08	0-0.5	0.03

*MM-Methyl mercaptan. DMS-Dimethyl sulphide. DMDS-Dimethyl Disulphide.

Source: UNEP,Energy Management in Pulp & Paper Industry. 1981.

8.0 MAGNITUDE OF POLLUTION AND CONTROL PRACTICES :

Paper manufacturing involves considerable amount of pollution as a lot of chemicals such as caustic, chlorine etc. are used in the various stages of paper manufacturing. The environmental pollution problems of the pulp and paper industry may be broadly classified as follows:-

a) air pollution by particulate matter, toxic gases and odour during the pulping stage;
b) water pollution by discharge of process water containing residue, chemicals and toxic compounds; and
c) land pollution through solid wastes, particularly lime sludge.

8.1 Air Pollution

Digester house operations, viz. liquor preparation, cooking and chemical recovery, involve discharge of particulates, boiler also releases particles. Air pollution control is generally exercised through provision of the following types of equipment.

a) Cyclones: Cylindrically shaped collectors in which the particles collect at the bottom. The clean gas rises from the centre and is released from the top. The cyclone collector is simple and reliable with a low initial cost and easy maintenance.

b) Dynamic Precipitators: The centrifugal fan and a dust collector, in which the centrifugal force of the fan pushes the particles to the tips of the blades from where they are drawn off in a concentrated stream;

c) Electrostatic Precipitators: Operate on the basis of electrostatic attraction, and can be used for dry particulates or fumes, as well as mists; and

d) Fume Incineration : Utilised for the collection and oxidation of blow gases and digestor release gases. Direct flame incineration is used when the waste materials are capable of combustion on mixing with air. If the stream does not contain enough combustibles to support a flame, thermal incineration is utilised by using gas burners.

8.2 Water Pollution

The manufacture of paper requires a large volume of water, the bulk of which is released as waste water. The process water discharged from paper mills contains bark, wood debris, fibres and lignin and their decomposition products;

clay, certain minerals, resins, phenolics, starch, etc.; unsaturated fatty terpenes, metal oxides and other suspended solids.

Apart from dissolved toxic pollutants which have an adverse effect on fish, aquatic fauna and flora, public health, a major problem associated with water pollution is the 'biological oxygen demand'' or BOD, BOD is the amount of oxygen required to biologically oxidise the water contaminants to carbon dioxide and is thus a measure of the suspended, colloidal or dissolved organics. Related to the BOD and often measured instead, is the COD, or chemical oxygen demand, which is a measure of the amount of oxygen required to chemically oxidise the contaminants to carbon dioxide. The value of the COD is higher than that of the BOD, since use of strong oxidants is involved in forcing many substances to react, which do not react to bilogical micro-organisms. The COD value represents almost 100 per cent of the total organics present. The discharge of suspended solids (SS) has a deleterious effect on the receiving streams as anaerobic decomposition of these solids consumes dissolved oxygen in the over-laying water and thus adversely affects the aquatic life. Effluents also impart colour and turbidity to the streams. Discharge of untreated waste water therefore creates serious water pollution problems resulting in damage to aquatic life, deterioration in water quality and increase in the cost of water treatment.

The common methods employed by the paper industry for water treatment are shown in **Fig.**-2.4 Brief description of these are as follows:

a) **Pre-treatment:** Coarse solids such as pieces of wood, stones, sand, etc., are generally removed by screening as a part of pre-treatment; excessive acid or alkaline content can also be neutralised at this stage by suitable treatment since pH adjustment (6 to 9) is an integral part of the system.

b) **Primary Treatment:** The most common method used by the paper industry to separate suspended matter is sedimentation by settling ponds or clarifiers. Clarifiers are basins to which the effluent is discharged, where the solids settle due to gravity at the bottom, while the water rises to the surface and is withdrawn. Rakes or scrapers are employed to remove the settled sluidge. Only the BOD related to organic and fibrous material is removed during primary treatment.

c) **Secondary Treatment:** The main purpose of treatment is to remove soluble BOD using biological water treatment process. This generally consists of the following stages:

(i) **Lagoons** - which is the most common method of treating pulp and paper effluents. These may be simple oxidation ponds utilising micro-organisms and

FIG. 2.4 EXTERNAL EFFLUENT TREATMENT METHODS IN PULP AND PAPER INDUSTRY

PRETREATMENT	SCREENING EQUALISATION
PRIMARY TREATMENT	*OIL SEPARATION SEDIMENTATION ALUM & LIME TREATMENT FLOATATION SCREENING
SECONDARY TREATMENT	MEDIA FILTERATION STABILISATION PONDS AREATED STABILISATION PONDS ACTIVATED SLUDGE *OXYGEN ACTIVATED SLUDGE *AIR ACTIVATED SLUDGE *TRICKLING FILTER UPFLOW ANAEROBIC SLUDGE BLANKET SYSTEM IRRIGATION & LAND APPLICATION
COLOUR REMOVAL	*MASSIVE & MINIMUM LIME TREATMENT ALUM COAGULATION *POLYMERIC ADSORBENTS & ION EXCHANGE RESINS *ACTIVATED CARBON ADSORPTION *MEMBRANE PROCESSES *OZONATION

*THESE PRACTICES ARE NOT BEING FOLLOWED IN INDIA

sedimentation, anaerobic lagoons utilising methane bacteria for stabilising the organic matter, or aerated lagoons having a mechanical aeration device to increase the supply of oxygen to the bacteria for achieving stabilisation; and

(ii) **Activated Sludge Ponds** - the activated sludge process utilises flocculant micro-organisms for treatment of organic matter which can be separated by physical means. It employs an aeration tank in which waste water and micro-organisms are aerated and the resultant mixed liquor flows into a clarifier, where the biological mass (reffered to as the ' activated sludge') is separated.

Generally, a combinatioin of one or more stages of these methods are employed, before the waste waters are discharged into rivers.

Present waste water treatment practices employing biological method is given in Table-2.8 below. Each process has its own advantages and disadvantages. These biological treatment processes are capable of reducing BOD,COD, foaming tendency and dispersed turbidity. However only slight reduction in TOCl and color is achieved. It is therefore essential to provide other suitable methods for treatment of bleach plant effluents.

d) **Tertiary Treatment:** This is primarily meant to recycle water through methods such as filtration, chemical oxidation, electrodialysis and reverse osmosis, and is generally not employed by Indian Paper mills.

All the standard operations used for waste water treatment can be successfully adopted for treating paper mill waste waters, and technology for suspended solids and BOD is available. Removal of color constitutes a more difficult problem as special methods involving high cost are called for. It is generally recognised that more attention has to be paid to internal preventive measures applied to the manufacturing process in the mill itself, reducing the pollutant load to be handled. One of the important measures of internal control is to reduce the amount of raw water used in the manufacturing process by recycling, so that the volume of effluent is lowered substantially, with consequent saving in investment on external treatment plants, and reduction in the quantity of pollutants discharged. Utilisation of waste water for irrigation has also been found feasible, after removal of settleable solids. Some units such as Seshasayee Pulp & Paper and Tamil Nadu Newsprint, both use the waste water for irrigation of nearby areas.

TABLE - 2.8

VARIOUS BIOLOGICAL WASTE WATER TREATMENT PRACTICES

Treatment Method	Area requirement	Load range	H.R.T. kg/m^3/day	BOD_5 Reduction	Remakrs
1	2	3	4	5	6
Stabilization Pond	Very large	0.055-0.01	10 days	50-80%	Capable of buffering accidential spills of strong waste without upset, no maintenance, no mechanical aeration required,aeration takes place by natual means from air. Large land requirement suitable where land is inexpensive.
Aerated lagoon	Large	0.04-0.2	5-10 days	50-90%	Capable of shock load absoption,general stability,less capital and operating cost than activated sludge. Temperature sensitivity and large land requirement than activated sludge.
Activated Sludge	Small	1-5 $BOD_5/m^3/d$	-	40-75%	Low BOD removal efficiency,not suitable for large scale volume,low sludge, large temperature drop,time to start after a stop-a week, operating cost high.
Anaerobic	Small	10-20Kg $COD/m^3/d$	4-12	70-80%	Lower electrical power, production of energy rich biogas, lower sludge,higher concentration of effluents
Land disposal	Large area	200 lb/acre/day 225 kg/ha/day	-	90-95%	Low cost,high purification and simplicity of operation Some of the disadvantages are large land requirement, soil sealing,odour,freezing problem in cold weather.

Source:IPPTA,March'90.

8.3 Solid Wastes

About 4 per cent of the wood processed by paper mills remains in the form of dust, rejects and grit. In addition about 550 kg of dry lime and sludge per tonne of paper is generated which is disposed off along with waste water or dumped on fallow land. The sludge from the treatment of effluent from the paper machine can be utilised for manufacture of cheap grades of paper and board, and that from the pulp mill effluent treatment, could be utilised as a manure or fuel. Extensive research is, however, required in these areas.

CHAPTER III

MEDIUM AND SMALL SIZED PULP & PAPER MILLS BASED ON AGRICULTURAL RESIDUES AND WASTE PAPER.

1.0 INTRODUCTION: STRUCTURE OF MEDIUM AND SMALL PAPER MILLS:

Small and medium sized paper mills are based on agro residues and waste papers. Of these,agro based units constitute 36% and others constitutes 26% of total production. Mills of capacity 16,500 tpa or below are regarded as small paper mills whereas mills with capacity above 16500 tpa to 33000 tpa are considered as medium paper mills. The agro based small /medium paper mills were encouraged with the following objectives.

1. To create additional paper making capacity and to meet future growing needs of paper with short gestation periods and low capital investment per tonne of paper.

2. To encourage utilisation of annually renewable agricultural residues and waste paper for paper manufacture in view of resource conservation and waste recycling.

3. To develop and employ appropriate/intermediate technology to utilise agro residues and create a sustained and non-violent alternative sector to conventional raw materials.

4. To disperse industries in rural areas and promote economic development and provide rural employment with a large objective of integrating industry & agriculture.

With the above objective,GOI and financial institutions encouraged setting up of small and medium sized paper mills based on imported second hand paper machinery.

The number of mills in India can be classified as small, medium and large depending upon their installed capacities and from the view point of technological advancement as well. Table-3.1 shows the categorisation of mills based on their annual installed capacities .

TABLE-3.1

CATEGORISATION OF MILLS ON INSTALLED CAPACITY

S.No.	Category of Mills (tonnes/annum)	Annual installed capacity Million tons/yr.
1.	Small	Upto 16,500
2.	Medium	16,500-33000
3.	Large (Integrated) (including Newsprint)	Above 33,000

2.0 RAW MATERIAL SCENARIO :

Fibrous raw material is one of the basic input and the short term planning adopted by the Indian Paper Industry has ultimately resulted in serious shortages of raw material supply. Consequent to which, industry was forced to use all available fibrous resources to augment the supply of raw material on sustained basis and as a result , there has been a considerable impact on the pollution issues faced by the industry today. The future of the raw material availability appears to be bleak and and the industry will have to depend on non-conventional raw materials like cereal straw, bagasse & other annual plants or will have to rely on imported pulp.

2.1 Availability & Collection of Raw Materials

India being one of the leading agricultural country,agro residues like cereal straws, bagasse and other annual plants like jute,kenaf are available and the published information clearly indicate surplus availability of the raw materials for pulp and paper manufacture. In some countries,the straw based mills with capacities more than 100 tpd are operating, primarily because of efficient collection, cleaning and transportation within economic distance. The scattered availability and manual harvesting practices,lack of baling practices have restricted the size of our mill to less than 100 tpd and small mills with capacities less than 5tpd are essentially based on waste paper and are producing paper & boards on waste paper and are producing paper boards of inferior quality and some time they use it as middle layer of boards.

2.2 Infrastructure of Small and Medium Sized Mills

Most of the mills came in existence by aquiring second hand machinery and equipments from other countries where the scale of operation was increased considerably.As a consequence,the machinery and the process followed in this sector of paper industry are not efficient and are not in position to produce quality papers for competition in global market. The industry requires modernisation in most of the sections and some mills have already started expansion programmes to improve overall efficiency.

3.0 BASIC INPUTS : ENERGY, WATER AND CHEMICALS :

In medium and small sector , the mills have to totally depend on external sources due to lack of chemical recovery technology.

3.1 Chemicals :

Medium sized pulp mill of 50 tpd capacity uses caustic soda not less than 10 tpd and total quantity per year comes to about 3300 tons . Even if we assume 100 such mills, the net caustic drain is not less than 0.3 million tons per year. Thus nearly 450 million rupees is the net recurring loss per year to the country due to the absence of appropriate tecnology for recovery of chemicals.

3.2 Energy :

The entire portion of the energy both electrical and heat energy has to be purchased, since none of the mills have cogeneration facility and the cogeneration for such scale will not be economical.

3.3 Water :

Water consumption in small mills on per ton basis is still on higher side and consumption figures are more or less close to the figures of water consumed by a large integrated mill.The excess dilution ,low consistency operations,absence of closing up of the water cycles in areas where it is possible are main reasons for higher water consumption. However,the water consumption on waste paper based mills are on lower side . Typical consumption figure of basic inputs are shown in Table 3.2

TABLE -3.2

OPERATIONAL EFFICIENCY WITH RESPECT TO PRIMARY INPUTS AND THEIR RANGES

Particulars	Agro based	Waste paper based
Raw material,T/T pulp	2.9	1.5
Chemicals,Kgs/T pulp	290	35
Energy		
Steam, T/T pulp	6.0-8.0	2.0-3.0
Power , Kwh/T pulp	1100-1250	600-650
Water , m^3/T pulp	150 - 200	60-70

4.0 MANUFACTURING PROCESS :

4.1 The Raw Material Collection & Preparation :

There is not much of the improvement in raw material collection & preparation practices especially with regards to cleanliness of the raw material. Due to lack of efficient equipments,significant proportions of extraneous material like sand, grit, metals, grains, husk etc. enter the pulping process. As a result, there is additional burden on cleaning systems which have to be operated at lower capacities.

4.2 Pulping :

The agro based mills use predominantly spherical digesters of varying capacities in multiple numbers. Some of the mills use as many as 8-10 digesters.Number of mills have not taken to the insulation of the digesters & often the temperature , maintained are somewhere between 140-150°C, requiring longer cooking cycles of 6-10 hrs, thus consuming more steam and electrical energy.

Most of the units do not have the blowing, system and which ultimately results in spillage of black liquor in to open streams. The waste paper based mills normally use hydrapulper for producing the pulp and lot of contrary, coming with the waste paper is also going along with the pulp which becomes major problem in screening operations. Since , no mill practices organised deinking

method, so the pulp from the waste paper is not ideal for producing quality papers.

4.3 Washing Systems :

The washing of pulps in these category of mill is an obsolete technique, normally employing poacher follwed by one or two drum washers. Often the drum washers do not work at required efficiency levels for lack of required pulp mat formation thereby reducing the vaccum.So the mills invariably use high quantities of water up to 40-60 m^3 in washing stage /ton of pulp for the purpose of extraction of the black liquor and mills producing unbleached varieties do not wash properly and carry over of the black liquor gets extended to the paper making process.

Segregation of black liquor in the concentrated form before washing is an essential step, the mills have to follow up for proper management of pollution problems.

4.4 Screening & Cleaning Systems :

Due to low temperature & low chemical dosage, nearly 10-15% of the uncooked material enters as reject with lot of extraneous material coming with the pulp. Battery of cleaning systems are employed requiring huge amount of water. In the waste paper based mills, the screening & cleaning have often been a problem since contraries like plastic pieces, resins are difficult to get rid off and sometimes appear as transparent spots on paper.

4.5 Bleaching :

Only few mills are producing bleached varieties and bleaching is done in an unconventional way by using either elemental chlorine or calcium hypochlorite. Since, these mill do not have chemical recovery, the mills produce pulps of high kappa number and chlorine consumption figures are reported as high as 20-25% in some mills. Required temperature , consistency for effective utilization of bleaching chemicals are not maintained.

4.6 Stock preparation & paper making :

These mills are using old machinary & equipments. The stock preparation equipments like conical refiners, wide angle refiners operating at low consistency require high energy inputs without giving the desired results. The paper machines are not ideally designed for straws and bagasse and as a result the required efficiency is not obtained.

5.0 ENERGY STATUS OF SMALL / MEDIUM PAPER MILLS :

In general, small and medium paper mills use energy in two forms namely electricity and steam. The entire power requirements are met from state grid power and steam from their own generation in boilers using primary fuel as coal and secondary fuels such as bagasse pith,rice husk etc. There are differences in specific energy consumption in forest based large mills and medium/small mills. It is mainly due to the differences in raw material usage, mill design, choice in selection of suitable process and process equipment, product mix and capacity utilization. The capacity utilization in these mills is only 50-60%,where as in large mills it is around 90%. The second hand imported machines being used by these mills are not only outdated but are designed for long fibred chemical pulps. These machines when operated on unconventional raw materials give lower production and hence the efficiency of the machines is much below their rated capacities. The Table- 3.3 shows the specific energy consumption in Indian mills:

TABLE -3.3

SPECIFIC ENERGY CONSUMPTION IN LARGE AND SMALL PAPER MILLS

	Small Paper Mills		Large Paper Mills	
	1	2	1	2
	Without Recovery		With Recovery	
Productiont/day	25	45	210	130
Power KWh/t	1208	1215	1500	1390
Steam tonne/tonne	7.0	8.0	12.0	11.0

There is no cogeneration system in small mills due to high investment costs. On this account mills are loosing significantly on electricity. Further,they are more porne to power failures and cuts leading to reduced capacity utilization which in turn leads to increased specific energy consumption.

6.0 ENVIRONMENTAL STATUS:

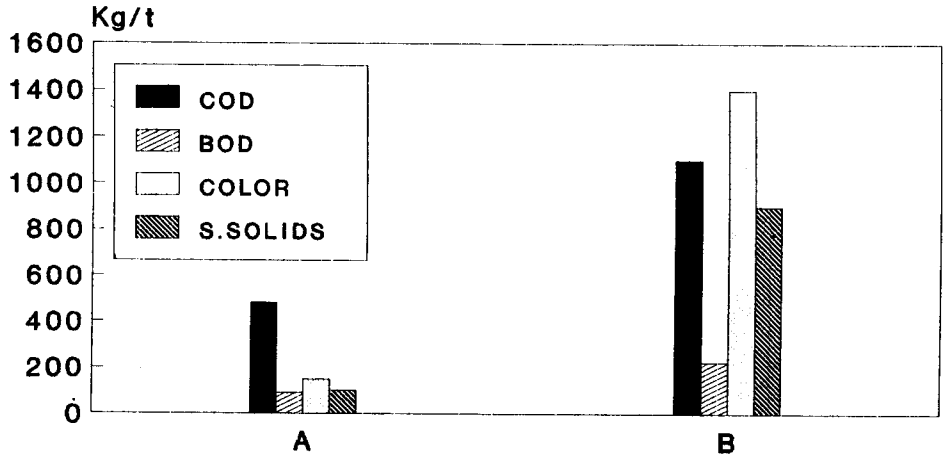
6.1 Liquid Effluents:

In absence of chemical recovery systems in small and most of medium sized paper mills, huge amount of energy and chemical rich biomass are discharged as waste products, aggravating the normal pollution loads already caused by paper mills. The pollution from a small mills is almost 3 times more than a mill integrated with chemical recovery (Fig.-3.1).

The primary reason for heavy pollution in small mills is discharge of spent pulping liquors carrying high proportion of organic matter. Fig.-3.2 indicates the different loads in black liquor, lignin and lignin free effluent. The lignin present in the black liquor is almost non-biodegradable.

There is a wide variation in the volume and composition of waste waters generated in different mills, even though making same varieties of paper employing similar raw materials and process. Medium/ Small paper mills use different raw materials at different periods and the proportion of these raw materials also vary appreciably. The manufacturing process differs widely depending on type of fibrous raw material and the quality required for pulping. Pulp making involves chemical, chemi-mechanical and/or hydrapulping processes using agro-residues and waste paper as raw material. Hence,the variation in flow characteristics will be much more in such mills. Further,mills with capacity 10 tpd and less use only waste paper and purchased pulp. Hence, the waste waters in these mills is very much lower as compared to waste waters from the small mills which make their own pulp. The characteristics of waste water from different mills with and without recovery are given in Table-3.4.

FIG.3.1 POLLUTION LOADS FROM LARGE INTEGRATED & SMALL AGROBASED PAPER MILLS

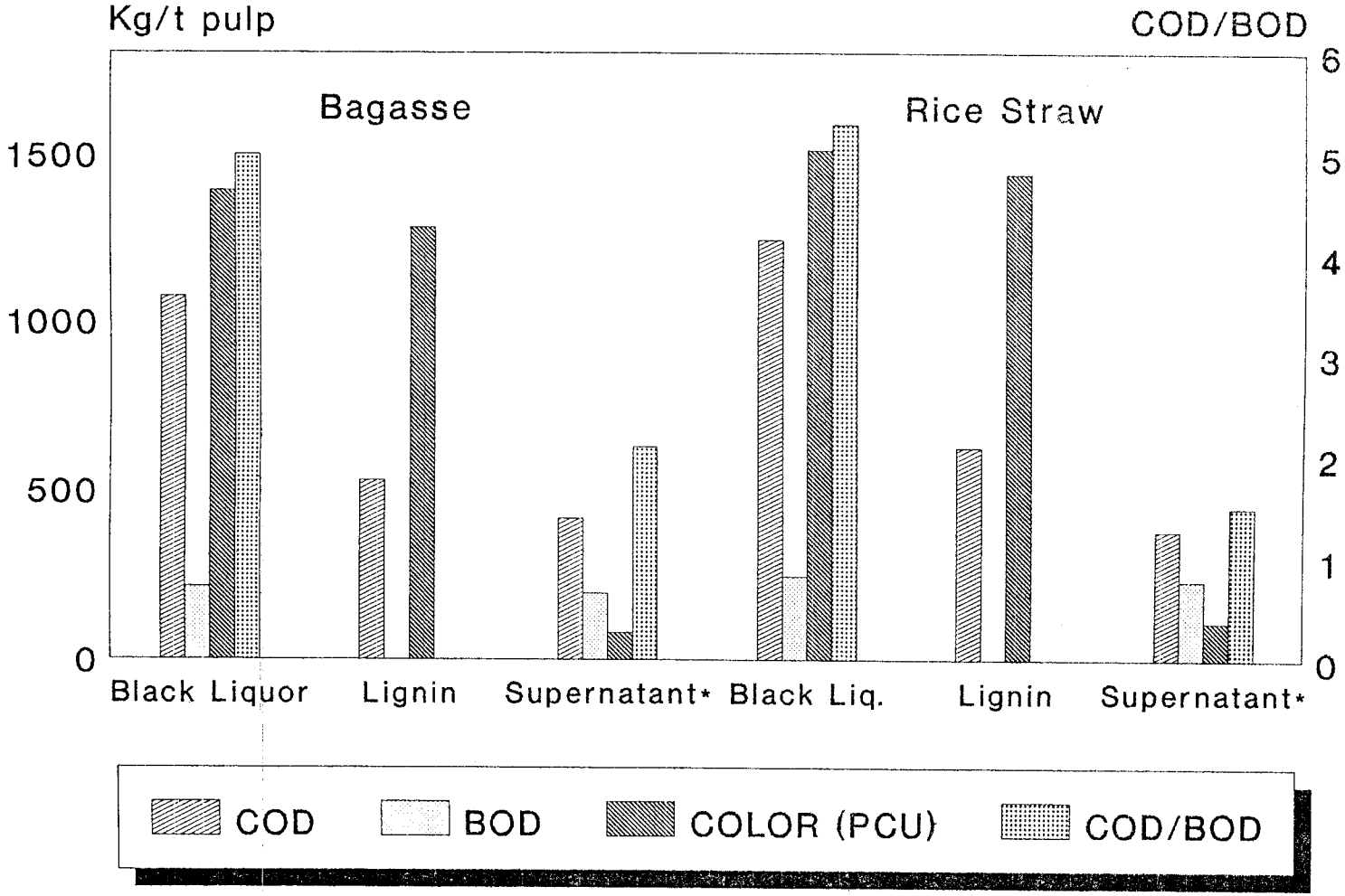


	A	B
COD	480	1100
BOD	90	225
COLOR	150	1400
S.SOLIDS	100	900

A - WOOD BASED MILL WITH CHEM.RECOVERY

B - NON WOOD MILL WITHOUT CHEM.RECOVERY

FIG.3.2 POLLUTION LOADS OF BLACK LIQUOR AND ORGANICS



*Lignin free liquor

TABLE - 3.4

CHARACTERISTICS OF COMBINED WASTE WATERS FROM PULP AND PAPER MILLS

Parameter	Large Paper Mills With Recovery	Small Paper Mills Without Recovery	
	Range (Av) (Reference)	Agro resi-dues based Range (av)	Waste Paper based Range (av)
Flow, m^3/t paper	167-281 (220)	187-383(252)	72-159(107)
pH	6.6-10	6-8.5	7.1-7.7
S.S., mg/l	620-1120(764)	600-1115(615)	350-885(542)
BOD_5,20°C,mg/l	240-380(295)	220-1067(698)	100-273(187)
COD, mg/l	840-1660(1118)	2120-4763(2940)	472-876 (65)
COD/BOD	2.95-4.37(3.8)	2.49-5.40(4.2)	2.7-5.7(3.5)
Colour Pt-CO unit	300-655	15000-24000	White to Blue
Lignin mg/l	-	320-700 (563)	-
SAR	2.0-5.3(3.5)	4.7-7.6 (6.40)	-
Pollution Load Kg/t Paper			
SS	168	155	150
BOD	65	176	20
COD	246	741	70

Source : NEERI Publication.

A generalised flow sheet of small paper mills showing sources of waste is shown in Fig.3.3

In agro based mills without chemical recovery, the lignin contribution to waste water is around 215-225 kg/t of paper. Likewise,the sodium contamination is also high. In other words a 30 tpd mill would be discharging a BOD load equivalent to that of 100 tpd mill with recovery. A small paper mill using waste paper and pulp from outside would be discharging less polluting waste water as compared to other group of small mills. The suspended solid load remains the same in both cases but in mills using waste paper the BOD and COD loads are nearly 40% and 60% respectively of the mills with the pulp making facilities. However, the S.S. and BOD in the waste water from small mills using waste paper can be appreciably reduced if the mills use effective system of fibre recovery and recycling as shown in Table-3.5

TABLE-3.5

WATER REQUIREMENT AND WASTE WATER GENERATION FROM AGRO BASED PULP & PAPER INDUSTRY

	Type of Industry	Water Requirement, m^3/t of product	Waste Water generation, m^3/tonne of products.
	Agricultural residue based mills:		
(i)	With no fibre recovery	300	225
(ii)	With fibre and water recovery	200	160
(iii)	Kraft (unbleached) paper	200	160
(iv)	Bleached paper	225	190
(v)	Duplex Board	150	120
(vi)	Waste Paper based mills	100-175	80-150

6.2 Air Pollution :

These mills may not have serious air pollution problems since they do not use sulphur compounds in pulping. Further these mills only generate steam for the process and do not have captive power. However, certain amount of maladrous organic compounds are released into the atmosphere during pulping. At times, chlorine leakage from plants affects the life of the workers.

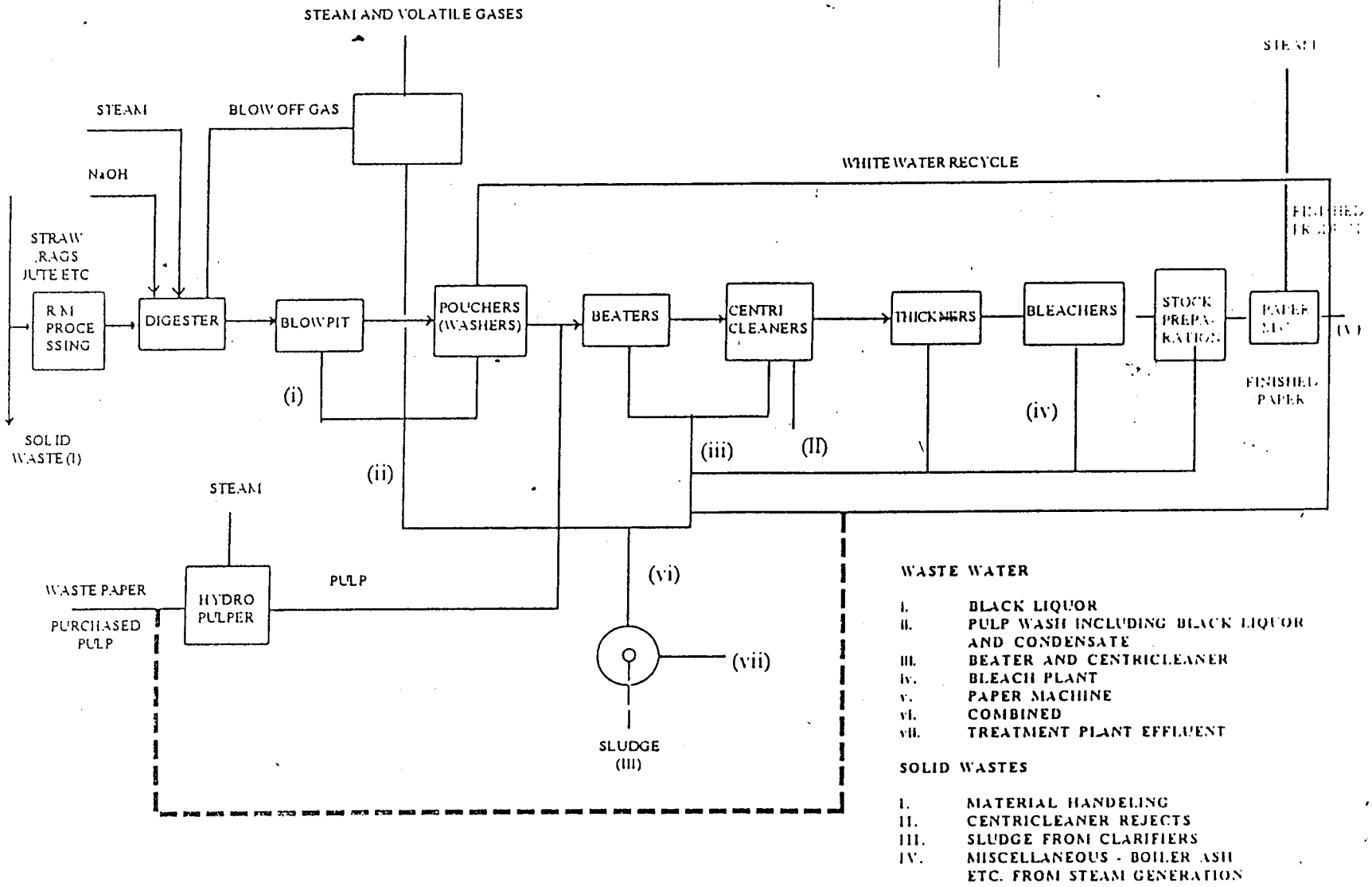


FIG. 3.3 GENERALISED PROCESS FLOW SHEET OF SMALL PAPER MILLS AND SOURCES OF WASTE

The nature and extent of pollution created by these mills have not yet been investigated.

However,most of these mills are equipped with package boilers without adequate control sytems as a result the fuel - air mixture is not controlled properly and consequently gaseous emmisions also carry carbon mono oxide and carbon dioxide levels more than the levels per tonne of steam. The pariculate emissions are also on higher side with excessive use of air and no intermediate equipments to control the particulate emissions.

6.3 Solid Waste:

Although, the paper industry generates large amount of solid waste, but in case of small mills the magnitude is much lesser than an integrated mills. The magnitude of solid wastes in these mills is shown in Table-3.6.

TABLE-3.6

SOLID WASTE GENERATION IN PAPER MILLS

Waste Sources	Kg. Dry Solid/Tonne paper
	Medium/ Small paper mills
Raw material handling/ preparation	210 Straws (550) (Bagasse)
Power plant/boiler ash*	1300
Waste water treatment plant	
Primary sludge	116
Secondary sludge**	105
Total	1731 (2071)
% organic solids	25 (35)
% Inorganic solids	75 (65)

Source : NEERI Reports

* Ash generation depends on % ash in coal and the amount of power /steam generation.

** Estimated assuming 0.5 kg mixed liquor suspended solids (MLSS) produced /kg BOD removed is activated sludge treatment plant.

7.0 EFFLUENT TREATMENT PRACTICES:

When these mills were envisaged,not much of the concern was shown to the environmental issues and mills continued to operate and despite loosing valuable chemicals the survivals of the mills was based on the facts that the production containing 75 % of unconventional raw material was exempted from excise duty and that is how the mills continued to survive economically. With passage of time, number of such mills grew rapidly and in some states cluster of mills started operating on sustained basis. Only in early 80's,the magnitude of pollution was realised by the regulatory and controlling authorities,which started formulating the standard limits which could be complied with in a phased manner. As a first attempt, MINAS was brought into force and mills were asked to comply with MINAS. Subsequently, mills started installing effluent treatment plants. As on today most of such mills do possess effluent treatment plant, but it appears that not enough concern has been shown in design of such effluent plants with the quality of effluent discharged from such mills and particularly, the major polluting stream i.e. the black liquor. Despite the efforts by the mills, it seems hardly any mill has shown stric compliance with the MINAS standards given in Table- 3.7

TABLE- 3.7

MINAS FOR SMALL PULP AND PAPER INDUSTRY :

Parameter	Concentration
pH	6.0 - 9.0
Suspended solids,mg/l	100
Bio-chemical oxygen demand,mg/l	50

The basic faclities mills possessed were -

1. Primary clarifier
2. Secondary treatment
3. Aerated ponds.

Since most of these mills are dependent on purchased power, so even if they possess aeration system,it was rather difficult for them to run the aerators continuously.

CHAPTER-4

STANDARD LIMITS IN FORCE

1.0 LIQUID DISCHARGE STANDARDS:

After the period given for compliance of MINAS, the pollution controlling and regulating bodies revised the MINAS and promulgated the legislative standards for small mills on similar lines, with those mills integrated with chemical recovery. The standards for large and small mills are as shown in Table-4.1

TABLE- 4.1

LIQUID EFFLUENT DISCHARGE STANDARDS IN PULP & PAPER MILLS

Parameter	Large Mills Above 24000T/year	Small Mills Upto 24000 T/year	
		Agro based	Waste Paper based
Volume,m^3/T (Pulp & Paper Mills)	175 (100)	200 (150)	75 (50)
Rayon grade Mills/ Newsprint	150		
pH	7.0-8.5	5.5-9.0	5.5-9.0
BOD at 20°C,mg/l	30	50	30
COD,mg/l	350	-	-
SS,mg/l	50	100	50
TOCl,kg/T * paper	2	-	-

Figures under bracket are for new mills set up after 1992.
*From January 1992.
Source: CPCB Standard Published in Gazette Notification, Feb. 1991.

Some of the mills particularly in small sectors, after primary and secondary clarifications have been claiming the use of treated effluents for irrigational purposes and some mills have arrangements with academic institutions to study the quality of sub soil after use of treated effluents over a period of time. The principle behind the use of effluents for irrigational purposes is -

- Use of soil as a treatment system
- Supplementary source for irrigation.
- Lowering of effluent treatment cost.

However, the effluent from agro based mills in particular, carries significant amounts of sodium. Although on a short term basis,the use of effluents for irrigation purpose may prove beneficial,but the salinity and SAR of the soil over a period of time needs to be critically evaluated. Number of guidelines and specifications are available to decide whether a particular effluent can be used for irrigation or not. Table 4.2 shows the limits for effluent for irrigation discharge.

TABLE - 4.2

STANDARD LIMITS OF EFFLUENTS FOR IRRIGATION PURPOSES*

BOD load	-	225 kg/hectare/d
pH value	-	6.5 - 9.0
Sodium Absorption Ratio	-	8 on permeable soils
Color	-	Investigation required
Land requirement	-	4.3 - 5.3 hectares per 1000m^3 effluent/d

* Source: BIS : 5061 (Part-I)-1978.

Table-4.3 shows the standard discharge limits for Industrial effluents to various recipient streams.

TABLE-4.3

TOLERANCE LIMITS FOR INDUSTRIAL EFFLUENTS :*

Particulars	In to Inland Surface Water	On land	Marine Coastal Area	Public Sewer
pH	5.5 - 9.0	5.5-9.0	5.5 -9.0	5.5-9.0
BOD 20°C , mg/l	30	100	100	350
COD,mg/l	250	-	250	-
Sus. Solids,mg/l	100	200	100	600
% Sodium	-	60	-	60

Source: BIS:2490 (Part I).

2.0 DISCHARGE STANDARDS FOR AIR EMISSIONS:

Recently,Indian Paper Industry has started installing cyclones, dynamic & electrostatic precipitators etc. to control air pollution. But there are very few mills who really are sticking to the tolerence limits laid down by the pollution control authorities. Table-4.4 shows the permissible stack emission limits for moderate polluting industries .

TABLE -4.4
MODERATE POLLUTING INDUSTRIES STACK EMISSIONS
(Permissible Concentrations)

Parameter	Industrial Area	Residential Area	Sensitive Area
SPM,mg/m^3	2000	1000	500
Iron dust,mg/m^3	1000	500	250
SO_2,ppm	5000	2000	1000

Source: CPCB -Standards Published in Gazatte Notification, Feb. 1991.

The standard air emission levels for large pulp & paper industries are shown in Table-4.5.

TABLE -4.5

STANDARD AIR EMISSIONS FROM LARGE PULP & PAPER MILLS

Particulate Matter,mg/Nm^3*	250
H_2S, mg/Nm^3	10

Source: CPCB -Standards Published in Gazatte Notification, Feb. 1991.

Limits to be reduced to 150 mg/NM^3 for mills set up after 1992.

Standards for Lime Kiln discharges as shown in Table-4.6

TABLE-4.6

EMISSION FROM LIME KILNS

Capacity of Kiln	Parameter	Standard
Upto 5T/day	Particulate matter	A hood should be provided with a stack of 30 mts.of height from ground level (including Kiln height).
5-40 T/day	Particulate matter	500 mg/Nm^3.
Over 40 T/day	Particulate matter	150 mg/Nm^3

Source: CPCB Proceedings on Waste Management in Pulp & Paper Industry, Nov. 1994.

3.0 NOISE POLLUTION :

The sources of noise pollution are from -

- Chipper house
- Vacuum pumps and
- Compressors used in various sections and
- The paper machine drives.

Table 4.7 shows the noise pollution standards laid down by CPCB.

TABLE- 4.7

STANDARD LEGISLATIONS FOR NOISE STANDARDS

Noise Levels,dB	Day Time	Night Time
Industrial Area	75	70
Commercial Area	65	55
Residential Area	55	45
Silent Zone	50	40

Source : CPCB -Standards Published in Gazatte Notification, Feb. 1991.

CONCLUSIONS

From the foregoing discussions based on the information collected following conclusions are arrived at:

i) There is enormous scope for resource recovery and environmental protection.

ii) Adequate modernisation needs to be taken up for cost effective production and improving the environmental situation.

iii) The environmental protection and resource conservation programme should become the responsibility of participating industry.

iv) Environmental awareness needs to be created at all levels of the mill management.
