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ENVIRONMENTAL MANAGEMENT IN PULP AND PAPER INDUSTRY

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ABSTRACT

India is a vast country with an average of 700 pulp and paper mills. It is one of the highest polluting industries in India and is highly water intensive. Relatively large wastewater discharges and accompanied release of high pollution load into the environment is the sequel of high water consumption and pollution generation in the process of pulp and paper manufacture. Steps are been taken to preserve the resources, especially water which is an integral part of the pulp and paper industrial functioning. The need of cleaner production programs has been felt in recent times by the paper industry by way of a resource and waste minimization concept. In India efforts have been going on for years to improve house keeping, optimize process parameters, increase recycles and adopt improved technology. This paper aims at highlighting the process used during manufacture, sources and types of waste generated and treatment options available for improving the quality of waste to be discharged.

INTRODUCTION

Water is a precious commodity and nature's greatest gift to the living kingdom. Total utilizable water resources in India in 2005 have been estimated to be 1122 billion cubic meter per year, 38% of which is presently exploited for total national use (Dahasahasra and Panse, 2005). Water consumption in agriculture, industrial sector and domestic purposes are 85.3, 8.0, and 6.6% respectively. Water use in industrial sector is 34 billion m^3 per year which is estimated to increase by four folds by 2050. With the continuously increasing demand and strong competition among industrial, agricultural and domestic sectors, water availability will be severely affected particularly to the large consuming industrial sectors like pulp and paper. Present national norm of water consumption per tonne of paper is 200 and 250 m^3 in agro and large pulp and paper sectors whereas that set up World Bank is much lower (56 and 55 m^3 per tonne of pulp and paper). By reducing the water consumption to 75m^3 per tonne of pulp and paper the paper industry can produce double the amount of paper with the existing water allocation/draw. Pulp and paper industry is the third largest water consuming industrial sector in the country (www. water and agro industries. org/pulp paper.htm). Fresh water consumption in wood based, agro-based and waste paper based mills is 125-200, 125-225, 75-100 m^3 per tonne of paper respectively (Chakrabarti, 2006). With average water consumption was 151m^3 per tonne of paper. With the moderate per capita paper consumption of 10kg, water demand in this sector might increase to more than 1.5billion cubic meter with the current rate of water consumption.

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MANUFACTURE OF PAPER

The basic steps in making paper include;

- Suspension of cellulosic fiber prepared by beating it in water so that the fibers are thoroughly separated and saturated in water.
- Paper stock filtered on a woolen screen to form matted sheets of fiber.
- The wet sheet pressed and compressed to squeeze out a large proportion of water.
- The remaining water removed by evaporation.
- Depending upon use requirement, the dry paper sheet is compressed, coated or impregnated.
- Hydropulping

SOURCES OF WASTE GENERATION

In pulp and paper industry, considerable quantity of water is used in paper making processes. The quantity of water consumption varies according to the quality and kind of paper to be manufactured. In addition considerable amount of solid waste and gaseous emission occurs.

(i) Waste Water Generation

The following are the major sources of wastewater generation in an integrated pulp and paper industry:

1. Raw material section

- Washing wooden chips in large-scale pulp and paper mills using wool as raw material.
- Washing of bagasse for separation of pith.
- Washing of rice/ wheat before pulping.

2. Pulping and bleaching

- Washing of chemically cooked pulp.
- Washing of pulp during bleaching.
- Pulp cleaning equipments.

3. Stock preparation and paper machine

- Cleaning of pulp in cleaning equipment.
- Filtration for wire section of paper machine.
- Paper machine presses.

4. Chemical recovery

- Foul condensate from evaporator and steam surface condenser.
- Boiler blowdown.

Beside above major sources of wastewater generation there are frequent leakages of black liquor from pump glands and its improper handling, which contribute significant color and pollution to the stream.

(ii) Solid Waste Generation

In pulp and paper industry solid wastes are generated from following operation;

- Raw material handling.
- Rejects from screening and centri-cleaners.
- Primary and secondary sludges from wastewater treatment system.
- Coal or boiler ash from steam and power generation.
- Lime sludges from causticizing section of chemical recovery plant.

(iii) Air Pollution

In pulp and paper industry air pollution is caused due to odour emitting reduced sulphur compounds such as hydrogen sulphide, methylmercaptan, dimethly sulphide, and particulate matter SO_2 and NOx present in the gases emitted by different process units. Gaseous emission from pulp and paper mills can be broadly classified into the following categories:

- Gases from digesters.
- Gases from multiple effect evaporators.
- Gases from recovery.

CHARACTERISTICS OF POLLUTANTS

Pulp and paper industry is intensive in terms of raw material consumption. Besides pollution load generation, the other consumption includes chemical, energy, water and capital requirements. About 41.8% of wood is recovered as bleached pulp. Of the remaining wood, roughly 4.2% ends up as solid waste, 5.25% goes into wastewaters as dissolved organic matter and 2.3% goes as suspended solids in wastewater (Nemade *et al*. 2003). The potential pollutants from pulp and paper mill fall into four principal categories as under:

Water effluents

- Suspended solids including bark particles, fiber, pigments and dirt.
- Dissolved colloidal organics like hemicelluloses, sugars, lignin compounds, alcohols, turpentine, sizing agents, adhesives like starch and synthetics.
- Color bodies, primarily lignin compounds and dyes.
- Dissolved inorganics such as NaOH, Na_2SO_4 and bleach chemicals.
- Thermal loads.
- Microorganisms such as coliform group.
- Toxic chemicals.

Gases

- Malodorous sulphur gases such as mercaptans and H_2S released from various stages in Kraft pulping and recovery process.
- Oxide of sulphur from power plants, kraft recovery furnace and lime kiln.
- Steam.

Particulates

- Fly ash from coal fired power boilers.
- Chemical particles primarily sodium and calcium based.
- Char from bark burners.

Solid wastes

- Sludges from primary and secondary treatment and causticizing in kraft mill recovery section.
- Solids such as grit bark and other mill wastes.
- Ash from coal fired boilers.

WATER CONSERVATION MEASURES

Pulp mill

- Raw material washing should be done with treated effluent.
- Washing efficiency of pulp washers should be improved.
- Paper machine back water should be used in the pulp dilution in the unbleached tower.
- Backwater should be used in centri cleaning of pulp and vacuum pump sealing.
- Bleach plant filtration should be recycled in pulp dilution in tower and vat, and shower sprays in the preceding stage.

Paper machine

- Efficiency of fiber separation with gravity save-all, krofta or disc filter should be increased to the best possible extent.
- Clarified back water of the fiber separator equipment should be used in pulper and head box dilution.
- Clarified back water should also be used in all showers except in felt cleaning.
- Cooling tower for vacuum pump and winder brake drum water should be installed and the water should be recycled.
- The condensate recovery in paper machines should be increased and reused in DM water make up.
- Back water should be utilized for alum/ PAC, filler and other chemical preparation.

Boiler house

- Treated effluent should be used in ash quenching
- Membrane based process for water softening should be installing in place of conventional chemical process.

POLLUTIONAL EFFECTS

The main polluting constituents in pulp and paper mill wastewater are suspended solids, color, foam, inorganics such as sodium carbonate, bicarbonate, chlorides and sulphates, toxic chemicals such as mercaptans and inorganic sulphides. The effluent has high BOD and COD and when discharged untreated will damage the receiving water courses due to the presence of high oxygen demanding organics and inorganic constituents. Further the effluents impart colour to the stream and it persists for a long distance since lignin and its derivatives present in the effluent are not readily biodegraded. The effluent may also impart odour to the stream.

CLEANER PRODUCTION

Cleaner production means continuous application of an integrated approach to improve mill operation through adoption of modern technologies, optimized process operation, resource recovery and maximum output per unit of the raw material inputs. The Indian paper industry still uses old pulping technologies and elemental chlorine bleaching resulting in high level of AOX generation. Cleaner technologies for pulping of raw materials are continuous pulping, RDH pulping, oxygen delingnification and for pulp bleaching are elemental chlorine free bleaching (EFC), chlorine dioxide bleaching, oxygen /peroxide bleaching.

Elements of Cleaner Production

There are few approaches to achieve cleaner production, which are known as CP technologies.

Source Reduction: It includes the change in existing practices or introducing new techniques in operating and maintaining equipments. The prevention

of spills and leakages are typical house keeping measures.

Process change: It includes four options viz: change in input material, better process control, equipment modifications, and change in technology.

Recycling : This covers on site recovery and reuse of materials and energy which otherwise was a waste. Recovered material is better used in same process or for other purposes.

Product Modification: Produce high yield varieties of paper in order to minimize the environmental impact from the disposal of the product.

The willingness of industrialists taking into account their view point is essential to improve the environment, corporate responsibility for environment protection (CREP) was therefore formulated jointly by CPCB and MOEF in close association with industry's association. The CREP action points, time frame and status of its implementation are given in Table No.5.

EFFLUENT TREATMENT PRACTICES IN PULP AND PAPER INDUSTRY

Several control and treatment technologies have been developed to reduce wastewater discharge from the pulp and paper industry. The two major technology approaches are:

1. At source treatment controls measurements aimed at reducing wastewater volume and pollutant load discharged from the mill.
2. Wastewater treatment technologies or end-of-pipe treatment system aimed at reducing discharge of pollutants in the wastewater.

Various approaches for the management of effluent discharged include (Tarar *et al.* 2000)

Segregation : Highly concentrated and offensive effluents are segregated from relatively voluminous effluents.

Chemical Recovery: Efficient recovery of chemicals from the spent liquor is an integral part of modern sulphate (kraft) and soda processes.

Good Housing Keeping: Proper installation and operation of equipment, keeping them well cleaned before emptying into drain. Avoiding unnecessary biodegradable material to be dumped into waste stream, reuse of water when possible, reduces considerably the pollution load.

Reclamation and Recycling: About 80-90% reduction in pollution load and 70 % reduction in effluent volume in chipper house can be achieved through effluent reuse. Similarly recirculation in multi-stage bleaching operation reduces pollution loads by 30-80%. Effective fiber recovery from paper machine can reduce the pollution load by 20- 60% and volume by 60-80% (Birdie and Birdie, 2008).

Primary Treatment : It includes coagulation & flocculation, floatation and sedimentation. A well designed clarifier is considered most suitable and is expected to settle 90-95 % of the settleable solids and removes 25-30% of BOD. Clarifier should be designed for an overflow rate of 30 cubic meters per square meter per day and a detention time of three hours. Settled sludge is regularly pumped out at about 3% solid consistency. The sludge can be dewatered to spedable consistency by drying on usual drying beds, vacuum bed filters, and solid bowl centrifuges.

Biological Treatment : Depending upon the conditions at site and degree of treatment required for final disposal of effluents, biological treatment methods that can be adopted include; oxidation pond, aeration lagoon, trickling filter with secondary clarifier and activated sludge process.

REUSE OF WASTEWATER

Land application of the pulp and paper mill wastewater for growing a variety of crops has been reported from several parts of the world. Studies carried out by NEERI in one of the large pulp and paper mills in the country have revealed that (Ghosh, 1997) :

- Wastewater can be successfully used by crop irrigation on coarse textured soils to raise salt tolerant crops, such as wheat, barley and maize, sugarcane and pulp grade wood plants.
- Soil retains color and removes COD in the wastewater.
- Sodium build up was noticed in the continuously irrigated soil with the wastewater, which could be overcome by using gypsum for reclamation.

PERMITTED TOLERANCE LIMITS

The Bureau of Indian standard has laid down various tolerance limits for discharge of industrial effluents into various areas. The standards applicable are B.I.S. 2490 (1947), which lays down tolerance limit

Table 1. Raw mMaterials used in pulp and paper industry (Tarar, 2000)

S.No.	Cellulosic raw material	Preparatory process	Pulping process normally adopted
1. Bamboo	Dry chipping, washing, chipping into small bits.	Sulphate, sulphide , Soda , semi-chemical & mechano-chemical	
2. Wood (soft or hard)	Debarking, chipping, screening	As above	
3. Straw (rice or wheat), grasses, bagasses, kenahm jute, sticksm hemp, hessain cotton, liners and rags	Chipping, dusting and dispatching for bagasse	Soda, lime soda, semi-chemical, mechano-chemical	
4. Waste paper	Sorting and dusting	Hydropulping	

Table 2. Pulping processes (Tarar, 2000)

S.No.	Pulping process	Major pulping chemical	Intermediate chemical	Recovery of chemical by products
1.	Sulphate	Caustic soda, sodium sulphate, sodium hyposulphide	Sodium carbonate	Chemicals are largely recovered in all big mills
2.	Sulphite	Sodium sulphite, sodium bisulphite	Sodium carbonate sodium bicarbonate	Chemicals are partly recovered. this prowess is dying out in presence of sulphate process
3.	Soda process	Caustic soda	Sodium carbonate	Chemicals are largely recovered in all big mills
4.	Semi chemical	Caustic soda, Sodium sulphide, Sodium Hydrogen sulphide	-	Partially recovered in medium and big mills
5.	Mechano-chemical	Caustic soda and mechanical grinding of raw material with water	-	No recovery
6.	Straw board and paper	Lime and caustic soda	-	No recovery

Table 3. Sources of waste water and their characteristics

Sources	Discharge	Intensity of Pollution
Fibrous raw material washing	Washing of raw materials.	Small volume with least pollutants.
Digester House	Spills and leakages of black liquor and gland cooling water	Small volume but high concentration of pollutants
Pulp washing	The final wash often referred as brown stock wash or unbleached wash.	Small volume and large quantity of pollutant.
Centricleaners	Rejects containing high concentration of fibres and girt or sand.	Small quantity but high-suspended solids.
Pulp bleaching	Wastewater from chlorination stage having low pH and high chlorolignins, from caustic extraction stage with dark brown colour and high pH as well as chlorolignins from hypochlorite stage.	Very large volume with high concentration of pollutants. About 60-65% of wastewater is contributed from this section. The effluents contain toxic chloro-organic compounds.
Paper machine	Often referred to as white water.	Volume depending upon the extent of recycling. It contains maximum suspended solids like fibres, fines and small quantity of dissolved pollutants.
Chemical Recovery	Spills of black liquor in the evaporators, foul condensates and washings of the cauticiser	Small volumes, but high pollutants.

Table 4. Quantity of Effluent Discharged by Pulp, Paper and Board Mills (Birdie and Birdie, 2008)

S. No.	Type of mill	Product	Output tones/day	Effluent /day	Discharge / tonne of product
1.	Sulphate mill				
A	No.1	White printing , writing and kraft paper	200	4400	220
B	No.2	White printing,	7000	350	
C	No.3	White printing , writing and kraft	200	61000	305
D	No.4	White printing , writing and kraft unbleached paper	200	61000	305
E	No.5	White printing writing and specially board	100	343000	343
F	No.6	Bleached pulp	80	16000	200
2	Sulphite mill	White printing and writing paper	55	13200	240
3	Newsprint mill (sulphate + ground wood)	Newsprint	130	34000	262
4	Packing paper mill (soda lime)	Packing paper	15	2040	136

Table 5. CREP plan of action for large scale pulp and paper mill (Ansari, 2006)

S.No.	CREP Action Point	Status
1	Discharge of Adsorbable Organic Halides- 1.5Kg/tonne of paper within 2 years (1st April, 2005) 1.0 Kg/tonne of paper in 5 years (1st April, 2008)	Before CREP AOX level was 2-2.5Kg/tonne of paper. After CREP, 11 mills achieved AOX level? 1.5 Kg/tonne and tonne of paper by cleaner technologies like oxygen delingnification and rine-di-oxide sub stitution.
	8 mills achieved AOX level? 1.0Kg/using chlo	
2	Wastewater discharge <140cum/tonne of paper within 2 years i.e. April, 2005 <120cum/tonne of paper in 4 years for units installed before 1992i.e. April, 2007 <100cum/tonne of paper for units installed after 1992.	Before CREP, the discharge level was between 180-25-cum/tonne of paper. After CREP, waste water discharge level has come down? 140cum/ tonne of paper and has been achieved by 9 mills while in 10 mills it is even less than 120cum/ of paper.
	tonne	
3.	Installation of lime- kiln for recalcination of lime sludge within 4 years (1st April, 2007)	9 mills have installed lime kiln and rest of the mills have submitted action plan for lime kiln in stallation. The installation by these mills is under different stage.
4	Odour control by burning reduced sulphur emissions in the boiler / lime kiln within 4years.	One of paper mills has installed odour control system. Other mills have submitted action plan for its implementation. Many mills requested for extension for another year.
5	Utilization of treated effluent wherever possible.	10 units partially using treated effluent for irrigation.
6	Colour removal from effluent. (IPMA take up the project on colour removal with CPPRI)	No project has been given by the IPMA to CPPRI as decided by the Task force. One of the mills is participating in demonstration of colour removal project of CPCB. The plant is under trial run.

for discharge of effluent into water courses, B.I.S. 7968 (1976) showing tolerance limit for discharge of effluent into marine coastal areas and B.I.S. 3307 (1965) which lays down such limit for use of effluent for irrigation. These are shown in Table 6.

All units are up to their maximum limit and in mg/L except pH and temperature.

CONCLUSIONS

- Energy- efficient pulping process should be used wherever feasible. Acceptability of less bright products (newsprint, thermo-mechanical processes) and recycled fiber should be promoted.
- Minimize the generation of effluent through process modifications and recycle wastewater, aiming for total recycling.
- Reduce effluent volume and treatment requirements by using dry debarking instead of wet one; recovering pulping chemicals by concentrating black liquor and burning the concentrate in a recovery furnace; recovering cooking chemicals by recausticizing the smelt from the recovery furnace; and using high efficiency washing and bleaching equipments.
- Minimize unplanned or non routine discharges of wastewater and black liquor, caused by equipment failures, human errors and faulty maintenance procedures. This can be done by training operators, establishing good operating practices, providing sumps and other facilities to recover liquor losses from the process.
- Aim for zero discharge wherever feasible.
- Reduce bleaching requirements by process design and operation.
- Sulphur emissions to the atmosphere should be minimized by using a low odour design black liquor recovery furnace.
- Energy efficient processes must be practiced for black liquor chemical recovery, preferably aiming for a solid content of 70%.

Table 6. Discharge Standards (as per BIS) (Ansari, 2006)

S.No.	Characteristics	I.S. 2490	I.S. 7968	I.S. 3307
1.	pH	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
2.	Temperature not to exceed	40oC	45oC	Not specified
3.	Total suspended solids	100	100	Not specified
4.	Total dissolved solids	-do-	-do-	2100
5.	BOD,5 day at 20oC	30	100	500
6.	COD	250	250	250
7.	Oil and grease	10	20	30
8.	Phenolic compounds	1	5	Not specified
9.	Cyanides	0.2	0.2	-do-
10.	Sulphides	2.0	5.0	-do-
11.	Sulphate as SO4	Not specified	Not specified	-do-
12.	Total residual chlorine	1.0	1.0	1.0
13.	Chlorides as Cl,	Not specified	Not specified	600
14.	Arsenic	0.2	0.2	-do-
15.	Cadmium	2	2	-do-
16.	Copper	3	3	-do-
17.	Mercury	0.01	0.01	-do-
18.	Ammonium Nitrogen	50.0	50.0	-do-
19.	Boron	Not specified	Not specified	2
20.	Percentage sodium.	-do-	-do-	60

Note : Values in mg/L except pH and otherwise specified

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