TREATMENT PROCESS AND POLLUTION CONTROLS ASPECTS IN PULP & PAPER INDUSTRY

[1]Prof. (Dr.) Ashok Dhariwal, [2]Mayank Vyas[2]
[1]Director (Academic), [2]Assistant Professor
[1,2]Department of Civil Engineering, Vyas Institute of Engineering & Technology, Jodhpur, Rajasthan, India

Abstract— Paper industry in India is one of the oldest core sector industries serving the nation by producing different quality of papers. Treatment of effluent generated during paper manufacturing has always been a subject of study for researchers and industry as well as to minimize the discharge of pollution load in the surrounding environment. Indian pulp and paper industry has progressed moderately from the first start of the mechanized paper mill. In India, efforts are going on for years to improve housekeeping, optimize process parameters; increase recycles and adopts improved technology and equipments. Prevention strategies must be incorporated as part of the original plan. An attempet has been made to reviews the process involved in paper making and evaluates the treatment process & pollution control aspects in pulp and paper industry, which are used to minimize the effects of wastewater discharged.

Index Terms— Pulp, Paper, Waste Generation, Processes, Technologies

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I. INTRODUCTION

Water is a precious commodity and nature's greatest gift to the living kingdom. Water consumption in agriculture, industrial sector and domestic purposes are 85.3, 8.0 and 6.6% respectively. Water use in industrial sector in 34 billion m3 per year which is estimated to increase by four folds by 2050. With continuously increasing demand and strong competition among industrial, agricultural and domestic sectors, water availability is severely affected particularly to the large consuming industrial sectors like pulp and paper. Pulp and paper industry is the third largest water consuming industrial sector in the country [Ansari P.M2016]. Present national norm of water consumption per tonne of paper is 200 and 250 m3 in agro and large pulp and paper sectors. By reducing the water consumption to 75m3 per tonne of pulp and paper, the paper industry can produce double the amount of paper with the existing water allocation/draw. Fresh water consumption in wood based, agro-based and waste paper based mills is 125-200, 125-225, 75-100 m3 per tonne of paper respectively [5], with average water consumption being 151m3 per tonne of paper. The problem of pollution is more predominant in the agro-based small scale pulp and paper industry, which lack in identification of key area of implementation of cleaner production option, better process technologies, resources crunch, small size of the mills and lack of consciousness to upgrade. Colour in the effluent from large-scale paper mills is still an unresolved problem due to aesthetic reasons.

Manufacturing of Paper

The basic steps involved in making of 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.

II. WASTE GENERATION

Pulp and paper industry is intensive in terms of raw material consumption. Besides pollution load generation, other consumption includes chemicals, energy, water, 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 [Birdie G.S,]. 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, Na2SO4 and bleach chemicals.
- Thermal loads.
- Microorganisms such as coliform group.
- Toxic chemicals.

Gases

- Malodorous sulphur gases such as mercaptans and H2S 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

- Sludge's 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.

Characteristics of Effluent

Wastewaters are discharged from almost all units operations. In large paper mills, wastewaters are generally segregated into two streams namely, colored stream (due to lignin of pulp washing, caustic extraction and chemical recovery section) and colorless/less colored stream (chipper house, chlorination, hypochlorite and paper machines). A third stream of uncontaminated wastewaters is usually segregated and reused.

The effluent from raw material preparation section does not contain many pollutants but has some amount of floating and readily settle able

- Solids such but has low B.O.D. and COD. Effluent from pulp mill is low in volume and dark brown in color. This effluent is low in suspended solids but high in B.O.D. as well as C.O.D.
- Effluent from pulp washing highly colored with high pH, suspended solids, B.O.D. and C.O.D. and sodium content is appreciable in this effluent.
- Effluent from bleach plant discharges chlorine water, caustic extraction and hypochlorate effluent. Bleach plant effluent is large in volume but low in B.O.D. and C.O.D. pH of the wastewater is generally near about neutral or slightly acidic. Suspended solids are low compared to other effluents.
- Chemical recovery effluent consists of barometric condensate and floor washes. Normally the effluent is colorless but occasionally shows brown colour due to black liquor spills and overflows. The effluent has the characteristic odour of mercaptants and is toxic to aquatic life. B.O.D. and C.O.D. in the effluent are not very high.
- Effluent from paper machine is large in volume but the quantity finally discharged depends on the extent of its reuse. The effluent has low pH and contains high amount of suspended solids.

Table 1: Raw Material Used in Pulp and Paper Industry

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 hand)		
3	Straw (rice or wheat), grasses, bagasses, Kenahm jute, sticksm hemp, hessian cotton, liners and rags	Debarking, chipping, screening Chipping, dusting and depitching for bagasse	As above Soda, lime soda, semi-chemical, mechano-chemical
4	Waste Paper	Sorting and dusting	Hydropulping

Table 2: Pulping Processes

S.No.	Pulping process	Major pulping chemicals	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 sodium bisulphate	Sodium carbonate, sodium bicarbonate	Chemicals are partly recovered. This process 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 Hudrogen 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	-	Not recovery

III. Best Available Technologies

Economically viable production process control technologies, identified as the best available technology, commonly adopted in the pulp and paper industry are:

- Cooling water segregation and recycle.
- Vacuum pump seal water collection and reuse.
- Evaporation surface condenser to replace barometric condenser to facilitate reuse or condensate.
- Caustic area spill collections for recovery and recycle.
- Spill collection in the evaporator, recovery, causticising liquor storage brown stock, paper machine and bleach plant areas for recycle.
- Lime-mud pond to reduce total suspended solids discharges in white liquor clarification and mud washing area.
- High pressure showers for wire and felt cleaning saves 90% of the water used in conventional shower applications.
- Improvement in save-alls by installing new vacuum disc save-alls.
- White water storage for wire cleaning shows, pulp dilution and bleach plant washing.
- Rejects separation using side hill screen cleaners. Pressure and centrifugal screen eliminate up to 40% of solids to the treatment plant. Separated rejects are fit for landfill disposal.

The production process control technologies, mentioned earlier, if introduced in a planned manner, are likely to result in a considerable saving of materials and energy and at the same time reduce the wastewater treatment cost.

IV. Effluent Treatment Practices in Pulp and Paper Industry

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

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

Various approaches for the management of effluents discharged include [Kumar S. Louis D]:

- **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% [Tarar J.L.2015].
- **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 settle able solids and removes 25-30% of BOD. Settled sludge can be dewatered 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 clarified and activated sludge process.

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 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 3.

Table 3: Discharge Standards (as per BIS)

S.No.	Characteristics	I.S. 2490	I.S. 7968	I.S. 3307
1	pH	5.5to 9.0	5.5 to 9.0	5.5 to 9.0
2	Temperature not to exceed	40°C	45°C	Not specified
3	Total suspended solids	100	100	Not specified
4	Total dissolve solids	-do-	-do-	2100
5	BOD, 5 day at 20°C	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 SO_4	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	Fluorides	2.0	15.0	Not specified
15	Arsenic	0.2	0.2	-do-
16	Cadmium	2	2	-do-
17	Copper	3	3	-do-
18	Mercury	0.01	0.014	-do-
19	Ammonium Nitrogen	50.0	50.0	-do-
20	Boron	Not specified	Not specified	2
21	Percentage sodium	-do-	-do-	60

All units upto their maximum limit and in mg/l except pH and temperature.

V. CONCLUSION

- 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.
- Energy efficient processes must be practiced for black liquor chemical recovery, preferably aiming for a solid content of 70%.
- 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 unplanned or non routine discharges of wastewater and black liquor.
- Reduce bleaching requirements by process design and operation.
- Sulphur emissions to the atmosphere should be mi9nimized by using a low odour design black liquor recovery furnace.
- Minimize the generation of effluent through process modifications and recycle wastewater, aiming for total recycling.

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About the Authors:

1. Prof. (Dr.) Ashok Dhariwal, Director (Academic), Vyas Institute of Engineering & Technology, Jodhpur
2. Prof. Mayank Vyas, Assistant Prof., Vyas Institute of Engineering & Technology, Jodhpur