REVIEW PAPER ON PAPER AND PULP INDUSTRY WASTE WATER TREATMENT

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Abstract : This paper reviewed three (4) researches on waste water treatment in paper and pulp industry. Paper and Pulp industries produce a large amount of waste water which has many types of contaminants in it this amount of waste water generation depends upon of the process used in the plant. Since the generated water is very polluting and can be prove harmful to the environment so it necessary to treat this waste water properly before its disposal in environment. The volume and characteristics of waste water generated depend upon the type of manufacturing process and the amount of water reuse. It is estimated that about 273-455m^3 is required per ton of paper produced (Subrahmanyam, 1975) of which 300 m3 is generated as waste water (Subrahmanyam and Hanumanulu, 1976). This paper reviews about the process and waste water treatment used in the paper and pulp industry along with the characteristics of contaminated wastewater.

I.INTRODUCTION

The waste water produced by various industries has a potential amount of contaminates in it which can impact our environment in various ways if proper treatment is not given before disposal. Paper and pulp industry arethe larger consumer of fresh water because they need water during their various stages of pulping and paper making activities. The waste water generated contain various polluting elements and can poses a serious threat to wild and human life. This industry produces the third largest amount of waste water after primary metals and chemicals industries (Savant et al., 2006). The waste water generated from theseindustries contains a variety of organic and inorganic contaminants that are mostly originated from tannins, lignins, resins and chlorine compounds (Buzzini and Pires, 2007). BOD, COD, TSS and organic are the major contaminants that should be removed or minimized in waste water treatment plants. If the quality of waste water after treatment is up to permit level then this water can be recycled or reused in paper and pulp industry at various manufacturing process. But before its disposal the point should be kept in mind that all the quality of waste water should meet the environmental standard then only it can be disposed in environment. Paper and Pulp industry use various treatment process such as physical, chemical, and biological treatment. The objective of this paper is to examine manufacturing and various treatment process along with the character tics of various contaminates in waste water.

II. Paper and Pulp industry: Manufacturing and waste water production processes

The manufacturing process of paper and pulp industry is mainly divided into parts out of which one is pulp making and other one is paper making. But there are also some industries which follow only one process out of two so the industry wherepaper and pulp both are manufactured by mill, then it is known as integrated paper mill. The Process like wood debarking or chip making, manufacturing pulp and bleaching are some of the process which require a lot fresh water for their process and are also the producer of waste water in large volume.

2.1Manufacturing process of a paper and pulp

2.1.1 Pulp making from wood

First of all, the logs of wood are soaked in the water for a specific period of time in a log pond because of which the barks of the wood get loosen and its removal gets easy, after this chipping is done in which logs of wood are chopped into small pieces to facilitate their proper digestion, after that digestion is done but depending upon the chemicals used for digestion the process are classified as

- Sulphate or Kraft process - chemical used sodium sulphate, sodium hydroxide and sodium sulphide
- Sulphite process – $CaHSO_3$ or $MgHSO_3$and sulphuric acid
- Alkali process - lime or sodium hydroxide

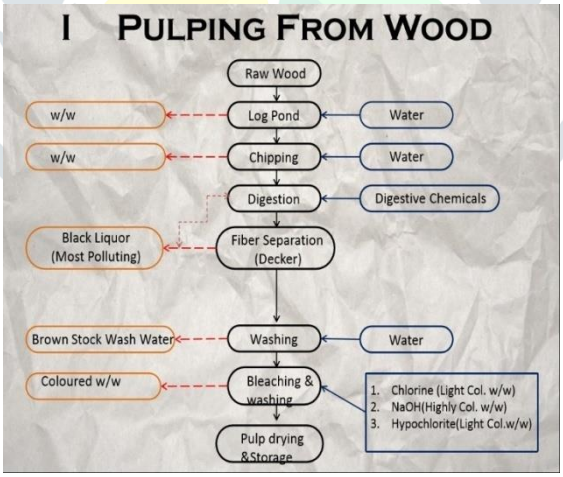

Fig No.1 Pulping From Wood

The process of digestion lasts for 2-5 hrs at 170-176°C and pressure 660-625 kPa with pulp 8-9 kg/sq.cm. After digestion the process of fibre separation is done in which cellulose is separated from digested pulp follow with washing then screening is done to remove knots from pulp and then the process of bleaching is done follow with drying and storing.

2.1.2 Wastewater production in paper and pulp process

Wood Preparation, pulp washing, pulp bleaching and paper making processes as well as the digester house are the major wastewater producer in paper and pulp industry.The volume of watewater generated depend upon the amount of pulp treated in industry (The World bank Group, 1999).The different sources of waste water generations are from log woods suspended solids are generated,Chipping and debraking are the source of light colour wastewater, black liquor is generated during the process of digestion, a brown stock wastewater from washinf of pulp after the separation of black liquor (Highly coloured) also a light colour watsewater from chlorine and hypo chlorine bleaching and and highly coloured wastewater from caustic bleaching. The combined charactesticis of wastewater excluding black liqour for 225-320 m^3/tonne of paper (shown in table 1)

Table 1 Characteristics of combined wastewater (excluding black liquor)

PARAMETERS	RANGE
pH	8-9
Total solids	1500-2500 mg/lit
TSS	600-1500 mg/lit
BOD	150-1000 mg/lit
COD	300-2500 mg/lit

Table 2 Characteristics of Black liquor (Kraft process)

PARAMETERS	RANGE
pH	9-11
TSS	800-1000 mg/lit
BOD	8000-12000 mg/lit
COD	35000-45000 mg/lit
Sodium	4000-8000 mg/lit
Sulphates	1200-2000 mg/lit
Chlorides	500-600 mg/lit
Phosphates	10-15 mg/lit

III. Wastewater Treatment

The increasing use of fresh water is growing concern regarding the environment so the use of recycle or reused water is the way by which we can minimize the use of fresh water at each and every unit in paper and pulp industry in this way we can also minimize the discharge to the environment. The main aim of waste water treatment plant is to completely remove or minimize the contaminants from the wastewater using different treatment processes like physical, chemical or biological treatment.

3.1 Physicochemical Treatment

Physicochemical process is used to remove floating matter, colour, suspended solids, toxic compounds and colloidal particles the processincluded in these treatments are Screening, sedimentation, Ultra filtration, flotation, coagulation, flocculation, ozonation, electrolysis, ion exchange, photochemical decolourization and Reverse osmosis. Physicochemical treatment is commonly used in preliminary, primary or tertiary stages of wastewater treatment plant. The concentration and contaminants of wastewater and the desire removal efficiency is the most important factor in choosing the physicochemical treatment method.

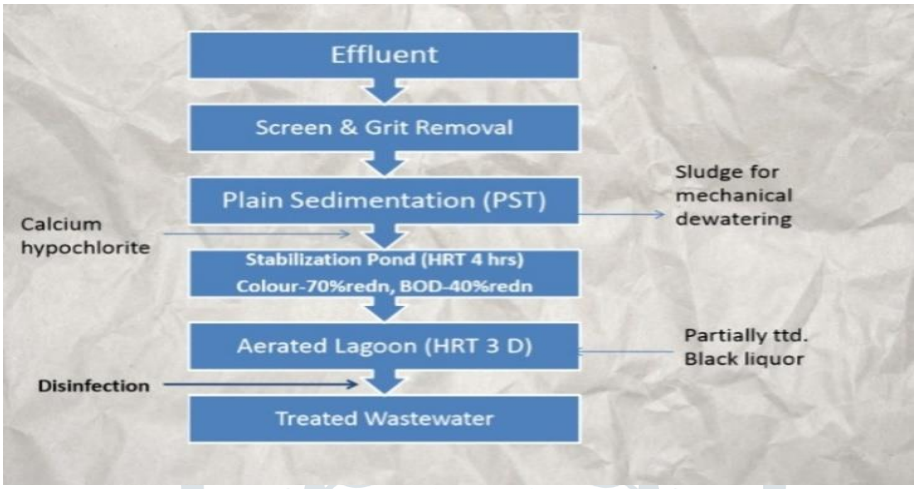

Fig No.2 Treatment Flow sheet 1

The presence of lignin and its compound contribute to strong colour in paper and pulp industry (Dilek and Gokcay, 1994). These wastewaters also contain high concentration of suspended solids and floating matters. Therefore, the use of a primary treatment, commonly sedimentation (Mulligan, 2002), is essential for the treatment process. Thompson et al. (2001)reported the possibility of removing 80 % of suspended matters from wastewater by sedimentation. Bhattacharjee et al. (2007)used sedimentation combined with adsorption and ultra- filtration for the treatment of Kraft black liquor and achieved 60% and 87% total solid removal respectively. Regarding BOD reduction with this plain sedimentation is up to 25-40% and the sludge is readily dewatered. Now in secondary treatment low cost systems lagoons and ponds are used, if the sufficient land is available then stabilization pond of shallow depth (0.9-1.2m) can be the cheapest option with 85% reduction for HRT of 1230 days. Another than this there are some drawbacks like a large amount of sludge production because of the heavy dosages and also the disposing of generated sludge. So, the physicochemical treatment which are used in mills till date are not cost-effective according to the plant and also there is no efficient method available currently.

Table 3 Characteristics of wastewater generated in various pulp and paper process (Dubeski et al., 2001; Pokhrel and viraraghavan, 2004; Rintala and Lepisto, 1992)

Sr No.	Process	pH	TS (mg/l)	SS (mg/l)	BOD (mg/l)	COD (mg/l)	N (mg/l)	Colour (Pt-Co)
1	TMP Whitewater	4.6	—	127	1541	2713	7	—
2	TMP	4.2	—	810	2800	5600	12	—
2	CTMP	6.2	—	500	2500	7300	—	—
3	Kraft mill	8.2	8260	3620	—	4112	350	4667.5
4	Bleach Kraft mill	10.1	—	37-74	128-184	1124-1738	2	—
5	Sulphite mill	2.5	—	—	2000-4000	4000-8000	—	—
6	pulping	10	1810	256	360	—	—	—
7	Bleaching	2.5	2285	216	140	—	—	40
8	Bleached Pulp mill	7.5	—	1133	1566	2572	—	4033
9	Wood preparation	—	1160	600	250	—	—	—
10	Paper making	7.8	1844	760	561	953	11	Black
11	Newsprint mill	—	3750	250	—	3500	—	1000
12	Chip wash	—	—	6095	12000	20000	86	—
13	Digester house	11.6	51,583	23,319	13088	38588	—	16.6

3.2Biological Treatment

Depending upon the process whether it is carried out in the presence of oxygen or in the absence of oxygen the biological treatment can be classified into aerobic (presence of O_2) and anaerobic treatment (absence of O_2).

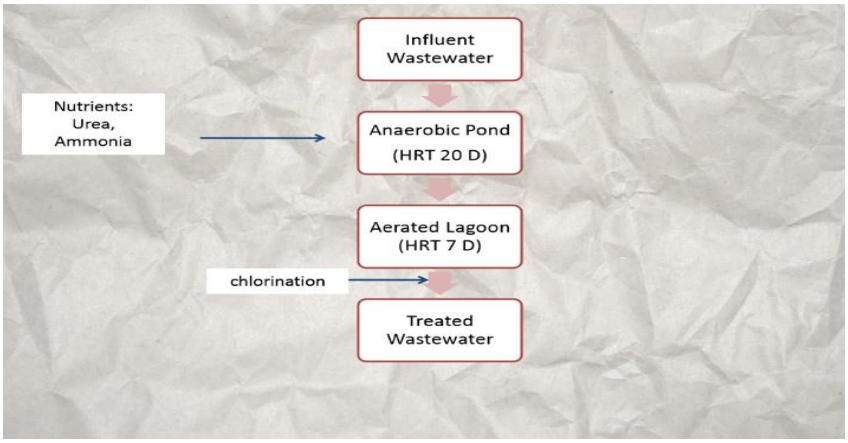

Fig No. 3 Treatment Flow Sheet

3.2.1 Aerobic Treatment

Aerobic treatment is the process in which biological oxidation of wastewater is done in the presence of air. This treatment is commonly used to remove BOD and the chlorinated organics because it is cost efficient. The processes like activated sludge process, aerated lagoons, aerobic biological reactors come under aerobic treatment.

Activated sludge process:

Gergov et al. (1988) reported that biological treatment by the activated sludge process removed 79-95% of chlorophenolics. Junna and Ruonala (1991) reported 90% BOD, 70% COD, 40-60% AOX, and 60-95% chlorinated phenols removal by the activated sludge process. High removal of BOD, COD, AOX, and chlorinated phenolics have been achieved in the activated sludge process (Saunamaki, 1997; Schnell et al.,2000).

Aerated lagoons:

Eriksson and Kolar (1995) have shown that the high molecular mass fraction in bleach effluent cannot be degraded in an aerated lagoon. Junna and Ruonala (1991) reported removal of BOD ranging between 50-75% and chlorinated phenolics 10-50% by an aerated lagoon. Chernysh et al. (1992) reported large variation in adsorbable organo halogens (AOX) and total organic carbon (TOC) removal in a controlled batch study of bleached Kraft effluent in an operating lagoon under both aerobic and anaerobic conditions.

3.2.2 Anaerobic Treatment:

The secondary treatment of industrial wastewater employed the process Anaerobic digestion and is considered more suitable for the treatment of organic effluents of high strength. The commonly used Anaerobic process to treat pulp and paper mill effluents are Anaerobic filter, Upflow sludge blanket (UASB), Fluidized bed, Anaerobic lagoon, and Anaerobic contact reactor methods. This treatment also destroys chlorophenolic compounds, mutagenicity and acute toxicity in the bleaching effluent (Bajpai and Bajpai, 1997).Compared to Aerobic treatment anaerobic treatment has many advantages that are the production of sludge is very low and also the chemical consumption is low along with this the requirement for land.

4. Recovery of Digestive Chemicals from Black Liquor

There are two processes of recovering digestive chemicals from the black liquor which are

- Kraft Process
- Sulphite Process

4.1 Kraft Process

In this processfirst of all the black liquor is concentrated by heating to increase solid content up to 30% then the vapours from this concentrator is condensed to recover Oil and

Turpentine oil further this solid content is increased to 85% and is treated with sodium sulphate and after that burnt in incinerator. The residues ("smelt") from incinerator are dissolve in water known as "Green Liquor". This liquid is treated with calcium oxide (quick lime), forming precipitates.

After settling, the supernatant known as "White Liquor" contains the digestive unused chemicals which can be reused again. The sediments or lime mud can be calcinated and can be reused again.

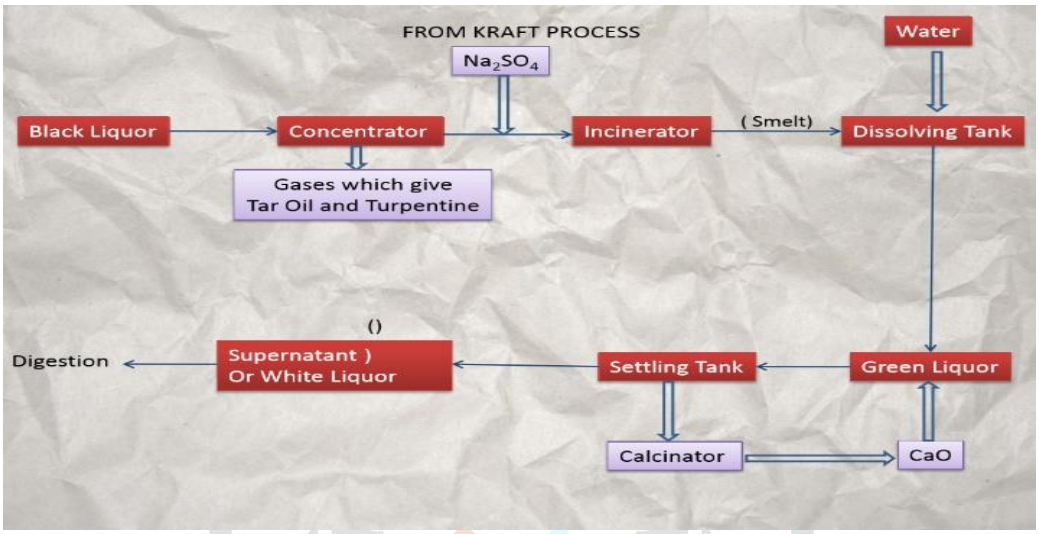

Fig No. 4 Recovery of chemicals from Kraft process

4.2 Sulphite Process

The recovery from sulphite process is possible only if Mg $(HNO_3)_2$is used. In this black liquor is concentrated to increase the solid content and is burned to for MgO. It is then slaked to give Mg $(OH)_2$ and later it is treated with SO_2 to recover Magnesium Bisulphate.

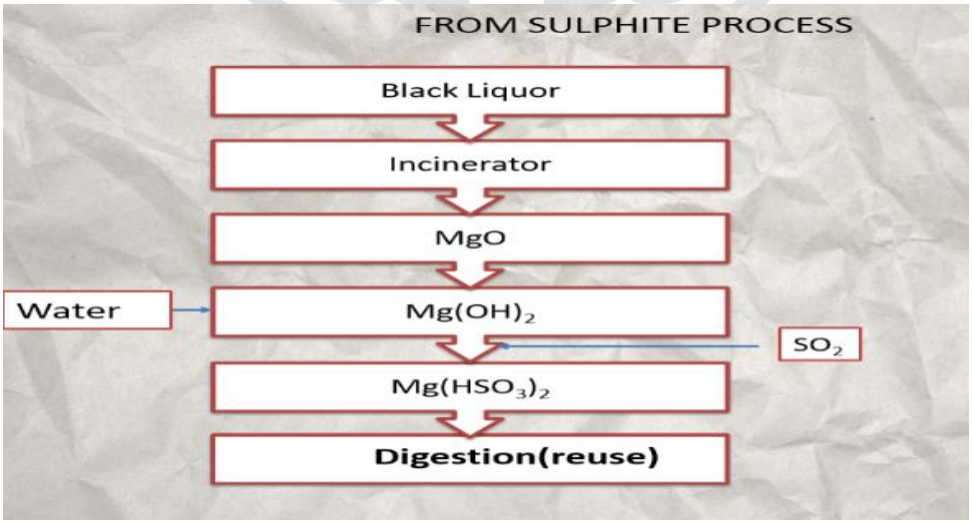

Fig No.5 Recovery of chemicals from sulphite process

V. Sludge Treatment

Sludge as we all know is the important end product of wastewater treatment and it very important to treat this sludge before its disposal. Right now, the handling and treatment of this produced sludge is done by the process called Dewatering and incineration. In Paper and pulp mill two common methods for handling this sludge is follow, first is mechanical dewatering and landfilling or composting, and second mechanical dewatering and incineration with landfilling of the generated ashes (Stoica et al., 2009). Paper and pulp incinerate solids with black liquor in recovery boilers, or mix them with bio-fuels and incinerate them in bio-fuel boilers, WHICH PRODUCE ash and contribute to SO2 and NO2 emissions (Singh and Thakur, 2006).

Table No. 4Wastewater discharge standard for large paper and pulp/rayon grade of capacity 24 tonne/annum

Sr No.	Parameters/Flow	Limits
1	Large pulp and paper	200 cum/tonne of paper
2	Large rayon grade/Newsprint	175 com/tonne of paper
3	pH	6.5-8.5
4	SS	100 mg/l
5	BOD at 27°C for 3 days	30 mg/l
6	COD	350 mg/l
7	TOCL*	2 kg tonne of paper produced
8	H_2S	10 mg/m3
9	Particulate matter	250 mg/m3

VI. Discussion

The treatment given to the waste generated from paper and pulp mill almost remove contaminants keeping in mind the regulation regarding environmental regulations. Among the treatment which is given to the wastewater are aerobic process which is commonly used in these mills because of their operation and high efficiency of COD removal which is in the range of 80-92%. Now regarding the waste minimization many paper and pulp mill are recovering digestive chemicals from black liquor also the reuse of waste water from log pond after the settling and chlorination is done, the white water which is generated from paper making machine is also used. Also, by recovering sodium ligno sulfonate (SLS) powder from black liquor. The sludge which we get after the process of dewatering it can be used for cement making (binder), emulsifier preparation etc.

VII.Conclusion

In this review of paper, different wastewater treatment process in paper and pulp mill were studied and investigated because of this there is control of waste discharge in water along with high efficiency of contaminant removal. These are the following conclusion result from this study:

i. In this review both aerobic and anaerobic biological process are used in the treatment process of paper and pulp industry.
ii. In this Kraft process and sulphite process are used so that the chemical which are harmful for environment can be recover from black liquor.
iii. In this both aerobic and anaerobic processhas good efficiency in removing COD.

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