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# Review on Biological Treatment processes of Pulp and Paper Industry Waste Water

L . Maria Subashini

Assistant Professor, Bharath University, Chennai, India

**ABSTRACT:** The pulp and paper industrial waste waters are a major environmental concern. Paper factory effluent is one of the major pollutants on the earth. The pulp and paper mill effluent is highly coloured.

The brown color of the effluent may increase water temperature and decrease photosynthesis, both of which may lead to decreased concentration of dissolved oxygen. Lignin and its derivatives are difficult to degrade because of the linkages within the molecule, especially the biphenyl type carbon-to-carbon linkages. It has been reported that production of one ton of paper contributes 100 Kg of color imparting substances and 2-4 Kg of organochlorines to the bleach plant effluents. The high chemical diversity of these pollutants causes a variety of clastogenic, carcinogenic and mutagenic effects on fishes and other aquatic communities in recipient water bodies. This paper reviews the various biological treatment processes to treat pulp and paper industry waste water.

**KEYWORDS:** secondary treatment, pulp and paper industry, biological treatment, microorganisms.

### I. INTRODUCTION

The pulp and paper industry has historically been considered a major consumer of natural resources (wood) and energy (fossil fuels, electricity), including water, and a significant contributor of pollutant discharges to the environment. Wood naturally contains around 50% water and the solid fraction is typically about 45% cellulose, 25 % hemicelluloses and 25% lignin and 5% other organic and inorganic materials. In chemical pulping, chemicals are used to dissolve the lignin and free the fibres.

Among the various sections in pulp and paper mills, the bleaching section is considered to be the most polluted. During this stage, chlorine or chlorine dioxide is used to bleach pulp and release chlorinated and nonchlorinated compounds from lignin and wood extractives. Typically, these effluents contain high concentrations of chlorophenolic compounds, chloroacetones and chloroform, which are colored and ecalcitrant. It has been reported that production of one ton of paper contributes 100 Kg of color imparting substances and 2-4 Kg of organochlorines to the bleach plant effluents. The high chemical diversity of these pollutants causes a variety of clastogenic, carcinogenic and mutagenic effects on fishes and other aquatic communities in recipient water bodies (Parveen Kumar *et al.*, 2011).

Worldwide, there are many existing biological and chemical treatment processes for paper and board mill effluent such as those based on aerobic, anaerobic, algal, fungal biomass, ozonation, electrochemical, photocatalysis, coagulation-flocculation treatment, etc. These classical treatments have been successful in lowering the chemical and biological oxygen demands (COD, BOD), but their applicability is limited by a great number of problems. Given the limitations of the current biological wastewater treatment, there is an increasing interest to develop a more effective treatment approach to reduce the impacts of pulp mill effluents on the environment (Marcia Regina *et al.*, 2009).

There is a large variety in external treatment technologies used for pulp and paper mill effluents and the preferred technology depends on many factors; characteristics of the matter to be removed, requirements on the purity of the effluent

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water, economical factors etc.

Primary treatment is mainly based on a physical removal of solids, secondary treatment on removal of dissolved organic compounds, and tertiary treatment used for effluent polishing and elimination of more advanced constituents. Tertiary treatments are rare at present, but can be an obligation in future due to possible new legislation. (Thompson et al, 2001).

Primary treatments remove suspended solids to a large extent. Dissolved organic compounds and colloidal particles on the other hand are still remained in the wastewater and must be removed with a secondary biological treatment (Thompson et al., 2001). Allowing microorganisms to utilize the pollutants as nutrients dissolved organic compounds and colloidal particles can be lowered and oxidized into low molecular fractions. The microorganisms grow and multiply in an aerobic or anaerobic environment, forming a sludge which later is separated. (Persson, 2011).

## **Aerobic Treatment**

Aerobic microorganisms require oxygen to support their metabolic activity. Oxygen is supplied in the form of air by aeration equipment. There are numerous of aerobic systems available for degradation of oxygen-demanding organic compounds in industrial wastewater; aerated lagoons, activated sludge systems, biofilm processes etc. (Persson, 2011).

## **II. AERATED LAGOON**

One type of biological treatment often used for pulp and paper effluents is the aerated lagoon, which is a large, shallow ( $\approx 4\text{m}$ ) pond where wastewater is treated biologically with active microorganisms and mechanical aeration. The aerated lagoon is very space consuming because it is dimensioned for a residence time of 5-7 days and consumes a lot of energy for aeration. However, it is very easy to operate and maintain, and the shock load capacity is high. In recent years some aerated lagoons have been converted into LAS-facilities which are long-term aerated activated sludge treatment plants with a residence time of around one day. Parts of the old aerated lagoon have then been utilized for the aeration and other parts used for temperature stabilization and cooling of hot wastewater effluents. The aerated lagoon will primarily remove BOD but can also reduce emissions of AOX to some extent. The removal efficiency is dependent on residence time, pH, temperature, amount of sludge and degree of aeration. (Hultman, 1997, Persson, 2011).

## **III. ACTIVATED SLUDGE PROCESS**

Pulp and paper mills that have limited space and sensitive recipients are using the activated sludge (AS) process for biological treatment. The wastewater is treated in two steps; aeration and sedimentation. In the first step, wastewater is treated with a high concentration of microorganism and a powerful aeration, and the retention time can vary between a couple of hours and up to a day. In the second step water and sludge is separated in a sedimentation basin and parts of the sludge is pumped back to the aeration basin. The recirculation of sludge enables a high concentration of microorganisms which is of importance for extensive reduction in organic material. The activated sludge systems are more sensitive than aerated lagoons and cannot stand fast load changes. However, the degree of efficiency can be controlled, and very high BOD-reductions are seen. (Thompson et al., 2001, Persson, 2011).

The removal of biodegradable organic substances; both soluble and finely dispersed is accomplished by biological oxidation with the help of microbial consortia principally bacteria. The ecology of microbial species, in activated sludge process is having the significant role in the bio-oxidation and subsequent clarification. The microorganisms; bacteria, protozoa, fungi, and rotifers exist in the activated sludge reaction vessel and clarifier as floc. The activated sludge process works well as long as the consortia of microorganisms, typically termed as sludge, grows in a healthy way, and settles and

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compacts in the secondary settling tank. The bio-oxidation of the pulp mill wastewater in the aerobic treatment process with change of dominant and significant operating parameters and environmental conditions is carried out. The effect of two operating conditions viz., pH and temperature on the operation of activated sludge process is done. The study has been carried out with the laboratory scale reactors operated under specified conditions with diluted pulp mill effluent having C E DD bleaching sequence.

## Moving Bed Bioreactor

Several plants have invested in the Moving Bed Bioreactor (MBBR) due to stricter environmental regulations and increase in production. The basin is filled with thousands of suspended plastic carriers that are floating free in a reactor, which have microorganism attached on a film on the carriers. Air is supplied from the bottom of the reactor, which keeps the carriers moving and permits a higher load, a better mixing, and a higher flush. The biggest advantage with a suspended biofilm process is that it does not require return of activated sludge, has very small space requirements, has good shock resistance and can operate at very high concentrations of biomass. (Persson, 2011)

## Biofiltration

Another type of biofilm reactor that is used for pulp and paper mill wastewater is the biofilter reactor. Here, the reactor is equipped with a biological filter of a fixed biomass carrier that serves as a filter as well as a biological contactor. Wastewater and air is fed from the bottom of the reactor and led in an upward direction through the dense granular bed. No subsequent clarifier is needed, because all material is retained within the filter, which with time must be cleaned (backwashed). The filter is operated with a hydraulic retention time of around 0.5 h, and very high BOD reductions are seen. The reactor is however only suitable for wastewaters containing low BOD concentrations due to clogging problems at higher concentrations. This treatment is also often used for tertiary treatment, where it functions as a polishing step. (Möbius, 2006).

## Anaerobic Treatment

Anaerobic treatment is a treatment without presence of oxygen and is more appropriate for treatment of high strength wastewaters. Effluents originated from recycled fibres are often treated anaerobic; apart from that, this technology is not used as widely as the aerobic treatments in the pulp and paper industry (Ochre-Media, 2001). However, the investment in this technology is increasing due to its many advantages in comparison to aerobic treatment; lower sludge production, lower chemical consumption, smaller space requirements and energy production in the form of bio gas. (Persson, 2011). The major problem with implementation of anaerobic treatment for pulp and paper effluents is the potential for hydrogen sulphide formation; since sulphate is widely used as active cooking chemical in many pulp mills. Another important issue with an anaerobic process is its sensitivity to toxic compounds present in the wastewater. (Thompson et al., 2001).

The anaerobic digestion process involves biological conversions in a step-wise fashion, of organic material to various end products including methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>). The process offers several advantages and disadvantages over other treatment method. A well managed anaerobic digestion system has the ability to produce maximum methane production, and will not discharge any gases to the atmosphere. This system will also provide a source of energy with no net increase in atmospheric carbon which contributes to climate change. Energy generated through the anaerobic digestion process can help reduce the demand for fossil fuels.

## Biological filtration

The compact design of the BioforB process is especially attractive where space is limited. Its modular design adapts well to production constraints. It is particularly suitable for treating low pollution loadings (SS < 200 mg/L and soluble chemical oxygen demand (COD) < 400 mg/L). Energy consumption is low and backwash water consumption is minimized thereby eliminating the need for secondary clarifiers and sludge recirculation systems. BioforB is an aerobic biological reactor, having attached biomass in an immersed fixed bed. The bed features a single support media of a specific grain size. A co-current upflow of air and water is used.

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The BioforB looks like a conventional sand filter, is backwashed like a conventional filter, but because of the introduction of oxygen is also a biological reactor. The BioforB process is designed to favor important biomass activity and solids retention during the filtration cycle. It also provides a partial evacuation of the biomass during the backwash cycle, which makes the biological filter a high-performance process, as compared to the conventional sand/carbon filter. A typical industrial installation will incorporate a minimum of four cells. Raw water enters the filter under a false floor and flows up through the support media. Process air is simultaneously introduced through a network of diffusers. This satisfies the oxygen requirements of the fixed biomass population and maintains biological activity and growth.

A mechanical filtration effect is created by the use of an appropriate selected support media. It retains the suspended solids introduced by the feed water as well as those generated by the biomass biological degradation. Biological filtration thus combines both biological degradation and mechanical filtration. Treated water is collected at the surface of the filter. After 24 to 72 hours of operation, the BioforB undergoes a cleaning process by upflow. The upflow cleaning process will expand the media, allowing suspended solids and any excess entrapped biomass to be washed out. This is accomplished using an airwater wash followed by a water-only rinse.

## IV. CONCLUSION

During the cleaning phase, the filter does not produce treated water. Following the final rinse, the filter immediately returns to service. A clean-up cycle lasts about 35 minutes, which corresponds to 1% of the filtration time, for a filter backwashed every 48 hours. The backwash sludge is then reintroduced at a low rate upstream of the primary clarifier or, for very large installations, may be treated separately in a very small flotation clarifier whose design flow corresponds to a very small fraction of the total mill effluent flow.

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