

Exploring The Effect of Aerobic And Anaerobic Biotechnology Based on Paper Industry Wastewater Treatment

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Abstract. The environmental risks associated with paper mills grow as demand for paper rises. Wastewater technology for paper mills needs to change due to the expected stricter water treatment regulations. This essay will discuss a combination of aerobic and anaerobic biological treatment and examine how technology advancement has improved the environment. This paper analyzes the new technology and concludes that new strains of bacteria can be introduced to break down the organic matter in the primary settling tank. What's more, a bubble generator was introduced in the SBR tank to increase the reaction contact area. And the adoption of ozone ceramic membrane bonding technology in the realization of solid-liquid separation in a secondary sedimentation tank. Meanwhile, the combined anaerobic and aerobic treatment process has low operating cost, low residual sludge, modifies the hard-to-degrade organic matter and improves the biochemical properties of the wastewater. Considering the impact on the environment, this paper proposes collecting gas for recycling, establishing tertiary treatment system and adding Fenton's reagent. By comparing the traditional papermaking process and the new microbial treatment technology, a new improvement scheme is proposed, which can help improve the economic efficiency, save resources and protect the environment, and can meet the dual requirements of social development and environmental protection.

Keywords: water treatment, environmental implication, combined anaerobic and aerobic treatment, sustainable development.

1. Introduction

Papermaking is one of the most important raw material industries, closely related to the country's economic development and people's life. The level of consumption of paper and paper products is regarded as a measure of the level of modernization and civilization of a country [1]. Packaging paper and paperboard consumption will increase with the increase of residents' daily consumption level (See Fig. 1).

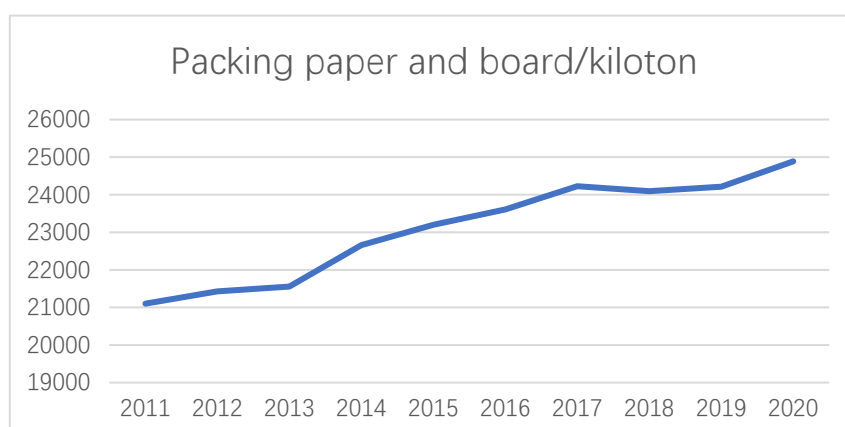


Fig. 1 Folding line graph of packaging paper and paperboard consumption

However, the environmental hazards of paper mills cannot be ignored. The paper industry in China has the third highest impact discharge in the whole wastewater discharge. Typically, paper industry wastewater is divided into three categories, namely pulp making wastewater, mid-stage wastewater from pulp washing, screening and bleaching, and paper copying wastewater. The cooking waste liquid of chemical pulp, that is, black liquid is one of the important pollution sources of papermaking industry wastewater. The Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) produced are about more than 90% of the total pollutants in the whole process of pulping, and its chemical composition and content are very different due to the different raw materials and the use of chemical agents. The wastewater in the middle section of paper making includes the wastewater produced by washing, selection and bleaching sections. Its chemical composition is similar to the black liquid, but the concentration is slightly lower, wastewater discharge is large, and the suspended solid (SS) and BOD values are high. The COD concentration of wastewater in the middle section is between 1500~2500 mg / L, and it can be treated to meet the standard. Among them, bleaching wastewater contains a large amount of organochloride, which has deep color and great toxicity. It is the main source of drainage pollution in pulp mills and also an important source of toxic substances [2]. The picture below shows a traditional paper mill wastewater treatment process (see Fig. 2) [3].

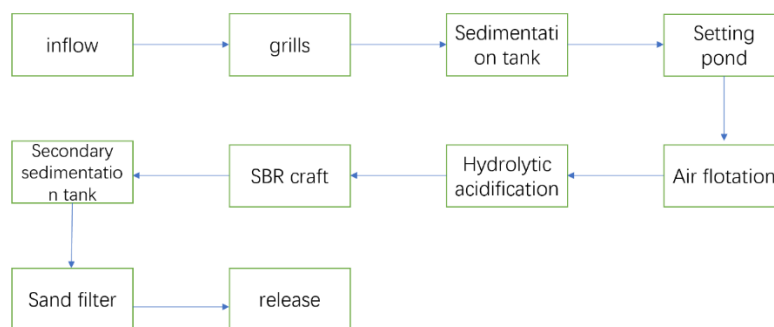


Fig. 2 The traditional industrial wastewater treatment process

Traditional industrial wastewater first uses physical technology to treat water quality and then uses microbial metabolism to treat organic matter decomposition into simple inorganic matter and finally treats some pollutants. The picture below shows a traditional paper mill wastewater treatment process. This paper will introduce the wastewater treatment process of an Indonesian factory. The main business of this factory is to manufacture and process corrugated paper with waste paper. The original sewage treatment station of the plant adopts the secondary treatment process of "pretreatment + aerobic treatment" to treat the production of sewage. Because the COD content of the effluent is still high after treatment, it cannot meet the requirements of the local government, Hu reformed the process of the plant through the water quality index of the production wastewater provided by the owner and added a set of anaerobic biological treatment process for some equipment [4]. The new main equipment is a sewage cooling tower, pre-acidification pool, anaerobic reactor, biogas regulator and biogas torch. These equipment through operation, once again reduces the COD content and improve the effect of sewage treatment.

2. Overview of the process and technology

As previously mentioned processes, grates are used to treat insoluble suspended matter, impoundments are used to treat and collect and balance the mass of the wastewater, and settling tanks are used to treat large insoluble particles. Air flotation is the adsorption of small particles by bubbles to achieve separation. Hydrolytic acidification pool is to convert refractory organic matter into small molecules easily degradable substances. SBR is a process of biological treatment of activated sludge with wastewater. Sand filter can remove heavy metal viruses and ensure that the effluent meets the relevant standards[5]. Also, with the development of technology, there are many processes have been improved. For example, some scientists found that after the traditional process treatment, the COD

value is still high. As a result, some new processes are added like pre-acidizing pool, anaerobic reactor, biogas burning torch and so on. After the new process, the efficiency of sewage treatment has been greatly improved.

The original part (solid line) sewage treatment process of this process also introduces aerobic tank and other active treatment means. Compared with the traditional treatment process, its efficiency will be improved to a certain extent. However, there are still some defects in achieving high quality discharge, and the steps of the original process will be analyzed below in conjunction with the traditional process.

2.1. Primary settling tank

The primary sedimentation tank is the most basic of all wastewater treatment steps, which is set behind the sedimentation tank in the wastewater treatment plant to reduce the concentration of suspended matter in the wastewater by gravity sedimentation. The primary sedimentation tank is an indispensable step in a wastewater station because it can obtain the SS removal rate of 60%-90% and BOD removal rate of 35%-75% [6]. Meanwhile, high-speed precipitation method is also used, a technical unit that integrates coagulation, flocculation, inclined plate precipitation and sludge reflux to reduce the concentration of suspended solids in sewage. But Chinese urban sewage treatment plants generally have the problem of carbon, nitrogen and phosphorus ratio imbalance. In order to mitigate the carbon source shortage, many sewage treatment plants generally adopt the method of additional carbon source, which also increases the operating cost of sewage plant to a great extent. Although the initial sedimentation tank cannot be directly cancelled, some improvements can be made. The transformation of organic matter in the sludge of the new sedimentation tank can be divided into two stages: hydrolysis stage, which granules organic matter under the action of decomposition, and acidification stage, which transform small molecules such as monosaccharides and amino acids into fatty acids, alcohols and ketones.

2.2. SBR tank

SBR is short for sequencing batch activated sludge process, which is an activated sludge treatment technology. Through a series of steps such as aeration, agitation, precipitation and drainage, it is used to remove COD and NH_4^+-N as well as to deal with TP and sludge settlement [7]. The average COD removal rate of aerobic granular sludge and aerobic granular sludge is 89.6%, and the removal rate of ammonia nitrogen is greater than 95.8%, showing a very good treatment effect on COD and ammonia nitrogen. However, since SBR uses live bacteria to decompose sludge, it has certain requirements on the operating temperature of the system. When the sewage temperature is lower than 10°C , the sludge activity decreases, and most microorganisms in the sewage cannot metabolize exogenous substances. Only when the temperature is kept at $20\text{-}35^\circ\text{C}$ can the SBR have a better treatment effect [8]. A small amount of steam can be transported to the SBR tank to keep the water temperature at an appropriate temperature, while increasing the contact area between sewage and live bacteria, and speeding up the efficiency and effect of sewage treatment (see Fig. 3) [9].

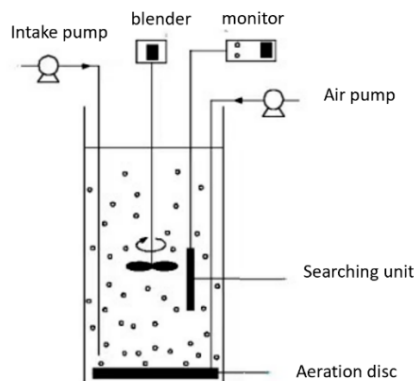


Fig. 3 Diagram of SBR reaction unit [9]

2.3. Secondary sedimentation tank

Secondary sedimentation tank is also a link to conventional sewage treatment, which is often located behind the biological treatment link. It is used to separate sludge from water, clarify the mixture and concentrate the sludge and return the separated sludge to the biological treatment section. If the precipitation and concentration effect is not good, the effluent will increase the activated sludge suspended matter, thus increasing the effluent BOD mass concentration. At the same time, the concentration of returned sludge will also decrease, thus reducing the concentration of mixed liquid in the aeration tank and affecting the purification effect. Ozonation technology is usually adopted and sewage treatment of secondary sedimentation tanks is realized [10].

Ozone can oxidize macromolecular organic matter which is difficult to degrade and has poor biochemical properties into small organic matter which is easy to degrade and has strong biochemical properties. But it is unstable in water, oxidation behavior has obvious selectivity, and the mineralization of organic matter in water is not complete, easy to produce harmful intermediate metabolites [11]. Through the use of ozone ceramic membrane combined technology to achieve solid-liquid separation, effectively improve effluent water quality and reduce membrane pollution.

3. Aerobic biological treatment

Aerobic bacteria treatment is a common process in the process of sewage treatment, using activated sludge and can self-coagulate to form aerobic granular sludge through specific culture. The anaerobic, facultative and aerobic environment formed by aerobic particles from the inside out can have better nitrogen and phosphorus removal effect [12]. Compared with traditional activated sludge, it has good settling performance and dense structure. The sludge concentration and volume load in the reactor can be increased effectively. To reduce the effects of toxic substances on microorganisms, thereby enhancing the protection of some of the more sensitive microorganisms [13]. But winter temperatures are lower in the north. The low activity of aerobic bacteria will lead to short residence time of sewage and low treatment efficiency. At the same time, the large amount of air in the north leads to a large number of air bubbles in the bottom of the tank, and the sewage in the tank is boiling, which leads to a large number of sludge bubbles floating on the surface and the concentration of activated sludge getting lower and lower, and the biochemical efficiency decreases.

By laying fillers in anoxic and aerobic tanks, microorganisms attached to the carrier grow, making the nitrifying bacteria and denitrifying bacteria easy to grow into dominant strains. In winter, reflux can improve the residence time of sewage and reduce the load rate, so as to improve the decline of effluent quality caused by low temperature. A village in the mountains near Beijing has adopted this treatment method [14]. At the same time, the aeration quality should be improved, the pipeline layout scheme should be optimized, the arrangement density should be increased, the bubble density should be increased, and the fine small bubbles should be formed to meet the needs of aerobic bacteria propagation [15].

4. Anaerobic biological treatment

As some indexes of the original project still cannot meet the requirements of local government after treatment, it is necessary to add a set of treatment process to reduce the organic content in wastewater based on the original process. Considering that the anaerobic method has the advantages of less sludge production, lower operating cost and energy consumption, Hu added a set of anaerobic biological treatment processes to reduce the content of organic matter in wastewater. At present, anaerobic bacteria widely used in the treatment of paper sewage are mainly methanogenic bacteria and acid-producing bacteria. Because anaerobic bacteria are very sensitive to oxygen, this type of anaerobic bacteria has relatively strict anaerobic growth conditions.

Generally speaking, the use of anaerobic bacteria biodegradation can be divided into three steps. The first is the hydrolysis fermentation stage, added in the sewage fermentation fine, bacteria,

carbohydrates, protein and lipid and other organic substances into monosaccharides, amino acids and fatty acids and other soluble substances, fermentation to alcohol and low-level fatty acids. The next stage is the stage of hydrogen production and acetic acid production. A large number of hydrogen-producing acetic acid-producing bacteria and isotype acetic acid-producing bacteria will convert the products of propionic acid, butyric acid and alcohol into acetic acid, methylamine and CO₂, H₂. Finally, the upper stage products were converted to methane by using methanogens. In the process of most anaerobic bacterial wastewater treatment, hydrogen acid production and methane production occur at the same time. Anaerobic bacteria can increase the efficiency of converting acetate and most-acid substances into methane in wastewater to 70%~75%. Related researchers in China have used anaerobic-acidification to treat the waste liquid of small alkali pulp and paper mills, whose removal rate of COD to 77% and that of BOD₅ to 80%. The decolorization rate is as high as 90% and the methane gas production rate can be controlled at 0.342~0.539 L/ L·d [16].

After the anaerobic biological treatment process is put into operation and stable operation, the operation test of the anaerobic system is conducted for about half a month. The overall operation effect of the treatment system is stable. The COD removal rate of the anaerobic system can reach about 70%~80%, and the outlet water COD after treatment is about 1000 mg / L [4]. Aerobic biological treatment

5. Aerobic biological treatment and anaerobic biological treatment

Anaerobic biological treatment technology is generally combined with aerobic biological treatment technology to achieve a better wastewater treatment effect. Many paper mills in China use this method to treat paper wastewater. Fujian South Paper Co., Ltd. uses IC anaerobic tower and aerobic aeration process to treat TMP and DIP mixed high-concentration wastewater. Sewage treatment has a good effect in that the COD removal rate is up to 87%, wastewater treatment system is stable and the operation cost is low [17]. Guangzhou Paper Co., Ltd. adopts the "IC anaerobic tower-SBR-air flotation" tertiary treatment process to treat the high-concentration pulping wastewater. The COD removal rate reaches 95%, which is an ideal treatment process [18]. In the reconstruction wastewater treatment project of Bandung paper mill, the anaerobic-aerobic process was adopted to significantly reduce the total emission of pollutants compared with the original aerobic process, saving the power by about 55%, and effectively controlling the water consumption [19].

The anaerobic + aerobic combined treatment process has low operation cost and a small amount of residual sludge, which has a modification effect on the refractory organic matter and can improve the biochemical properties of wastewater. The anaerobic state can inhibit the growth of filamentous bacteria and prevent sludge swelling. This operation process is especially suitable for the treatment of high-concentration organic wastewater. After the anaerobic system transformation project, from single aerobic treatment to aerobic biological treatment + anaerobic biological treatment, the effluent COD of the sewage treatment station terminal was controlled from the original 500 mg/L to within 200 mg / L, which met the environmental protection requirements of the local government Aerobic biological treatment [4].

6. Suggestions

In the process of pulp and paper production, the content of precipitable solid particles, ammonia nitrogen is high. There are a large number of toxic components, and the concentration of COD and BOD is high. The degree of biodegradability is greater [20]. Biogas will be produced during anaerobic treatment of paper mill wastewater. If the biogas generated in the treatment process of production wastewater is disposed directly by the torch-burning mode, it is not utilized as resources. Through direct recovery and combustion of power generation or heating after pretreatment, one cubic meter of biogas can produce heat equivalent to 0.7 kg of anthracite after complete combustion, which can reduce energy consumption and save costs [21].

As each link of the paper mill will produce wastewater, and the discharge amount is large. We can introduce the –three-level treatment. Grasp the pollution source of wastewater in the process of environmental impact assessment. Through the reasonable classification of wastewater, grasping the characteristics of each link wastewater quality, and establishing a database. More accurate data can be provided for the design of subsequent links, which can realize the comprehensive utilization of wastewater after pretreatment and reduce the difficulty and cost of treatment [22].

The cAOP process can be added. It is believed that Fenton reagent can improve the bioavailability of paper wastewater. An industrial park project in Vietnam adopts anaerobic / aerobic / Fenton fluidized bed process to treat paper comprehensive wastewater produced from corrugated paper as raw material [23]. Anaerobic process adopts UASB Plus reactor, aerobic aeration adopts a microporous tube aerator, and Fenton fluidized bed process is used for advanced treatment. After treatment, the effluent is $COD \leq 48$ mg/L, and $BOD_5 \leq 12$ mg/L, which has met the local environmental protection emission requirements.

7. Conclusion

To sum up, with the continuous development of science and technology, the environmental protection treatment of papermaking industry also needs innovation and optimization. The current use of microbial technology to achieve green wastewater treatment has become the main research and development task, a large number of fungi, bacteria and protozoa can effectively realize the organic matter and most of the heavy metal elements in papermaking wastewater filtration degradation. At the same time, the use of anaerobic + aerobic treatment to achieve a recyclable sewage treatment system can not only improve the economic benefits but also can further save resources and reduce the impact on the environment. This way can promote the application of paper waste microorganisms in the paper industry wastewater treatment water treatment to the direction of ecological and diversification transformation, so as to meet the dual requirements of social development and environmental protection.

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