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Start-up of a bioaugmentation anoxic-oxic (A/O) biofilm process treating natural rubber wastewater

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ABSTRACT

This study adopted A/O biofilm process for the treatment of natural rubber wastewater. Through continuous adding of MEM flora (exclusive natural rubber wastewater degradation bacteria) into the system, the concentration of pollutants in the effluent of the system can be effectively reduced. After 10 days of system start-up, the removal rate of COD and NH3-N reached more than 90% and 83% respectively. Bioaugmentation A/O biofilm process can effectively shorten the start-up time of the system as compared with traditional biofilm process without adding of MEM flora; when adding MEM flora by 30mg/L into every cubic meter of wastewater, the best effluent quality can be obtained with regard to COD and NH_3-N concentration. The quality of natural rubber wastewater effluent after bioaugmentation A/O biofilm process treatment is lower than grade I discharge standard specified in the *Integrated Wastewater Discharge Standard* (GB8987-1996)

KEYWORDS

MEM flora;
Bioaugmentation;
Natural rubber wastewater;
Biofilm process.

INTRODUCTION

Pollutants in natural rubber wastewater mainly include soluble organic matters, ammoniacal nitrogen, sulfate radical and others. Due to the washing of machines and the ground, there are also much silt, leaves and other debris in the wastewater. If it is directly discharged without treatment, dissolved oxygen in water body will be exhausted, thus leading to the suffocation of large amount of algae and aquatic organisms and posing serious threat to ecological environment[1]. Therefore, rubber wastewater must be properly treated before discharge. The BOD/ COD of rubber wastewater is about 0.78 which shows good biodegradability. Warburg apparatus was applied by Wang Huizhen and others to test the wastewater. According to the test, microbial respiration curve in the wastewater was above the endogenous respiration curve which demonstrated that biological treatment process would be suitable for the treatment of natural rubber wastewater. Due to the high concentration and large fluctuation in water quality and quantity of natural rubber wastewater, the application of MEM flora bioaugmentation A/O biofilm process can effectively guarantee the effluent quality.

Bioaugmentation is the application of indigenous or allochthonous or genetically modified organisms to polluted hazardous waste sites or bioreactors in order to accelerate the removal of undesired pollutants[2-5]. The key and difficulty to ensure stable standard compliance of rubber wastewater after biological treatment is that it must be ensured that there is adequate quantity of effective microorganisms[6]. Through adding exclusive bacteria suitable for the wastewater treatment to natural rubber wastewater, the removal rate of hardly degradable substance can be effectively improved by bioaugmentation technology. The reason is that compound microbial bacterial flora can quickly grow and decompose pollutants in wastewater under appropriate conditions. Besides, the stable and complex ecosystem can also be formed based on synergy, thus suppressing the growth and breeding of harmful microbes. The purpose of pollutant removal and water purification can be realized through comprehensive effect of these creatures[7,8].

METHOD

A/O biofilm process

The process chart adopted by the test is as shown in Figure 1. Natural rubber wastewater enters the system through the distribution tank. Add MEM flora at the inlet of the distribution tank. A, O1 and O2 reaction tanks are made of organic glass with the effective volume of 72L, 24L and 24L respectively. Baffle plates are set in these tanks to ensure plug flow of water. Combination packing is hung in these tanks. Oxygen required in aerobic biofilm reaction tanks is supplied by air pump. Even oxygen filling is realized through micropore ous diffusers located at the bottom of the contact oxidation reactor.

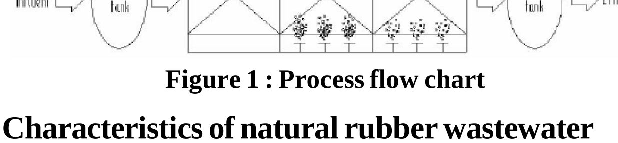

Figure 1 : Process flow chart

Characteristics of natural rubber wastewater

Rubber wastewater is the wastewater discharged when produce raw natural rubber with natural rubber latex or collagen gel as raw materials and when produce concentrated latex and skim rubber with natural rubber latex as raw material. As high concentration organic wastewater, rubber wastewater has complex composition. In addition to the main component of rubber whey, it also contains protein, carbohydrate, lipids, amino acids, organic acids, inorganic salts and others. It is characterized by seasonal emission, large fluctuation of water quantity, high concentration of organic matters, good biodegradability, high SS concentration, acidity, particularly high ammonia and nitrogen concentration, high S^{2-} concentration, favorable environment for the growth of sulfur bacteria and other filamentous bacteria and adverse environment for the growth of other bacteria. See rubber wastewater quality and emission standard as shown in TABLE 1.

TABLE 1 : Rubber wastewater quality and china's national discharge standard

Item	COD	NH3-N	PH	SS
Wastewater	1650-8761	11.27-468.52	5.2-6.5	52-6377
Grade I discharge standard	100	20	6-9	70

MEM flora

MEM flora is compound microbial flora screened, separated and cultivated based on characteristics of rubber wastewater and biological flora requirements. The bacterium liquid is the microbial polymer composed of dozens of efficient microorganisms by certain proportion. The composition conforms to the principle of microbial ecology. Through industrial expansion, biological rapid value-added active fluid of bacteria for industrial application can be obtained.

Start-up process

The purpose to start wastewater biological reactor is to increase, constitute and maintain the balanced biomass concentration with efficient activity. Immobilized biological technology can greatly improve the biomass of the biochemical treatment system. It can prevent the loss of organisms with special metabolic ability but growing slowly[9] and at the same time, it is characterized by strong resistance to impact load and high organic load capacity[7,10].

This test adopted continuous flora adding and physical adsorption methods for direct inoculation of composite fiber packing to start the A/O reactor. Terminal activated sludge was taken in the anaerobic tank and the oxidation ditch in Jinghong Rubber Factory Sewage Treatment Station of Yunnan Natural Rubber

Co., Ltd.. In the start-up process, the removal rate of COD and NH_4-N^+ and the biofilm growth condition were taken as evaluation indexes.

Analysis method

Sample water was taken regularly in the anaerobic tank and the two aerobic tanks for offline test of COD and NH_4-N^+. National standard methods were taken as the test method (State Environmental Protection Administration, 2002); SS was tested by SS-1Z intelligent suspension tester; pH was tested by Phs-3C pH tester.

CONCLUSION AND DISCUSSION

Change of COD and NH_4-N^+ concentration in various reaction tanks in the start-up stage:Start-up of a newly built or upgraded wastewater treatment process is a procedure to make it perform effectively and stably. Stable pollutants removal efficiency and high effluent water quality was the most evident sign for a successful start-up[11]. In early stage in the test device start-up process, fix the successfully filmed combined packing in the system and continuously add MEM flora in the distribution tank for engineering bacteria adaption domestication and system start-up operation. It can be seen from Figure 2 and Figure 3 that in the device start-up process, the influent COD concentration fluctuates in the range of 760~ 2442 mg/L. After 10 days of operation of the device after engineering flora adding, COD removal rate reached 93.28% and the outflow water was stabilized lower than 100mg/L, lower than national sewage grade I discharge standard (State Environmental Protection Administration, 1996). The influent NH_4-N^+ concentration fluctuates in the range of 39~70 mg/L. After 11 days of operation of the device, the effluent NH_4-N^+ concentration can be stabilized to be less than 10mg/L. Water quality is better than national sewage grade I discharge standard. From the 11th day to the 15th day, the pollutant concentration of effluent no longer fluctuated along with the increase of influent organic load; the removal rate was steadily increased; the effluent quality was stable and in line with standard. Biofilm attached on the packing was quite thick and the thickness was no longer change. It is believed that biofilm culturing got success after 11 days of continuous operation.

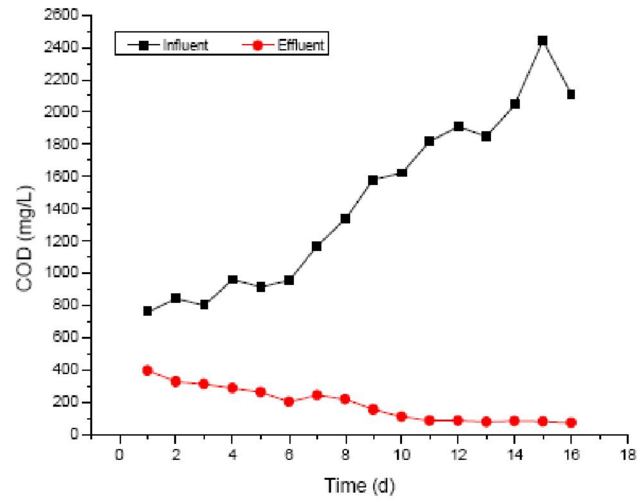

Figure 2 : The daily COD concentration and removal efficiency during start-up phase

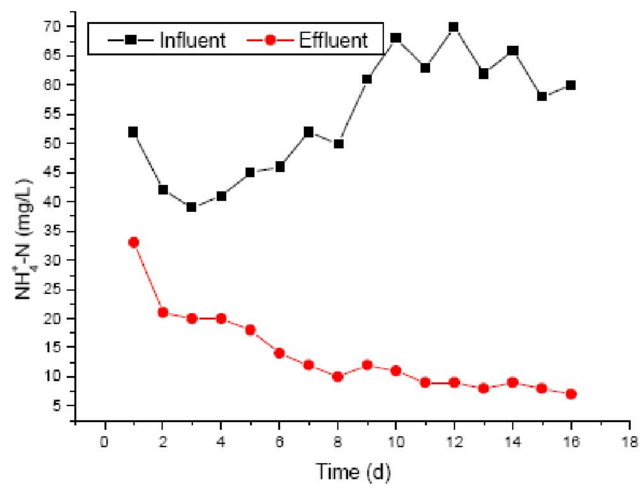

Figure 3 : The daily NH_4-N^+ concentration and removal efficiency during start-up phase

It is detected that COD and NH_4-N^+ removal rate in the system start-up stage is generally in constantly rising trend. The system has strong degradation ability for rubber wastewater. When the pollutant load increases significantly, the removal ability can also be quickly recovered. Besides, the system's COD removal rate has been slightly higher than the removal rate of NH_4-N^+. It is analyzed that the introduction of MEM flora and the formation of dominant population can optimize biological phase relationship in activated sludge to a certain degree, improve the concentration of effective microorganism in the system, improve the work performance of activated sludge and improve the system's pollutant degradation ability. Microorganism for COD degradation are mainly heterotrophic bacteria; bacteria for NH_4-N^+ degradation is mainly autotrophic bacteria. Since long growth cycle of autotrophic bacteria, the reproductive rate of heterotrophic bacteria is much faster than autotrophic bacteria, COD removal ability of the system in the start-up stage is higher than the removal ability of NH_4-N^+.

The removal of organic pollutants by the system in the start-up stage under different MEM adding proportion

In the start-up stage, the system start-up time was tested in contrast way for bioaugmentation system added with MEM and traditional biofilm system without bioaugmentation; the test also compared COD removal effect at different MEM adding amount. The test was conducted under conditions that the HRT was 168h, the gas water ratio was 70:1 and the O1/O2 aeration proportioning was 2:1. MEM flora were added by 0L, 1.0L, 1.5L and 2.0L per cubic meter respectively and different COD removal effect under different MEE adding amount is as shown in Figure 4. The results show that it took the bioaugmented A/O contact oxidation system 11 days to meet the national discharge standards. For the unbioaugmented activated sludge system, it required 21 days to reach the same effluent quality. This demonstrated that bioaugmentation was a powerful tool to shorten the adaptation time of the biological system.

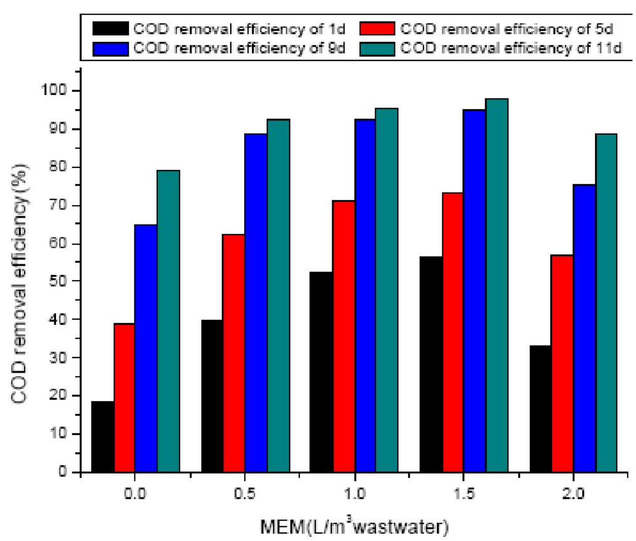

Figure 4 : COD removal efficiency at different dosage of MEM during start-up phase

Appropriate dosing of MEM flora can enhance COD degradation and removal ability of the system. The best dosage is 1.5L/m^3. For the dosage lower than this value, the COD removal rate will increase along with increase of the dosage at the maximum growth rate of 5.74%; when the dosage is increased to 1.5L/m^3, COD removal rate stops increase but reduces by 9.24%. This may be related to the increase of organic load in influent. Besides, since MEM flora is the composite flora, the excessive bacteria concentration due to excessive dosage will inhibit normal breeding of effective biological bacteria, thus reflecting "inefficiency" or "negative effect" of MEM flora and further leading to water quality degradation.

CONCLUSIONS

The results of this work lead to the following conclusions:

In the test device start-up stage, successfully filmed combined packing was fixed in the system and MEM flora was added in the distribution tank. Engineering bacteria adaption domestication and system start-up operation can be realized after 11 days; MEM flora bioaugmentation anaerobic- contact oxidation process has good effect on the treatment of natural rubber wastewater, better than the treatment effect in the way without adding of MEM flora. MEM flora can enhance the system's COD degradation and removal ability; the appropriate MEM dosage is 1.5L/m^3 when the COD removal rate of the system can reach 97.75%.

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