

# Biofilm Accretion and Start-up By Aerated Active Sand Biofilter

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**Abstract.** This experiment proposed aerated active sand biofilter (AASB) to strengthen biological effects in sewage treatment. It explores the method of biofilm accretion and start-up by AASB, then inoculated by active sludge and incremental flow rate to accelerate the start-up, when HRT is 3h, the temperature is 21.0 ~ 26.5°C, gas-water ratio is 3:1, biofilm accretion and start-up of AASB can be completed in 23d. At this point removal rates of COD, NH<sub>3</sub>-N and turbidity are stabilized at 70%, 38%, 92%, which are better than common active reactor to be a new way to treatment domestic sewage.

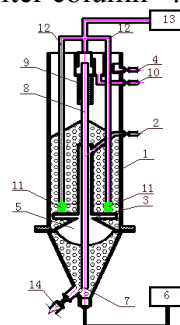
## 1 Introduction

Active sand biofilter is a continuous filtration equipment to set flocculation, clarification and filtration together<sup>[1]</sup>, because of its small floor area and low energy consumption, it has been widely used both at home and abroad. But based on less of its biological, the removal to organic contaminant is limited, and the flow dynamics of active sand can be washed to cause loss of biofilm<sup>[3]</sup>, so this study presents aerated active sand biofilter (AASB). The device is a new active sand filters used in advanced wastewater treatment, under the original premise of the filter turbidity function, increase aeration device to enhance the biological effects to achieve the good removal of ammonia and other indicators. This article is intended to find a way to biofilm start-up and operating parameters by AASB.

## 2 Apparatus and methods

### 2.1 Apparatus and process

As we see in Fig.1, AASB is 1.15m with 45L effective volume and inner diameter is 320mm. The thickness of filter layer is 580mm, the bottom set aeration zone and the height of aeration is 300mm for providing sufficient oxygen to microorganisms. The filter is granular activated carbon produce by a factory in Henan, with specific surface area is 500~900m<sup>2</sup>/g and packing density is 0.45~0.55g/cm<sup>3</sup>. The diameter of filter column is much greater than activated carbon by 50 times so we can ignore the effect by the side of filter column<sup>[4]</sup>.



- 1.Active sand 2.The water inlet pipe 3. The water distributing device 4.The water out weir  
5.The guide sand cone 6.Pump 7.Blowhole 8.Pipe 9.Sand washer 10. The water out weir 11.  
The aeration hole 12. The aeration pipe 13. Air compressor 14.Vent pipe

Fig.1 Structure of aerated active sand biofilter

## 2.2 Raw water quality

The raw water is from sewage by a university which is shown in Tab. 1.

Tab. 1 Quality of raw water

Item	COD /(mg·L <sup>-1</sup> )	NH <sub>3</sub> -N /(mg·L <sup>-1</sup> )	Turbidity /NTU	pH	T /°C	DO /(mg·L <sup>-1</sup> )
Range	136.9~170.3	22.5~34.0	15.4~10.3	7.3~8.5	21.0~26.5	0~0.8

## 2.3 The way of analysis

The determination of water quality indicators is refer to Water Monitoring and Analysis Methods (Fourth edition)<sup>[5]</sup>.

## 2.4 Starting method

In order to strengthen the biological oxidation function of AASB, biofilm formation on the filter surface must be stable. The way of biofilm accretion and start-up at home and abroad can be divided into three types: natural biofilm accretion, vaccinate biofilm accretion and complex biofilm accretion<sup>[6]</sup>. The experiment chose complex biofilm accretion and started under the temperature of 21.0 ~ 26.5 °C. Firstly added 1L of activated sludge which was taken from a secondary settling tank while pumped the fresh sewage into the reactor. Closed the inlet valve, and then aerated by 40L/h with 10.0g glucose to promote the growth of microorganisms. After aeration 2 days, emptied mud and water in the filter and then influent with small flow, which initial flow was 4.5 L/h. Gradually increase the flow to the set value by 15L/h, with HRT is 3h. Maintain aeration for 16L/h, so that microbes can adapt to water gradually.

We usually use COD and NH<sub>3</sub>-N as indicators to determine biofilm growth in municipal wastewater treatment, usually analyze their trends of removal to determine whether the biofilm completed<sup>[7]</sup>. During the whole time of biofilm accretion, set COD, NH<sub>3</sub>-N and turbidity as indicators. During biofilm accretion and start-up, the first 1-6 days is initial phase, 7-15 days is middle phase, 16-23 days is last phase. To avoid clogging the filter voids by a large number of particulate matter so that influence the removal efficient, wash active sand at the sixth and ninth day. Because of the impact of active sand, voids between the particles was increased, interception and adsorption by active sand was weakened, so each indicator has a sudden drop of the removal, but the recovery of filter layer was good so that it can achieve the original removal on the second day.

## 3 Results and discussion

### 3.1 The apparent phenomenon of biofilm accretion

After the aeration, activated sludge absorbed nutrients and growth on the filter surface, at the same time something transparent and goo has began to appear. Microorganisms absorbed nutrients so that proliferated continual, then it formed a new brown velvet-like film. With the extension time of biofilm accretion, until the end of the process it can be observed red-brown zoogloea wrapped by the filamentous fungus. Observe the biofilm with microscopic examination, there were paramecium, rotifer, trichomoniasis, nematodes and other protozoa and metazoan.

### 3.2 The removal of COD during the biofilm accretion

Fig. 2 has reaction the removal of COD during the biofilm accretion. After the aeration, because of the static adsorption by filter media and interception of initial biofilm<sup>[8]</sup>, the removal of COD was good and the average rate can reached 47%. To the middle phase of biofilm accretion initial flow was 10 L/h, heterotrophic bacteria adapt the condition quickly and began breed, the average removal rate of COD stabled at 62%. At this point heterotrophic bacteria grown well, it can be considered the peak of they grown in middle phase. After continuous inflow water, the removal of COD rate was approximately more than 70% when HRT reached the test value 3h. At this time effluent water was stabilized and concentrations of COD was less than 50 mg·L<sup>-1</sup>. Biofilm accretion and start-up can be considered succeed at the 23th day.

### 3.3 The removal of NH<sub>3</sub>-N during the biofilm accretion

In Fig. 3, NH<sub>3</sub>-N has been removed in initial phase, which removal rate is 8%~14%. Because of the denitrifying bacteria adapt to the environment longer than heterotrophic bacteria<sup>[9]</sup>, so in this time

heterotrophic bacteria was in the ascendant,  $\text{NH}_3\text{-N}$  is mainly removed by adsorption of granular activated carbon. After continuous inflow water, with adapting the environment gradually, denitrifying bacteria began to grown on media stabilized, which removal rate of  $\text{NH}_3\text{-N}$  reached 23%. Although the denitrifying bacteria was susceptible to the competitive inhibition of heterotrophic bacteria[10] so that grown slow, however the removal rate was significantly increased in middle phase. Due to nitrification at this time, nitrobacteria growth well. With its further growth, the removal rate was 38% in the last phase, far more than the removal efficiency by active sand filters (10%~20%) .

### 3.4 The removal of turbidity during the biofilm accretion

Removal efficiency of turbidity during biofilm accretion and start-up by AASB are shown in Fig.4. In the initial phase of biofilm accretion, the removal was significantly since the effect of interception and adsorption by the filter. During the middle phase removal has rapidly increased, the average turbidity was 3NTU and removal rate has stabilized at 90%. After 16<sup>th</sup> day, though turbidity was generally low in influent, the removal has still on an upward trend and maintain a good level. It can be seen that under conditions of some fluctuations in turbidity, mature biofilms had effect of adhesion and degradation. Until the end of biofilm accretion, most of the suspended particles are trapped in the pores of the filter layer by adsorption and retention as well as the role of media in Most of the suspended particles are trapped in the pores of the filter layer by adsorption and retention as well as the role of media in bioflocculation, turbidity was less than 1NTU.

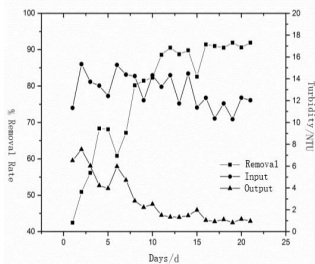


Fig.2 COD removal of AASB

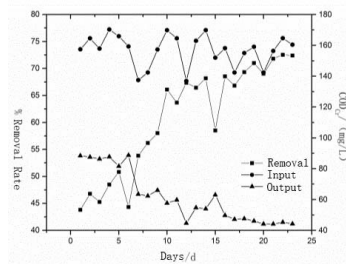


Fig.3  $\text{NH}_3\text{-N}$  removal of AASB

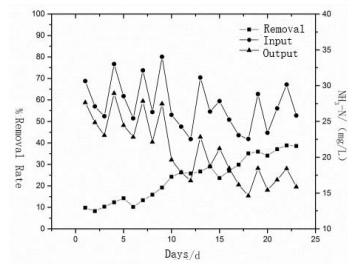


Fig.4 Turbidity removal of AASB

## 4. Conclusion

(1) Proposed aerated active sand biofilter (AASB) to strengthen biological effects in sewage treatment. In addition to the function of filter by normal activity sand biofilter, AASB used indirect cleaning mode to overcome the traditional problems such as backwash, and increase the aeration device to enhance the biological effects so that the removal of  $\text{NH}_3\text{-N}$  has greatly increased. AASB is an efficient new way to sewage treatment.

(2) This experiment explores the complex biofilm accretion by AASB during sewage treatment, then according to the requirements of urban sewage treatment selected removal rate of COD and  $\text{NH}_3\text{-N}$  as sign of biofilm maturity. Under the conditions of HRT is 3h, temperature is 21.0 ~ 26.5 $^{\circ}\text{C}$ , gas-water ratio is 3: 1, after 23d AASB completed start-up.

(3) After biofilm accretion and start-up by AASB has been completed, the removal of COD,  $\text{NH}_3\text{-N}$  and turbidity were stabilized at 70%, 38%, 92%. The quality of effluent is good, it can reach emissions standards and provide a reference for subsequent experiment.

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