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Study on Sludge Reduction of Printing and Dyeing Wastewater Treatment by Biofilm Process

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Abstract. Aiming at the problem of large output of sludge in the traditional activated sludge process, the sludge reduction efficiency of the biofilm process was investigated on treating the printing and dyeing wastewater. The coefficient of producing sludge of three kinds of biofilm reactors for basalt fiber filler, combined filler and elastic filler were calculated and analyzed. The results indicated that, the coefficient of producing sludge of basalt fiber filler, combined filler and elastic filler reactors were 0.36gSS/g COD, 0.46gSS/gCOD and 0.60gSS/gCOD respectively. The sludge reduction ratios were 52.6%, 39.5% and 21.1% comparing with the traditional activated sludge method respectively and sludge reduction has the best effect on the basalt fiber biofilm reactor. The microscopic examination showed that there were abundant protozoa and metazoan in the biofilm and the reduction of sludge was realized by the predation relationship in the microbial ecosystem.

1. Introduction
Most of the waste water treatment processes still use activated sludge process. During this process, a large amount of excess sludge will be generated. The excess sludge does not only possess high disposal cost, but also contains various toxic and harmful substances such as bacteria and viruses. When handled improperly, secondary pollution will easily be formed, which will cause greater harm[1-3]. Domestic and foreign scholars have studied on the sludge reduction process: aerobic-anaerobic technology[4], delayed aeration method[5], decoupling agent method[6] and ozone oxidation method[7].

However, these sludge reduction processes are associated with many problems in practical applications, such as large energy consumption, secondary pollution, high equipment cost as well as complex operation and management. In the wastewater treatment process dominated by the biofilm process, a biofilm consisting of a large number of bacteria, fungi, protozoa and metazoa are attached to the fillers. When the wastewater passes through the biofilm, it can effectively degrade the organic pollutants. Sludge reduction can be achieved. So therefore, the application of biofilm sludge reduction is more extensive.

At present, most domestic printing and dyeing wastewater treatment plants adopt the “Biochemical method and Physicochemical method” treatment process[8]. The bio-chemical method basically adopts the biofilm method recommended in the “Guidelines for Printing and Dyeing Waste-water Pollution Prevention and Control” edited by the former State of Environmental Protection Administration[9]. The properties of the fillers dominate the biofilm technology. It is expected that, the fillers will have strong
hydrophilicity and fast filming speeds. The amount of film hanging is high and can't easily fall off. This results in a lower sludge production in the biofilm reactor system. In this paper, a biofilm reactor with basalt fiber fillers, combined fillers and elastic fillers were constructed to treat printing and dyeing waste water. The efficiency of sludge reduction in biofilm reactors with three kinds of fillers were investigated for practical application.

2. Materials and Methods

2.1. Materials
In this experiment, a biofilm reactor was constructed with elastic and combined fillers (Guangzhou Lv Ye Environmental Protection Company) and basalt fiber fillers (Jiangsu University and ATK Holding Limited by Share Ltd joint research and development) to deal with printing and dyeing waste water. The biofilm reactor is made of plexiglass with a diameter of 200 mm and an effective height of 600 mm. The schematic diagram of the structure is shown in Figure 1. A total of three sets of biofilm reactors were compared in parallel.

![Figure 1. Schematic diagram of biofilm reactor.](image)

The raw water of printing and dyeing waste water was collected from a printing and dyeing factory in Da Gang, Zhenjiang and its quality are as follows: COD value 300-1000 mg/L, pH value 6-8, NH₄⁺-N value 7-20 mg/L, TP value 0.5-3.5 mg/L, temperature 19-36℃.

2.2. Method
Sequential Batch Influent Method was employed for the experiment, start experiment after successful inoculation. The study was conducted using the different influent concentration of printing and dyeing waste water, keeping the reactor sludge concentration at about 2500 mg/L and Experimental study on sludge reduction for three different fillers.

The apparent yield of sludge Y, is the amount of sludge produced per gram of CODCr. This parameter is used to characterize the effect of sludge reduction in biofilm reactors. References [10]. The hydrophilicity of the filler was compared with the test contact angle θ, the contact angle meter (Dong Guan Precision Instrument Co., Ltd. SDC-100). Microbiological microscopy, optical microscopy (Phoenix PH100) combined with a digital camera.

CODcr and NH₄⁺-N was adopted from Shanghai Lianhua Science and Technology Co., Ltd. A multi-parameter water quality analyzer (5B-3B type (V8)); MLSS, MLVSS adopt dry weight method; water temperature and dissolved oxygen JYB-607A dissolved oxygen meter.

3. Results and Discussion

3.1. Three Filler Contact Angles
The contact angle $\theta$ of the basalt fiber, the combined filler fiber and the elastic filler measured by the contact angle meter was 60.523°, 66.724°, and 63.359°, respectively, as shown in Figure 2. The three fillers have a filament diameter of approximately 13 μm, 25 μm, 500 μm. When the angle of $\theta$ is greater than 90°, the material is hydrophobicity. But when the angle of $\theta$ is less than 90°, the material exhibits hydrophilicity, and the smaller the angle, the stronger the hydrophilicity [11]. From the measured results, it can be seen that the contact angles of all three kinds of fillers are less than 90 degrees and they all possess strong hydrophilicity. Hence, the most hydrophilic ones are basalt fiber fillers. The hydrophilicity of the filler is strong, it is conducive to the attachment of biofilms and it's not easy to fall off.

Figure 2. Contact angle of three kinds of fillers.

3.2. Sludge apparent yield

The experiment examined three consecutive time periods. It can be seen from Figure 3 that, the apparent yield of the sludge in the basalt packed reactor gradually decreased and the apparent yield of the sludge averaged was 0.36 gSS/gCOD whereas the corresponding sludge reduction ratio gradually increased. It is lower than two reactors with elastic filler and combined filler, the apparent yield of sludge in combined filler reactor is relatively stable in three time periods of about 0.45 gSS/gCOD which is slightly higher than that of basalt filler reactor. The apparent yield of the reactor sludge was basically maintained at 0.6 gSS/gCOD and the sludge yield was the highest in the three time periods. This was inferior to the sludge reduction effect, which was mainly due to the poor effect of the elastic filler film. The membrane is easy to fall off and it is difficult to form a stable microbial ecosystem, so more residual sludge is produced. After consulting the relevant literature [12], the apparent yield of sludge from the traditional activated sludge process was 0.76 gSS/gCOD as compared with the sludge yield of the traditional activated sludge process, the biofilm reactor fouling of the three fillers. The mud reduction effect is better than the traditional activated sludge method. As compared with the traditional activated sludge process, the sludge reduction ratios of the basalt filler reactor, the elastic filler reactor as well as the combined filler reactor were 52.6%, 21.1% and 39.5%, respectively. But the sludge reduction effect of the basalt fiber filler reactor was best reduced.
3.3. Biofilm Microscopy Analysis

The biofilm process filler is affixed with a large number of biofilms composed of bacteria, fungi, protozoa and metazoa. The biofilm process produces less sludge than traditional active methods and there is a biological predation relationship in the microbial ecosystem of the main biofilm[13]. After the filler is added to the reactor, it can reduce the discharge of activated sludge, the sludge reduction of the system is decreased, and the biofilm formed on the filler is microscopically found to be rich in biological phase on the filler. A large number of protozoa such as ciliates as well as a small number of nematodes can form a complete microbial ecosystem. The rich biological phase can form a long food chain and the sludge itself can be digested resulting in a great reduction of the amount of excess sludge produced. A microscopic examination of the microbial community of the biofilm on the three fillers was carried out, as shown in Figure 4. In the early stage, the microbial community in the biofilm was single. Only nematodes and paramecium were found during the microscopic examination. With the stable operation of the reactor, the microbial community was diversified and the biodiversity was very rich. During the middle and late acclimation period, rotifers, bell insects, and tiredness begin to appear. Micro-animals such as branch worms and oligochaetes form a long food chain, thereby achieving sludge reduction.

![Figure 3. Apparent yield histogram of sludge.](image)
4. Conclusion
The following three conclusions are obtained by using the new basalt fiber fillers, combined fillers and elastic fillers for sludge reduction test.

1. The contact angles of basalt fiber fillers, combined fillers, and elastic fillers are 60.523°, 66.724° and 63.359° respectively. They all have strong hydrophilicity and the most hydrophilic ones are basalt fiber fillers.

2. The apparent sludge yields of the biofilm reactor based on basalt fiber packing, combined packing and elastic packing were 0.36 gSS/gCOD, 0.60 g SS/g COD and 0.46 gSS/gCOD respectively as compared to the conventional activated sludge process. Sludge reduction was 52.6%, 21.1%, and 39.5% respectively, of which the basalt fiber filler biofilm reactor had the best sludge reduction effect.

3. Microscopic examination indicated that, there are abundant protozoa and metazoa in the biofilm reactor system and sludge reduction is achieved by using the predation relationship in the microbial ecosystem.

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References
[1] Alcock R and Jones K 1996 Environ. Sci. Technol. 130 3133.
[2] Mantis I, Voutsa D and Samara C 2005 Ecotox. Environ. Safe. 62 397.
[3] Ding W, Li L and Liu J 2015 Water Sci. Technol. A J. Int. Assoc. Water Pollut. Res. 72 543.
[4] Vellingir K, Ramachandran T and Thirugnanasambantham A 2015 Int. J. Eng. Technol. Innov. 5 66.
[5] Deleris S, Geauge V, Camacho P, Debelletontaine H and Paul E 2002 Water Sci. Technol. A J. Int. Assoc. Water Pollut. Res. 46 63.
[6] Liu Y 2000 Water Res. 34 2025.
[7] Sakai Y, Fukase T and Yasui H 1997 Water Sci. Technol. 36 163.
[8] Peng Y, Han Y and Li J 1997 Techniques & Equipment (Enviro.poll.cont) 5 56.
[9] Science and Technology Standards Division, State Environmental Protection Administration.2002 China Environmental Science Press.1 133.
[10] Liang P, Huang and X, Qian Y 2004 China Water & Wastewater 20 13.
[11] Wang H, Hui S and Yang-Yang L 2010 Chinese J. Ecology 29 630.
[12] Yu L and Wang H 2003 Water Wastewater 29 23.
[13] Lee N and Welander T 1996 Water Res. 30 1781.