Scientific Research

Study on the Technology of Raw Water Treatment for Power Plant Cooling System

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Abstract: This study is based on pilot test of the treatment of the secondary effluent in Xingtai, Hebei, by using the BAF+Highly efficient coagulation and sedimentation combined process. The results showed that the secondary effluent treatment through the combination of technology, the average removal rate of CODcr, turbidity and NH_3 was 63.4～69.2%,91.8～95.4%,90.5～95.9% respectively, which can meet the power plant cooling water requirements.

Keywords: BAF; highly efficient coagulative precipitation; circulating cooling water; secondary effluent

1 Introduction

With acceleration of the process of urbanization and rapid development of industry and agriculture in China, the total amount of existing water resources has been unable to meet the growing demands, resulting in prominent contradiction between supply and demand of water resources[1]. Plenty of municipal sewage discharged from secondary treatment directly flow into receiving water bodies. Not only self-purification capacity of the receiving water is undermined, but also the water resources are indirectly wasted. In urban water supply, as much as 60~80% are offered to industry in which power plants are the major users, while the water is consumed by circulation cooling system in power plants account for 70~80%. Because of huge recharging amount for circulation cooling and relatively low requirement of water quality, using the regenerated secondary effluent of municipal sewage treatment plants as the make-up water for circulation cooling system, is one of effective approaches to solve current problem.

In this pilot study, the secondary effluent of one municipal wastewater treatment plant in Xingtai of Hebei province was used as water source. The technology of BAF combined with efficient coagulation-sedimentation process for municipal secondary effluent treatment which can be reused in circulation cooling system of one power plant in Xingtai was estimated. With meeting the requirements of makeup water quality of the circulation cooling system, design and operating management of engineering practice were provided the optimum technical parameters and scientific guidance.

2 Materials and Methods

2.1 Experimental Water Quality

This pilot study used secondary effluent of a municipal wastewater treatment plant in Xingtai of Hebei province, the water quality indicators and the standards of water quality were respectively listed in table 1.

Table 1. Secondary effluent and cooling water requirements compared

	CODcr（mg/L）	TP（mg/L）	Turbidity (NTU)	NH_3（mg/L）
secondary effluent	40-70	0.5-1.0	10-30	10-20
Cooling water requirements	≤30	≤1	≤5	≤3

In Table 1, the quality standards of circulation cooling water based on recommended standards of reclaimed water as circulation cooling water was utilized to control indicators[2]. As Table 1 shows，indicators of water quality of secondary effluent, except TP, did not reach the standards of water for circulation cooling. Therefore, CODcr, turbidity and NH_3 need further removal.

2.2 Experimental reactor

Secondary effluents from a sewage treatment plant were treated by adopting the process of BAF combined with efficient coagulation-sedimentation.

2.2.1 BAF

The reactor made of welded steel plates with length× width×height= 0.8× 0.8× 7.5m was design for up-flowing and designed water quantity is $2m^3/h$. The tank was filled with ceramicite providing by Sanhe Light-chemical company in Pingxiang, Jiangxi province. The height of packing layer was 4m. Influent pipes, aeration pipes, influent pipes for backwashing, air inlet pipes for backwashing, effluent pipes for production, effluent pipes for backwashing, temporary sewage pipes are set in the filter. Water and air inlet pipes of this system are equipped with manual ball valve and fluid meter. Influent and air inlet pipes for backwashing, effluent pipes for

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production and temporary sewage pipes were equipped with manual ball valve.

2.2.2 Efficient coagulation-sedimentation tank[3]

The designed flow was $2m^3/h$, length × width × height = 1.5 ×0.8 ×2.2m, and the designed reaction time was 14min. Up-flowing rate of sedimentation area was 0.0023m/s in which there were flow meter installed in front of efficient micro-vortex mixer, micro-vortex folded plates for flocculation set in the reaction zone, and efficient complex slant plate set in the precipitation zone.

3 Results and Discussion

3.1 Startup of the Combined Process

3.1.1 Biofilm-Culturing Stage of BAF

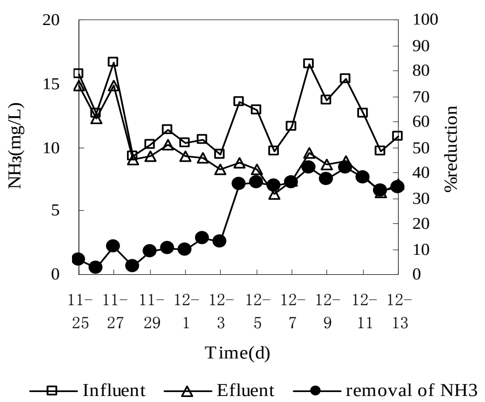

Figure 1. removal of NH_3 during the biofilm-culturing stage

The experiment utilized aerobic sludge of wastewater treatment plant for vaccination in the start stage of film culturing by intermittent influent and continuous aeration. At beginning, the influent flow was diminished to $1.5m^3/h$, and aeration was $4m^3/h$. From November 23, 2007 to December 13, 2007, film culturing was conducted considering there was no significant effect in early days. The ammonia of influent and effluent were detected from November 25 shown in Figure 1. During formation of film, the ammonia of inlet water varied between 9.3~16.7mg/L. Before December 4, the ammonia and nitrogen values of influent and effluent differed little. 2.4~14.2% of ammonia was removed indicating that microorganisms have not yet been effective in that period. After December 4, ammonia of effluent was obviously lower than that of influent, removal rate of ammonia also significantly increased to 33.0~42.2%, showing that nitrifying bacteria have already occurred and multiplied rapidly in that time.

3.1.2 The biofilm domesticating stage of BAF

The inflow and aeration amount were adjusted to $2.0m^3/h$ and 4～6 m^3/h respectively. Biofilm had been domesticating from December 15, 2007 to January 2, 2008. The NH_3 and COD_{Cr} of influent and effluent were measured everyday.

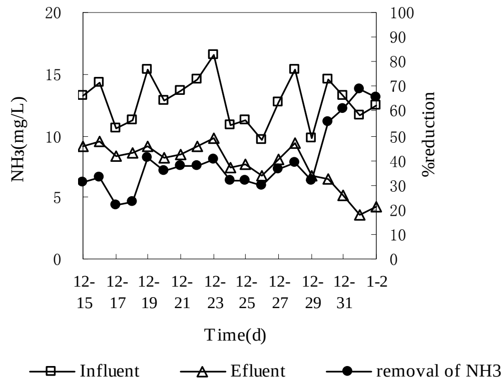

Figure 2 removal of NH_3 during the biofilm domesticating stage

As Figure 2 shows, the NH_3 of influent had been constantly changing in the period of biofilm acclimating. And it's difficult to domesticate the biofilm in a short term of winter. Before December 29, NH_3 in effluent was steadily around 8.4mg/L. The average removal rate of NH_3 was 33.5%, which did not differ much from that of film-culturing stage. From December 29, NH_3 in effluent decreased gradually with an average of 4.9mg/L. The removal rate rose dramatically with an average of 62.7%, indicating that the domestication of nitrifying bacteria had become mature[4]. It can be run continuously.

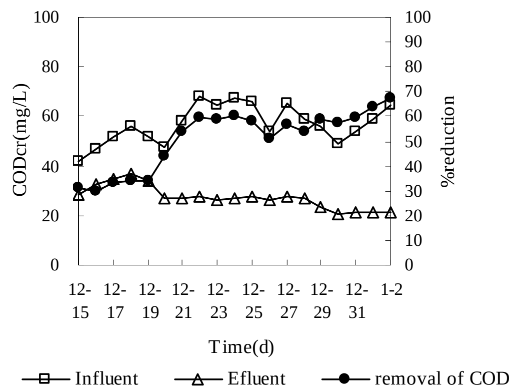

Figure 3 removal of COD during the biofilm domesticating stage

Seen from Figure 3, average removal rate of COD_{Cr} was 32.4% before December 19. Then it increased to 55.6% between December 19~December 29, and the removal was relatively stable. However, the average removal rate of NH_3 was 33.5% in the same period (Figure 2), illustrating that domestication of carbonizing bacteria whose generation cycle was shorter than that of nitrifying bacteria gradually became mature. From December 29, the average removal rate of COD_{Cr} increased further to 62.2%, meaning that the domestication was already mature.

3.1.3 The starting of efficient coagulation sedimentation tank

Efficient coagulation-sedimentation tank just need turbidity of the BAF effluent to determine appropriate dosage of flocculants. PAC was used in this study with the optimum dosage of 30mg/L.

3.2 The operation of combined process

3.2.1 COD_{Cr} removal by combined process

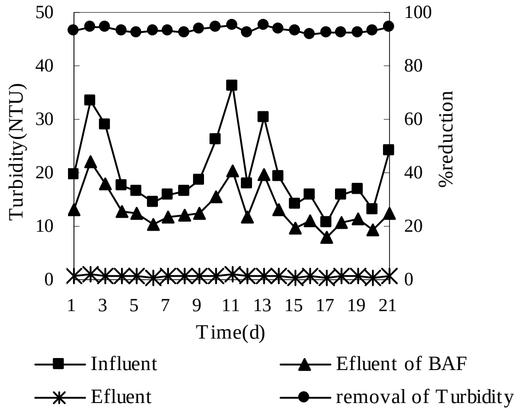

Figure 4 removal of COD by combined process

As can be seen from Figure 4, COD_{Cr} of secondary effluent was 42.1~51.5 mg/L. The value was 20.1~ 23.4mg/L after BAF, and then reduced to 14.7~16.7 mg/L after efficient coagulation-sedimentation. The removal rate on the secondary effluent was 63.4~69.2% by BAF combined with efficient coagulation-sedimentation process. A great deal of dissolved organic matters in municipal secondary effluent were first removed by pretreatment of BAF. Then non-dissolved organic matters were removed, further. Therefore the removal efficiency of organics was highly increased.

3.2.2 Turbidity removal by combined process

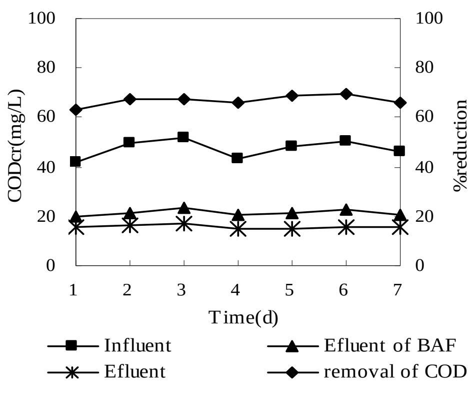

Figure 5 removal of turbidity by combined process

Shown from Figure 5, the turbidity of municipal secondary effluent varied between 10.8~36.1 NTU. Some turbidity were removed by function of adsorption on ceramic surface in BAF and physical interception of packing layer, with the average removal rate of 32.9%. Effluent turbidity was steadily below 3 NTU after treatment of efficient coagulation-sedimentation, with removal rate of 91.8~95.4%. Turbidity was highly removed by BAF combined with efficient coagulation-sedimentation process in which efficient coagulation-sedimentation play a dominant role.

3.2.3 NH_3 removal by combined process

As Figure 6 shows, the NH_3 of municipal secondary effluent varying between 9.7~15.6mg/L was reduced to 0.4~1.2mg/L by the combined process with a removal rate of 90.5~95.9%, showing that this combination removed NH_3 effectively. But efficient coagulation-sedimentation basically had no effect on NH_3 removal.

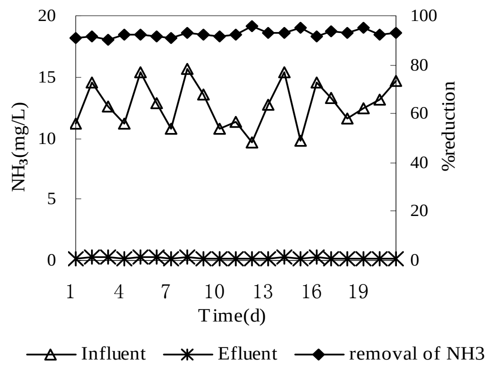

Figure 6 removal of NH_3 by combined process

4 Conclusion

(1) After treating by BAF combined with efficient coagulation-sedimentation process, the quality of secondary effluent of a wastewater treatment plant in Xingtai, Hebei province steadily reached the requirements of circulation cooling system of a power plant with an average COD_{Cr} removal rate of 63.4~69.2%, turbidity of 91.8~95.4% and NH_3 of 90.5~95.9%.

(2) Film-culturing and domestication of BAF cost long time because of low temperature in winter. In engineering practice, steam boilers of a power plant can be used to pre-heat the water for shortening film-culturing and domestication period.

(3) Recommended design parameters of combined process. BAF: NH_3 volume load is low than $0.5kg \cdot COD_{Cr}/m^3 \cdot d$ with gas-water ratio 1.5~2.5:1 and backwashing cycle 3~5 days. Efficient coagulation-sedimentation tank: the flow rate of efficient micro-vortex mixer is 0.8~1.2m/s; reaction time of flocculation is 12 ~ 15min; up-flow velocity in precipitation area is 2~3mm/s.

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