Treatment of Chemical Wastewater by O_3-BAC Method

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Abstract. Aiming at the problem of lower biodegradability and higher chromaticity of two stage biochemical treatment of petrochemical industries wasterwater treatment plant, O_3-BAC is used to treat the water outlet of sewage treatment plant and the $COD_{Cr,}$ and Ammonia-nitrogen and sewage chroma are analyzed as well. The results show that the treatment efficiency could be achieved through O_3-BAC method, that is, the COD_{Cr} is 26.7mg/L, the Ammonia-nitrogen is 0.18mg/L and the sewage chroma is 5 times.

1. Introduction

O_3-BAC (O_3-Biological Activated Carbon) is a wastewater treatment based on organic matters in ozonation. This process integrates O_3 pre-oxidation, activated carbon adsorption, biological oxidation and activated carbon regeneration. The O_3 pre-oxidation means that the 0.002~0.08μm particles are oxidized into particles less than 0.002μm so that both of adsorption efficiency of activated carbon and degradation efficiency of microbe are improved. The absorption of activated carbon could easily lead to a enrichment of higher concentration pollutants in local area, which is beneficial to the diffusion of pollutants into cell membrane and improves the treatment efficiency of low concentration wastewater[1]. Activated carbon has developed internal pores which is beneficial to microbe reproductions [2]. In addition, the unit area of activated carbon is too large to accumulate microbes, which is beneficial to improve the removal effieciency of organic matters [3]. At last, the microbial degradation of activated carbon could decompose organic pollutants into CO_2 and H_2O. When completing the degradation, the activated carbon could recover its adsorbability[4]. The former treatment of coagulation air is to remove pollutants larger than 0.08μm so that the oxidation efficiency of O_3 could be improved. The O_3-BAC method solve the problem of high cost of O_3 oxidation and the difficulty of activated carbon adsorption.

2. The Development of O3-BAC

After 1960s, with the development of industry, the source water was generally polluted by organic matter, such as pesticides, insecticides, herbicides, various additives, endocrine interferons, etc.. In 1970s, chlorine disinfection was found to react with organic compounds to produce disinfection by-products, which is harmful to human health. At the same time, the conventional treatment process had no removal ability for these organic compounds, so that the impact of drinking water on human health has been a great concern, forcing people to seek new drinking water purification technology to make up for the shortcomings of conventional treatment processes. In this context, O_3-BAC has been developed and applied.

The first use of O_3-BAC was a water plant in Dusseldorf, Germany, in 1961 [5]. On the basis of the original ozone+filtration, the activated carbon adsorption was added, by which the effluent water quality was obviously improved. Its success has attracted the attention of the German and Western European water treatment engineering circles. In 1967, Parkhurst et al [6] affirmed the beneficial effect of microorganisms on activated carbon, and finally established the O_3-BAC Technology. Since the beginning of 1970s, O_3-BAC technology has been extensively studied and applied [7].

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3. Case Study

3.1. Case description

The design scale of sewage treatment plant in Petrochemical Industry is $5.5\times10^4 m^3/d$, and the operating scale is 2.40×10^4~$3.36\times10^4 m^3/d$. The process of O_3-BAC includes oil separation, average adjustment, hydrolyzation, A/O and the treatment of aeration tank and clarifier. The sewage comes from refinery, addictive plants, auxiliary plants and fine chemical plants. The composition of sewage could be divided into naphthalene, quinoline, pyridine, polyvinyl alchohol, styrene, acrylonitrile, nitrobenzene and two vinylichloride, which cause the two stage biochemical treatment effluent has lower biodegradability and higher chromaticity, and the sewage quality cannot meet the requirement of wastewater reuse pretreatment after the removal of COD_{Cr}. Therefore, the O_3-BAC method could treat the two stage biochemical effluent of sewage treatment plant properly.

3.2. The processing installation of O3-BAC method

The processing installation of O_3-BAC includes floatation tank, O_3 contact oxidation tower, intermediate regulating tank, BAC reaction column and auxilary equipments, the processing flow is shown in Fig.1.

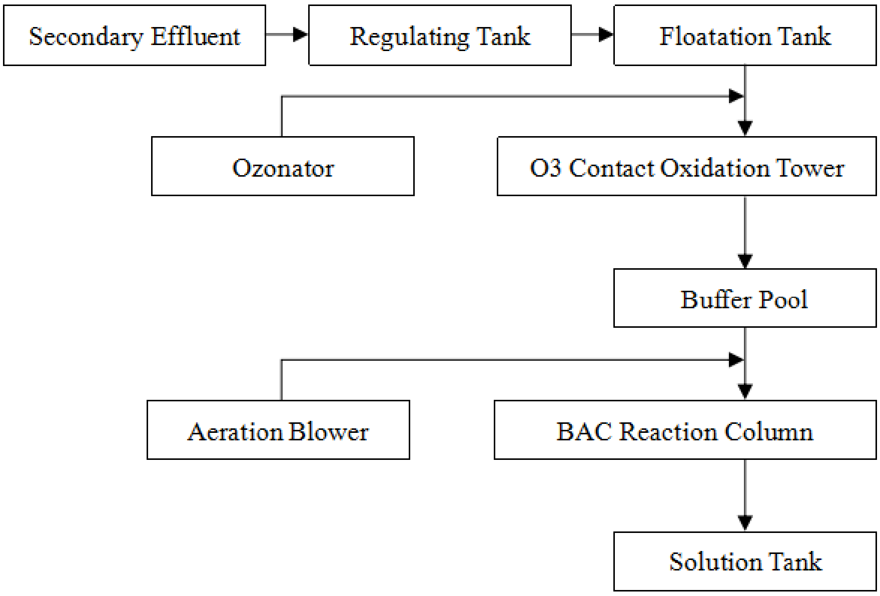

Figure 1: The processing flow of O_3-BAC

3.3. Sewage quality

The sewage comes from sewage treatment plant in Lanzhou Petrochemical Industry. The sewage quality and effluent design index are shown in Tab.1.

TABLE I. The sewage quality and effluent design inde

Items	Sewage quality	Effluent design index
COD_{Cr}/mg/L	60~70	≤30
Ammonia-nitrogen/mg/L	≤10	≤3
Petroleummg/L	≤5	≤1
SS/mg/L	≤20	≤5
PH	6~9	6~9
BOD_5/mg/L	≤10	≤3

3.4. Analytical method

COD_{Cr} is measured by the dichromate titration, and BOD_5 is measured by tacheometer, then the sewage chroma is measured by a dulution multiple method, besides Ammonia-nitrogen is measured by reagent spectrophotometer, at last, the biological phase is photographed by microscope.

3.5. Processing parameters
The processing parameters of O_3-BAC is shown in Tab.2.

TABLE II. The processing parameters of O_3-BAC

Items	Parameters
Sewage loads/kgCOD/m^{3}d	1.3~1.5
Aeration	Gas-water ratio is (2~3):1
Agent addition/mg/L	10~15
O_3 concentration/mg/L	4.2~4.5
Temperature/°C	18~25
PH	7~9

4. BAC Hanging and Domestication
Cultivation of biological membrane: the sewage temperature is about 30°C, which is beneficial to microbe cultivation. Before the operation of BAC column, it is essential to conduct the microbiological inoculation. After a week of cultivation and domestication, efficient microbe, selected from ordinary microbe, is full of BAC column with 72h aeration. Afterwards, 1/3 sewage in the column is discharged and new sewage is added to conduct the aeration again. At the beginning of aeration, the sewage is muddy. After 3-week treatment,

5. Results Analysis

5.1. The analysis of CODCr treatment efficiency
The influent COD_{Cr} is not stable and fluctuates between 50~80mg/L. The treatment efficiency of COD_{Cr} by O_3-BAC is shown in Fig.2.

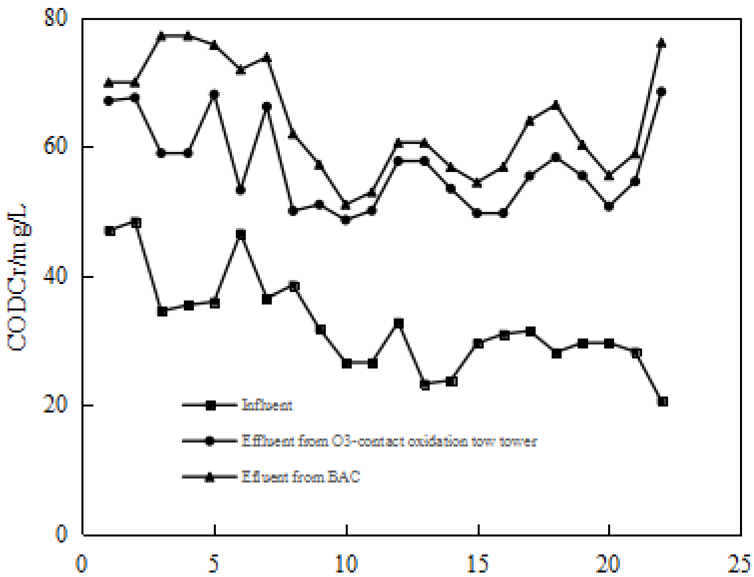

Figure 2. The CODCr removal efficiency by O3-BAC

As shown in Fig.2, when the process runs continuously, the average COD_{Cr} removal is above 50%. When the influent pollutant concentration changes, the concentration of pollutants in the effluent is slightly increased and is below 30mg/L, indicating that the O_3-BAC has a strong impact load resistance. Comparing the contribution of each unit to the COD_{Cr} removal, the contribution of O_3 contact oxidation tower is about 10% and average effluent COD_{Cr} concentration is about 56mg/L. it is seen that O_3 oxidation is not complete oxidation, which reduces the cost of sewage treatment. In addition, the BAC is main unit for degrading COD_{Cr} and the average COD_{Cr} concentration and removal respectively are 26.7mg/L and 56%, and then the BAC could continuously operate 3~4 months without washing. If the total amount of COD_{Cr} removal in each washing cycle is about 60 times more that the theory removal, it shows that the biodegradation of microbe contributes to the

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COD_{Cr} removal and the BAC plays a key role during the whole process. At last, it takes about 3~4 weeks from the beginning of BAC hanging to the stable operation.

5.2. The analysis of Ammonia-nitrogen treatment efficiency

The fluctuation of influent Ammonia-nitrogen concentration is between 0.2mg/L and 1.0mg/L, but its total content is low. After the O_3-BAC, the Ammonia-nitrogen concentration is 0.18mg/L and removal is 75%, which could be detected in Fig.3.

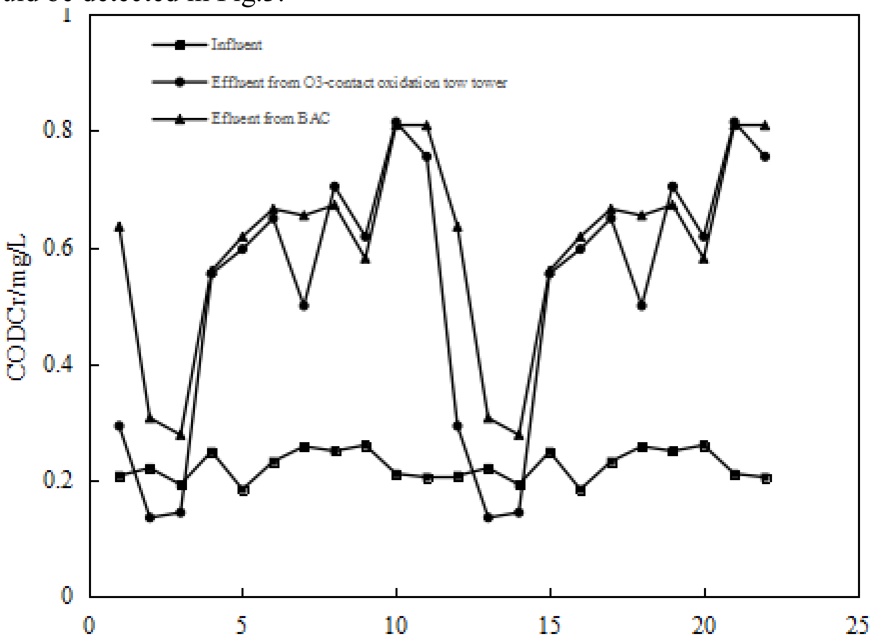

Figure 3. The Ammonia-nitrogen removal efficiency by O_3-BAC

As shown in Fig.3, The Ammonia-nitrogen removal by O_3 contact oxidation tower could be divided into two steps. At the first stage, the removal efficiency is transparent, but the Ammonia-nitrogen concentration in the second stage is almost unchanged and even higher than the influent Ammonia-nitrogen concentration. This maybe due to the organic nitrogen in sewage is oxidized by O_3, releasing and increasing the Ammonia-nitrogen concentration.

The BAC unit is main place to remove Ammonia-nitrogen. In the BAC bed, microbe grow in the pores of the carbon particles and remove Ammonia-nitrogen. At last, Ammonia-nitrogen is eventually removed and the BAC regenerated. As shown in Fig.3, although the influent Ammonia-nitrogen fluctuates dramatically, the BAC effluent is relatively stable, the effluent Ammonia-nitrogen concentration is 0.2mg/L and average removal is about 75%.

5.3. The analysis of chroma treatment efficiency

The influent chroma changes between 12~16 times. The effluent chroma is about 5 times. The chroma removal by O_3-BAC is shown in Fig.4.

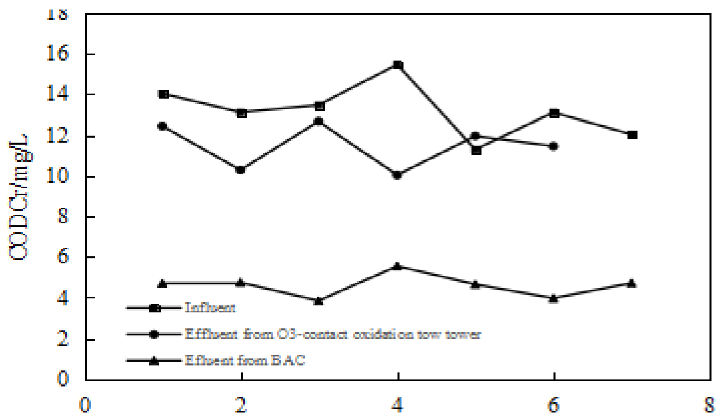

Figure 4. The chroma removal efficiency by O_3-BAC

As shown in Fig.4, BAC is the main unit of chroma removal, which accounting fore more than 90% of the total removal. However, the contribution of O_3 is relatively low and about 5%~10%, due to the chromophoric groups in sewage is hard to remove by O_3.

5.4. The analysis of biodegradability of sewage

The biodegradability of effluent from Lanzhou Petroleum Industry is low. Before entering the O_3 contact oxidation tower, the sewage BOD_5/COD_{Cr} ratio is about 0.08, which is difficult to degrade. In the pilot test, the O_3 addictive is about 4.0~4.5mg/L, and the BOD_5/COD_{Cr} ratio of effluent is about 0.21 due to incomplete oxidation between O_3 and organic pollutants in sewage.

5.5. The analysis of microbe in BAC tower

Biodegradation of BAC degradation are the main mechanism of activated carbon adsorption and biofilm, and microbial degradation of pollutants test plays a direct role in the process of test. Through the examination, the operating state of system could be marked in accordance with the species and activity of microbe. During the pilot test, the biological observation of BAC was conducted irregularly so as to better understand the operation of the system and make appropriate adjustment.

The observation of the biological phase was carried out by 100 times optical microscope. Before the observation, the carbon samples in the BAC reaction tower were placed in the beaker, and then the carbon particles were broken with tweezers. Through the observation, didinium, rotifers, nematodes, insects roaming, dun pellionella, caterpillar and other protozoa and metazoan daphnia are detected, which means there are lots of species on the microbial membrane in BAC tower. At the same time, The emergence of protozoa and metazoan showed good effluent quality and stable system operation.

6. Conclusion

The O_3-BAC process can be used for a stable treatment of the two grade biochemical effluent of Lanzhou Petrochemical Industry wastewater treatment plant. The influent COD_{Cr} concentration is fluctuated between 50mg/L and 80mg/L, and the average effluent COD_{Cr} concentration is 26.7mg/L. The influent Ammonia-nitrogen concentration is 0.2~1.0mg/L, and the average Ammonia-nitrogen concentration is 0.18mg/L. The influent chroma is about 12~16 times, and the effluent chroma is nearly 5 times. About analysis shows that O_3-BAC has a strong impact load resistance.

O_3 contact oxidation tower can not only degrade some pollutants, but also improve the biodegradability of sewage. The BOD_5/COD_{Cr} ratio of sewage before entering O_3 contact oxidation tower is about 0.08, and the effluent BOD_5/COD_{Cr} ratio is about 0.21. Through the observation, the biological composition of the activated carbon filler is complete and the microbial population is abundant, indicating the stable operation of the system.

7. References

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