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Study on rapid adsorption of organic compounds in two-stage ASBR

Yun Duan[1, a],Ying Zhao[2,b],Jing Jing Yang[3,c],YunGui Du[4, d]

[1]Dept. of Environmental Science and Engineering, Taiyuan University of Technology, Taiyuan, PRC

[2]Taiyuan University of Technology, Taiyuan, PRC

[3]Taiyuan University of Technology, Taiyuan, PRC

[4]Taiyuan University of Technology, Taiyuan, PRC

[a]6387995@qq.com, [b]18234003693@163.com, [c]18234006091@163.com,[d]2549380301@qq.com

Key words: ASBR process; two-stage ASBR process; rapid adsorption

Abstract: In this paper, two-stageASBR process composed of two anaerobic sequencing batch reactors (ASBR) was used as the reaction device to remove organic matter and ammonia nitrogen in high concentration nitrogen-containing organic wastewater,stage1 to adsorb and remove the organic matter, stage2 to remove ammonianitrogen in the wastewater. After the reactor was successfully started, the removal of organic matter in the stage1 was studied deeply. The optimum adsorption time and the optimum reaction time were investigated. The results showed that when the volume of the reactor was 2 kg·(m^3·d) $^{-1}$ and the hydraulic retention time was 12 h, The optimum adsorption time of organic matter was 15 min, the adsorption rate of organic matter was up to 90%; Degradation happenedafter adsorbing,the optimum reaction time was 8 h, and the removal rate of organic matter was more than 95%.

introduction

With the rapid development of livestock and poultry breeding industry in China, livestock and poultry farms waste, especially large-scale livestock and poultry farms wastewater was the main source of pollution in many areas of our country. This kind of wastewater had the characteristics of high content of organic matter and high content of ammonia nitrogen [1]. If the organic matter and ammonia nitrogen in livestock wastewater couldnot be properly treated, it would seriously pollute the water, soil and air [2,3]. Large releases of livestock and poultry wastewater could also pose a significant threat to public health [4]. Anaerobic digestion tended to solve the problem of high levels of organic matter in wastewater by utilizing the availability of renewable energy from methane produced [5,6,7].

In the 1990s, Dague et al in the United States Used an aerobic biological treatment SBR process for anaerobic biological treatment, developed anaerobic sequencing activated sludge (Anaerobic Sequencing Batch Reactor, referred to as ASBR) [8]. The structure of ASBR reactor was simple, which no need to set up a clear pool, greatly reducing the area; The ASBR reactor without adding a variety of separation devices, solid-liquid separation could be completed within the culture of sludge had a good settling performance [9]; The ASBR reactor could also cultivate granular sludge with obvious particle size. A variety of microorganisms remained stable inside the reactor. The granular sludge had good adsorption performance and could deal with high concentration organic wastewater, which had strong impact resistance and so on. The ASBR reactor process was probably influent, reaction, precipitation and effluent. The factors influencing the reactor had the hydraulic retention time, temperature, pH, and alkalinity and so on. According to the different types

of sewage treatment, different reaction conditions weresettled. The process was widely used in biological treatment of wastewater as a new process.

In this paper, we used the artificial wastewater to simulate the actual wastewater, and studied the removal of organic matter and ammonia nitrogen in livestock and poultry wastewater. Two-stageASBR reactor was used as the main reaction device to explore the optimum adsorption time and the optimum reaction time in the process of removing organic matter in stage1 anaerobic activated sludge.

Materials and methods

Experimental device

The two-stage ASBR process reaction device and process shown in Fig. 1, the two cylindrical reactors were the two ASBR reactor, which was made of Plexiglas.Its high diameter ratio was 1.9, diameter was 150 mm andheight was 285 mm. The ASBR reactorsettled 5 outlet, and its total volume was 5L, which the effective volume was 2.5L, adding the initial sludge 1.0L. The temperature of the ASBR reactor was controlled by constant temperature incubator at 35 °C, and the pH of the ASBR reactor was about 7.40 in stage1. The reaction system consisted of influent, reaction, sedimentation, drainage and idle. The operation period was 12 h, the artificial wastewater was first blown off with N_2 for 15 minutes. With the high difference, 1L of water was used for each cycle, and 1 L was drained. The reaction was carried out by intermittent aeration and the reaction stage was stirred for 1min every 1h, and the micro-vacuum pump was used for stirring. The micro-vacuum pump was used for pneumatic stirring and the mixing time was controlled by the time relay.

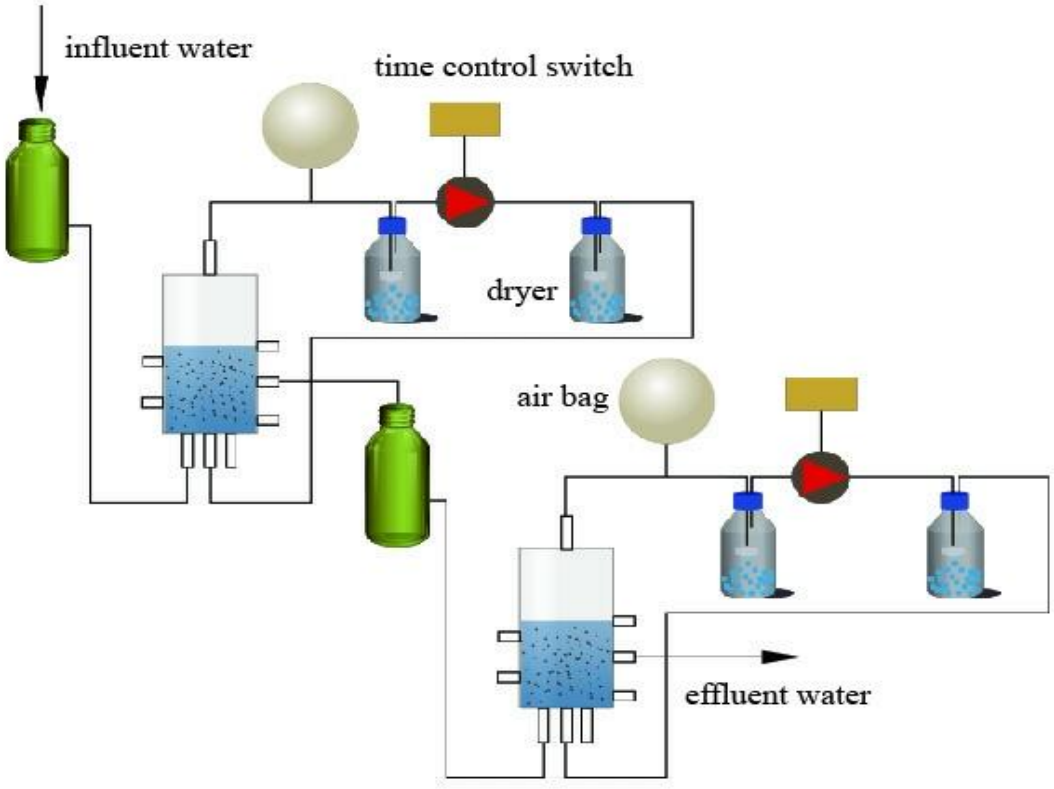

Fig. 1 Experimental device diagram

Test water and inoculation of sludge

The test water was using artificial wastewater, its chemical composition shown in Table 1. The artificial wastewater was first blown off with $N_2$to remove the Dissolved Oxygen (DO) for 15 minutes, and the DO concentration was maintained below 0.2 $mg \cdot L^{-1}$.The influent temperature was maintained at (35 ± 1) °C, and the influent pH was adjusted with $NaHCO_3$orHCl The pH of stage1 was maintained at 7.40.

Table 1 Nitrogen-containing organic wastewater composition in two-stage ASBR reactor

Components	Concentration($mg \cdot L^{-1}$)
$C_6H_{12}O_6$	1-2000
NH_4Cl	0-300
$NaHCO_3$	1500
KH_2PO_4	30
$MgSO_4 \cdot 7H_2O$	300
$CaCl_2 \cdot 7H_2O$	300
Traceelement I	1 $ml \cdot L^{-1}$
Traceelement Ⅱ	1 $ml \cdot L^{-1}$

Traceelement I （$mg \cdot L^{-1}$）：EDTA 5000 $FeSO_4$ 5000

Traceelement Ⅱ（$mg \cdot L^{-1}$）：$ZnSO_4 \cdot 7H_2O$ 430,$CuSO_4 \cdot 5H_2O$ 250, $MnCl_2 \cdot 4H_2O$ 990,$NiCl_2 \cdot 6H_2O$ 190, $CoCl_2 \cdot 6H_2O$ 240, H_3BO_4 14

Analysis of the project and measurement methods

pH: pHS-3C type precision pH meter; COD: rapid closed digestion method; DO: YSI dissolved oxygen meter; NH_4^+-N: Nessler reagent spectrophotometry; time: time relay

Results and discussion

The start of the operation to remove of organic matter in stage1

Running 1-30 days in stage1, the concentration of influent COD was increased from 500 $mg \cdot L^{-1}$,increasing the amplitude was 50 mg·（L·d）$^{-1}$, the concentration of NH_4^+-N was 0, and the hydraulic retention time was 12h. The not addition of NH_4^+-N in the beginning 30 days was to make sludge of anaerobic domesticated into methane-producing sludge, so that the bacteria grew methanogens; Running for 31-55 days,the concentration of influent COD was 2000 $mg \cdot L^{-1}$, the concentration of NH_4^+-N was 0, then added some flocculants to granulate the sludge, the flow was influent (1min) → reaction (716min) → precipitation (2min) → drainage (1min); Running for 56-75 days, keep its concentration of influent COD was 2000 $mg \cdot L^{-1}$, the concentration of NH_4^+-N was 300 $mg \cdot L^{-1}$, its flowchanged to influent (1min)→ adsorption (15min) → drainage (1min) → regeneration and degradation (480min) → idle (223min). The concentrationsof COD and NH_4^+-N in the effluent were measured. The results were shown in Fig. 2 and Fig. 3.

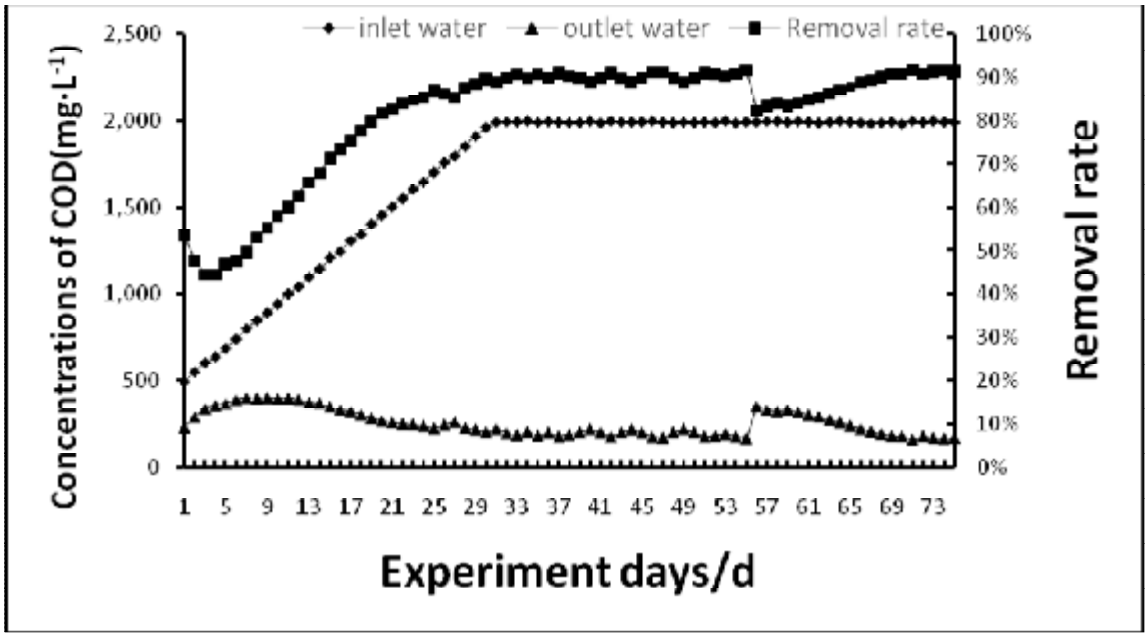

Fig. 2Effluent COD concentration changes and removal rate in stage1

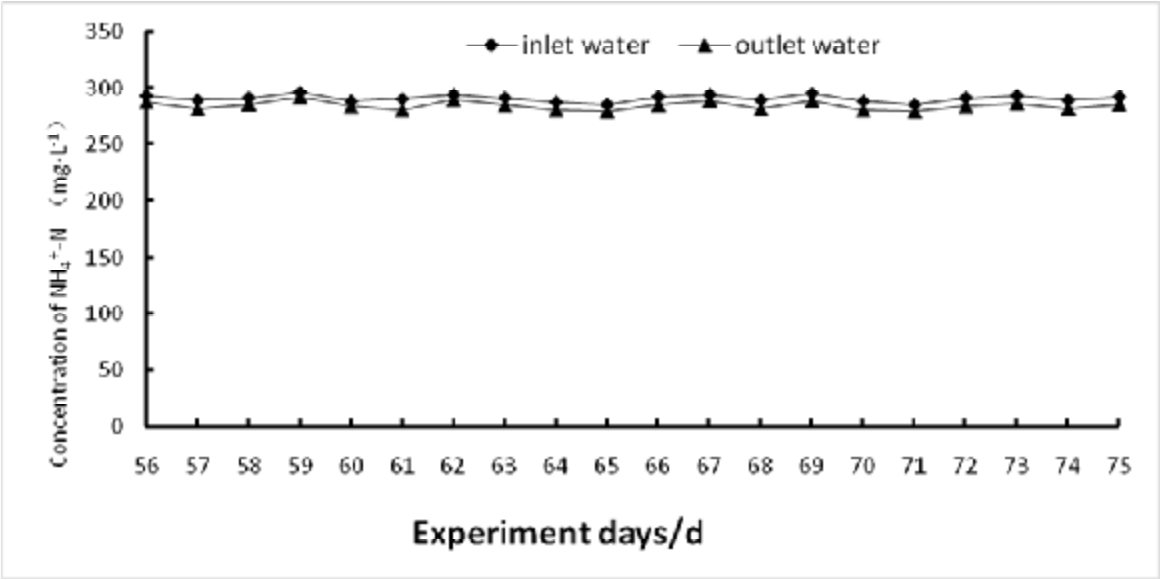

Fig. 3NH_4^+-N concentration changes in stage1

It could be seen from figure 2, the reactor running 1-30 days, the removal rate of COD in the first 5 days was a downward trend, and the analysis was that the initial sludge activity was poor and was weak to adapt to the new environment, in addition, it was easy to lead to the accumulation of volatile fatty acids that affecting COD removal, then the removal rate of COD followed by a stable increase. Running for 31-55 days, there was formedthe significant granular sludge, and the removal rate of COD stabilized at about 90%, then the system of methanogens activity stable; Running 56-75 days, the inlet water introducedtheNH_4^+-N, then changed the time that the sewage reacted, and the removal rate of COD was decreased after changing of the mode, and then gradually increased. Combinedwith the figure 2 and 3, we could see that the methanogens had been dominated, and it had little effect of the content of NH_4^+-N, then stage1was stable.

Determination of the optimum adsorption time of stage1

After 55 days of continuous operation, the concentration of influent COD in stage1reached 2000 mg·L^{-1} and the concentration of NH_4^+-N was 0. To explore the optimum adsorption time of the sludge in stage1,take a water sample every 5 minutes, in whichstir wastewater with a micro-vacuum pump for 10 seconds and adsorb and settle for the remaining 4 minutes and 50 seconds.Mixing time should not be too long, because mixing to long mightcause the organic matter that had been adsorbed on the surface of the granular sludge to fall off.After measuringthe concentration of the effluent COD,the measurement results were shown in Fig. 4.

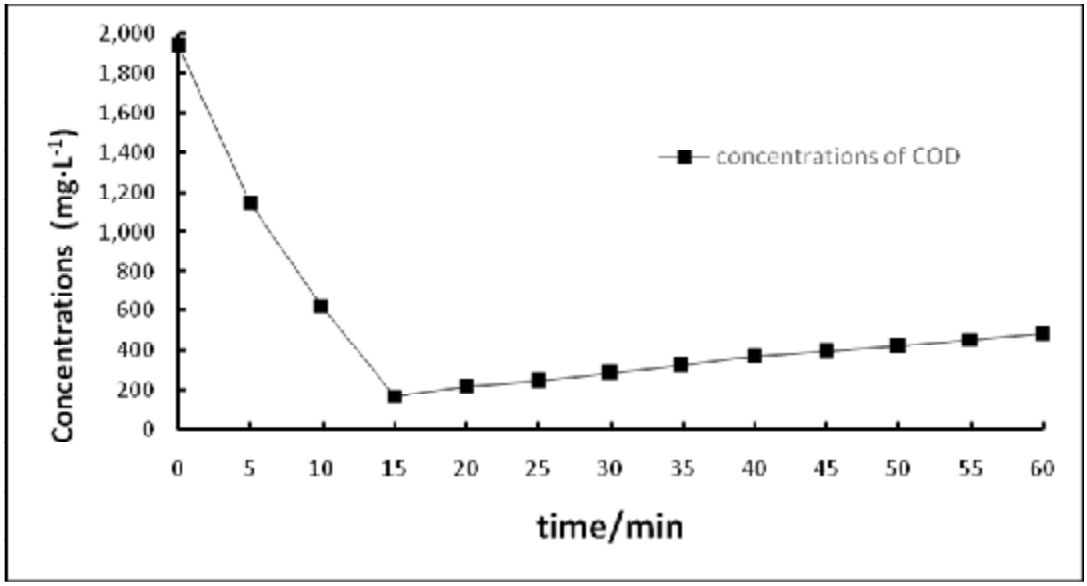

Fig. 4 Change of COD concentration in inlet water 1 h in stage1

As shown in figure 4, the removal rate of organic matter reached 90% at 15 minutes after influent. The results showed that the system had formed a methanogenic flora with obvious adsorption effect, and the flora had rapid adsorption of organic matter.

Determination of the optimum reaction time in the stage1

After the reactor was operated for 55 days, the optimum adsorption time of the organic matter had determined. To explore the optimum reaction time of the organic matter. After 15 min reacted, the reactor was drained, and the organic matter was regenerated and degraded. Stirring for one minute each hour, so that the sludge and the remaining sewage in full contact with the reaction, sampling detection every hour, removal of organic matter was shown in Fig. 5.

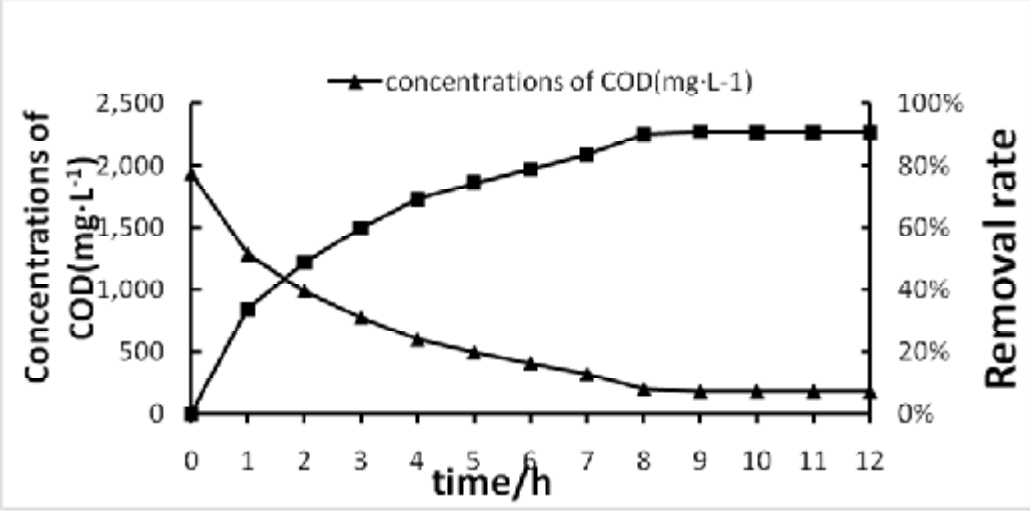

Fig. 5 Concentration changes of outlet water COD in a period at different times

As shown in figure 5, the removal rate of COD reached the highest at 8 h, and the removal rate was almost constant after 8 h. Therefore, the optimum reaction time was 8 h.

Conclusion

The two-stage of ASBR process was used in treatinghigh concentration of nitrogen-containing organic wastewater.When organic volume load ofstage1was 2 $kg\cdot(m^3\cdot d)^{-1}$and the hydraulic retention time was 12h, the optimum adsorption time of organic matter was 15min, with the organic adsorption rate was up to 90%; Degradation and Regenerating happened after adsorption, Theoptimum reaction time was 8h andthe organic matter removal rate was up to 95%.

Acknowledgements

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