The effect of the external carbon source on each stages of A²/O process for simultaneously removing nitrogen and phosphorus

Dong-chen Na^{1,a}, Yang Zhang^{1,a}, Hong Zhang^{2,b}, Lu-ning Wang^{2,b},
Cai-yu Sun^{2,b}, Yong-feng Li^{2,b,*}

¹ College of Life Science, Shanxi Normal University, Linfen 041004, China

² College of Forestry, Northeast Forestry University, Harbin 150040, China

^a 007ndc007@163.com.cn, ^b dr_lyf@163.com

*Corresponding author

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Abstract: In this study, the aim was to investigate the various carbon sources, included methanol, glucose and ethanol, to estimate the removal efficiency of nitrogen and phosphorus in anaerobic-anoxic-oxic (A²/O) process by laboratory experiments. Total nitrogen (TN) and total phosphorus (TP) removal efficiencies were 78.23% and 78.18%. The removal efficiencies of TN, NH₃-N and TP were 82.36%, 96.67% and 92.18%, respectively. The effluent concentrations were 11.43mg/L, 4.1mg/L and 0.45mg/L, respectively, which reached the type A standard GB18918-2002 level.

Introduction

Water eutrophication had become a worldwide problem, which also known as "ecological tumor"^[1]. As the urban sewage concentrations of nitrogen and phosphorus were higher and higher, the environmental problems were more and more serious. One of the most commonly used processes is the Anaerobic- Anoxic-Oxic (A²/O) system^[2]. Nitrogen and phosphorus removal can be achieved synchronously in A²/O process, which is widely applied in the large and medium-sized cities and towns in China.

In this study, the nutrient removed was investigated by taking consideration about various carbon sources in the A²/O system. The effects of nitrate recycling ratios on simultaneously nitrogen and phosphorus removed performance in the A²/O system were observed by treating actual urban domestic wastewater.

Materials and methods

Experimental system and operation

The experimental system is a laboratory-scale anaerobic-anoxic-oxic (A²/O) reactor. The volume ratio of the anoxic zone to anaerobic to aerobic was 1:1:2. Trial operation conditions as follows: The quantity of water intake was controlled at 4.3 L·h⁻¹, and the hydraulic retention time (HRT) was 12 h; the sludge retention time (SRT) in A²/O reactor was controlled at 15 days; the concentration of mixed liquor suspended solid (MLSS) was about 2800 mg·L⁻¹~3000 mg·L⁻¹; the ambient temperatures were controlled at 27°C±1°C.

Sludge and waste water

The seed sludge was collected from the Wenchang wastewater treatment plant in Harbin (China). The time of sludge acclimation was paid about 30 days to begin the experiments.

During the experiment period, the first stage was running with synthetic wastewater fed into the reactor contained: glucose, NH_4Cl , KH_2PO_4 and kinds of trace elements at 7.2 ± 0.3 , and the remaining stages were running with the actual domestic wastewater which was collected from the residential area of the Northeast Forestry University.

Analytical methods

COD_{Cr}, total nitrogen (TN), ammonium ($\text{NH}_4^+\text{-N}$) and $\text{PO}_4^{3-}\text{-P}$ were performed as described in the Standard Methods of SEPA. DO, pH and temperature were monitored online by using wTw-Multi-340i (Germany).

Results and discussion

The effect of various external carbon sources on A²/O process

Fig. 1 TP removal characteristics of each stage at various carbon sources

After the addition of different external carbon sources, the removal efficiency of TN and $\text{NH}_4^+\text{-N}$ changed obviously (Fig.1 and Fig.2).

From Fig.1, among external various carbon sources, when ethanol was taken as the external carbon source of the A²/O system, the removal efficiency of TP was the highest and the removal efficiency was 78.18%. During anaerobic period, the PAOs could simultaneously absorb VFA and release phosphorus^[3]. In general, the more VAF taken-in, the more phosphorus released. And the more phosphorus released in anaerobic zones, the more phosphorus taken-in in aerobic zones.

Fig. 2 $\text{NH}_4^+\text{-N}$ removal characteristic of each stage at various carbon sources

In Fig. 4, the nitrogen removal efficiencies at various carbon sources of the A^2/O system were 75.81%, 66.67% and 78.23%, respectively. The concentrations of ammonia nitrogen at various carbon sources were 40.56, 37.09 and 46.15 mg/L, respectively. From the data in Fig4, when ethanol was taken as the external carbon source of the A^2/O system, the nitrogen removal efficiencies and the concentration of ammonia nitrogen was the highest among various external carbon sources. From Fig 4, the ammonia nitrogen concentrations in anaerobic and anoxic period increased, mainly might be transformed from the available carbon sources.

The effect of various nitrate recycling ratios on the A^2/O system

During the period (154-193days), the evolution of TP in A^2/O system at various nitrate recycling ratios was depicted in Fig. 3 and Fig. 4.

Fig. 3 TP removal characteristics at various nitrate recycling ratios during the period

In Fig. 3, TP removal efficiencies at various nitrate recycling ratios were 77.31%, 84.31%, 92.18%, 89.15% and 83.56%, respectively. The TP removal efficiencies of stage III reached the highest among the five stages, and the TP removal efficiencies was 92.56%, while the effluent TP concentration was 0.45 mg/L, reaching the type A standard GB18918-2002 level. With the nitrate recycling ratios increasing, lengthening the reaction time resulted to a second release of phosphorus, which illustrated the effluent concentration at the stage V was higher than which at the stage III.

From Fig. 4, TN removal efficiencies at various recycling ratios were 51.52%, 72.36, 82.36%, 83.13% and 78.51%. Ammonia nitrogen removal efficiencies at various recycling ratios were 75.17%, 89.42%, 96.67%, 98.30% and 99.9%, respectively, which presented a trend of increasing at various recycling ratios. As the nitrate recycling ratio was 300% at stage IV, the TN removal efficiencies

Fig. 4 Nitrogen removal characteristics at various nitrate recycling ratios

reached the highest at various recycling ratios which was 83.13%, and the effluent concentration was 11.43mg/L. However, considering the energy consumption, choosing the nitrate recycling ratio was 250% was a wise choice

Conclusions

The main findings from this study were summarized as the following: (1) The A²/O system operated perfectly as the external carbon source was ethanol, and the removal efficiencies of TN and TP were respectively 78.23% and 78.18%, while the time for nitrate nitrogen removed was 20min. (2) The effluent concentrations were 11.43mg/L, 4.1mg/L and 0.45mg/L, respectively, which reached the type A standard GB18918-2002 level. (3) The novel method solved simultaneously shortage of carbon source and maximized the utilized of carbon sources.

Key References:

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