The Impact of Mn$^{2+}$ on Anammox

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Keywords: Mn$^{2+}$; ANAMMOX; normal temperature

Abstract. This paper aims to study on the impact of different of Mn$^{2+}$ concentration on anammox to determine the perfect Mn$^{2+}$ concentration to realize anammox. The experiment uses real life wastewater of Shenyang Jianzhu University, under the condition of temperature at 35°C, infusing argon to removal DO, controlling pH value in 7~8. Using static tests investigated anammox of NH$_4^+$-N removal case and NO$_2^-$-N removal case under the condition of different Mn$^{2+}$ concentration (5, 10, 15, 20mg/L). The anammox was perfect was high when the Mn$^{2+}$ concentration was 5~10mg/L. The Mn$^{2+}$ as the growth factor could accelerate the activity of anammox bacterial when the Mn$^{2+}$ concentration was 5~10mg/L. The high concentration of Mn$^{2+}$ was could not applied and the Mn$^{2+}$ as heavy metal inhibit the activity of anammox bacterial when the Mn$^{2+}$ concentration above 15mg/L.

Introduction

The anammox, as the novel biological nitrogen removal processes, has the low addition of organic, alkali dosage and no DO$^{[1-3]}$. The research results of anammox were different, in recent years, more scholars consider that the anammox could be realized when the temperature was 30~35°C, pH controlling at 7~8, HRT stabling at 48h$^{[4-8]}$. However some wastewater treatment plant could interfuse industrial wastewater in sewage for poor management, causing overproof metal ions in sewage. The high metal ions could inhibit the activity of anammox bacterial, but the generation time of anammox bacterial was too long and cultivate was difficult$^{[8-10]}$. The anammox could not natural process if metal ions infect the activity of anammox bacterial. There were few reports of influence of metal ions on anammox. The impact of metal ions on anammox was studied that lay the foundation for the anammox in actual wastewater treatment.

Result and Discussion.

Influence of Mn$^{2+}$ on nitrogen removal of anammox

Metal ions were not only one of trace elements to promote the growth of anammox bacteria but also one of heavy toxic metal ions. Studies have shown that different heavy metal ions have different effects on anaerobic ammonia oxidation reaction. An appropriate amount of heavy metal ions can promote the growth of anammox bacteria via growth factors, but an excess of heavy metal ions begin poison anammox bacteria’s activity. Therefore, exploring the optimal concentration of heavy metal ions is significant for the stability of the operation of ANAMMOX$^{[11-12]}$.

![Fig. 1](image1.png)
![Fig. 2](image2.png)
![Fig. 3](image3.png)
As can be seen from Figure 1,2, different concentration of Mn$^{2+}$ can cause different ANAMMOX denitrification performance. When the Mn$^{2+}$ concentration exceeds a certain value, ANAMMOX activity was significantly inhibited, and the nitrogen removal was significantly decreased.

When the Mn$^{2+}$ concentration was 5mg/L, anammox bacteria can better remove NH$_4^+$-N and NO$_2^-$-N, the effluent concentrations of NH$_4^+$-N and NO$_2^-$-N are 26.819mg/L, 32.211mg/L, NH$_4^+$-N and NO$_2^-$-N removal rate can reach 73.795%, 75.79%. With Mn$^{2+}$ concentration continue to increase, ANAMMOX activity continue to be released, the denitrification performance continue improve. When Mn$^{2+}$ concentration reach 10mg/L, the removal ratio of NH$_4^+$-N and NO$_2^-$-N could stabilize at 84.865%, 83.896%, the effluent concentration of NH$_4^+$-N and NO$_2^-$-N can be decreased to 14.935mg/L, 21.591mg/L. At this time, ANAMMOX activity is fully released, NH$_4^+$-N and NO$_2^-$-N removal efficiency is the best. When the Mn$^{2+}$ concentration continues to rise, the activity of anammox bacteria began to be suppressed, the effluent concentration of NH$_4^+$-N and NO$_2^-$-N began to increase, NH$_4^+$-N and NO$_2^-$-N removal efficiency decreased gradually. When Mn$^{2+}$ concentration was increased to 15mg/L, NH$_4^+$-N and NO$_2^-$-N effluent concentration increased to 65.321mg/L, 75.851mg/L, compared to Mn$^{2+}$ concentration was 10mg/L, the activity of anammox bacteria almost completely suppressed, the removal rate of NH$_4^+$-N and NO$_2^-$-N decreased significantly.

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The results show that at low Mn$^{2+}$ concentration condition, the inhibition of anammox bacteria activity is not great, and low concentration of Mn$^{2+}$ can promote the growth of anaerobic ammonium oxidizing bacteria. Studies have shown that low concentration of Mn$^{2+}$ can stimulate the activity of anammox bacteria, and from the experimental data can be seen when Mn$^{2+}$ concentration changes in the 5~10mg/L, NH$_4^+$-N and NO$_2^-$-N removal efficiency gradually increased. When Mn$^{2+}$ concentration reach 10mg/L, the removal efficiency of NH$_4^+$-N and NO$_2^-$-N are the best. And when Mn$^{2+}$ concentrations continued to increase, NH$_4^+$-N and NO$_2^-$-N removal declining, anammox bacteria activity was significantly inhibited. Wang Xiuheng scholars also found by the experiment that when the Mn$^{2+}$ concentration is 10mg/L, it can better promote the activity of anammox bacteria. Analyze the reasons why low concentration of Mn$^{2+}$ is able to promote the activity of anammox bacteria, on the one hand, because of low Mn$^{2+}$ concentration presence in the form of trace elements, it can better promote the growth of anammox bacteria, and stimulate the activity of anammox bacteria. On the other hand, the trace elements which added in influent water contains other trace metal ions, these trace metal ions can cause synergistic effect with Mn$^{2+}$. When the Mn$^{2+}$ concentration exceeds the value as a growth factor to promote the growth of anaerobic ammonium oxidizing bacteria, Mn$^{2+}$ will cause synergies with other trace metal ions, Mn$^{2+}$ as heavy metal ion, the synergy can effectively eliminate the toxic effects of heavy metals. What’s more, slight excess of Mn$^{2+}$ can effectively inhibit the activity of other autotrophic and heterotrophic bacteria, creating a better living space for the growth of anaerobic ammonium oxidizing bacteria. When the Mn$^{2+}$ concentration exceeds the optimum value, Mn$^{2+}$ will inhibit or even poison the activity of anammox bacteria by the way of heavy metal ions. Excess of Mn$^{2+}$ not only will not produce synergies with other trace metal ions but also will cause antagonism and increase the toxic effects of Mn$^{2+}$, resulting in a significant reduction in the removal rate of NH$_4^+$-N and NO$_2^-$-N.

**Influence of anammox on Mn$^{2+}$ removal effect**

As it can be seen from Figure 3, anammox bacteria has different treatment effect on different concentration of Mn$^{2+}$. Anammox bacteria can better absorb and degradation low concentration of Mn$^{2+}$. When Mn$^{2+}$ concentration changes in 5~10mg/L, the removal rate can be stabilized at above 65%. When the influent concentration of Mn$^{2+}$ was 5mg/L, after anammox process, the effluent concentration of Mn$^{2+}$ was 1.749mg/L, Mn$^{2+}$ removal rate was 65.928%. When Mn$^{2+}$ influent
concentration increased to 10mg/L, Mn$^{2+}$ effluent concentration decrease to 2.781mg/L, Mn$^{2+}$ removal rate rise to 72.852%. With the Mn$^{2+}$ concentration continue to rise, the activity of anammox bacteria began to be inhibited. When Mn$^{2+}$ influent concentration increased to 15mg/L, the activity of anaerobic ammonium oxidizing bacteria was inhibited, Mn$^{2+}$ effluent concentration increased to 9.043mg/L, Mn$^{2+}$ removal rate dropped to 39.206 percent. At this time, although Mn$^{2+}$ removal ratio decreased, but anammox bacteria also can treat part of Mn$^{2+}$. When Mn$^{2+}$ concentration was 20mg/L, Mn$^{2+}$ removal efficiency decreased significantly, Mn$^{2+}$ removal rate significantly reduced. At this point, Mn$^{2+}$ effluent concentration was 7.99mg/L, Mn$^{2+}$ removal rate was only 30.11%.

Experimental data show that anammox bacteria can degrade and better treat low concentration of Mn$^{2+}$. Anammox bacteria can absorb Mn$^{2+}$ to promote their own growth as a growth factor. However, high concentration of Mn$^{2+}$ is toxic, and can inhibit the activity of anammox bacteria. When Mn$^{2+}$ concentration is less than 10mg/L, Mn$^{2+}$ can be absorbed by anammox bacteria. Mn$^{2+}$ is effectively degraded, which can be seen from the removal rate. When Mn$^{2+}$ concentration exceeds 10mg/L, Mn$^{2+}$ began to play its heavy metal ions’ characteristic, hinder the growth of anammox bacteria, and poison its activity. Continued decline of Mn$^{2+}$ removal rate and rising Mn$^{2+}$ effluent concentration can prove these. On the other hand, other autotrophic bacteria and heterotrophic bacteria begun to compete living space with anammox bacteria. Due to the long generation time, slow-growing and anammox bacteria cannot effectively enrich, anammox bacteria was eliminated by other species. Figure 3 shows that when the concentration of Mn$^{2+}$ was 10mg/L, it was more suitable for the growth of anammox bacteria, when Mn$^{2+}$ concentration exceeds 10mg/L, anammox bacteria can not handle high concentration of Mn$^{2+}$. Thus, the suitable concentration of Mn$^{2+}$ was 10mg/L.

Conclusion

(1) The microscale Mn$^{2+}$ as the growth factor could accelerate the when the Mn$^{2+}$ < 10mg/L. Besides the high Mn$^{2+}$ could inhibit the growth of autotrophic bacterial and heterotrophic bacterial for providing living space for anammox bacterial; In conclusion, the Mn$^{2+}$ with the other metal ions accelerate the activity of anammox bacterial by making synergistic effect. The removal effect of NH$_4^+$-N and NO$_2^-$-N was perfect when the Mn$^{2+}$ concentration under 5~10mg/L and the removal rate of NH$_4^+$-N and NO$_2^-$-N could stable at 73%, 75%.

(2) Anammox bacterial could stimulate growth and metabolism by absorbing Mn$^{2+}$ when the Mn$^{2+}$ was low concentration. The anammox bacterial could remove Mn$^{2+}$ when the activity of anammox bacterial was high. The variation of effluent Mn$^{2+}$ was 2.781mg/L and the removal rate of Mn$^{2+}$ could stable at 70%. The anammox bacterial could not removal high Mn$^{2+}$ when the concentration of Mn$^{2+}$ above 10mg/L and Mn$^{2+}$ with the other metal ions inhibit the growth of anammox bacterial.

References


Reference to a book:


Reference to a chapter in an edited book:


