The Impact of Mn^{2+} on Anammox

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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℃, 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℃、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[9~10]. 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].

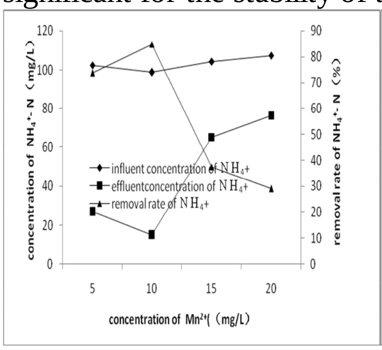

Fig. 1

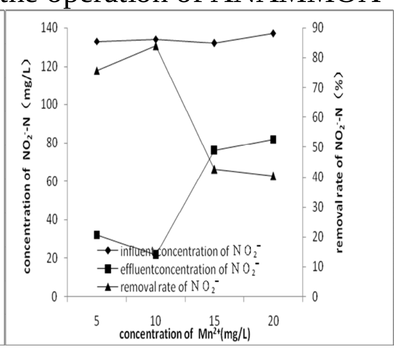

Fig. 2

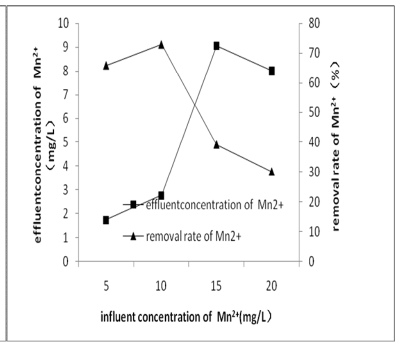

Fig. 3

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 50.386mg/L, NH_4^+- N and NO_2^--N removal rate decreased to 37.381%, 42.548%.With the further increase concentration of Mn^{2+},ANAMMOX activity was significantly inhibited, a significant decline in NH_4^+- N and NO_2^--N removal rate was showned, the effluent concentration of NH_4^+- N and NO_2^--N increased significantly.When Mn^{2+} concentration reach 20mg/L, the activity of anammox bacteria almost completely suppressed,the removal rate of NH_4^+- N and NO_2^--N decreased significantly.In this case, the effluent concentration of NH_4^+- N and NO_2^--N has reached 76.254mg/L, 81.919mg/L,compared to Mn^{2+} concentration was 10mg/L, NH_4^+- N and NO_2^--N removal rate was only 28.968%, 40.267%, barely noticeable anaerobic ammonium oxidation.

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 the5~10mg/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. WangXiuheng scholars also found by the experiment that when the Mn^{2+} concentration is 10mg/L ,it can better promote the activity of anammox bacteria[13].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+}[13].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 bacteria 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 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 Figure3, 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 proison 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 removal 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.

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