

Activity of nitrifying bacteria in aerobic granular sludge treating food industry wastewater

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Abstract

Aerobic Granular Sludge (AGS) is an innovative wastewater biological treatment, which uses less energy and space compared to other technological solutions. AGS presents a diverse microbial community responsible for the simultaneous removal of carbon and nutrients. These communities are protected by extracellular polymeric substances (EPS), which provide a compact structure to the granules. As a result, bacteria present in the aerobic granules are more resistant to variable wastewater composition, as commonly produced in food industry. In this study, carbon and NH_4^+ removal from a fish canning plant wastewater was evaluated using an AGS-SBR (sequential batch reactor), operated during 90 days. Chemical oxygen demand (COD) at the outlet was below the discharge limit of 125 mg $\text{O}_2 \text{L}^{-1}$ throughout the operation. Nitrification occurred during the first 23 days of operation. Between days 24 and 60, nitrification was completely inhibited, without ammonium removal from the wastewater. Nitrifying bacteria recovered their activity right after a decrease in the wastewater organic load, showing that the inhibition of the nitrification process was reversible. This study will contribute to our knowledge on the application of the AGS process to food industry wastewater treatment.

Keywords

Aerobic granules; wastewater; nitrification; organic load; fish canning; food industry.

INTRODUCTION

Aerobic granular sludge (AGS) is a promising technology, which uses granules composed by bacteria embedded in extracellular polymeric substances (EPS). The compact structure of these granules increases the tolerance of AGS to toxic compounds and also their resistance to variable wastewater composition (Amorim *et al.*, 2017). The fish canning wastewater is characterized by a variable composition in organic matter, nitrogen and phosphorous (Cristovão *et al.*, 2015). The main objective of this work is to use an AGS-SBR for treating wastewater from a fish canning plant and to evaluate the performance in terms of chemical oxygen demand (COD) and NH_4^+ removal, relating these two parameters.

MATERIAL AND METHODS

A lab-scale AGS-SBR, with a working volume of 2.5 L, was operated in four successive treatments of 6 h-cycles per day. The reactor was inoculated with a mixture of granular sludge adapted to fish-canning wastewater and granular sludge from a municipal AGS-SBR. Wastewater from a fish canning plant was collected at different time points for sequential treatment. The performance of the AGS-SBR was assessed during 90 days for COD, ammonium, nitrate and nitrite.

RESULTS AND DISCUSSION

The AGS-SBR performance was evaluated during 90 days of operation which were divided into three phases (I, II and III). The organic loading rate (OLR) and concentration of ammonium of the wastewater fed to the reactor was variable (Table 1).

Table 1. OLR and N-NH₄⁺ concentration present in the wastewater during phases I, II and III (minimum and maximum values).

Parameters	Phase I	Phase II	Phase III
Period (days)	0 – 23	24 – 55	56 – 93
OLR (g COD L ⁻¹ day ⁻¹)	0.8 – 1.3	1.4 – 1.7	0.1 – 0.5
N-NH ₄ ⁺ (mg L ⁻¹)	17.3 – 31.0	18.3 – 41.5	10.3 – 40.5

Throughout the reactor operation, the COD concentration at the outlet reached less than 100 mg O₂ L⁻¹. The higher OLR applied during phases I and II did not affect the overall COD removal, despite the COD available during the aerated period. During phase II, a COD concentration between 200 and 300 mg O₂ L⁻¹ was present after the anoxic feeding. This led to the growth of suspended biomass, observed as an increase in the bed volume of the reactor. This excess of biomass was washed out during phase III, when most of the COD removal occurred during the anoxic feeding period. Ammonium removal was variable during phase I, reaching values lower than 4 mg N-NH₄⁺ L⁻¹ at the outlet. During this first phase, nitrite did not accumulate in the process (N-NO₂⁻ < 1 mg L⁻¹) and nitrate concentration reached up to 18.6 mg N-NO₃⁻ L⁻¹. Ammonium removal was inhibited during phase II, without nitrite and nitrate formation. During phase III, the lower OLR led to a fast improvement of the nitrification process. Nitrite concentration reached 6 mg N-NO₂⁻ L⁻¹ and nitrate increased up to 18 mg N-NO₃⁻ L⁻¹. Our results show that nitrifying bacteria were able to rapidly recover after a long-term inhibition. Nitrifying bacteria can be sensitive to different process parameters, such as dissolved oxygen, pH and carbon to nitrogen ratio (Tang and Chen, 2015). In addition, when COD is available for heterotrophic growth, nitrification can be limited (Mosquera-Corral *et al.*, 2005).

CONCLUSION

The AGS-SBR presented a good COD removal from fish canning wastewater. When a higher OLR was applied, the growth of heterotrophic bacteria possibly affected the nitrification process. The AGS-SBR reactor operation is still ongoing to better understand the relationship between nitrification, organic load and other parameters relevant for the treatment of fish canning wastewater using AGS. Further, EPS from the AGS will be extracted for obtaining biopolymers with application in different fields.

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