Impact of industrial wastewater on aerobic granules morphology and nitrification process in bioreactors

Ana M. S. Paulo[(1)], Joana Costa[(2)], Catarina L. Amorim[(1)], Daniela P. Mesquita[(2)], Eugénio C. Ferreira[(2)] and Paula M.L. Castro[(1)]

(1) Universidade Católica Portuguesa, CBQF - Centro de Biotecnologia e Química Fina – Laboratório Associado, Escola Superior de Biotecnologia, Rua Diogo Botelho 1327, 4169-005 Porto, Portugal

(2) CEB - Centre of Biological Engineering, Universidade do Minho, Campus de Gualtar, 4710-057 Braga, Portugal

CATÓLICA FACULTY OF BIOTECHNOLOGY PORTO

Universidade do Minho Escola de Engenharia

CENTRE OF BIOLOGICAL ENGINEERING

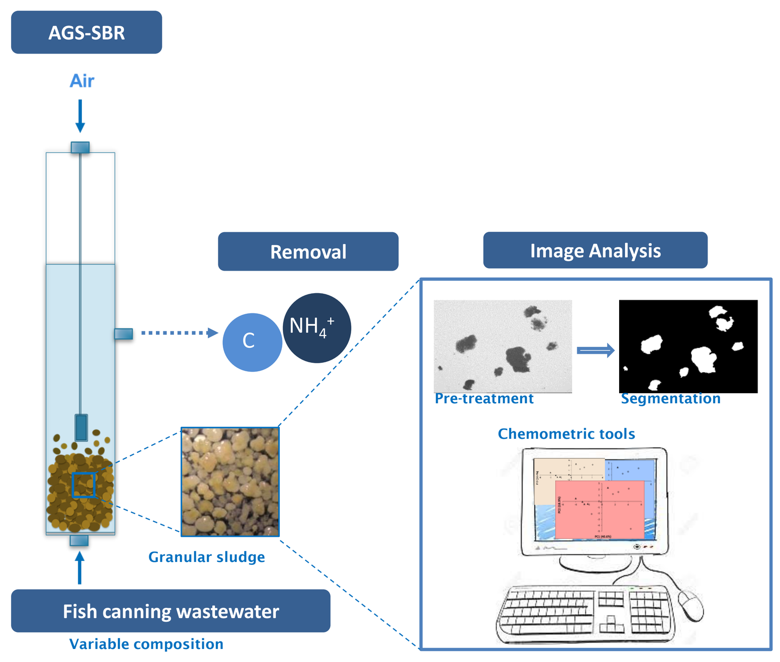
Introduction

Aerobic Granular Sludge (AGS) is an innovative wastewater treatment process used for carbon and nutrients removal from wastewater. Aerobic granules present a compact structure resistant to variable wastewater composition. Process disturbances might affect bacteria, especially those present in the granules outer layers, such as nitrifiers. In this study, fish canning wastewater with variable composition was treated for 107 days using an AGS sequential batch reactor. Carbon removal and nitrification performance were evaluated. Morphological and structural changes within granules were followed by **quantitative image analysis (QIA)**.

The **objective** of this work is to relate carbon and nitrogen removal with granules morphological and structural changes during the treatment of industrial wastewater by AGS process.

Methods

A lab-scale AGS-SBR (sequential batch reactor) was operated using wastewater from a fish canning plant. The performance of the AGS-SBR was assessed for COD, NH_4^+ and NO_3^-. Morphological and structural changes within granules were followed by quantitative image analysis (QIA). Principal component analysis (PCA) was performed using QIA data alone and relating QIA with reactor performance.



Results

Reactor performance

The AGS-SBR performance was evaluated during 107 days of operation, divided into two phases. Wastewater with variable composition was fed to the reactor (Table 1).

Table 1. Organic Loading Rate (OLR) and NH_4^+-N concentration in the fish canning wastewater (minimum and maximum values)

Parameters	Phase I	Phase II
Period (days)	0 – 55	56 – 107
OLR (g COD L^{-1} day^{-1})	0.7 – 1.7	0.1 – 0.8
NH_4^+-N (mg L^{-1})	17.3 – 41.5	10.3 – 40.5

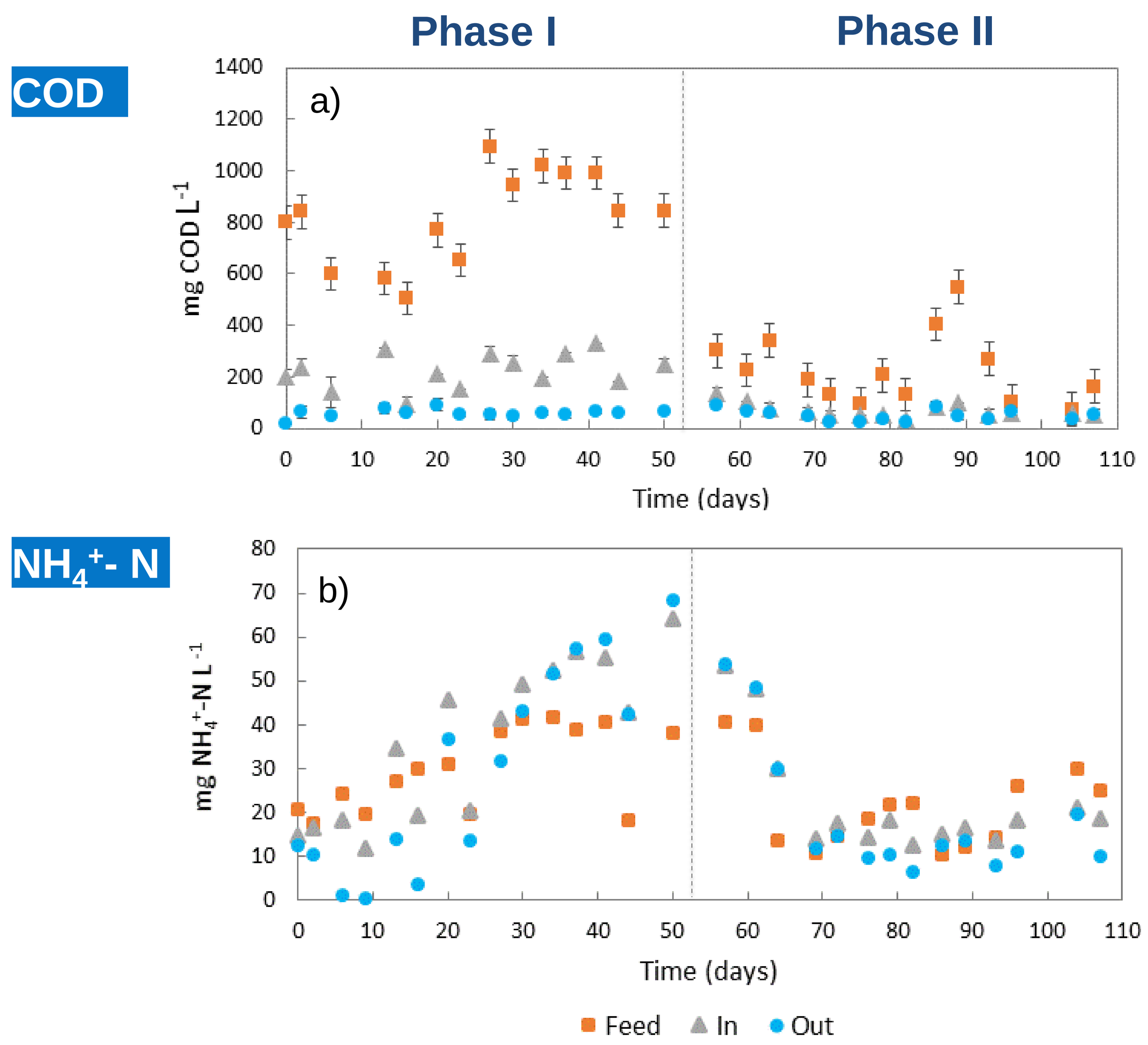


Figure 1. Concentration at the influent (■), in the reactor bulk liquid after anaerobic feeding (▲) and at the effluent (●) are shown.

COD and NH_4^+ removal

- **COD concentration** at the outlet reached less than 100 mg O_2 L^{-1} throughout the operation; the higher OLR applied during phase I did not affect COD removal (Figure 1, a).
- **Nitrification** was inhibited at the end of phase I, with a decrease in nitrate concentration from 14 NO_3^--N mg L^{-1} to zero (data not shown);
- A fast improvement of the nitrification process occurred during phase II (Figure 1, b), with increase in nitrate concentration in the medium up to 16 mg NO_3^--N mg L^{-1}.

Quantitative Image Analysis

PCA was applied by performing a crossed correlation of key data retrieved from QIA (Figure 2, a) and from QIA and operational parameters such as OLR, COD and related to nitrification (Figure 2, b).

Biomass changes

QIA data alone

- With reactor start-up, the initial biomass structure changed since the biomass was not adapted to the industrial wastewater; however, the biomass kept changing throughout the entire phase I;
- On the other hand, all biomass samples from phase II formed a cluster, indicating a greater stability of the granules (Figure 2, a).

QIA and operational data

- These results corroborate the previous: an evolution of the initial biomass structure occurred until the beginning of phase II (Figure 2, b);
- Most of biomass samples from phase II formed a cluster;
- Furthermore, this second PCA showed that PC1 was strongly affected by OLR; this parameter allowed a better distinction between samples.

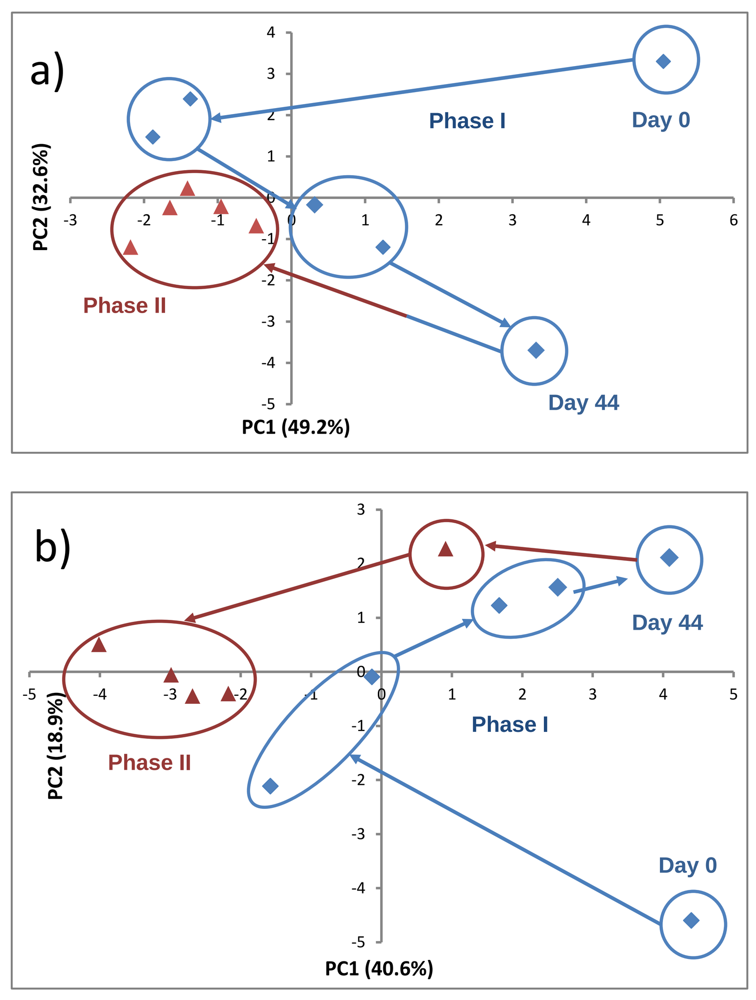


Figure 2. PCA of PC1 vs PC2 for identification of morphological and structural biomass changes using QIA data (a) and QIA together with operational data (b); samples from phase I identified in blue; samples from phase II identified in dark red.

Conclusions

- The removal of NH_4^+ was temporarily affected by a high OLR;
- PCA analysis of the QIA data alone and of QIA together with operational data revealed that this high OLR might also lead to continuous changes in biomass structure and robustness. However, both NH_4^+ removal and biomass stability were recovered during a subsequent lower OLR operational period;
- AGS can treat an industrial wastewater with variable composition due to the fast adaptation and recovery of granular biomass and its biological processes;
- OLR, nitrification process and biomass morphological and structural changes are possibly correlated during real wastewater treatment by an AGS process.

Acknowledgements

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