Microalgae-Bacterial Granular Sludge For The Treatment of Low Carbon and Nutrient Loaded Effluents

Catarina Miranda[1]*, Ana T. Couto[1], Catarina L. Amorim[1], P. 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.
*cmiranda@ucp.pt

Introduction

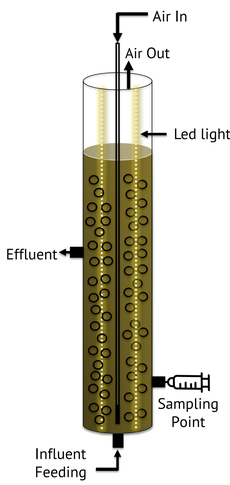
- Aerobic granular sludge (AGS) technology has plenty of advantages over conventional suspended sludge systems, with proven effectivity in the treatment of urban and industrial wastewater;
- AGS technology it is well-known thanks to its extraordinary capacity for simultaneous carbon and nutrient removal, its efficient biomass settling properties and the feasibility to adapt to the variable composition of the wastewater;
- Microalgae-bacterial granules biomass can increase the efficiency of the treatment process, as the presence of microalgae could potentiate nutrient removal while generating O_2 that can be used by bacteria in their biological processes;
- This work main aim was to assess the ability of a microalgae-bacterial consortia to treat streams with low organic and nutrient levels while following the changes in the microbiome dynamics imposed by the feeding composition.

Methods

- A photo sequencing batch reactor (SBR) was inoculated with bacterial granules from a full-scale WWTP and a suspended microalgae consortium composed by strains isolated from sludge of a freshwater aquaculture filtration system. For 8 months (251 days) the reactor was fed varying the ammonium load rate as following:

Stage	Duration of operation (d)	SBR mode (cycles/d)	Ammonium loading rate mg/(L.d)	
I	0-71	4	186.0	
II	72-89	6	279.0	
III	90-144		23.4	
IV	145-195		11.6	Extremely low carbon and nutrient content
V	196-251	16	31.0	

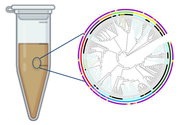
- Reactor performance in terms of N-removal and microbial community assessment were followed:



Photobioreactor with microalgae-bacterial granules

Influent at feeding
Influent (after feeding)
Effluent

Content of NH_4^+, NO_2^- and NO_3^- were followed at the influent feeding, influent after feeding and effluent throughout reactor operation.

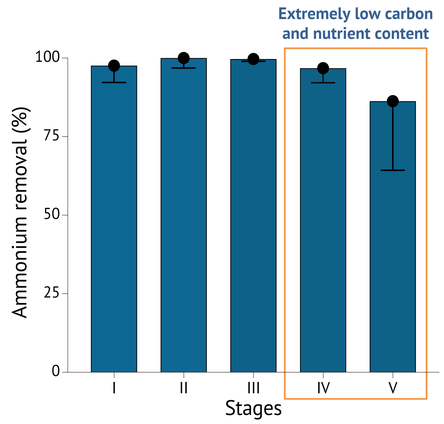


Crushed biomass

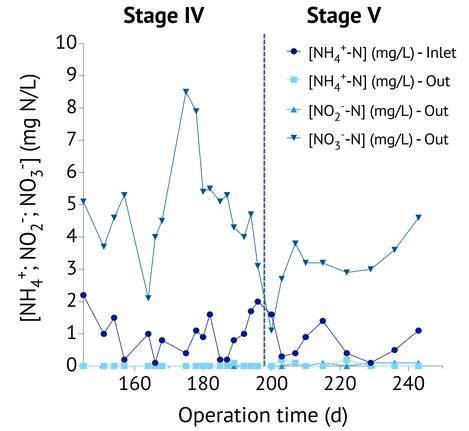
Biomass samples were collected along reactor operation, and bacterial community was followed by **NGS sequencing technology**.

Results & Discussion

Nitrogen removal performance

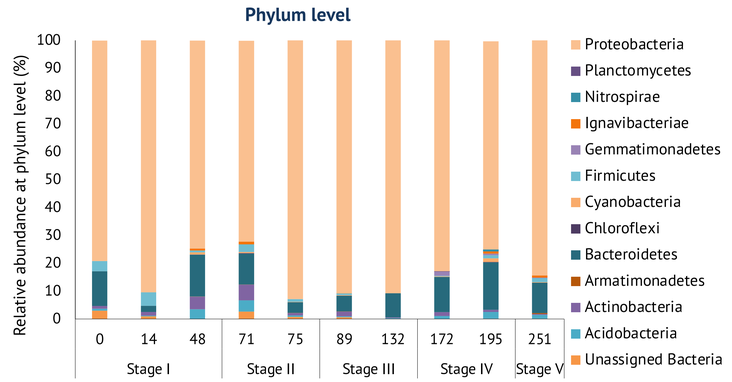


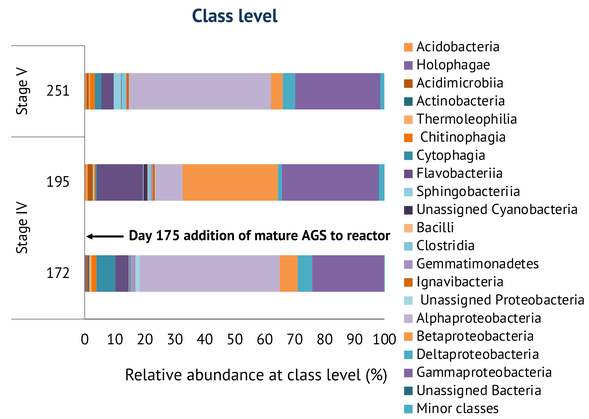
- Ammonium removal was almost 100 % all the time;
- In the stage V, with 16 cycles per day, biomass was able to remove ca. 86% of ammonium, proving the efficiency of the system in the treatment of streams with low nutrient levels.



- Even at extremely low nutrient loaded influent, ammonium fed was completely removed through nitrification, without nitrite accumulation.

Bacterial granules community





- Proteobacteria and Bacteroidetes were the most abundant phyla during reactor operation;
- The addition of new AGS was performed on day-175 changed the bacterial granules community composition; however on day-251 the bacterial population returned to a identical previous composition of day-172;
- A gradual adaptation of the bacterial population to the variable feeding composition was observed at class level in the two last stages of the reactor.

Conclusions

- The microalgae-bacterial granules were efficient for the treatment of water streams mimicking freshwater aquaculture wastewater, presenting excellent results in terms of nitrogen removal even at extremely low carbon and nutrient content;
- Bacterial granules community was heterogenous and dynamic throughout reactor operation, with bacterial groups related to the reactor's nitrogen removal and phosphate accumulation;
- A selection of most adaptable bacterial groups to the low loaded wastewater composition was observed along reactor operation, namely in the classes Alphaproteobacteria and Betaproteobacteria.

Acknowledgements

The authors thank the EU and FCT (Fundação para a Ciência e Tecnologia) for funding, in the frame of the collaborative international Consortium AquaVal (Water JPI/0003/2016) financed under the ERA-NET WaterWorks2015 Cofunded Call. This ERA-NET is an integral part of the 2016 Joint Activities developed by the Water Challenges for a Changing World Joint Programme Initiative (Water JPI). We would also like to thank the CBQF scientific collaboration under the FCT project UID/Multi/50016/2019. Catarina Miranda and Ana T. Couto would like to thank the research grants from FCT, Portugal (2020.06577.BD; SFRH/BD/139924/2018) and POCH, supported by the European Social Fund and MCTES national funds.