ETH
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Swiss Federal Institute of Technology Zurich

IfU
Institut für Umweltingenieurwissenschaften
Institute of Environmental Engineering
Chairs of Urban Water Management

Master Thesis 2023:

Possible Topics in Urban Water Management

Toward full Total Nitrogen (TN) removal in Aerobic Granular Sludge (AGS) systems operated in continuous-flow mode?

Background

A large fraction of Swiss wastewater treatment plants (WWTP) is reaching their maximum treatment/clarification capacities, resulting in operational problems such as incomplete nitrification. It is therefore crucial to develop new technologies to upgrade existing WWTP and intensify their treatment capacities. Aerobic granular sludge (AGS) represents on the other hand a key advance for wastewater treatment processes (van Loosdrecht and Brdjanovic, 2014), and is presented as the main alternative to conventional activated sludge systems. AGS systems are however usually operated as sequencing batch reactors (SBR), where both microbial and physical selection mechanisms take place and ultimately lead to the formation of granules. But most of the existing WWTP are operated in continuous-flow (CF) mode, while the conversion of CF systems into SBR is very challenging. A main challenge is therefore **to develop aerobic granules in systems operated in CF mode, where conditions in terms of microbial and hydraulic selection are not favourable**.
Also, mass-transfer in AGS is limited by diffusion, resulting in the formation of concentration gradients within the granules. During the aerated phase, an oxygen gradient thus develops within the granules, whereby the outer layer is aerobic and the inner core is anoxic or anaerobic. The formation of different redox conditions within the granules allows nitrification and denitrification to occur simultaneously. But practical experience however indicates that SND is limited during the treatment of municipal WW with AGS systems (Layer et al., 2020) while model predictions suggested TN removal could be maximized by adjusting the aeration strategy. However, it is not clear how the aeration influences the fate of organic substrates (hydrolysis, fermentation, storage), their utilization by the different microbial communities and the denitrification and total nitrogen (TN) removal. Another challenge is therefore **to better understand how to control aeration in order to increase SND and TN removal, without increasing green-house gas emissions such as N_2O.**

Objectives

The main objective is of the proposed master thesis is to better understand **how to control aeration in order to regulate of microbial utilisation of organic substrates, and ultimately to maximize SND and TN removal in AGS systems operated in CF mode**.

The specific objectives are:

- To better understand the fate of organic substrates (turn-over, local availability, anoxic vs aerobic oxidation),
- To compare the effect of different aeration strategies (constant DOSP, 2-step DOSP, intermittent aeration, etc.) on the nitrification, denitrification (in the aerated tanks) and overall on the TN removal,
- To assess the N_2O emission as a result of different aeration strategies

This master thesis is part of a **collaboration between Eawag, Hunziker Betatech AG, ARA Consult and the WWTPs of Gossau and Laufacker**.

Approach

External physical selectors (hydrocyclones) were installed in May 2022 at the WWTP of Gossau and Laufäcker, in order to select for aerobic granular sludge. This master thesis will consist in monitoring the granulation process and to test different aeration strategies, while assessing the treatment performances and N_2O emissions over time. The specific nitrifying/denitrifying activities in the flocs and granules will then be characterized through ex-situ activity tests.

Requirements

Interests in (1) advanced technologies for biological wastewater treatment, and (2) microbial processes applied to wastewater treatment
Language: English and German

Advisors

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References

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