PhD position

Understanding the mechanisms of nitrous oxide production in nitrifying biological aerated filters: pilot scale measurements to refine full-scale models

Key words: biofilm, nitrogen removal, modelling, full-scale, pilot-scale, mass transfer, carbon footprint

Motivations

This PhD project fits into one of the main forthcoming challenges of wastewater management, which is to increase the ecological sustainability of facilities while facing increased urban densification. Specifically, the main goal is to deepen the understanding of the mechanisms underlying N_2O emissions by biologically aerated filters (BAFs). This will contribute to the development of mathematical models, calibrated on two of the biggest French facilities using the BAF technology for nitrogen removal. Ultimately the model will be used to optimize the operation and design of the bioreactor considering effluent quality and operating costs and to mitigate greenhouse gas emissions.

Thesis overview and objectives

Climate change caused by greenhouse gas (GHG) emissions is one of the major challenges facing mankind today. In the past years, increasing attention has been paid to nitrous oxide (N_2O) emissions from wastewater resource recovery facilities (WRRF) due to its detrimental environmental effect (potent GHG and ozone depleting substance) and high impact on the carbon footprint of WRRFs. Measurement campaigns performed by the host team, suggested that biologically aerated filters (BAF, intensive biofilm processes widespread in large European cities) produce much higher amounts of N_2O compared to the conventional activated sludge systems [1,2].

To get insights into the mechanisms of N_2O production, a full-scale nitrifying BAF [3] model was upgraded to include N_2O production pathways [4,5] and calibrated on data from the Seine Aval plant (largest plant in Europe, 5.5 million PE). The developed model successfully described long-term nitrification (over 2 years) and high-frequency N_2O production (10 min averages over two short periods). Nevertheless, to validate the predictive capacity of the model, the latter should be confronted to data from another plant and preferably tested against long-term N_2O datasets. Additionally, the work performed on the gas/liquid mass transfer sub-model evidenced the lack of experimental data on oxygen transfer in full-scale BAF and consequently the poor understanding of the mechanisms affecting it in real conditions [5,6].

This PhD project is aimed at deepen the understanding of the mechanisms underlying N_2O production in nitrifying BAFs by coupling experiments carried out at pilot scale (controlled and well defined conditions) with dynamic model development applied on an industrial scale. The research objectives are: (1) to evaluate the impact of biofilm presence on oxygen gas/liquid mass transfer parameters, (2) to analyse the mechanisms of N_2O production for contrasted operating conditions (eg, aeration rate, influent composition, etc.), (3) to compare results obtained at pilot-scale with full-scale in order to assess potential differences and refine full-scale models, and (4) to evaluate N_2O mitigation strategies using the developed model or based on the pilot-scale testing.

Working conditions

Context: Following to the experimental and modelling work performed in the ANR project-N2Otrack (2015-2020), the proposed thesis will be carried out within the framework of the research program Mocopée in close collaboration with SIAAP (Public Sanitation Service in the Paris area). The candidate will be located in INRAE – research unit PROSE - under the supervision of Ahlem Filali (INRAE, PROSE), Sylvie Gillot (INRAE, REVERSAAL, PhD director) and Mathieu Spérandio (INSA Toulouse, PhD co-director). The candidate will be hosted (2nd year for the pilot-scale experiments) by the SIAAP in their offices, located near the Seine Centre WRRF.

Localisation address: Unit PROSE – PRocédés biOtechnologiques au Service de l'Environnement
INRAE – 1 rue Pierre Gilles de Gennes CS 10030 92 761 Antony Cedex

Starting period: October 2020

Duration: 3 years

Gross salary: 1770 € / month (50% Mocopée, 50% INRAE)

Deadline for application: June 2020

Candidate profile

Competence in **process engineering** completed by a Master or an internship in **(waste)water treatment**. Modelling experience would be appreciated. In addition, the candidate will have to **master scientific English**. A **taste for field missions** is a necessary prerequisite (the candidate will have to carry out campaigns on site with the help of the technical team).

Contact

Ahlem Filali (INRAE, PROSE) - **ahlem.filali@inrae.fr**
- Cover letter with a focus on past research and motivations
- Detailed academic CV with laboratory/modelling skills and contact details of one academic referee.

References

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