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Learning to better predict biofiltration-process greenhouse gas emissions

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Bollon J, Filali A, Fayolle Y, Guerin S, Rocher V, Gillot S

N_2O emissions from full-scale nitrifying biofilters.

Water Research . 2016

Fiat J, Filali A, Fayolle Y, Bernier J, Rocher V, Spérandio M, Gillot S

Considering the plug-flow behavior of the gas phase in nitrifying BAF models significantly improves the prediction of N_2O emissions.

Water Research . 2019

Collaboration

This research was carried out as part of the ANR-sponsored 'N2Otrack' project (ANR-15-CE040014-02) and the 'Mocopée' research programme, in tight collaboration with SIAAP–the Greater Paris sanitation authority, TBI–Toulouse Biotechnology Institute, Bio & Chemical Engineering and the research unit REVERSAAL.

Contact

Ahlem Filali

UR PROSE

ahlem.filali@inrae.fr

Context

Biofiltration is an intensive wastewater treatment process based on a biofilm grown over a bed media filter. However, nitrifying biofilters are significant emitters of nitrous oxide (N_2O)–a greenhouse gas with potent global warming potential that also contributes to ozone layer depletion. Reducing the carbon footprint of biofiltration facilities thus revolves entirely around learning to control these N_2O emissions.

To gain deeper insight into the mechanisms underpinning N_2O production, we extended a biofiltration model to take in equations describing the main microbially-driven N_2O pathways.

Results

The current crop of biofiltration models make heavy simplifications on the description of gas–liquid exchanges, chiefly by ignoring the change in gas composition through the depth of the biofilter. To integrate this change factor, we proposed to make some structure modifications to the model, such as considering gas hold-up in the biofilter and adding a mass balance for gas-phase reactions.

Our results find that integrating the mass balance for gas-phase reactions has relatively little impact on oxygen mass transfer (little change in oxygen concentration). However, it proves essential to describe the substantial N_2O fluxing into the gas phase (1000-fold change in N_2O from bottom to top of the biofilter bed) and equally essential to properly model N_2O gas–liquid flux partitioning.

The model developed successfully predicts the nitrification performances and seasonal variability in N_2O emissions of the nitrifying biofilters of Seine Aval, Europe's biggest wastewater treatment facility.

Future Outlook

Research is now turning to assess how well the model can describe N_2O emissions from other big industrial facilities, and to employ it to propose operationalizable emissions reduction strategies. Our hope is that this tool will ultimately serve to refocus operational biofilter scale-up and practice onto environmental criteria including global warming.