• N_2O EMISSIONS FROM A FULL-SCALE BIOFILTRATION WASTEWATER TREATMENT PLANT

• ABSTRACT

Nitrous oxide (N_2O) emissions from a full-scale nitrifying and denitrifying biofiltration wastewater treatment plant were characterized over two periods (summer and winter campaigns). N_2O emissions were monitored on-line in both gaseous and liquid phases. Operating conditions of the biofilters (such as nitrogen load, concentration of nitrogen forms, oxygen, pH, temperature…) were characterized in order to highlight the main parameters inducing N_2O emissions.

The main results of the study are:

For the nitrifying biofilters:

- The N_2O emission factors represented 2.26% ± 0.46% and 4.86% ± 0.54% of the ammonium uptake rate during summer and winter, respectively;
- The major part of N_2O flux is directed to the gaseous phase. However, the monitoring of the liquid phase is required as liquid N_2O flux can represent up to 45% of the total N_2O flux depending on process conditions (temperature and aeration rate);
- Results highlighted high diurnal variability of N_2O emissions. Thus, monitoring of N_2O fluxes over at least one filtration cycle is required;
- Possible links between biofilter operating conditions and N_2O fluxes were examined via multivariate regression modelling using R software. Results indicated that N_2O fluxes were correlated to 6 parameters: (1) influent temperature, (2) influent ammonium concentration, (3) influent flow rate, (4) influent nitrate concentration, (5) filtration time and (6) air flow rate. Effluent nitrite concentration (that was not considered for the statistical analysis) is also an important factor influencing N_2O emissions;
- The increase in N_2O emissions in winter were imputed to higher production of N_2O via nitrifier denitrification due to higher oxygen limitations within the biofilm;
- A strategy of mitigation of N_2O emissions from nitrifying biofilters includes the control of biofilm thickness and the control of aeration rate.

For the denitrification biofilters:

- More than 99% of N_2O flux is discharged into the river with the effluent;
- The N_2O emission factors represented 1.28% ± 1.99% and 0.22% ± 0.31% of the nitrate uptake rate during summer and winter, respectively.
- Denitrification was able to consume a large amount of dissolved N_2O coming from the upstream nitrification stage. On average a reduction of 86% of the dissolved N_2O flux was measured during the winter campaign;
- The control of the influent C to N ratio is essential to maximize the reduction of dissolved N_2O coming from the upstream nitrification stage and minimize the accumulation of N_2O during the reduction of nitrate.

For the BNR stage:

- The N_2O emission factor of the BNR stage represented 2.11% of the inlet nitrogen load (based on results of the winter campaign).
- N_2O emissions contributed to more than 80% of the carbon footprint of the BNR stage of the WWTPs (excluding sludge treatment).

- **KEY WORDS: NITROUS OXIDE, N_2O, GREENHOUSE GAS, NITRIFICATION, DENITRIFICATION, WASTEWATER TREATMENT PLANT, BIOFILTER, FULL-SCALE.**