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Quantification of greenhouse gas (GHG) emissions from wastewater treatment plants using a ground-based remote sensing approach

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The direct release of nitrous oxide (N_2O) and methane (CH_4) from wastewater treatment plants (WWTP) is important because it contributes to the global greenhouse gases (GHGs) release and strongly effects the WWTP carbon footprint. Biological nitrogen removal technologies could increase the direct emission of N_2O (IPCC, 2006), while CH_4 losses are of environmental, economic and safety concern. Currently, reporting of N_2O and CH_4 emissions from WWTPs are performed mainly using methods suggested by IPCC which are not site specific (IPCC, 2006).

The dynamic tracer dispersion method (TDM), a ground based remote sensing approach implemented at DTU Environment, was demonstrated to be a novel and successful tool for full-scale CH_4 and N_2O quantification from WWTPs. The method combines a controlled release of tracer gas from the facility with concentration measurements downwind of the plant (Mønster et al., 2014; Yoshida et al., 2014). TDM in general is based on the assumption that a tracer gas released at an emission source, in this case a WWTP, disperses into the atmosphere in the same way as the GHG emitted from process units. Since the ratio of their concentrations remains constant along their atmospheric dispersion, the GHG emission rate can be calculated using the following expression when the tracer gas release rate is known:

$$E_{GHG} = Q_{tr} * (C_{GHG}/C_{tr}) * (MW_{GHG}/MW_{tr})$$

E_{GHG} is the GHG emission in mass per time, Q_{tr} is the tracer release in mass per time, C_{GHG} and C_{tr} are the concentrations measured downwind in parts per billion subtracted of their background values and integrated over the whole plume, and MW_{GHG} and MW_{tr} are the molar weights of GHG and tracer gas respectively (Mønster et al. 2014).

In this study, acetylene (C_2H_2) was used as tracer. Downwind plume concentrations were measured driving along transects with two cavity ring down spectrometers (Yoshida et al., 2014).

TDM was successfully applied in different seasons at several Scandinavian WWTPs characterized by different capacity, process unit technologies and locations. The method was applied at plants with different combination of nitrogen removal technologies and sewage sludge treatment. According to the plant capacity and technologies, quantified emissions ranged in the following intervals: from 0.7 to 3.4 kg N_2O /h and from 1.1 to 17.6 kg CH_4 /h.

In addition to quantifying the whole emission from the facilities, main sources in the plants were identified. While CH_4 was generally emitted from sludge treatment areas, N_2O was detected from nitrogen removal technologies both in the main stream and in the side treatment. Process units like biosolids storage and aeration tanks were the only units releasing both GHGs, although in different magnitude.

References

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