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Abstract

Accumulation of greenhouse gases (GHGs) in the atmosphere changes the energy balance of the Earth and leads to global warming [1]. The direct release of nitrous oxide (N_2O) and methane (CH_4) from wastewater treatment plants (WWTP) is important because it contributes to the total release of GHGs and also strongly effects the carbon footprint of these facilities [2]. Biological nitrogen removal technologies could increase the direct emission of N_2O [3], while CH_4 losses are of environmental, economic and safety concern. Currently, reporting of N_2O and CH_4 emissions from WWTPs are performed using either indirect methods suggested by IPCC [3], or using single point measurements [4].

The dynamic tracer dispersion method (TDM), implemented at DTU Environment [5], [6], 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 [5], [6]. The tracer dispersion method 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:

$$E_{GHG} = Q_{tr} * \frac{\int_{plume\ start}^{plume\ end}(C_{GHG})dx}{\int_{plume\ start}^{plume\ end}(C_{tr})dx}\frac{MW_{GHG}}{MW_{tr}}$$

where 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 measured downwind concentrations in parts per billion subtracted of their background concentrations and MW_{GHG} and MW_{tr} are the molar weights of methane and tracer gas, respectively [6].

In this study, acetylene (C_2H_2) was used as tracer due to its long atmospheric lifetime. Downwind plume concentrations were measured driving along transects with two cavity ring down spectrometers [5].

TDM was successfully applied in different seasons at several Scandinavian WWTPs characterized by different capacity (people equivalent), process unit technologies and locations. The method was applied at plants with different combination of nitrogen removal technologies and sewage sludge treatment with or without side treatment for sludge liquor and leachate from landfills. The study includes technologies such as Bio-Denitro and Bio-Denipho, Sequencing Batch Reactors, Activated Sludge, Moving Bad Biofilm Reactor. All investigated plants had sewage sludge digestion followed by either incineration or biosolids storage before land application. According to the plant capacity and technologies, quantified emissions ranged in the following intervals: from 0.5 to 3 kg NO_2/h and from 3 to 20 kg CH_4/h.

In addition to quantifying the whole emission from the facilities, emission hot spots were identified as well. 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.

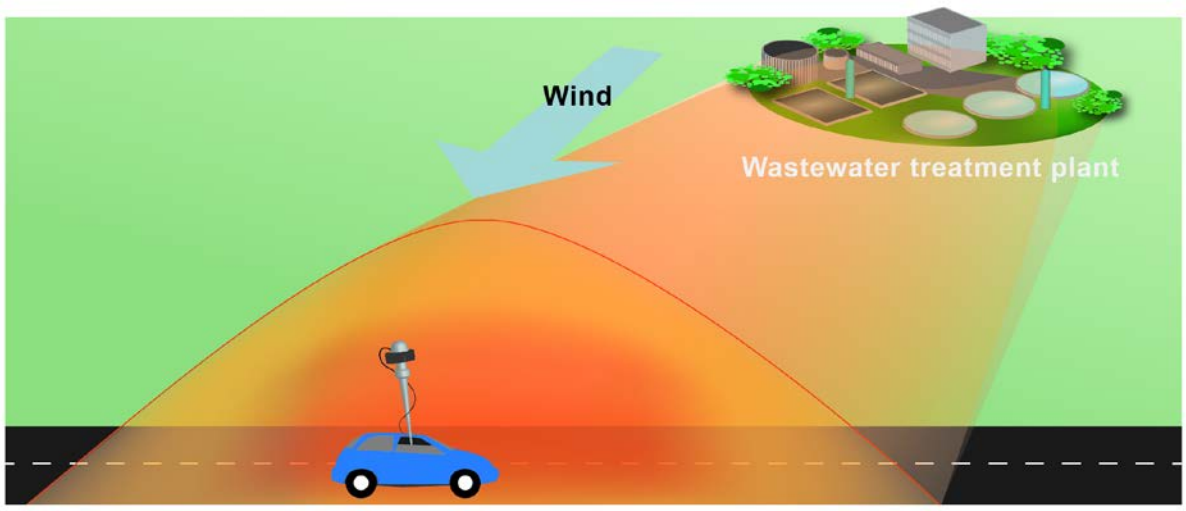

Figure 1 - Illustration of the TDM application where tracer and GHG concentrations are measured along downwind transects.

References

[1] IPCC, “Climate Change 2013 The Physical Science Basis - Working Group I: Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,” 2013.

[2] D. J. I. Gustavsson and S. Tumlin, “Carbon footprints of Scandinavian wastewater treatment plants.,” *Water Sci. Technol.*, vol. 68, no. 4, pp. 887–93, Jan. 2013.

[3] IPCC, “Guidelines for National Greenhouse Gas Inventories,” in *Volume 5 - Waste*, 2006, pp. 6.1 – 6.28.

[4] K. Chandran, *Protocol for the measurement of nitrous oxide fluxes from biological wastewater treatment plants.*, 1st ed., vol. 486, no. 11. Elsevier Inc., 2011.

[5] H. Yoshida, J. Mønster, and C. Scheutz, “Plant-integrated measurement of greenhouse gas emissions from a municipal wastewater treatment plant,” *Water Res.*, vol. 1, no. 61, pp. 108–118, May 2014.

[6] J. Mønster, J. Samuelsson, P. Kjeldsen, C. W. Rella, and C. Scheutz, “Quantifying methane emission from fugitive sources by combining tracer release and downwind measurements - a sensitivity analysis based on multiple field surveys.,” *Waste Manag.*, vol. 34, no. 8, pp. 1416–28, Aug. 2014.

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