N_2O Dynamics of N-transforming microbial communities: from mechanistic insights to full-scale process control

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Abstract

Nitrous oxide (N_2O) is a strong greenhouse gas and ozone depleter, with a warming potential 300 times higher than that of CO_2. Anthropogenic N_2O emissions accounts for 6% of the total greenhouse gas emissions and 3% of the total N_2O emissions are thought to originate from the wastewater treatment (WWT) sector. Conventional biological nutrient removal processes relying on nitrification and denitrification are known produce N_2O. The Intergovernmental Panel on Climate Change (IPCC) still recommends an N_2O emission factor (EF) of 0.0032 kg N_2O-N person^{-1} year^{-1} or 0.035% of the influent nitrogen to estimate the N_2O emissions from domestic wastewater treatment plants (WWTP). However, full-scale N_2O measurement campaigns have revealed that emissions can range from less than 0.1 to more than 10% of the influent nitrogen load. Hence, there is a strong need to develop a more complete understanding of the mechanisms, magnitudes, and controlling factors of N_2O emissions from wastewater treatment operations – in order to develop more defensible N_2O emission factors and to identify mitigation approaches to reduce N_2O emissions.

I will present results of 5-year multidisciplinary and multi-institutional study that had the aim to improve the diagnostics, monitoring and mitigation of N_2O emissions from wastewater treatment operations. The overall outcomes of the project were (1) the applicaton of new plant-wide techniques for the quantification of both whole-plant and reactor-scale N2O emission factors, yielding emission factors of 0.1 to 5.2% of the nitrogen removed, (2) the development of assays based on ^{15}N and ^{18}O for N_2O source partitioning, which revealed that both hydroxylamine oxidation and nitrifier-denitrification are important pathways for N_2O production (3) the development and validation of new predictive models, both plant-wide and biokinetic-based, to capture N_2O dynamics in wastewater operations (4) the identification and application of mitigation strategies to control N_2O emissions at full-scale (5) the filing of two patents describing two different control strategies for N2O emissions.