Faculty of Civil, Geo and Environmental Engineering
Chair of Urban Water Systems Engineering

„Innovative monitoring and control strategies to minimize emissions of nitrous oxide during biological wastewater treatment"

Name	**Carmen Leix**
E-Mail	**c.leix@tum.de**
Supervisor	**Prof. Dr.-Ing. Jörg E. Drewes** **Chair of Urban Water Systems Engineering (TU München)**
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Referees	**Prof. Dr. Eberhard Morgenroth (ETH Zürich)**

Introduction

Nitrous oxide (N_2O) can be emitted as an intermediate or as an undesired side product during biological nitrogen removal in wastewater treatment [1]. As N_2O has a global warming potential 298 times higher than that of carbon dioxide based on a time horizon of 100 years, persists in the atmosphere for approximately 114 years, and furthermore, causes ozone depletion, it has a highly negative long-term impact on the environment [2].

These facts highlight the importance to reduce emissions of N_2O as far as possible in order to protect the environmental and future generations to come.

Research Objectives

This dissertation focuses on a fundamental understanding of biological production pathways of N_2O during the process of deammonification (partial nitritation coupled with anaerobic ammonium oxidation, so-called anammox). The examination of this process is chosen because it combines different advantages regarding energy and cost effectiveness compared to conventional nitrification and denitrification. High ammonium loaded process water which originates from the dewatering of sludge can be treated in side stream. This practice can reduce the nitrogen load of the whole wastewater treatment operating in main stream of up to 15 - 25 % [3]. As an autotrophic process, no external carbon source is needed and excess carbon can be transferred to additional methane. Moreover, the energy for aeration can be reduced by over 50 % [4]. With being an energy saving process, an undesired production of N_2O would be counterproductive in environmental aspects.

This is why the different pathways of biological formation of N_2O (see Fig. 1) with regard to the biocoenosis and varying boundary conditions, such as peak ammonium and nitrite loads, changing pH values, high and low concentrations of oxygen, etc., are investigated in order to derive strategies for mitigating N_2O followed by recommendations for wastewater treatment plant operators.

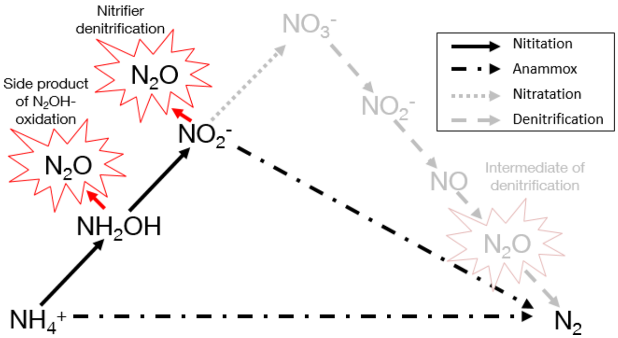

Fig. 1: Possible production pathways of N_2O (adapted from [5])

Experimental Setup

Three automated, gas-tight lab-scale reactors with a volume of 12 l and online measurement devices for oxygen, ammonium, nitrate, pH, ORP, conductivity and temperature are being used. For the measurement of gaseous N_2O in the headspace, an innovative photoacoustic cell is utilised. N_2O in the liquid phase is measured with a Clark-type microsensor. For the analysis of the biocoenosis, fluorescence-in-situ-hybridization (FISH) as well as next generation pyrosequencing are applied.

Single-stage deammonification with suspended sludge as well as with fixed biofilm carriers are examined for the assessment of N_2O emissions regarding both systems.

Expected outcomes and contributions

The results will help to quantify the relationship between N_2O emissions and process parameters as well as to distinguish between bacterial species which are responsible for causing emissions during aerobic and anoxic operating phases.

Based on this knowledge, process strategies with direct feedback are developed for immediate control of the deammonification process and mitigation of N_2O emissions, respectively.

References

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