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

Dissertation Fact Sheet

Nitrous oxide – a possible energy resource

Name	**Max Weißbach**
E-Mail	**max.weissbach@tum.de**
Supervisor	**Univ.-Prof. Jörg Drewes** **Chair of Urban Water Systems Engineering**
Started	**10/2013**
Status	**ongoing** **finalized: -**
Referees	-

Introduction

On common biological wastewater treatment plants nitrogen loads are becoming an increasing threat to operators and environment. Effluent threshold values can often be held only at additional financial and environmental costs.

One of the main contributions to the nitrogen load is process water generated by on-site digester operation typically carrying more than 1 g/L of ammonia (NH_4).

Recently developed side stream treatment processes are economic, but emit significant amounts of nitrous oxide (N_2O), a potent greenhouse gas with a carbon dioxide (CO_2) equivalence of 300 (Ravishankara et al., 2009).

Next to its climatic relevance N_2O is a chemical resource useable as oxidant in fuel combustion or propellant in rocket engines. By combustion, N_2O is reduced to climate-neutral Nitrogen gas.

Thus an alternative solution for both nitrogen elimination and GHG mitigation is an integrated process for intentional biogenic N_2O production and subsequent combustion such as the coupled aerobic anoxic denitrification operation (CANDO) (Scherson et al., 2013) possibly with a positive energy output.

Objectives

Tight Process control and optimization of the CANDO process (Fig. 1) are the main objectives. Therefore feedback and -forward mechanisms in the process chain as well as implementation of high resolution monitoring techniques are developed.

In this respect key role players responsible for N_2O formation (e.g., dynamic changes of ammonium, nitrite, pH, ORP, oxygen concentrations, COD:N ratios) are elucidated.

For process understanding, microbial communities are characterized and responsible N_2O producers identified. Additionally the community shift is monitored.

For energy recovery nitrous oxide harvesting techniques for gas/liquid phase separation are investigated and evaluated and accompanied by feasibility studies. Among the off-gas measurements, a closed nitrogen mass-balance is investigated.

A pilot scale treatment system for reject wastewater shall finalize the work.

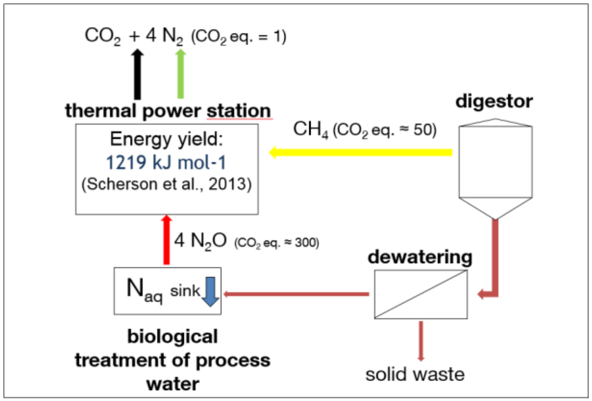

Fig. 1: Intended process scheme for Energy recovery via nitrogen and methane

Methods

For lab-scale studies six PLC controlled reactor systems have been set up in the „Technikum“ of the institute of Urban Water Systems Engineering (Fig. 2) equipped with in-situ online monitoring devices for all relevant parameters

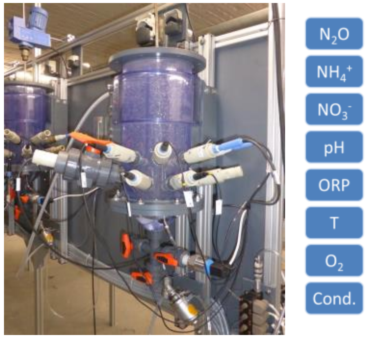

Fig. 2: Lab-scale reactor systems for process investigations

For off-gas measurements, a novel fast-response measurement device based on photo-acoustic measurement principles is developed and tuned in collaboration with the chair of Water Chemistry (Prof. Nießner).

Among microbial analysis techniques are florescence in-situ hybridization (FISH), polymerase chain reaction (PCR) and Pyrosequencing.

References

Ravishankara, A. R., Daniel, J. S., and Portmann, R. W. (2009) Nitrous Oxide (N2O): The Dominant Ozone-Depleting Substance Emitted in the 21st Century. Science, 326(5949), 123–125.

Scherson, Y. D., Wells, G. F., Woo, S.-G., Lee, J., Park, J., Cantwell, B. J., and Criddle, C. S. (2013) Nitrogen removal with energy recovery through N2O decomposition. En. & Env. Science, 6(1), 241–248.