UNISENSE
ENVIRONMENT

Significant 3-fold increase in $IPCC_{2019}$ wastewater N_2O emission factor supported by Danish Studies

Wastewater treatment plants (WWTP's) contribute significantly to the global greenhouse gas stock through the production and emissions of nitrous oxide (N_2O), and the more than 3-fold increase of the wastewater N_2O emission factor by $IPCC_{2019}$ underlines this.

Nitrous oxide emission contributes with about 42% of the CO_2 footprint from Danish WWTPs, emphasizing earlier years underestimation of the impact of N_2O and the importance of control strategies targeted at understanding and reducing N_2O emissions from WWTPs.

Danish studies support the increased $IPCC_{2019}$ wastewater N_2O emission factor, but also elucidate the large temporal and WWTP site variations. In the VARGA study, N_2O emission control has shown an up to 65% CO_2 footprint reduction potential, while other WWTP sites shows lower N_2O emission. Overall a reduction potential of 50% in CO_2 footprint is expected in Denmark and this number will increase with the new $IPCC_{2019}$ wastewater N_2O emission factor. However, with the site and temporal variations that exist, online monitoring and control strategies are essential for harvesting this reduction potential.

In this note we show data of successful N_2O emission monitoring and control strategies.

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IPCC greenhouse emission factors

In May 2019, IPCC refined the greenhouse gas emission factors and more than tripled the N_2O emission factors emissions for WWTP's incl. the factor for direct sewage discharge to nutrient-impacted freshwater, estuarine, and marine environments.

Furthermore, IPCC stated that a shift towards higher bioenergy demand can increase emissions of nitrous oxide. Hence, the ammonia waste from biogas production needs appropriate management approaches to avoid a negative CO_2 footprint impact.

> **IPCC 2019 report**
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> Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories
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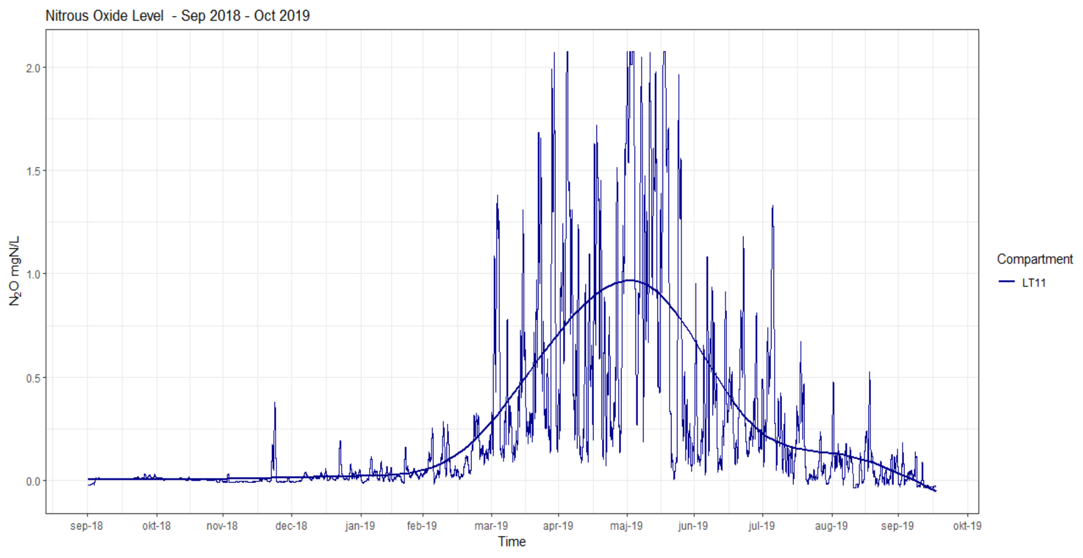
> | Wastewater Treatment 1,6% N_2O-N/TN $IPCC_{2019}$ | Untreated Wastewater 1,9% N_2O-N/TN $IPCC_{2019}$ |
> |---|---|
> | Local Challenge | Local Challenge |
>
> *High bioenergy demand can increase emissions of nitrous oxide*

Real-time N_2O monitoring data

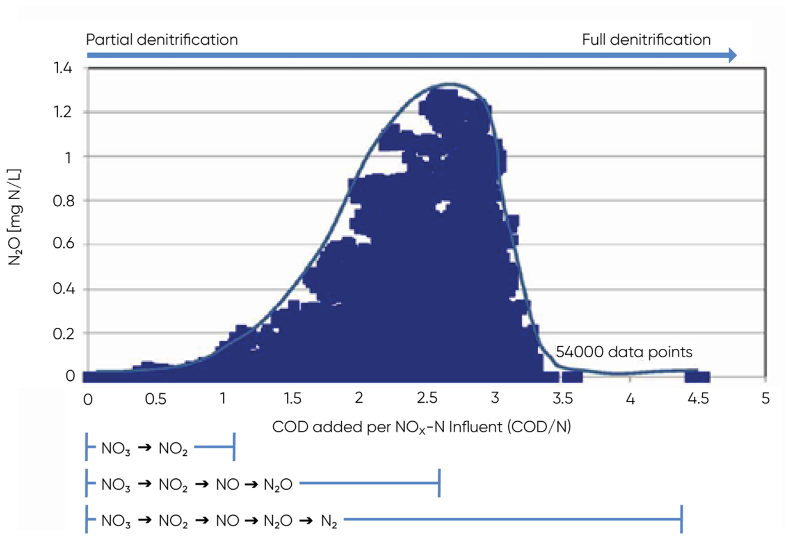
More than 1.5 years of online monitoring of the N_2O concentration in a 350,000 PE WWTP shows a highly variable and also dynamic seasonal pattern. In this example, the cumulative N_2O emissions over +365 days was over 2.5% of daily N-load on the plant (not shown). This N_2O emission is 60% higher than the average $IPCC_{2019}$ factor and indicates the importance of performing on-site monitoring of N_2O rather than relying on average assumption.

Moreover, the majority of the emission is accumulated from March to August. Clearly, the large seasonal/monthly variations undermines results deducted from typical short-term scientific monitoring campaigns, especially when results are extrapolated to a seasonal or yearly emission result or an N_2O emission factor.



Mitigation Strategy

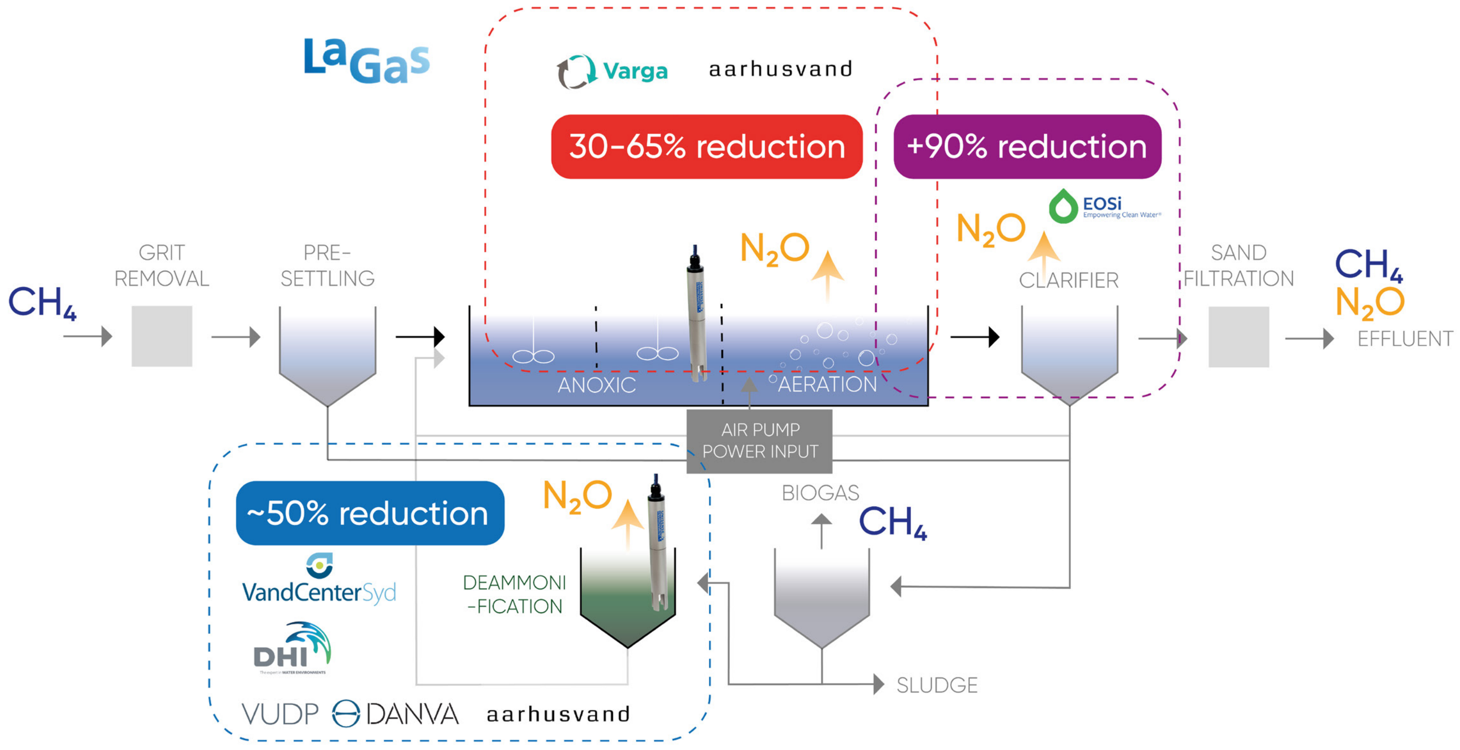
A mitigation strategy to decrease the greenhouse gas emission and cost of operation of a WWTP, already dosing carbon sources to improve the effluent quality, is shown in the figure below. To demonstrate the applicability of the N_2O wastewater sensors for automation of COD dosing pumps, two sensors were used in two treatment plants in parallel with NO_x-N probes. The effects of operational conditions such as COD/N ratios and the correlation between NO_x and N2O were followed. In particular, the N_2O production were found to be a function of influent nitrogen load and the ratio of COD/N. A combination of a feedforward control algorithm with nitrates as its measured variable and a feedback control algorithm with N_2O as input variable, was proposed for optimum automation of external carbon source dosage as well as mitigating N_2O as one of the most potent greenhouse gases when a very low nitrogen limit is targeted. By using the N_2O sensor as a proxy sensor for nitrates in a feedback automation of the dosing pumps, N_2O emissions could be completely avoided while the effluent quality was maintained below 1.2 mg N/L NO_x.



Andalib, M. & Andersen, M. H. et al, Water Sci Tchnol (2017) 77 (2):426-438

VARGA Project

The Danish project VARGA has implemented and tested a number of new controls for minimizing nitrous oxide at the Avedøre WWTP and demonstrated a 30% reduction (4,260 Ton of CO_2 equivalents) early in the project. The full minimization potential is expected to be even greater - up to a 50-80% reduction. Similarly, multiple Unisense Environment clients have demonstrated N_2O minimization potentials between 25% and 90% by controlling aeration, loading, and carbon resources more balanced by integration of the N_2O wastewater sensor. On a Danish scale the reduction potential in Denmark will be 42-152,000 Ton CO_2 equivalents annually, and with the adjusted upward $IPCC_{2019}$ emission factor, the potential is likely significantly greater.



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UNISENSE ENVIRONMENT

Nitrous Oxide process sensor for online wastewater treatment optimization, low-cost greenhouse gas reduction, and reliable sustainability accounting

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