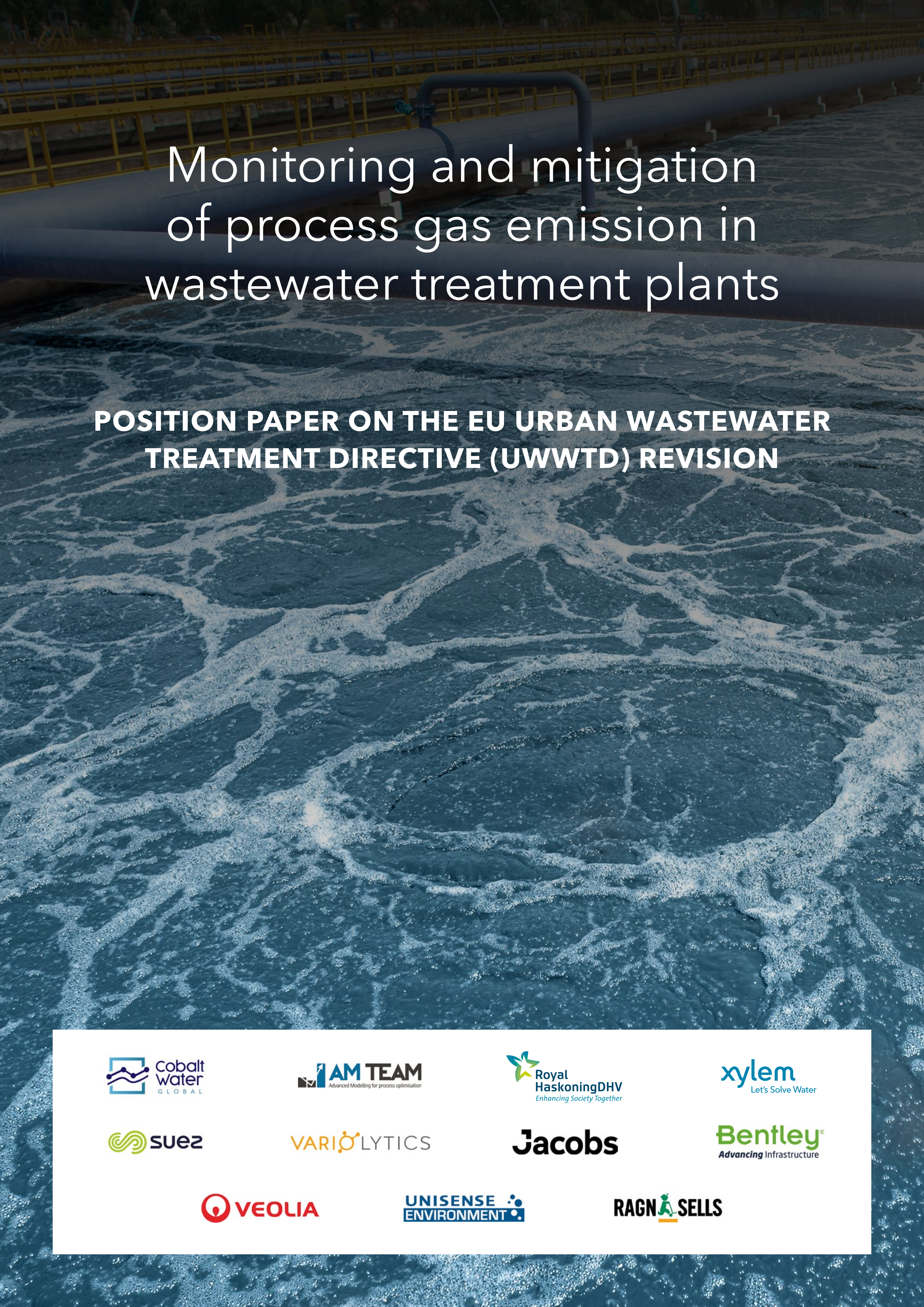

# Monitoring and mitigation of process gas emission in wastewater treatment plants

## POSITION PAPER ON THE EU URBAN WASTEWATER TREATMENT DIRECTIVE (UWWTD) REVISION

Cobalt Water Global
AM TEAM Advanced Modelling for process optimisation
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**Summary**

As technology and application experts, we welcome the latest ambitious proposal for a revised Urban Wastewater Treatment Directive. With this paper, we highlight the following facts and core element for improvement regarding monitoring and mitigation of process gas emissions in wastewater treatment plants:

- Emissions of process gases, i.e., nitrous oxide ($N_2O$) and methane ($CH_4$), from wastewater and sludge treatment make up 60-70% of the GHG from wastewater treatment plants.
- $N_2O$ emissions represent a global warming potential 273 times higher than that of carbon dioxide.
- Technologies to monitor and mitigate $N_2O$ emissions have been developed in last 2 decades and successful case studies of their application are available in this paper.
- The revision of the Urban Wastewater Treatment Directive presents an important opportunity to address the monitoring and mitigation of $N_2O$ emissions, paving the way for the wastewater treatment sector's contribution to EU's Climate Law targets.

We strongly recommend the inclusion of monitoring requirements for emissions of all process gas, including $N_2O$ and $CH_4$, in the revised Directive, outlined in more detail in this paper.

As technology and application experts, we welcome the latest ambitious proposal for a revised Urban Wastewater Treatment Directive (UWWTD). However, we now feel there is a need to specifically address the monitoring and mitigation of process gas emissions and suggest important amendments to the UWWTD proposal to address this.

Emissions of process gases, i.e., nitrous oxide ($N_2O$) and methane ($CH_4$), from wastewater and sludge treatment), make up 60-70% of the greenhouse gas emissions from wastewater treatment plants – making them the leading contributor to the overall environmental footprint of wastewater operation[1,2]. The economic value of methane as an energy source is well understood and captured in the UWWTD proposal. Nevertheless, the proposal fails to address the mitigation of nitrous oxide emissions, which represent a global warming potential 273 times higher than that of carbon dioxide[3].

Nitrous oxide is produced and released into the atmosphere due to complex biochemical and physical processes involved in removing nitrogen in wastewater and sludge treatments. In conventional biological processes, total nitrogen removal (nitrification and denitrification) results in net emissions of nitrous oxide. Whilst some aspects of process (notably the denitrification phase) may provide opportunities to mitigate nitrous oxide generation, only through active monitoring can emissions of $N_2O$ be understood. Additionally, given the recognized large variability in emissions across treatment processes, operating conditions and geographies, the Intergovernmental Panel on Climate Change (IPCC) Guidance[3] clearly sets out the need for facility-level monitoring to gather evidence on nitrous oxide generation and release, and the specific emission factors. This is to support accurate greenhouse gas accounting and, most importantly, to support mitigation. Both methane and nitrous oxide are highly site dependent, but unlike methane, we cannot easily identify, and 'fix' nitrous oxide leaks and a deeper process understanding is required.

Increased awareness of the impact of nitrous oxide and methane on global warming over the last decade has accelerated the technical development of monitoring and mitigation technologies in activated sludge treatment. Online sensors, advances in biokinetics and flow mechanics, as well as modelling approaches, offer reliable and affordable solutions for monitoring real-time emissions of nitrous oxide in wastewater treatment. Full-scale monitoring is a prerequisite to identify and verify effective mitigation. Multiple full-scale references are available today which support the validity of nitrous oxide monitoring and emerging mitigation case studies[4,5] in addition to emerging knowledge-based and data-driven approaches[6]. Capital investment or annual monitoring services are available from existing market providers and are being implemented at scale by leading utilities and practitioners.

Current and emerging mitigation solutions – including those driven by optimization digital platforms – come from sufficient and affordable nitrous oxide monitoring. These solutions put wastewater operators in real control of energy use and nitrous oxide emissions of their biological process. For example, recent full-scale work in Australia, Denmark and The Netherlands reported emissions reductions of 35%[7], 74%[8] and 90%[9], respectively, in published studies.

Beyond the application of demonstrated mitigation approaches, there are significant opportunities to further develop treatment technologies, optimize the harvesting of resources, and prevent the generation of nitrous oxide – this potential remains very much untapped but, critically, it also requires an understanding of nitrous oxide emissions through site-level monitoring.
Only with a requirement for nitrous oxide monitoring in the monitoring obligation of the UWWTD proposal will Member States be able to support near-term mitigation and accelerate the technology development required for advanced wastewater treatment - for example to technologies that do not produce nitrous oxide. This opportunity is currently missing in the UWWTD proposal.

In addition, conventional biological treatment technologies with high $N_2O$-emissions are widely implemented in Europe and it would not be realistic to replace them all with zero-emission treatment technologies (if these existed) within the next 50 years. Therefore, it is of critical importance to simultaneously advance wastewater treatment and implement today's monitoring and mitigation solutions to start minimizing emissions from our current and future infrastructure through process optimization, while gradually retrofitting them into zero-emission treatment technologies.

To provide the opportunity to reduce the potent greenhouse gas emissions from wastewater treatment, we recommend Member States be required to monitor the emissions of all process gas, including nitrous oxide, produced by the operational activities of the water utilities, in addition to the energy used and produced by urban wastewater treatment plants of above 10 000 p.e.

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1 Monitoring, modelling and mitigating nitrous oxide emissions. Market Map, GWI Magazine, December 2022

2 Evaluation of greenhouse gas emissions from the European urban wastewater sector, and options for their reduction, Science of the Total Environment 838 (2022) 156322

3 https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/ $N_2O$ and $CH_4$ have global warming potential of 273- and 30-times that of $CO_2$ for 100-year time horizon according to IPCC AR6 2021

4 Andersen et al., (2022) Andersen et al., (2022) https://unisense-environment.com/applications/direct-effect-of-activated-sludge-concentration/

5 Baresel et al., (2016) Comparison of nitrous oxide ($N_2O$) emissions calculations at a Swedish wastewater treatment plant based on water concentrations versus off-gas concentrations, Advances in Climate Change Research 7

6 Porro et al., (2022) https://iwaponline.com/ebooks/book/844/chapter/2860689/Knowledge-based-and-data-driven-approaches-for

7 Duan et al. (2020) https://pubmed.ncbi.nlm.nih.gov/32738601/ which resulted in a 35% reduction in $N_2O$ emissions and 20% aeration energy reduction.

8 Andersen et al., (2022) https://unisense-environment.com/applications/direct-effect-of-activated-sludge-concentration/ - which undertook a 2 year testing period for full scale mitigation with 74% reduction realised relative to reference lanes in a 12 month period.

9 Porro et al., (2022) https://iwaponline.com/ebooks/book/844/chapter/2860689/Knowledge-based-and-data-driven-approaches-for

2023, Position paper endorsed by: