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Geavanceerd monitoring, modellering en proces- optimalisatie voor het beheer van N₂O-emissie in RWZI

Kees Roest

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KWR

Bridging Science to Practice

AQUA
NEDERLAND 
DE TOEKOMST VAN WATER MANAGEMENT

KWR Water Research Institute

Bridging Science and Practice

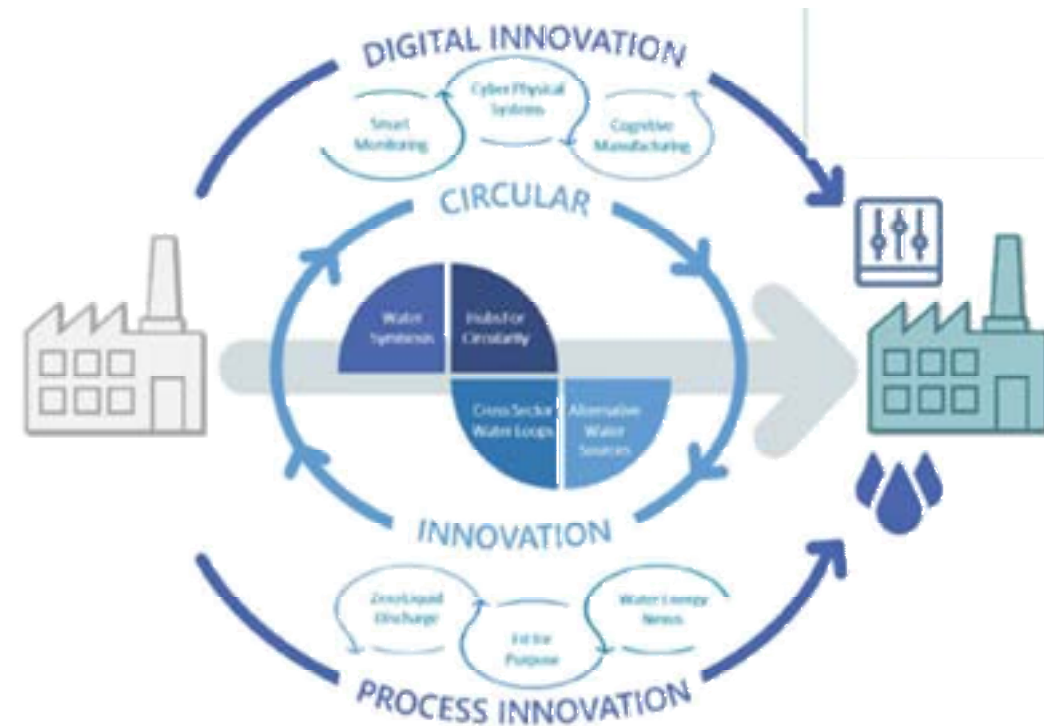
KWR

- Research-based since 1973
- Independent not-for-profit entity since 2006
- +/-210 employees: +/- 170 researchers
- Main goal: sustainable water provision in the entire water cycle
- KWR is a WHO Collaborating Centre on Water Quality & Health



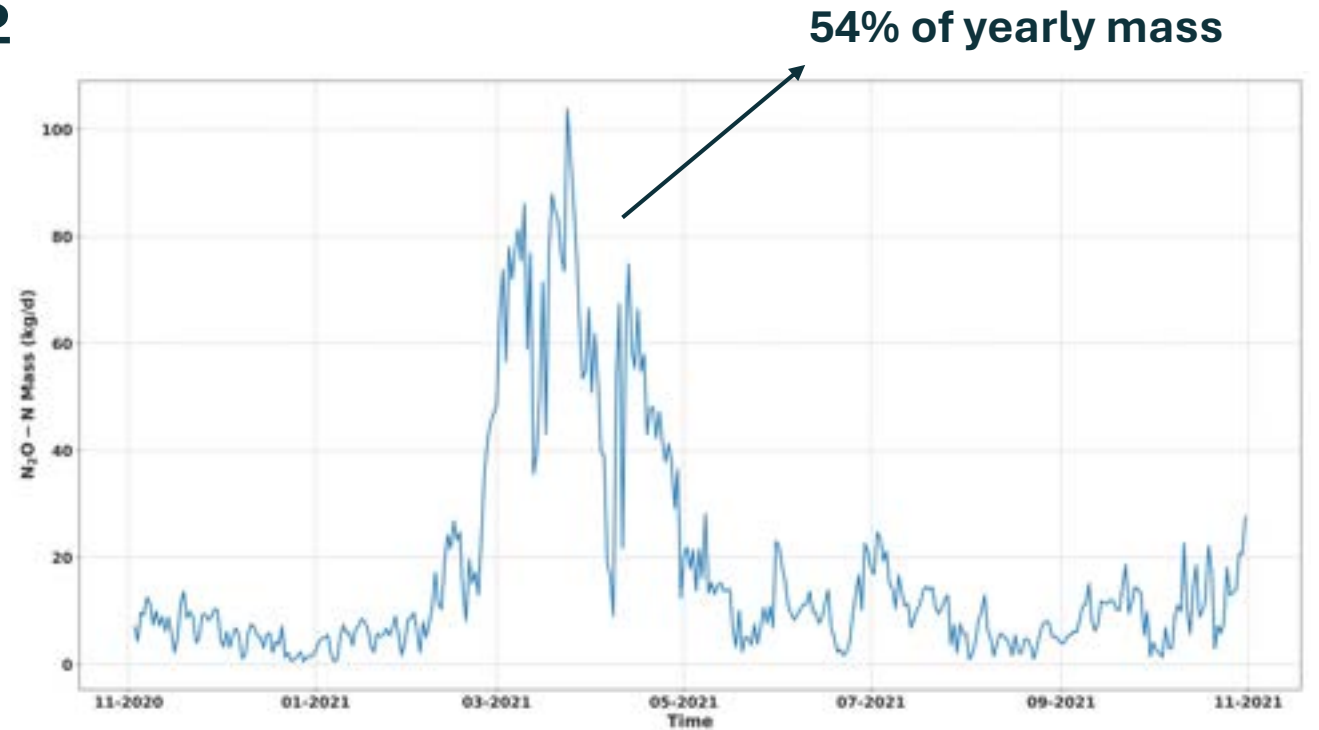
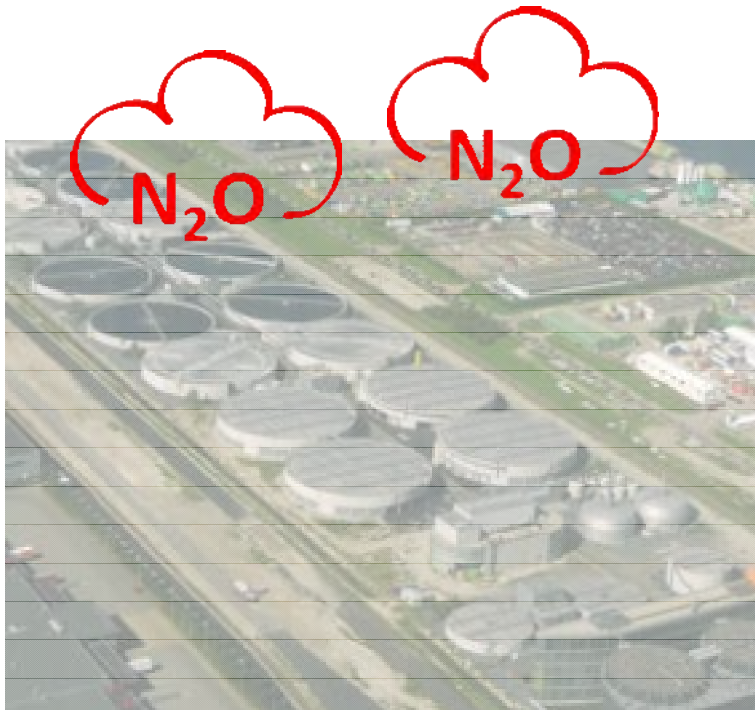
KWR at the forefront of wastewater treatment research

- Applied research, technology development and evaluation for wastewater treatment processes.
- **Water Line**
 - High effluent quality
 - Removal of organics, OMPs and PFAS
 - Primary, secondary, quaternary, and quinary treatments
- **Sludge Line**
 - Anaerobic digestion
 - Resource recovery
- **Reducing Carbon Footprint**
 - LCA studies
 - Mitigating scope 1 (N₂O, CO₂, CH₄) and scope 2 emissions (reducing energy consumption)
- Developing **digital technologies** to solve complex wastewater treatment challenges.



WWTPs a significant source of nitrous oxide (N₂O) emissions

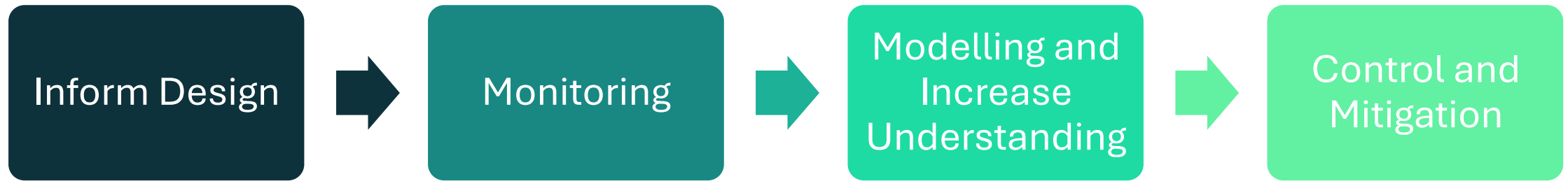
 = 273 times × CO₂



N₂O emissions from WWTPs show distinct seasonal variations

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Comprehensive Experience on N₂O Emissions Management in Wastewater Treatment



Advisory roles:



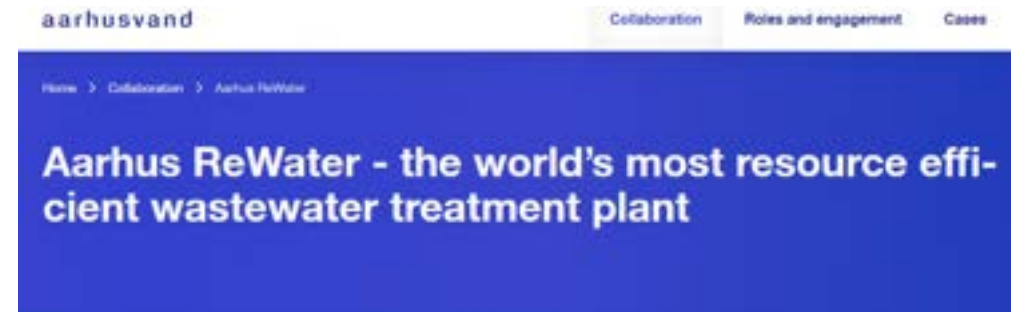
Advisory Expert Group: N₂O GWRC monitoring protocol



Expert Team: N₂O Acceleration Programme

Consider N₂O Emissions in the design of a large WRRF (ReWater) in Denmark

- Member of consortium for overall design of a new treatment plant for Aarhus Vand
 - Focus on ensuring design supports reduced N₂O emissions when operational.
 - Ambition: less than half the Emission Factor from the Danish standards (0.84%)
- Roadmap developed for the mitigation of N₂O emissions – from design to operations.
- Consideration of process optimization, N₂O mitigation technologies and more.



Monitoring, modelling and reducing nitrous oxide emissions from WWTPs

Public-private partnership project (TKI)

- Golden triangle: Knowledge institute, technology/service provider(s), end users(s)
- Project Duration: March 2023 – July 2027
- Diverse full-scale case studies:
 - AGS - Nereda®
 - CAS
 - AI-based predictive control
- Complementary research project with strong links to the N₂O national acceleration program



Project Lead & Knowledge Institute



KWR

Technology Providers – Monitoring Equipment



End Users – Water Boards

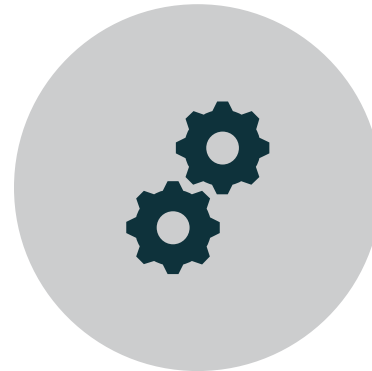




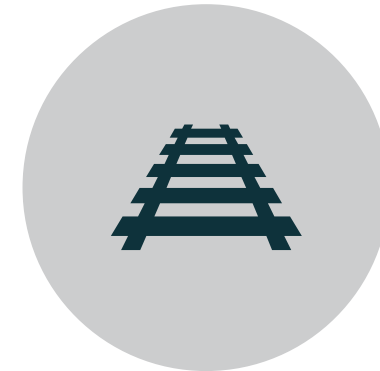
TKI Project Activities and Deliverables



***INTENSIVE MONITORING
AND DATA COLLECTION OF
N₂O EMISSIONS IN WWTPS.***



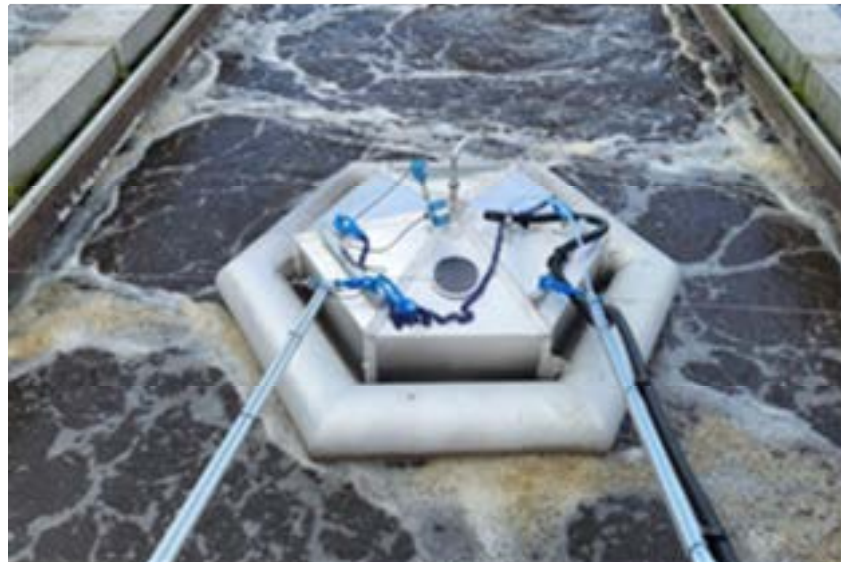
***DATA-DRIVEN MODELLING
OF N₂O PRODUCTION AND
FORECASTING EMISSIONS.***



***ROADMAP TO DEVELOP
MITIGATION STRATEGIES TO
REDUCE N₂O EMISSIONS.***

To learn more on
this project, scan
here →

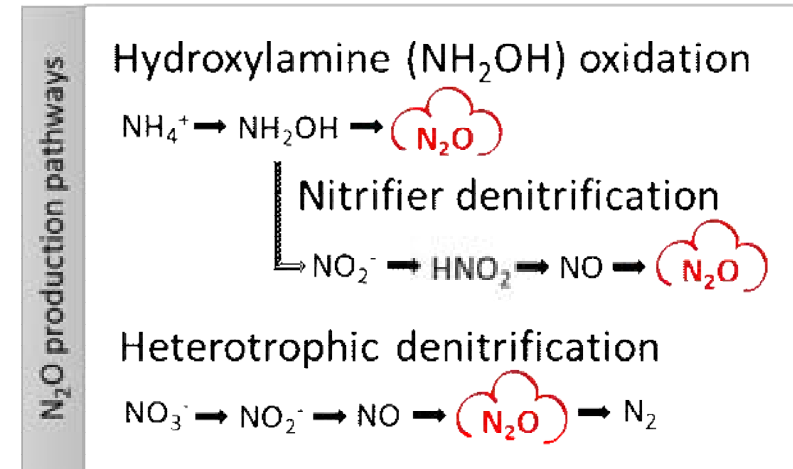
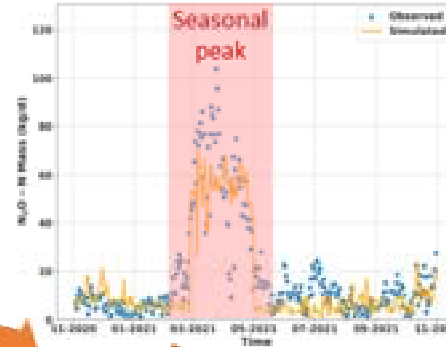
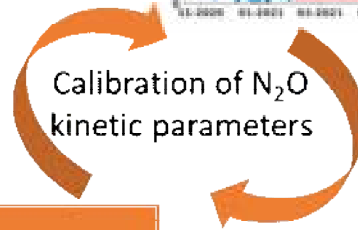
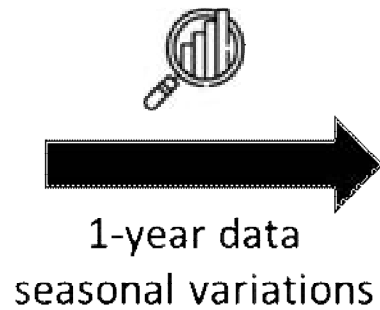
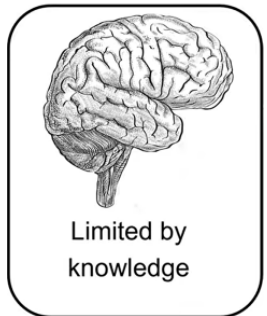




Biokinetical Modelling Seasonal Variations of N₂O Emissions



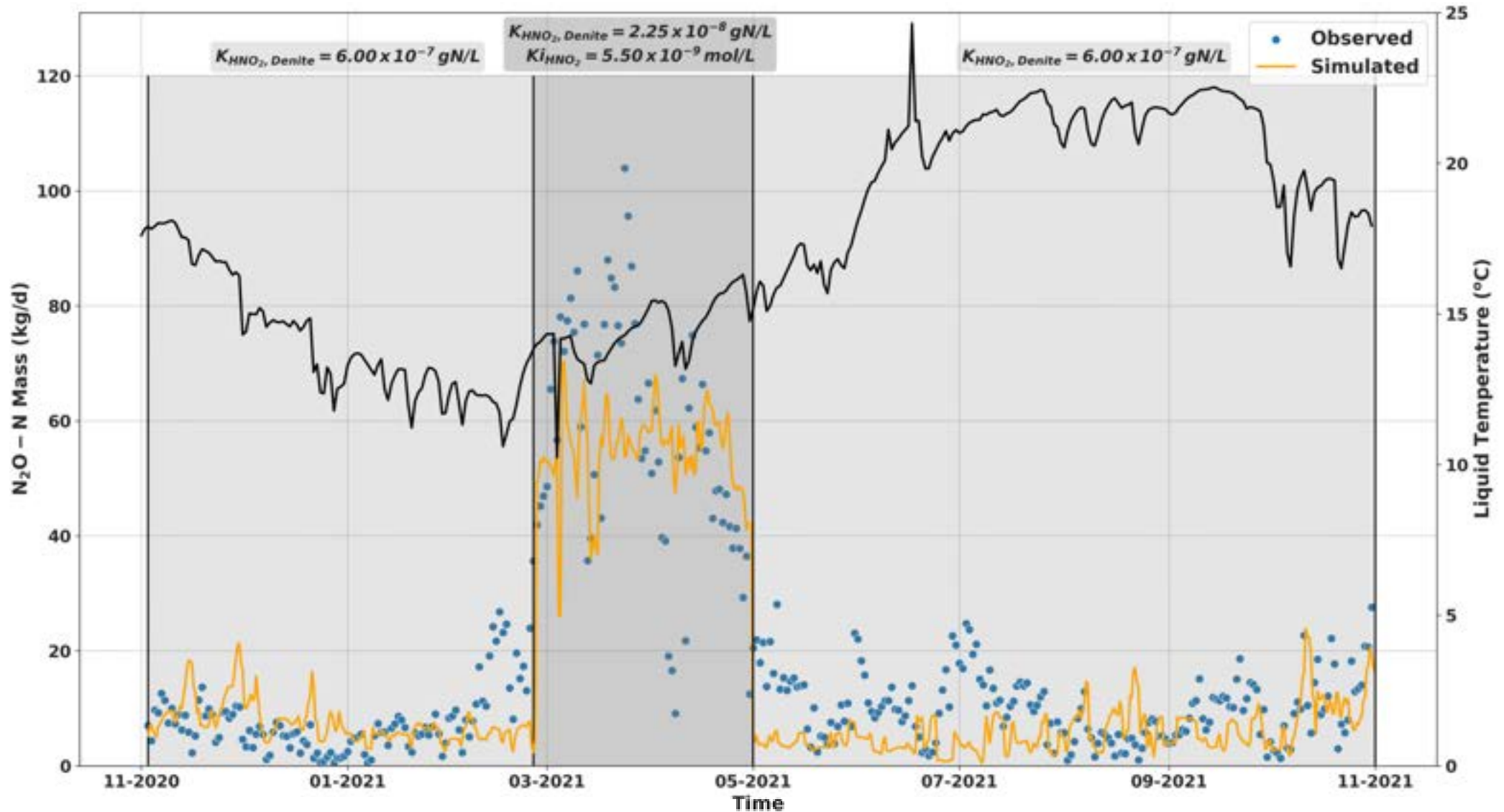
Mechanistic



Science of the Total Environment
 Limitations of a biokinetic model to predict the seasonal variations of nitrous oxide emissions from a full-scale wastewater treatment plant
 Authors: ...
 1. KWR Water Research Institute, Arnhem, The Netherlands
 2. Institute for Water and Wetland Research, Wageningen University, Wageningen, The Netherlands
 3. Department of Environmental and Water Management Engineering, Technical University of Denmark, Lyngby, Denmark
 4. Waternet, Amsterdam, The Netherlands

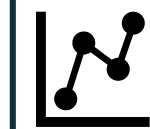


Unjustifiable Kinetic Parameter Adjustments Point Towards Missing Biokinetic Processes



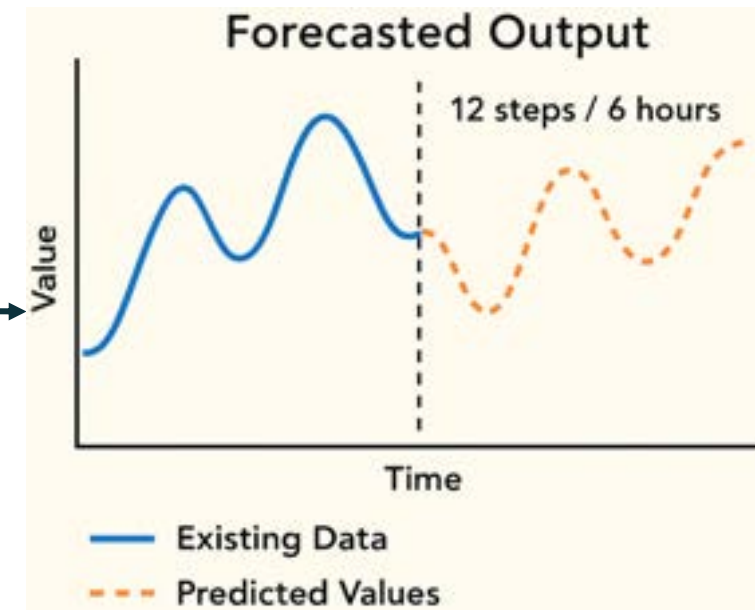
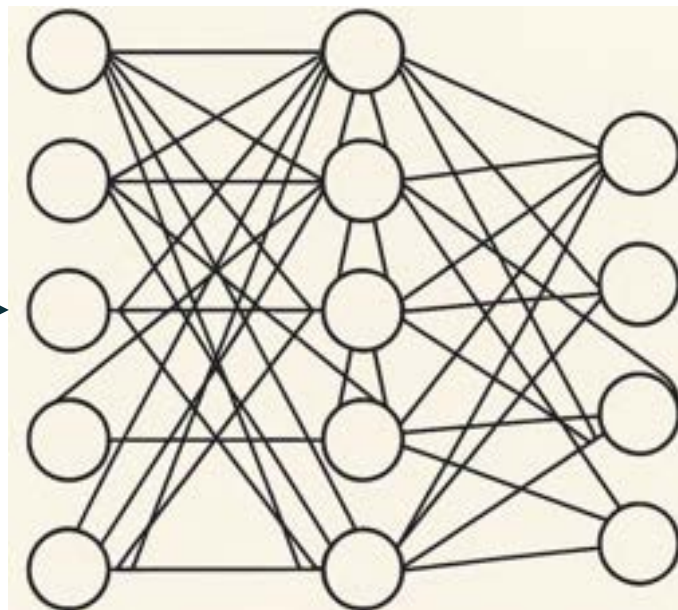
Modelling and Increase Understanding

Forecasting N₂O Emissions using Deep Learning Neural Network Models



Data on process and environmental conditions

Black-box deep learning models



Data-driven



Limited by data

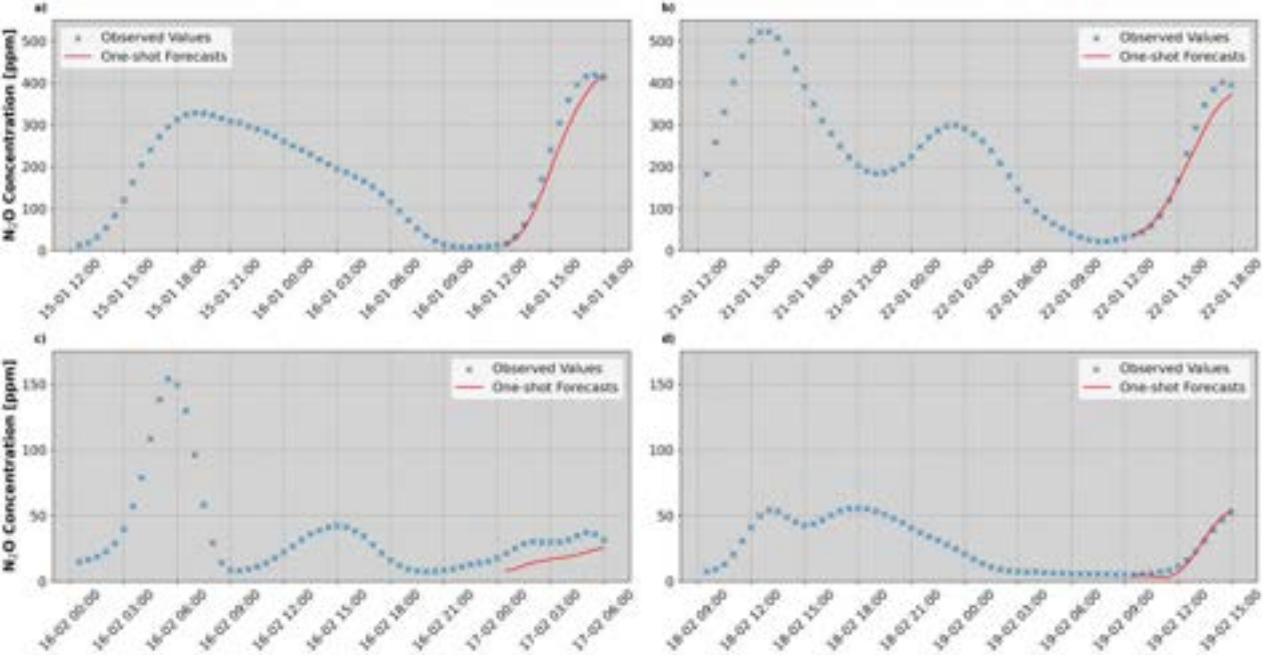


Forecasting nitrous oxide emissions from a full-scale wastewater treatment plant using LSTM-based deep learning models

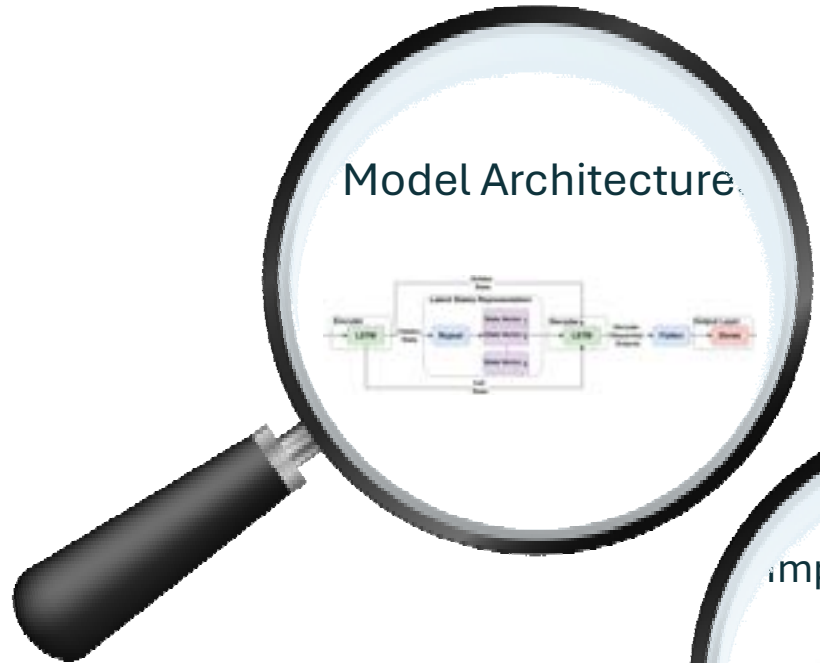
Wouter de Boer, J. B. J. M. (2023) Forecasting nitrous oxide emissions from a full-scale wastewater treatment plant using LSTM-based deep learning models. *Water Research*, 238, 119814. doi:10.1016/j.watres.2023.119814



Improving N₂O Emissions Forecasting but still a Black-Box with Limited Process Insights



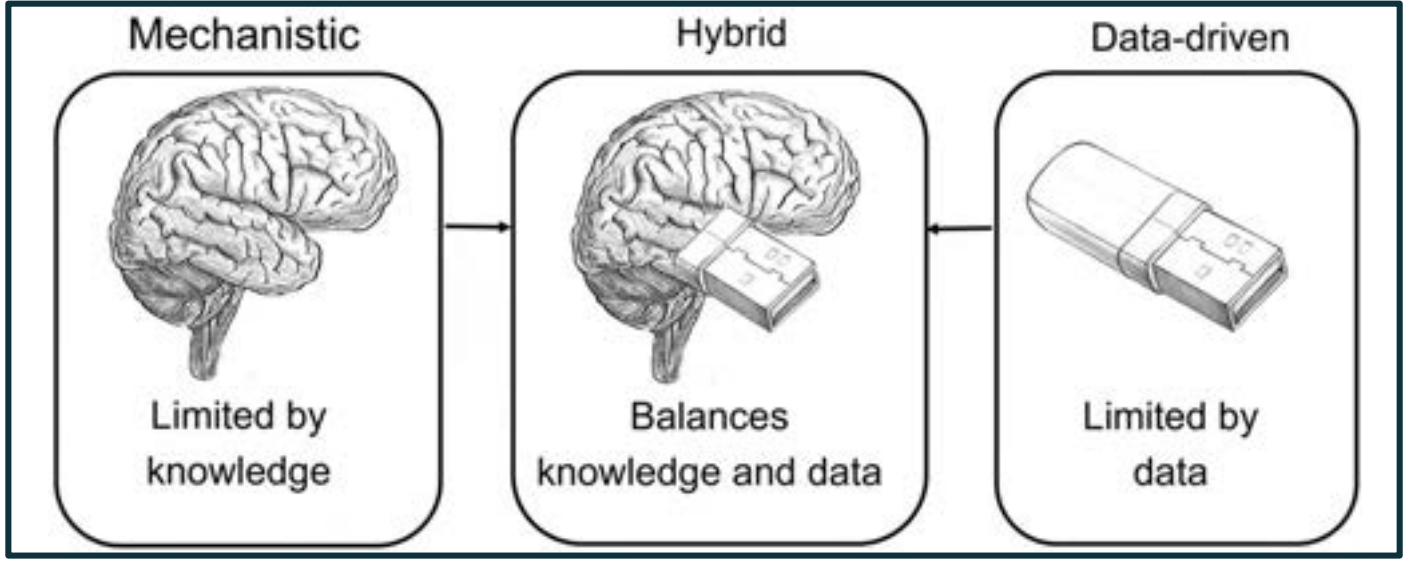
Examples of 6-hourly forecasts by best performing deep learning model



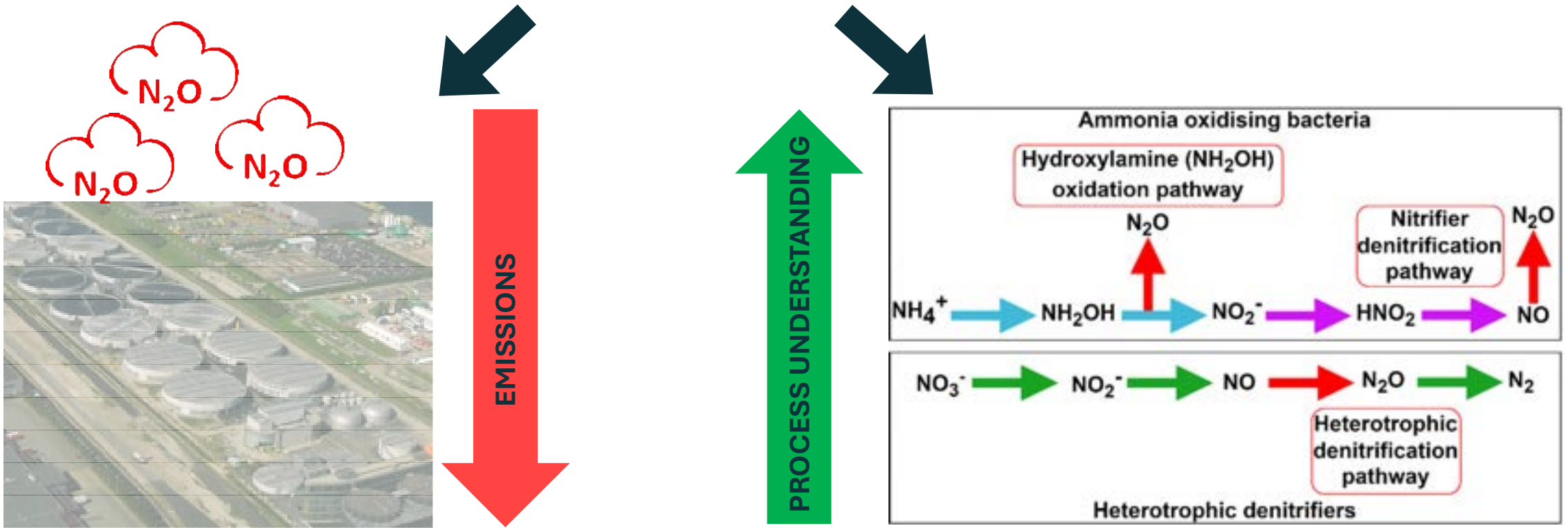
Model Architecture



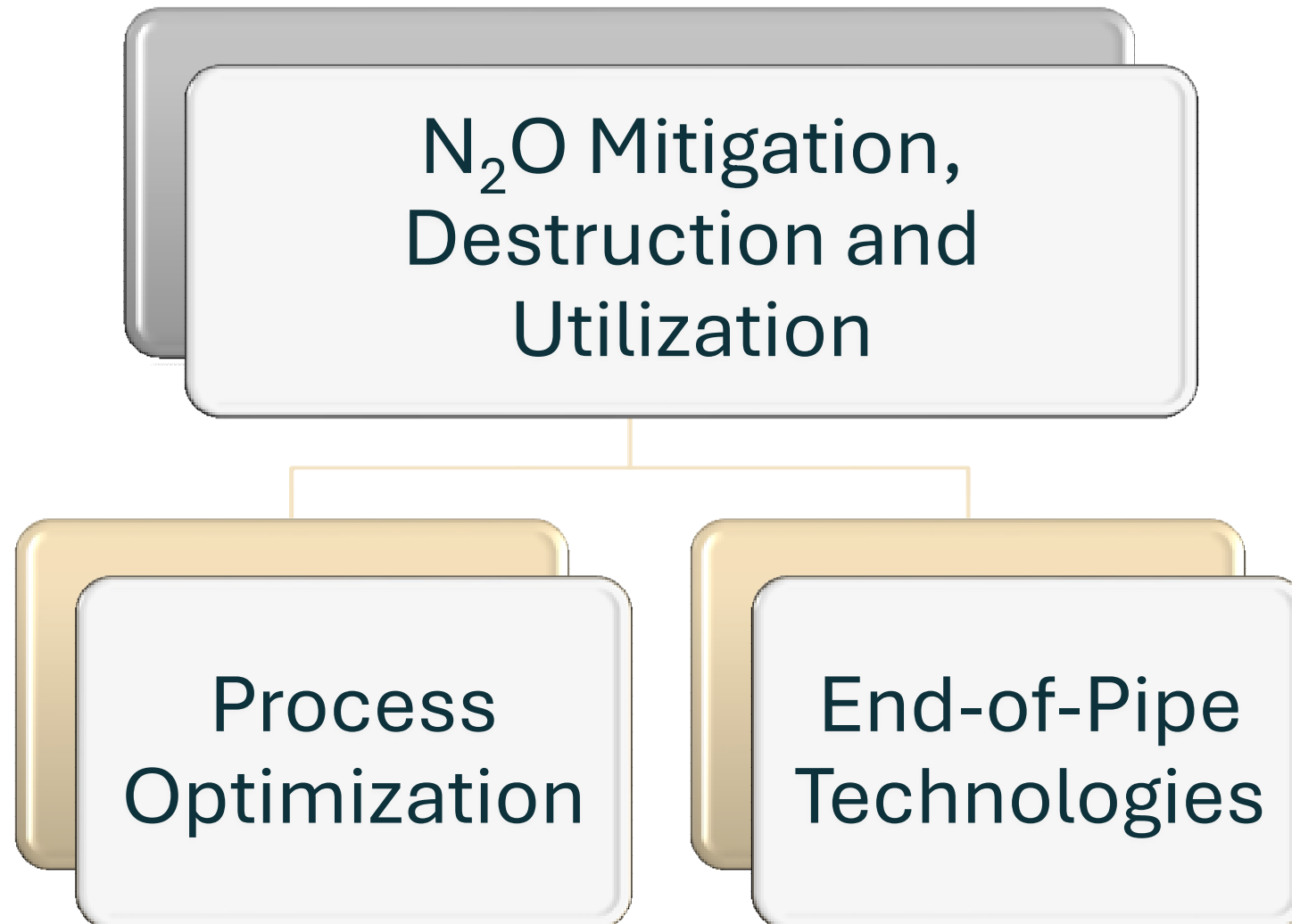
Process Data Importance for N₂O Forecasting



Elena Torfs presented in webinar – Data-driven modeling in the water sector: A paradigm shift in predictive methods (December 2025), IWA MIA Specialist Group



Moving towards N₂O Reduction & Mitigation Strategies



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