Dr Bing Guo
University of Surrey

Prof Tao Chen
University of Surrey
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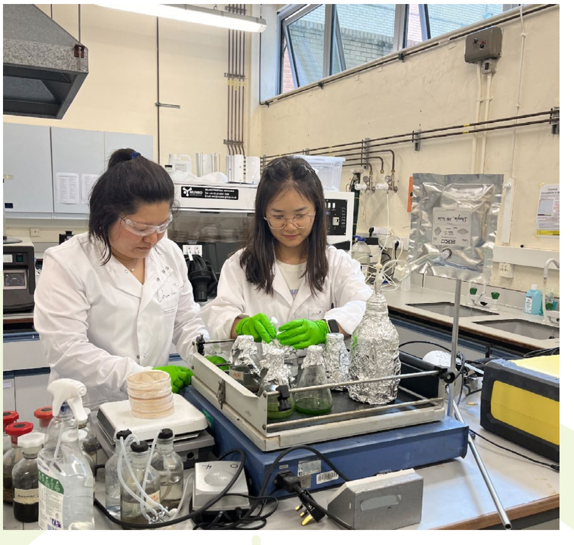
Mitigating N_2O emissions from wastewater treatment processes

"From an industrial perspective, this project offers a significant advancement in optimising wastewater treatment processes to minimize nitrous oxide (N_2O) emissions, a critical concern for sustainability and regulatory compliance. By integrating microbiology, process engineering, and AI-driven data analytics, the research identifies key factors that influence N_2O production in full-scale treatment systems like biological nutrient removal and partial nitrification/anammox. The application of AI models for predictive insights allows operators to implement targeted control strategies, enhancing operational efficiency and reducing emissions. Additionally, the project takes a pragmatic approach by considering data acquisition costs, resource constraints, and scalability, making it highly relevant for industry adoption in the push towards greener and more cost-effective wastewater treatment solutions" – **Water Industry Partner**

PROJECT

The UK has committed to meet net-zero targets by 2050 to avoid the worst effects of climate change. The water sector is the first to commit to net zero by 2030. According to the Water UK Net Zero 2030 Routemap, annual emissions are 2.4 $MtCO_2e$, and N_2O emissions from wastewater treatment are about 0.24 $MtCO_2e$, contributing to 14% of total emissions and 37% of the process emissions in wastewater treatment.

N_2O mitigation is a big challenge and represents one of the greatest uncertainties for decarbonisation interventions. Mitigation of N_2O emission faces several challenges, e.g., monitoring and measurement, data quality, biological mechanisms, and understanding process factor impact and control points.



RESULTS

This project integrated cross-disciplinary expertise from microbiology, process engineering, and data science, and combined valuable resources from research and the water industry to investigate key factors for N_2O emission in full-scale wastewater treatment processes (biological nutrient removal and partial nitrification/anammox). In-situ monitoring data and lab measurements were compiled and curated using several AI-based data cleaning methods. Then a selected subset of data was used to build, train, and test a variety of AI models for feature engineering and model prediction.

With input from microbiology, engineering and process control knowledge, key features of high importance to N_2O emission were identified, suggesting in-process control strategies for N_2O mitigation. The AI models' real-world applications also considered data acquisition strategy, cost and capacity. In the second part of the project, microbial samples were collected from every process unit of a full-scale treatment system and analysed using metagenomics and bioinformatics tools. Process alteration of the side-stream ammonium removal unit was shown to have a significant impact on the nitrogen cycle, nitrogen balance, microbiome composition and functional pathways and N_2O emission, emphasising the importance of holistic process control for N_2O mitigation.

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