



**Dr Bing Guo**  
**Prof. Tao Chen**  
University of Surrey  
POC202204



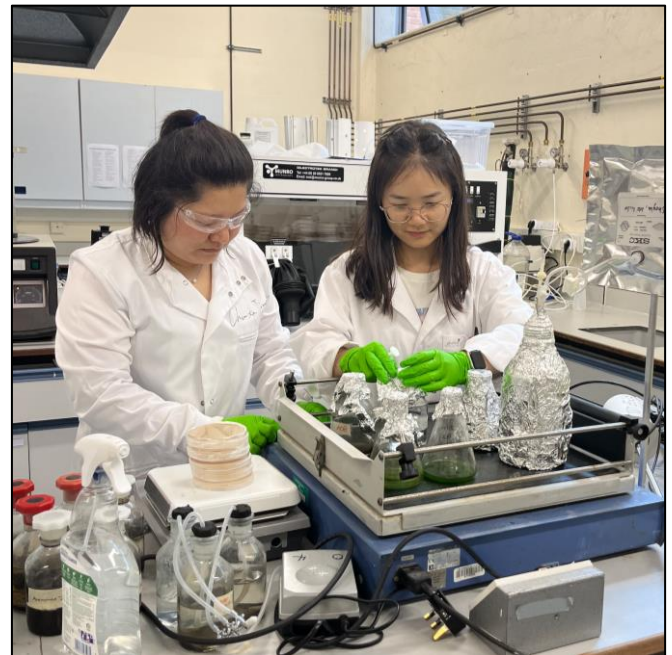
## Mitigating N<sub>2</sub>O emissions from wastewater treatment processes

“From an industrial perspective, this project offers a significant advancement in optimising wastewater treatment processes to minimize nitrous oxide (N<sub>2</sub>O) 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<sub>2</sub>O 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.” – Industry Partner quote

### Project

The UK has committed to meet net-zero target by 2050 to avoid the worst effects of climate change. The water sector is the first sector to commit to net zero by 2030. According to Water UK Net Zero 2030 Routemap, the annual emission is 2.4 MtCO<sub>2</sub>e, and N<sub>2</sub>O emission from wastewater treatment process is about 0.24 MtCO<sub>2</sub>e, contributing to 14% of total emission and 37% of the process emissions in wastewater treatment process.

N<sub>2</sub>O mitigation is a big challenge and represents one of the greatest uncertainties for decarbonisation interventions. Mitigation of N<sub>2</sub>O emission faces several challenges, e.g., monitoring and measurement, data quality, biological mechanisms, and understanding process factor impact and control points.



### Results

This project integrates cross-disciplinary expertise from microbiology, process engineering, and data science, and combines valuable resources from research and water industry to investigate N<sub>2</sub>O emission and key influential factors in full-scale wastewater treatment process (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 the aims of feature engineering and model prediction.

With input from microbiology, engineering, and process control knowledge, key features of high importance to N<sub>2</sub>O emission were identified, suggesting in-process control strategies for N<sub>2</sub>O 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 the full-scale wastewater treatment system and analysed using metagenomics and bioinformatics tools. Process alteration of the side-stream ammonium removal unit was shown to induce significant impact to the nitrogen cycle, nitrogen balance, microbiome composition and functional pathways, and N<sub>2</sub>O emission, emphasising the importance of holistic process control for N<sub>2</sub>O mitigation.