EBNet POC2022 Summary Sheet – Funded Projects

POC202204

Dr Bing Guo, University of Surrey (£100K cross-disciplinary award)

Mitigating N_2O emission from wastewater treatment processes

Proposal Summary

Wastewater industry confronts challenges to meet net zero by 2030 in advance of UK's 2050 goal. There is a need for urgent action to mitigate greenhouse gas (GHG) mission. Nitrous oxide (N_2O) contributes to 14% of total emission and 37% of the process emissions in wastewater treatment processes, produced by multiple microorganisms and fluctuates in the dynamic reactor environment. Operational factors have been investigated on how they affect N_2O emission using "black-box" experimental or modelling approaches, which provide limited understanding of the underlying biochemical mechanisms and thus unsatisfactory efficacy in N_2O control.

The primary challenge is the difficulty in identifying N_2O production pathways and quantifying contributions of the pathways. Major biochemical pathways of N_2O production include Hydroxylamine oxidation, Nitrifier denitrification and Heterotrophic denitrification, which are not easily differentiated using routine analytical methods, despite that the total N_2O can be monitored by online real-time sensors. The second challenge is how to implement the process data, analytical measurements, and microbial pathway knowledge into models with high accuracy and predication power and use sensitivity analysis to inform process design and operation management to control N_2O emission.

Using the project collaborator (Thames Water)'s full-scale biological nutrient removal and partial nitrification/anammox systems as case studies, we propose a combination of interdisciplinary methods - analytical chemistry, molecular biology, and computer modelling - to develop a reliable and robust toolkit to address the two challenges above. This toolkit will have the potential for practical application to existing and future full-scale wastewater treatment systems for N_2O emission control.

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POC202207

Dr Elizabeth Heidrich, Newcastle University (£100K cross-disciplinary award)

Pure biomethane - rather than biogas - from a single waste stream

Proposal Summary

Separation is one of the most challenging aspects of any recycling process: anaerobic digestion of wastes is no exception. AD plants produce biogas, a mixture of methane and CO2. Biogas upgrading to biomethane is attractive, yet fairly expensive, requiring multiple treatment steps, and some methane (with high global warming potential) is lost in the CO2 off-gas. We have developed a concept for an autarkic stand-alone approach to produce pure biomethane.

Anaerobic digestion results in a mixture of CH4 and CO2, while anaerobic treatment in a Microbial Electrolysis Cell (MEC) results in pure CO2 and protons and electrons. Our concept is to couple these two systems, using the electrons generated in the MEC to reduce CO2 in the AD compartment to methane resulting in a system with two products: pure biomethane and pure CO2. Coupled MEC-AD technologies exist, and are beginning to be commercialised (e.g. WASE - https://wase.co.uk/), these use the advantage of MEC's to work at low temperatures, but do so in open tanks resulting in mixed biogas. We propose a new MEC-AD concept - by manipulating the bioreactor space using bioelectrochemical and membrane technology, we will deliberately and intelligently separate the functionality and outputs of the microbes into separate compartments, thus separating the gaseous products into pure CO2 and pure CH4. This has the potential to be a simple retrofittable upgrade to all AD reactors which would deliver improved environmental protection and enhanced resource recovery. The approach also has the potential for wide scale use throughout the biotech industry.

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POC202214

Dr Zhugen Yang, Cranfield University (£50K single discipline)

CRISPR/Cas-enabled paper-based sensors for rapid monitoring of antimicrobial resistance

Proposal Summary

Environmental contamination with pathogenic bacteria and chemical pollutants is a global issue. However, current analytical methods for environmental samples are challenged by the complexity and heterogeneity of the matrices, as well as the ultralow concentrations of the analytes. Recently, beyond its extraordinary genome editing ability, clustered regularly interspaced short palindromic repeats and CRISPR-associated systems (CRISPR/Cas) have initiated a new era of biosensing applications due to their high base resolution and isothermal signal amplification, providing ultrasensitive, single-molecule level, and highly specific sensing. This capability can significantly improve the detection of low-level contaminants (such as antibiotics, including β-lactams etc.) in wastewater samples and aid in interpreting the detection with the engineering method onto devices for point-of-need monitoring (e.g., paper-microfluidic analytical device). This project aims to develop a novel, ultra-sensitive, and low-cost sensing platform to identify chemical pollutants in the environment, which will leverage the CRISPR/Cas platform to offer a range of next generation of environmental sensors for rapid and on-site monitoring of chemical contaminants. By deploying these portable sensors, the applicants will obtain data on contamination patterns and dynamics, which in turn will provide the ability to not only rapidly respond to the contamination, but also design new surveillance systems and build new understandings of the pathways taken by the contaminants in the environment. In future, the proposed sensing platform will also enable source tracking and monitoring in the wider environment (e.g., agricultural processes), including antimicrobial resistance genes, heavy metals, and other contaminants of emerging concern, thus providing a cornerstone in solving challenges arising to maintain a healthy population and ecosystems.