

Introduction

The demand for mineral and energy resources is increasing rapidly due to the growing world population and rising economies. Organic waste generated by humans alone has an energy content of ca. 600 – 1200 TWh/yr. Energy use for a domestic aerobic wastewater treatment plant treating 1000 m³ of wastewater daily is estimated at 2-4 x 10^3 kWh per day.

Microorganisms play a central role in global elemental cycles. Metal oxide reduction can account for 30-90% of organic carbon turnover in marine sediments and may be highly significant for organic carbon mineralization in low sulfate environments.



Microbial metal oxide reducing bacteria have evolved mechanisms that allow them to transfer electrons to solid phase electron acceptors are exploited in microbial bioelectrochemical systems with electrodes as e⁻ acceptors/donors.

University Chemviron University of Glasgow Carbon T ΤΛΤΛ UNIVERSITEIT TATA STEEL SPECIAL ANODES B.V. GENT Microbial ecology modelling **Bioremediation&Bioproduction** Carbon Materials **Metal recovery & CO₂ reduction** Anode catalysed Cathode applications: by (1) $M^+ + e^- \rightarrow M$ M: metal, H_2 microorganisms (2) $CO_2 + 2H^+ + 2e^- \rightarrow HCOOH$ wastewater Organics Cathode catalysed Membrane by microbial or chemical catalysts CO_2 ≽H⁺━→ H⁺ **e**⁻ External power supply For MEC Economic MANCHESTER Microbial metal evaluation 1824 reduction

In Bioelectrochemical Systems (BES), living microorganisms convert chemical energy from organic waste into electricity or hydrogen or other chemical products using microbial electrolysis cells (MECs)). This emerging technology can provide the solution to combine waste treatment and resource recovery with positive impacts on the environment and society. Main BES applications to explore: a) metal recovery from wastewater; b) CO₂ reduction to produce valuable chemicals; c) salt recovery and energy production.



Resource recovery from wastewater with **Bioelectrochemical Systems**

Bioelectrochemical Systems

Benefits of the approach environment & the economy: • Reduction of energy required for wastewater treatment process • Sustainable production/recovery of high value substances from waste • Renewable energy and resource **Salt recovery & Energy generation** School of Chemical Engineering &Advanced Materials **Newcastle** NORTHUMBRIAN WATER **University** Wastewater Methane Civil Engineering &Geosciences (organic matter) Saltwater Hydrogen gas Integrated BES combining wastewater treatment and resource recovery Anode Cathode Freshwater **Biochemicals** Acetate Treated membrane H_2O_2 wastewater - Caustic arrays Contact **Professor Ian Head (PI)** e **Prof of Environmental Microbiology** Email: <u>ian.head@ncl.ac.uk</u> Tel: +44 (0) 191 246 4806 Waste water School of Civil Engineering and Geosciences Newcastle University, Newcastle upon Tyne, NE1 7RU, UK Dr. Eileen Yu (Col), Email: <u>eileen.yu@ncl.ac.uk</u> MEC **Professor Keith Scott (Col) Treated** water **Prof of electrochemcial Engineering** WH Partnership University o Email: keith.scott@ncl.ac.uk South Wales Sludge Prifysgol De Cymru **Professor Tom Curtis (Col)**

System development & scale up

The main objectives:

The use of BES for resource recovery benefits both the



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Aims and Objectives

To develop integrated BES to use the energy in waste and biomass to recover valuable mineral resources.

• Identify novel approaches that can be used for resource recovery using an integrated bioelectrochemical system combining anodic organic carbon oxidation and cathodic reductions as a first step towards an integrated system

• Carry out economic and environmental impact evaluations on the processes and systems based on mass-energy balance, material/energy requirements and thermodynamics.