PROJECT TITLE: Electric soils: using bacteria as mini power stations for sustainable energy

DTP Research Theme(s): Dynamic Earth, Living World, Changing Planet

Lead Institution: University of Bristol

Lead Supervisor: James Byrne, University of Bristol, School of Earth Sciences

Co-Supervisor: Mirella Di Lorenzo, University of Bath, Department of Chemical Engineering

Project Enquiries: james.byrne@bristol.ac.uk

Project keywords: Biogeobatteries, Microbial fuel cells, energy resources, microbial cycling

Microbial Fuel cells (MFCs) and Microbes: (A) Schematic of a MFC. A biofilm of bacteria (e.g. Geobacter sulfurreducens) donates electrons to an anode. Electrons travel from the anode to the cathode through an external circuit and reduce oxygen to form water. Redox cycling leads to current which can be used to power a device. (B) Iron reducing bacteria associated with magnetite iron minerals can improve MFC performance.

Project Background

Access to energy resources is critical to global development and, considering the climate emergency, we need to develop alternative ways to extract and store energy. An underexploited approach takes advantage of bacteria which have been shuttling electrons between one compound or another for billions of years. Despite the ubiquity of these “mini power stations” in every ecosystem on Earth, we have only just begun to scratch the surface of what they are capable of. In recent years, the ability for different types of iron breathing bacteria to use iron based biogeochemical batteries (biogeobatteries) has emerged. Biogeobatteries are mixed valence iron minerals containing both reduced and oxidized forms of iron that can sustainably act as electron sources or sinks without undergoing physical transformation. This broad definition of a biogeobattery potentially applies to a wide range of mineral phases such as iron oxides, iron-bearing clays, sulphides or green rust. Consequently, such minerals could be responsible for an as yet unknown, and potentially massive, proportion of energy transfer in subsurface environments. In this interdisciplinary project, which has relevance to all three DTP research themes (Dynamic Earth, Living World, Changing Planet), the student will develop a fundamental understanding of how bacteria exchange electrons with biogeobatteries and initiate the advancement of low-cost, low-power energy storage devices for remote locations.

Project Aims and Methods

The aim of this project is to develop new ways of exploiting energy production by iron metabolizing bacteria in microbial fuel cells supplemented with natural biogeobatteries. More specifically, the student will:

- Synthesize/extract mixed valent iron minerals (biogeobatteries) under controlled laboratory conditions
- Apply electrochemical methods and construct innovative MFCs
- Use advanced analytical methods including spectroscopy, electron microscopy and X-ray diffraction to build a mechanistic understanding of how bacteria exchange electrons with biogeobatteries
- Develop methods for energy recovery from soils and sediments using MFCs
This interdisciplinary project covers a broad range of research areas including environmental sciences, chemistry, microbiology and engineering. The project will look at how we can use bacteria as natural power stations to improve access to sustainably energy sources and reduce environmental impact associated with our technologically driven world. The project will provide the student with the opportunity to develop as an independent researcher and shape their project with their own ideas from the beginning. Ultimately the student will develop skills that will provide a competitive edge for a future career in either academia, industry, or the private sector.

**Candidate requirements**
This project would be best suited for a student who has a passion for tackling environmental challenges, with a background in environmental science, (bio)geochemistry, microbiology, or another related field (preferably to MSc-level). Highly motivated multi-disciplinary students from other backgrounds will also be considered. The work will include the planning, setup and running of all experiments under the supervision of the supervisors including data analysis, presentations in group seminars and at conferences, as well as writing of publications together with supervisors. The PhD student will be sent on relevant training workshops to learn new techniques where appropriate. We welcome and encourage student applications from under-represented groups. We value a diverse research environment.

**Training**
The student will be trained in a range of laboratory-based techniques including mineral synthesis, microbial cultivation, geochemical measurements and analytical methods including spectroscopy, electrochemistry and electron microscopy. They will be encouraged to participate in NERC GW4+ DTP training courses and be able to access training opportunities from Bristol and Bath such as lectures within BSc/MSc courses. Funding is provided for the student to present their research at a high-profile international conference and will be encouraged to apply for grants that support further travel opportunities.

**Background reading and references**

**Useful links**
http://www.bristol.ac.uk/earthsciences/courses/postgraduate/

**NERC GW4+ DTP Website:**
For more information about the NERC GW4+ Doctoral Training Partnership please visit
https://www.nercgw4plus.ac.uk.

**Bristol NERC GW4+ DTP Prospectus:**
http://www.bristol.ac.uk/study/postgraduate/2022/doc doctor phd-great-western-four-dtp/

**How to apply to the University of Bristol:**
http://www.bristol.ac.uk/study/postgraduate/apply/

The application deadline is Monday 10 January at 2359 GMT.
Interviews will take place during the period 23 February – 9 March 2022.

**General Enquiries:**
Bristol NERC GW4+ DTP Administrator
Email: bristol-nercgw4plusdtp-admin@bristol.ac.uk