PROJECT TITLE: Biomagnetism & biogeochemical batteries: applications to achieving sustainable development goals

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

Lead Institution: University of Bristol

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Project keywords: Water quality, iron minerals, nanotechnology, spectroscopy, sustainability

Biogenic, magnetic, biogeochemical batteries containing mixed valent iron will be developed as a treatment method for improving water quality.

Project Background: Poor water quality, as a result of natural and anthropogenic drivers, is responsible for adversely impacting public and environmental health, and reducing agricultural productivity around the world. Providing cost-effective and simple to use methods for removing contaminants, e.g. arsenic, nickel, cadmium, lead, etc., at both small and large scales is thus critical to achieving several of the UN sustainable development goals (https://sdgs.un.org/goals).

Considerable research in recent decades has concentrated on harnessing the adsorption capabilities of iron minerals, which exhibit affinity for various toxic contaminants present in soils, water bodies, and solid-water interfaces. However, the focus has predominantly been on oxidized iron minerals, with insufficient attention paid to the significance of magnetic mixed valent iron minerals produced by bacteria (biomagnets). These mixed valent minerals, encompassing both Fe(II) and Fe(III), possess the unique potential to concurrently adsorb and facilitate the oxidation or reduction of problematic contaminants. By acting as sources and sinks for electrons (biogeochemical batteries), they offer an innovative approach to tackling a broader range of inorganic and organic pollutants.

Despite their promising attributes, the behaviour of mixed valent iron minerals as adsorbents for contaminants within environmental settings remains relatively unexplored. Consequently, a deeper understanding of the contaminant removal efficacy of mixed valent iron minerals within real-world contexts is essential.

Project Aims and Methods: The main aim of the project is to develop biogenic, magnetic, biogeochemical batteries to sustainably enhance water quality in different environments. At the fundamental level, the student will synthesise novel materials, and evaluate the interactions between them and inorganic contaminants under varying environmental conditions. The student will use this knowledge to subsequently address methods for improving water quality. The student will couple analytical and spectroscopic methods to conduct laboratory-based experiments on contaminants such as arsenic, cadmium, nickel, and lead in simulated and real world samples. They will use column studies to develop reactive transport models and elucidate how to optimise these novel materials for water treatment.
The student will also explore options to scale up processes. The core objectives of this project include: (1) determine the sorption capacity of different contaminants on mixed valent iron minerals; (2) evaluate the fate and kinetics of contaminants exposed to mixed valent iron minerals in simulated and natural groundwater; (3) design systems which can be upscaled for treating contaminated water. The student’s involvement in project design and research direction will be essential to ensuring a successful outcome.

**Candidate requirements:** This project is suitable for a student passionate about solving environmental issues with sustainable solutions for a better climate. The student will have a background in environmental science, chemistry (bio)geochemistry, or another Earth Science related field (preferably to MSc-level). Highly motivated multi-disciplinary students from other backgrounds will also be considered. The work will involve 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 highly value a diverse research environment.

**Project partners:** This project will take advantage of world leading research happening at two GW4 Universities Bristol and Cardiff. In particular, the combination of the School of Earth Sciences with the School of Engineering will help ensure technological development from fundamentals to application.

**Training:** The student will be trained in a range of laboratory-based techniques on water quality assessment, mineralogy, and water treatment. This includes mineral synthesis, microbial cultivation, geochemical measurements and analytical methods including synchrotron based tools, 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 Cardiff 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/](http://www.bristol.ac.uk/earthsciences/courses/postgraduate/)
- [https://envmin.github.io/bristolbiogeochem/](https://envmin.github.io/bristolbiogeochem/)

**Bristol NERC GW4+ DTP Prospectus:**
- [https://www.bristol.ac.uk/study/postgraduate/research/great-western-four-doctoral-training-partnership-nerc/](https://www.bristol.ac.uk/study/postgraduate/research/great-western-four-doctoral-training-partnership-nerc/)

**How to apply to the University of Bristol:**
Go to [http://www.bristol.ac.uk/study/postgraduate/apply/](http://www.bristol.ac.uk/study/postgraduate/apply/) and search for “Geology (PhD)”

Please note: If you wish to apply for more than one project please contact the Bristol NERC GW4+ DTP Administrator to find out the process for doing this.

**The application deadline is Tuesday 9 January 2024 at 2359 GMT. Interviews will take place from 26 February to 8 March 2024.**

**For more information about the NERC GW4+ Doctoral Training Partnership please visit**
- [https://www.nercgw4plus.ac.uk](https://www.nercgw4plus.ac.uk)

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