PROJECT TITLE: Selective recovery of critical metals from environmental and anthropogenic waste by biologically mediated fractionation

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

Lead Institution: University of Bristol

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Project keywords: Remediation, environmental minerals, heavy metal recovery, microbial cycling

Magnetic nanoparticles from microbial or geogenic processes can be found in almost every environment on earth. A) Magnetite will strongly respond to a magnet and can act as a sink for different metals. B) Magnetite formed in association with bacteria observed by Scanning Electron Microscopy.

Project Background

Critical metals (CMs) such as zinc, copper, lead, cobalt, as well as rare earth elements (REEs) are under increasing global demand as the consumption of devices dependent upon such metals continues to grow. However, the long-term supply and availability of such metals are under strain, with extremely low rates of recycling meaning that more sustainable methods for CM recovery are required. The use of sorbent materials such as reactive, magnetic nanoparticles offers a promising solution for the extraction of CMs from a range of sources such as in ash material, from mine tailings, or wastewater. Magnetic nanoparticles, such as magnetite, are naturally occurring and can be produced via biogenic approaches which are low cost and sustainable alternatives to harsher chemical extraction methods. This project will investigate how biogenic magnetic minerals can be used to selectively extract, i.e. fractionate, different metals and CMs from different sources. The candidate will collaborate with the University of Bristol, The University of Exeter, and an industrial CASE partner (Indivus) to develop innovative solutions to a complex problem, as well as exploring the wider issue of metal contamination in environmental field sites.

Project Aims and Methods

The aim of this project is to develop new materials for the extraction of CMs through bioinspired processes. More specifically, the student will:

- Synthesize magnetic nanoparticles under controlled laboratory conditions
- Use advanced analytical methods including spectroscopy, electron microscopy, synchrotron techniques and x-ray diffraction to build a mechanistic understanding of how CMs bind to reactive nanoparticles
- Develop methods for selectively targeting specific CMs
- Collect samples from several field sites where CMs have been identified as present in waste waters, biosolids and mine tailings in the South West of England (e.g. Wheal Maid, Cornwall; the County Adit, Cornwall; Poldice, Cornwall)
- Collaborate with Indivus for obtaining CM contaminated materials, and gain experience with industrial process management, and environmental risk assessment

This interdisciplinary project covers a broad range of research areas including environmental sciences, chemistry, and biology in an emerging field of bioinspired metal recovery. The project will look at how we can use bacteria as natural factories for metal recovery to improve sustainability 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 with the opportunity to 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 problems, 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.

CASE partner
Indivus Limited is working with Clinipower Avonmouth LLP which operates a pioneering pyrolysis plant in Avonmouth for processing hazardous waste which largely consists of clinical and pharmaceutical waste. The process leads to the production of bottom ash material which will be used as one of the principle sources of CMs in this project. As part of the collaboration, the student will gain experience working with an industrial partner, developing skills in process management, environmental risk assessment, and provide analytical support.

Training
The student will be trained in a range of laboratory-based techniques including mineral synthesis, microbial cultivation, geochemical measurements and analytical methods including synchrotron based tools, electron microscopy and QEMSCAN. They will be encouraged to participate in NERC GW4+ DTP training courses and be able to access training opportunities from UoB and UoE such as lectures within BSc/MSc courses: Geomicrobiology; Soil and Water Contamination; Mine Waste Characterisation, Prediction and Treatment. 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/2021/doctoral/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 Friday 8 January 2021 at 2359 GMT. Interviews will take place during the week commencing 8th February 2021.

General Enquiries:
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