EBNet POC2020 Summary Sheet – Winning applications

POC2020001

Professor Andy Cundy, National Oceanography Centre (Southampton)

Enhancing PFASs Attenuation in Coastal brownfield Soils (EPACS): enhancing natural system attenuation capacity for a key emerging contaminant

Proposal Summary

The problem

Perfluoroalkyl substances (PFASs) are key emerging contaminants which have been used for over 60 years in a wide range of industrial applications (e.g. fire-fighting foams, adhesives, waxes, nonstick cookware etc.), with the result that they are now ubiquitous in environmental matrices. Several PFASs bioaccumulate in marine food webs, and so their presence in coastal brownfield soils is of significant concern – particularly given their recalcitrant and mobile nature. Current remediation technologies involve highly invasive interventions such as soil removal and off-site landfilling or incineration, sorption/stabilization through ex-situ soil mixing, and ex-situ thermal desorption with off-gas destruction.

The solution

EPACS will provide a Proof of Concept for the application of in-situ Enhanced Natural Attenuation approaches to PFASs contamination in coastal brownfield sites, by stimulating the natural adsorption and bioremediation capacity of coastal soils through targeted soil amendment or nutrient addition. Here we will assess the capability of zero-valent iron (ZVI) combined with highly sorptive biochar to enhance PFASs attenuation, improve soil functionality and stimulate local microbial communities to enhance breakdown of PFASs. Recent work in the USA has noted the ability of common soil bacteria to degrade PFAS, and here we will test this concept as part of an integrative, *in-situ* “gentle” bioremediation approach for PFASs in UK coastal brownfield soils, which aims to protect local estuarine ecosystems and circumvent the need for intrusive physical and chemical remediation methods which may limit subsequent land reuse.

……….

POC202008

Dr Tony Gutierrez, Heriot-Watt University

Bio-engineering of biochar for enhanced remediation of contaminated land

Proposal Summary

Based on a 2016 House of Commons report, there are ~300,000 contaminated sites in the UK with an economic value >£1 billion. Meanwhile, progress on remediation technologies has been lacked momentum. This project proposes an innovative systematic approach that will marry specific physicochemical properties of biochar with selected bacterial species for enhancing the bioremediation of soils contaminated with persistent priority pollutants. Our focus will be on polycyclic aromatic hydrocarbons (PAHs) and toxic heavy metals (i.e. Ni, Cr, Cd), including the metalloid arsenic (As) that are recognised as some of the most common and important contaminants in UK and European soils.

Our approach in this project is expected to result in a significant technological step forward in this field of soil pollution remediation because it will lead to producing new microbe-biochar composite materials (MBCs) that are tailor-made for the targeted and enhanced bioremediation of polluted soils. Specifically, the project represents the first synthesis approach taken to evaluate a range of waste feedstock source materials to matchmake biochar with microbes for soil pollution remediation, with state-of-the-art techniques used to characterise the biochar materials to identify which are best suited for the colonisation of specific bioremediation microbes. This work endeavours to take a scientific leap in demonstrating biochar as a cheap and effective, carbon negative matrix to marry with microbes for tailored and enhanced bioremediation of contaminated land, and which may form the basis of sustainable business opportunities in the UK, Europe and elsewhere on land reclamation.

…….

POC2020015 (Cross-discipline, max. £100K)

Dr Angela Sherry, Northumbria University

Fibre Highways: translocation of the microbiome for pollutant bioremediation

Proposal Summary

This proof of concept study will combine expertise in environmental molecular microbiology and material and textile science to demonstrate translocation of the microbiome along ‘fungal or fibre highways’ to facilitate pollutant biodegradation. The study will expand upon previous research into bacterial motility on fungal highways to investigate ‘fibre highways’ - the directional movement and dispersal of microbes on a range of natural and synthetic fibres, using a combination of growth experiments, visualisation technology, low-cost sequencing and bioinformatics. Outcomes will include a deeper understanding of the interactive dynamics of motility in hydrocarbon-degrading multispecies microbiomes along fungal mycelium and natural / synthetic fibres, with multiple potential areas of application. The preliminary data generated will facilitate the translation of fundamental science into biotechnological solutions that can be utilised in the bioremediation of environmental pollutants, taking the research from TRL1 to TRL3 with potential to advance to higher TRLs. The study will ultimately lead to the development of environmentally responsive textile systems composed of natural and sustainable material that could be used to e.g. increase the contact time of microbes with the pollutant for more efficient bioremediation or ‘seed’ polluted sites which are difficult to reach. The study will be of interest to the textiles industry, pharmaceutical companies treating wastes, and sustainability divisions of the oil and gas industry. Research into microbiome interactions, dynamics, dispersal and translocation on fibres in particular environments is also timely and relevant, given the current COVID-19 pandemic and the decision by governments for indoor self-isolation.

…….

POC202029

Dr Simon Gregory, British Geological Survey

Development of a monooxygenase gene-based assay to characterise 1,4-dioxane bioremediation potential

Proposal Summary

1,4-Dioxane is an "emerging contaminant", which is hazardous to the environment and human health. Its high solubility and the low degradability under some conditions, means that it can be a challenge to remediate. It is known that it can be degraded by some types of monooxygenase enzymes. In order to better understand the potential for bioremediation at different sites, more information is required about which enzymes in this broad family of monooxygenase enzymes are most important in biodegradation, and under what conditions. We will use a qPCR and DNA sequencing approach to tackle this. Existing literature will be reviewed to identify key monooxygenase enzymes thought to be important in bioremediation of 1,4-dioxane, and existing PCR primers sets will be aligned to gene sequences in available databases to select those with optimal coverage and specificity. Once optimized, these will be tested on samples from sites with 1,4-dioxane contamination. A DNA sequencing assay will also be developed which will provide information about the diversity of monooxygenase genes and identify addition monooxygenase targets. These data sets will be combined with physico-chemical data from the samples to evaluate the optimal conditions for bioremediation.

…….

POC202031

Dr Russell J. Davenport, Newcastle University

***In Situ* Monitoring of Wastewater Treatment Plant Microbial Communities for Better Treatment Management**

Proposal Summary

The measurement of microbial biomass is perhaps the single most important controlling parameter in the operation of wastewater treatment assets in an industry facing unprecedented challenges. Measurement of microbial biomass is reliant on a method that has remained unchanged for over 70 years and does not allow the fine control of dynamic wastewater treatment systems that is required for the 21st century. We have developed a flow cytometry (FCM) method that provides accurate, speedy and high throughput biomass measurements, phenotypic microbial community fingerprints and diversity metrics that could provide data in real time for the finer control of such assets. We are now able to further demonstrate and test such an application by simulating real-time FCM on full-scale activated sludge systems, the world's most frequently used type of wastewater treatment plant (WWTP). Working with project partners we will take advantage of in-situ, discrete auto-samplers at several failing and nonfailing full-scale WWTPs to collect influent, mixed liquor and effluent samples at high frequency. FCM bacterial biomass estimates, phenotypic microbial community fingerprints and diversity metrics will then be obtained using our semi-automated FCM method and links to plant failure examined. The design of a fully automated prototype system will be developed and costed, as will the costs and benefits of such a system to the wastewater industry. Such real-time monitoring of biomass and microbial community dynamics could transform industry operations, making activated sludge systems more efficient and resilient at a time when the industry faces unprecedented challenges.