The net effect of microbial siderophores on above- and belowground soil health

Supervisory team:
Main supervisor: Dr Elze Hesse (University of Exeter)
Second supervisor: Prof Angus Buckling (University of Exeter)
Prof Karen Hudson-Edwards (University of Exeter), Dr Abraham Kuijper (University of Exeter), Dr Julia Sanchez Vilas (Cardiff University)

Collaborators: Prof Andy Gardner (University of St Andrews)

Host institution: University of Exeter (Penryn)

Project description:

The production of mine waste comes at great socio-economic and environmental costs. There is a clear need for sustainable strategies that allow for rapid recovery of mining sites with minimal intervention. While researchers have started using microbes to clean up mine waste, they have mainly done so in the context of single species. But this is too simplistic: microbes work much better as a community in a division of labour. When different species work together to detoxify metals, this is predicted to improve remediation. However, not all individuals might pay their fair share and cheat the system. This classic problem is well understood in evolutionary biology for single species, but not at the community level. This project aims to understand the conditions under which different species and individuals work together to detoxify metals by focusing on a key social trait: siderophores.

Microbes release siderophores into the environment in response to metal stress, where they bind metals and prevent them from being taken up and killing cells. Because detoxification takes place outside of the cell, the system is open to the invasion of ‘cheats’. Community-wide siderophore levels are thus shaped by a balance between local detoxifying benefits and costs associated with exploitation. The first major aim of the project is to determine how theoretically important variables - notably tilling and fertiliser - affect siderophore production and detoxification.

Siderophores not only play a key role in driving social interactions between microbes, but also in plant-microbe feedbacks. These feedbacks are ubiquitous and a crucial determinant of their combined functioning. For example, plants and microbes produce signals that affect each other’s behaviour, often to mutual benefit. However, we have little understanding of how these interactions are affected by cooperation and conflict within the interacting microbial communities. The second aim is to determine how siderophore-based cooperation in the rhizosphere affects the efficacy of phytoremediation, which relies on the synergistic action between plants and microbes to clean up toxic metal waste. We will achieve these aims using a highly interdisciplinary approach. Depending on the preference of the candidate, these will include theory (Kuijper, Gardner), microbiology (Buckling, Hesse), metal chemistry (Hudsen-Edwards), soil biology (Hudsen-Edwards, Buckling, Hesse), and plant physiology (Sanchez Vilas, Hesse).