PROJECT PARTNERS: Elizabeth Rylott, University of York; Barbara Zeeb, Royal Military College, Kingston, Ontario, Canada; Kevin Chown, Kew Technology; Martin Atkins, Green Lizard Technologies

POCE3B028 BB/S009787/1

Tailoring nickel uptake capacity of willow for phytoremediation, biomass pyrolysis and metal recovery

"The E3B funding and E3B Network have been instrumental in helping us develop a strong academic–industrial collaboration, with the commitment and vision to develop and scale-up plant-based metal recovery systems."

PROJECT AIMS: Cost-effective technologies that recapture polluting metals for re-use and land remediation are urgently needed. This proposal investigates ways of improving nickel uptake in the biomass crop willow. The research examines ways to mobilize more nickel into the aerial tissues:
1. Investigate the effects of cyanogenic and plant growth-promoting (PGP) bacteria on nickel uptake and plant tolerance. 2. Use transcriptomics analysis to identify marker genes for Ni uptake and tolerance. 3. Establish Ni partitioning in leaf versus stem of high-biomass, Ni-tolerant lines. 4. Supply Ni-rich biomass to the University of York Green Chemistry Centre for Excellence for pyrolysis testing.

RESULTS: Do plant-growth promoting bacteria enhance uptake and tolerance to Ni? When bioaugmented with PGP, nickel-dosed plants tended to have lower biomasses and higher tissue concentrations of Ni than controls, but results were not significant, and more studies are needed. What are the key Ni response genes? The leaf concentration of Ni positively correlated with toxicity symptoms. However, high variability in the quality and quantity of the RNA extracted meant samples were unsuitable for subsequent analysis; a smaller scale experiment is underway.

Nickel toxicity symptoms in willow plants

The Ni-rich plant biomass has been used in experiments to optimise microwave pyrolysis at the Green Chemistry Centre for Excellence.

Technology readiness level: The project remains at TRL4, with partners actively seeking funding that will move the technology into field trials and towards testing at industrial scale (TRL5/6).

OUTCOMES & NEXT STEPS:

- The PI has submitted funding proposals to the NSF–UKRI Global Centres in Clean Energy and Climate Change, with Green Lizard and Kew Technology as partners. The proposal describes scale-up to field trials on Ni-contaminated soils and on-site testing of metal-rich biomass.
- Discussions with the project partners enabled the plant-based metal recovery technology to be broadened to include rare earth elements; funding for this project is via an E3B BIV.
- Papers: *Biologically bound nickel accelerated depolymerization of polyethylene to high value hydrocarbons and hydrogen* https://doi.org/10.1039/d2su00001f | *Plants to mine metals and remediate land* https://doi.org/10.1126/science.abn6337 | *Biologically bound nickel as a sustainable catalyst for the selective hydrogenation of cinnamaldehyde* https://doi.org/10.1016/j.apcatb.2022.121105
- The project and other E3B funding and activities helped PI Liz Rylott secure a permanent Senior Lecturer position at the University of York.
- Outreach: The PI was part of a team that produced a comic — Greenkid Issue #2 — on phytomining that is available for all KS2 and KS3 school children in the York area.