PROJECT PARTNERS: Liz Rylott and John Angus, University of York; Jake Barnes-Gott, Hive Energy

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Characterising fly ash wastes for phytomining of rare earth elements

"We were delighted to work with Liz and colleagues at the University of York. This funding has enabled us to visualise the potential of a phytomining project for REE recovery in the UK."

PROJECT AIMS: The project aimed to assess if hyperaccumulator species of plants, which can take up rare earth elements REEs at many thousand-fold concentrations in their tissues, can be used to recover REEs from fly ash wastes. We measured the REE content of UK samples of coal fly ash — a waste product from the burning of coal provided by Hive Aggregates. We then tested if hyperaccumulator plant species such as *Dicranopteris linearis* and *Phytolacca americana* can be used to recover REEs from coal fly ash.

OUTCOMES & NEXT STEPS:

- The results have enabled the partners to assess the viability of phytomining for REEs, namely does the % REEs in the ashed plant biomass exceed the financially viable threshold for subsequent recovery.
- The University of York is developing downstream methods, such as acid extractions and direct smelting, to recover REEs from the ashed plant biomass.
- The research has contributed to a BBSRC-funded project '*Engineering Biology Hub for environmental processing of metals*" that will support a five-year post-doctoral position and bioinformatics support.
- The project supported the career development of a summer placement student and supervision skills of a new technician.
- The project led to a Fulbright Visiting Scholarship for a researcher from North Carolina State University, working with the Rylott group on the project "*Novel Agricultural Products for Rare Earth Element Recovery and Processing from Coal Mining Wastes*"

RESULTS:

Our ICP-MS analysis confirmed that fly ash waste contained REEs at concentrations and elemental profiles similar to those reported in waste from other countries (300-600 mg/kg), albeit with a high pH.

Cuttings of the herbaceous perennial *P. americana* and the temperate fern *Dryopteris erythrosora* grown in compost containing pH-adjusted fly ash or compost artificially dosed with REEs were analysed. The growth, appearance, and biomass of *D. erythrosora* was unaffected by fly ash, while the biomass of *P. americana*, although still green and healthy, was reduced by ~50% in the presence of 50% and 90% fly ash.

Both species hyperaccumulated REEs from the artificially dosed soil at levels comparable to those previously reported; approx. 5mg/kg each of La, Ce, Nd, Sm, Gd, Yb and Y.

The REE profiles in fly ash-grown plants reflected those found in the fly ash but were ten-fold lower than those in plants grown in the artificially-dosed compost.

Analysis of soil water samples revealed a strong, negative correlation between pH and REE uptake.

Change in technology readiness level: 2 to 3

Researcher Ben Bruce growing plants that hyperaccumulate rare earth elements at the University of York.