

Bioengineering of a Plant System to Sustainably Remove Heavy Metals and to Harvest Rare Earth Elements (REEs) from Industrial Wastes

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Abstract : Rare Earth Elements (REEs) are critical metals for modern electronics, green technologies, and defense systems. However, due to their dispersed nature in the Earth's crust, frequent co-occurrence with radioactive materials, and similar chemical properties, acquiring and purifying REEs is costly and environmentally damaging, restricting access to these metals. Plants could serve as resources for bioengineering REE mining systems. Although there is limited information on how REEs affect plants at a cellular and molecular level, plants with high REE tolerance and hyperaccumulation have been identified. This dissertation aims to develop a plant-based system for harvesting REEs from industrial waste material with a focus on Acid Mine Drainage (AMD), a toxic coal mining product. The objectives are 1) to develop a non-destructive, in vivo detection method for REE detection in *Phytolacca* plants (REE hyperaccumulator) plants utilizing fluorescence spectroscopy and with a primary focus on dysprosium, 2) to characterize the uptake of REE and Heavy Metals in *Phytolacca americana* and *Phytolacca acinosa* (REE hyperaccumulator) in AMD for potential implementation in the plant-based system, 3) to implement the REE detection method to identify REE-binding proteins and peptides for potential enhancement of uptake and selectivity for targeted REEs in the plants implemented in the plant-based system. The candidates are known REE-binding peptides or proteins, orthologs of known metal-binding proteins from REE hyperaccumulator plants, and novel proteins and peptides identified by comparative plant transcriptomics. Lanmodulin, a high-affinity REE-binding protein from methylotrophic bacteria, is used as a benchmark for the REE-protein binding fluorescence assays and expression in *A. thaliana* to test for changes in REE plant tolerance and uptake.

Keywords : phytomining, agromining, rare earth elements, pokeweed, *phytolacca*

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