Title: Rare earth element remediation and recovery using lanthanide-binding tag induced *Escherichia coli*

As critical metals for clean energy technologies, consumer products, and military applications, rare earth elements (REEs) have been heavily mined, leading to an increased contamination problem from mining leachates. Biosorption is a promising technology that allows for remediation, recovery, and reuse of REEs present in complex aqueous solutions, but wild type cell surfaces are not highly selective for REE adsorption compared to some other metals. Lanthanide binding tags (LBTs) have been engineered onto the cell surface of *E. coli* to enhance REE biosorption. A multi-discrete site, constant capacitance surface complexation approach was taken to study rare earth adsorption to wild type and engineered cell surfaces. Engineered bacterial surfaces display high-affinity lanthanide binding tags as well as an increase in lower-affinity carboxyl surface site densities compared to the wild type, increasing both sorption capacity and selectivity for the REEs. Efficient *ex situ* recovery of REEs from mining leachates requires that the cells be immobilized in a flow-through system. Thus, we developed a dual porosity 1D reactive transport model for single- and mixed-REE adsorption to the engineered *E. coli* immobilized in non-sorbing, permeable polyethylene glycol diacrylate (PEGDA) beads. The model accurately predicts Nd breakthrough under varying inlet concentrations for columns of various sizes. Stability constants for REE surface complexation were computed for all of the lanthanides, allowing us to predict the separation efficiency and recovery of individual REEs. Our study successfully demonstrates the application of reactive transport modeling for microbial REE biosorption, facilitating the design of reactors for optimal recovery of REEs found in environmental fluids.