Treating PFAS-Impacted Bulk Soil: Evaluation of High-Pressure Thermal Treatment Technologies

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Background/Objectives. Remediation of per- and polyfluoroalkyl substances (PFAS)-impacted soils is a significant challenge for long-term site management. Soil treatments are currently limited to sorption and stabilization, and excavation and disposal (ITRC, 2020). However, there are emerging destructive high-pressure thermal treatment technologies for PFAS, such as supercritical water oxidation (SCWO), high energy electron beam (E-Beam), and hydrothermal alkaline treatment (HALT) that are promising because of their rapid reactions, mineralization of all contaminants, no byproduct creation, and scalability.

Overall, these technologies provide both heating and high pressures to the PFAS-impacted liquid streams in order to facilitate PFAS degradation. SCWO, for instance, is applied at the commercial scale and has been tested with liquid streams (e.g., IDW, concentrated AFFF, landfill leachate), as well as wastewater sludge and GAC/IX regenerants. SCWO utilizes the unique properties of supercritical water (temperature > 374 °C; pressure > 218 atm) to enable the destruction of PFAS in liquid and sludge streams. At supercritical conditions, water is able to facilitate chemical reactions, such as oxidation of PFAS, that do not occur under normal conditions. HALT on the other hand, involves the heating of liquid water in a sealed vessel to temperatures and pressures below supercritical conditions, typically 200-350 °C. Under these subcritical conditions, water has altered solvent properties that provide a reactive medium capable of catalyzing many reactions (Hao et al., 2022; Li et al., 2022). Destruction of PFAS is further facilitated under alkaline conditions via base-mediated mechanisms. HALT has been tested primarily with PFAS-impacted liquids such as groundwater and AFFF mixtures, as well as limited testing of impacted soil. Additional high-pressure thermal treatment technologies that are under consideration for this study include: high energy electron beam (E-Beam), smoldering, and ball-milling.

Approach/Activities. In this study, several thermal technologies will be used to evaluate treatability of PFAS-impacted soils. PFAS-impacted investigation derived waste (IDW) soils will be used for bench-scale testing and technology developers will then evaluate the following: i) decrease in target PFAS concentrations and treatment kinetics; ii) transformation or byproduct generation, if any; iii) effect of PFAS mixtures, co-contaminants, other soil quality parameters; iv) physical state of soil mixtures needed; v) energy usage; and vi) other data gaps.

Results/Lessons Learned. Results from bench-scale testing of SCWO and HALT will be presented. Key metrics include:

i) reduction in PFAS concentrations and treatment time;
ii) generation of any byproducts;
iii) scalability for soil treatment; and
iv) energy usage.