STAR and STARx – A Smouldering Solution to PFAS from Laboratory to Field

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Per- and polyfluoroalkyl substances (PFAS) have been identified by many regulatory agencies as being compounds of emerging concern within the environment. PFAS are commonly associated with fire training areas, aviation hangars, municipal fire stations, and transportation crash sites (due to the use of aqueous film-forming foam [AFFF]); however, consideration of the potential presence and risks associated with PFAS is expanding to wastewater treatment plants, landfills, and brownfields sites. PFAS can present many challenges for remediation given their chemical/physical properties, resistance to degradation and treatment by conventional approaches, and their rapidly evolving regulatory framework.

Smouldering is a self-sustaining (i.e., energy efficient), flameless form of combustion that can use low volatility, high energy contaminants as the fuel to support their own destruction. This approach is commercially available as the STAR (in situ) and STARx (ex-situ) technologies and has traditionally been used for the treatment of heavy hydrocarbons. Per- and polyfluoroalkyl substances (PFAS) do not support smouldering combustion in and of themselves, and their high thermal stability often requires temperatures greater than 900°C for destruction; however, a supplementary fuel can be used to reach these temperatures in a smouldering combustion reaction to facilitate the destruction of PFAS.

A study was conducted under the US Department of Defense (DoD) Strategic Environmental Research Program (SERDP) to evaluate the application of ex situ smouldering to treat PFAS-impacted soils and media with the use of low concentrations of granular activated carbon (GAC) as a supplementary fuel. The experimental program explored smouldering treatment at three scales: (1) laboratory column tests (~0.01 m3) to characterize the fluorine mass balance and explore the use of mineral amendments (e.g., calcium oxide [CaO]) to enhance the thermal decomposition of PFAS; (2) Intermediate Scale Reactor (ISR) tests (~0.3 m3) to evaluate scale and heterogeneity impacts on the efficiency of PFAS destruction; and (3) field pilot tests (~10 m3) at Canadian Forces Base (CFB) Trenton to evaluate the practical steps of implementing the technology at field scale.

Results to date have demonstrated reduction of PFAS concentrations in soil to near or below detection limits for tests across all scales. Both targeted PFAS analysis and particle-induced gamma emission (PIGE) were used to close the PFAS mass balance during smouldering based on tracking total fluorine (F-). Less than 1% of the total PFAS mass was found in emissions, with the removal of PFAS and fluorinated breakdown products in emissions to be achieved via vapour phase GAC. When spent, this GAC can be recycled for use as supplementary fuel in subsequent treatment batches.

This presentation will provide a summary of the results of the ex situ scale up and field pilot testing program, as well as an update on work in progress evaluating in situ smouldering of PFAS.

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Laura Kinsman, M.E.Sc., is a Project Professional at Savron. She completed her M.E.Sc. studies at the University of Western Ontario under the direction of Dr. Jason Gerhard and Dr. Jose Torero – co-inventors of the STAR technology. Ms. Kinsman joined Savron in 2014 and has been actively involved in system design, field operations, and project management at sites across North America and Asia, including pilot testing and full-scale applications of both in situ and ex situ smouldering remediation.