An Enhanced Contact Electrical Discharge Plasma Reactor: An Effective Technology to Degrade Per- and Poly-Fluoroalkyl Substances (PFAS)

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Background/Objectives. Historical use of aqueous film forming foams containing per- and poly-fluoroalkyl substances (PFASs) at Department of Defense (DoD) fire-training areas has led to concern for potential groundwater contamination at over 600 sites. Because current health advisory levels for PFASs are three to four orders of magnitude lower than concentrations measured at several DoD sites, there is a clear need to develop innovative, cost-effective treatment technologies that address the unique chemical properties of PFASs (e.g., high solubility, low volatility, emulsification behavior, recalcitrance) and overcome the limitations of current PFAS treatment methods (e.g., granular activated carbon [GAC], ion exchange [IX]). The objective of this Air Force Civil Engineer Center (AFCEC) Broad Agency Announcement (BAA) project is to demonstrate operation of an enhanced contact electrical discharge plasma reactor for the treatment of PFAS-contaminated groundwater at Air Force installations.

Approach/Activities. The Clarkson-developed technology is a “next-generation” gas-discharge plasma reactor that incorporates several innovations (e.g., integration of gas diffusers; shape of grounded electrode; recirculation of inert process gas) aimed at targeting PFASs in a variety of water sources and improving the efficiency of large-scale PFAS treatment. Key benefits of the plasma reactor over existing technologies include: i) simultaneous generation of OH radicals and reductive aqueous electrons for destruction of PFAS and other co-contaminants (e.g., trichloroethene [TCE], nitrate); ii) the technology requires no chemical additions and produces no residual waste; and iii) cost estimates for plasma-assisted removal of PFOA and PFOS indicate that the treatment is >50% less expensive than GAC.

This recently awarded BAA project (August 2017) consists of three phases: i) bench-scale testing of PFAS-impacted water from several Air Force sites; ii) follow-on laboratory testing of the plasma reactor to optimize operational characteristics with respect to site-specific groundwater quality; and iii) design, construction and operation of field-ready plasma reactor skid at an Air Force site.

Results/Lessons Learned. Previous experiments (Stratton et al., 2017) conducted with the prototype plasma reactor on PFAS-impacted groundwater from a navy site demonstrated that i) PFOA concentrations decreased 90% to below regulatory limits within 1 minute of treatment (at ~1 gallon per minute); ii) short-chain PFAS (C5 – C7) were transformed; and iii) co-contaminants (e.g., TCE) do not impact reactor efficiency. For the current BAA project, samples of varying water quality (e.g., concentrations of PFASs and co-contaminants, pH, specific conductivity, total dissolved solids, total organic carbon) from a minimum of five Air Force installations will be treated using the bench-scale enhanced contact plasma reactor. Preliminary results from this task are anticipated in January 2018 and will guide optimization of the full-scale reactor design.

The enhanced contact electrical discharge plasma reactor offers a reliable, cost effective method for treating PFAS-impacted groundwater. Plasma reactors will: i) eliminate the need to

“stretch” existing technologies (GAC, IX) to their operational limits; and ii) reduce associated waste and expenses at Air Force installations.

Stratton, G. R.; Dai, F.; Bellona, C. L.; Holsen, T. M.; Dickenson, E. R. V.; Mededovic Thagard, S., Plasma-Based Water Treatment: Efficient Transformation of Perfluoroalkyl Substances in Prepared Solutions and Contaminated Groundwater. Environmental Science & Technology 2017, 51, (3), 1643-1648.