An Innovative Plasma Technology for Treatment of PFAS-Impacted Water at Two Fire Training Areas

Stephen Richardson, Poonam Kulkarni, and Whitney Bailey (GSI Environmental Inc.)
Selma Mededovic and Thomas Holsen (Clarkson University and DMAX Plasma, Inc.)
Chase Nau-Hix and Will Knudson (DMAX Plasma, Inc.)
Heather Luckarift (Battelle)
Bridgett Ashley (Air Force Civil Engineer Center)

Background/Objectives. Aqueous film-forming foams (AFFFs) have been widely used as a fire-suppressant for fire-fighting efforts and training activities at hundreds of Department of Defense (DoD) installations nationwide. Ongoing assessment of former fire/crash sites has identified concentrations of PFOA, PFOS, and other PFAS in groundwater well above established health advisory levels. Based on their recalcitrant and often dilute nature, PFAS can be very challenging to remediate in groundwater environments and require technologies capable of breaking the stable C-F bond of the molecules and handling large volumes of water. The overall objective of this project, funded by National Defense Center for Energy & Environment, was to demonstrate operation of a mobile plasma treatment system for the treatment of various sources of PFAS-impacted water (e.g., surface waters, groundwater) at fire training areas. Based on previous successful field testing, a new plasma treatment trailer system was constructed incorporating multiple reactors enabling treatment of larger volumes and greater flowrates (up to 10 gpm), and addition of surfactants to enhance destruction of short-chain PFAS.

Approach/Activities. Field demonstrations were conducted at fire-training areas at Tyndall Air Force Base (AFB) and Fort Leavenworth Army Garrison. Source waters for the field demonstrations were i) surface water from a stormwater collection pond from Tyndall AFB and ii) shallow groundwater at Ft. Leavenworth. For each demonstration, several experimental conditions including flowrate, surfactant dose, and recirculation were tested to evaluate optimal treatment parameters for each source water. Both source waters contained elevated concentrations of PFAS precursors (e.g., 6:2 FTS, 4:2 FTS), long-chain PFAS (e.g., PFOA, PFOS, PFHpA), and short-chain PFAS (PFBA, PFBS, PFPeA). Maximum PFOA concentrations at Tyndall AFB and Ft. Leavenworth were over 6,000 and 2,000 ng/L, respectively; maximum PFOS concentrations were 9,000 ng/L and 13,000 ng/L, respectively.

Results/Lessons Learned. Key findings from the field demonstrations include:

- ***Treatment Capacity:*** Multiple reactors in series enabled the system to treat a volume of water with twice the reactor residence time. For the field demonstrations, 3,100 and 5,700 gallons of PFAS-impacted water were treated resulting in treatment rates of 190-230 gallons/hr.
- ***Precursors:*** Significant removal of PFAS precursors was achieved. At both sites, 6:2 FTS concentrations decreased by 98-100%. Some generation of 4:2 FTS was observed from the breakdown of longer chain precursors.
- ***Long-Chain PFAS:*** PFOA and PFOS concentrations were reduced to below the detection limit (<9 ng/L) at optimal operating conditions.
- ***Short-chain PFAS:*** The addition of surfactant significantly improved removal of short-chain PFAS including PFBS, PFPeA, PFPeS, and PFHxA. For example, at Tyndall AFB, short-chain PFAS removals of 77% to 100% were achieved after 75-165 minutes of total treatment time.
- ***Energy Use:*** Electrical energy per order (EE/O) of 6-24 kWh/m^3 was achieved.
- Results from the field demonstrations are very promising. The plasma treatment system offers an alternative technology for the destruction of PFAS in a variety of PFAS-impacted waters. It provides a cost-effective, reliable remedy without the need for off-site disposal (incineration) or costly GAC changeout.