Status of Gas-Based PFAS Remediation Technologies

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Background/Objectives. Currently there is an intense effort to research and develop new approaches for treating and managing PFAS-impacted water. These technologies fall into three general treatment categories: (1) ex situ nondestructive approaches that remove PFAS from water and other matrices to create concentrated PFAS streams; (2) enhancements to existing ex situ destructive technologies that break carbon–fluorine and carbon–carbon bonds to create nontoxic products; and (3) in situ nondestructive approaches that remove PFAS from water. The gas-based technologies are across the technology development spectrum from experimental to proven technologies.

Approach/Activities. Experimental, emerging, and proven PFAS remediation technologies were screened to determine which ones involve the use of gases in some way or another. An extensive literature review of PFAS remediation technologies, SERDP/ESTCP projects, and PFAS remediation survey articles (e.g., Ross et al., 2018; Meegoda et al., 2020; Newell et al., 2022) was conducted. Technologies that are being developed or being used to treat PFAS impacted water were compiled and summarized by development status (experimental, emerging, proven using the Pankow and Cherry (1996) technology pyramid; federally funded R&D projects (e.g., SERDP/ESTCP); and any other technology development metrics.

Results/Lessons Learned.

- Ex situ Surface Active Foam Fractionation (SAFF©) that is designed to remove PFAS from water streams by exploiting the tendency for some PFAS to partition on air-water interfaces. The technology has been used at a relatively large scale with high removal rates for key regulated PFAS (e.g., PFOS and PFOA). Large-scale treatment units are now being marketed by the technology developer, EPOC Enviro, via Allonia in the U.S.
- DMAX Inc. is using ex situ argon gas sparging to concentrate PFAS from the bulk liquid in a low temperature plasma reactor (“enhanced contact plasma”) where the PFAS is then destroyed by the plasma at the water interface. The developers have reported results in several journal articles and DoD reports.
- Several R&D groups are testing different aspects of using gases for in situ remediation of PFAS plumes. The ESTCP program has funded Geosyntec to evaluate D-FAS, an in situ, in-well foam fractionation process. ESTCP has also funded CDM Smith to test passive in situ treatment of PFAS-impacted groundwater using foam fractionation in an air sparge trench. Through the SERDP program, GSI Environmental and Colorado State University are performing laboratory tests of the gas sparging technology, focusing on optimizing sparge pulsing, biotransformation of precursors to PFAAs, performance thresholds, and other aspects of gas sparging to remove PFAS from aquifers. Additionally, Colorado School of Mines has investigated biotransformation of precursors due to biosparging (Nickerson et al., 2021).
- GSI Environmental has proposed that gas sparging in aquifers may be a useful Enhanced Attenuation (EA) technology, where sparging would separate and then retain PFAS near the water table for long time periods (Newell et al., 2022).
- Finally, GSI Environmental is developing a PFAS removal technology based on Colloidal Gas Aphrons (CGAs), a unique gas containing microstructure with different properties than gas bubbles. Testing by GSI and Clarkson U. shows that CGAs have

an unusual property of being able to remove short-chained PFAS that are more difficult to remove with gas bubbles (Kulkarni et al., 2022).