Effective Comparison of the Parameters for Per- and Polyfluoroalkyl Substances Destructive Technologies

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Background/Objectives. Current practices for the treatment of per- and polyfluoroalkyl substances (PFAS) contaminated water is limited to adsorption/separation technologies. These approaches may result in a small volume of the PFAS concentrated solution (e.g., still bottoms or reject from reverse osmosis). As part of the treatment train approach, a separation-based technology can be coupled with one of several emerging destructive technologies (e.g., electrochemical oxidation, non-thermal plasma, e-beam, sonolysis, supercritical water oxidation, hydrothermal oxidation etc.) to mineralize PFAS in the contaminated media.

Approach/Activities. Most of destructive technologies are still emerging. The effectiveness and adeptness of these technologies vary based on several factors including initial system cost, operation and maintenance, use of additional chemicals/reactants, risk factors, scalability, treatment mechanism, PFAS destruction, impact of co-contaminants, and formation of byproducts. However, there is no standardized method for comparing these destructive technologies that can help in selecting the best technology for field applications based on effectiveness/ performance, implementability, cost, and overall protection of human health and the environment. For example, advanced oxidation process such as electrochemical oxidation employs sequential defluorination, resulting in formation of short-chain PFAS (e.g., PFBA) which are resistant to further degradation, whereas a sonolysis process exploits pyrolysis of PFAS resulting in complete mineralization of PFAS. Non-thermal plasma has the lowest operating costs reported in the literature, however, the presence of co-contaminants can increase operation and maintenance by an order of magnitude, whereas the presence of salt and co-contaminants may not impact the mineralization of PFAS using sonolysis or hydrothermal processes. One of the most common parameters currently used for comparison of these treatment technologies is electrical energy consumed per order of magnitude (EEO), however, this parameter doesn't consider the formation of short-chain PFAS and assumes complete decomposition of the PFAS. A thorough literature review was performed for the various destructive technologies and key criteria for the field applicability were evaluated.

Results/Lessons Learned. The criteria selected for comparing the effectiveness includes influence of PFAS destruction mechanism, occurrence of co-contaminants, use of additional chemicals, addition of a catalyst enhancing the destruction of PFAS, and meeting treatment guidelines. Additionally, an implementability evaluation includes scalability of the treatment system, operation and maintenance, and formation and mitigation of generated byproducts. Risk and health and safety during field implementation are evaluated to address overall protection to human health and the environment. Finally, energy requirements and total cost are compared for these technologies and the complete defluorination using fluorine mass balance approach is suggested as an alternative approach for evaluating energy requirement of the treatment approaches. This information will be used in developing a more robust assessment criteria for selection of optimal destructive technologies for the treatment of the concentrated PFAS media.