Treating PFAS to Near-Zero Concentrations: Life Cycle Assessment Considerations

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Background/Objectives. PFAS have potential threats to human health. Carbon-based sorbents and single-use anion exchange resin (S-AIX) are proven effective on removing PFAS from water sources, but such treatments generate PFAS-laden spent media (i.e., waste) requiring waste management. With growing PFAS regulations globally, more PFAS treatment waste will be generated. R&D has focused on circular processes to minimize PFAS-laden treatment waste generation, reduce the downstream PFAS mass loading to the publicly owned waste receivers, and permanently destroy PFAS economically and sustainably. This study was developed to evaluate the life cycles of six different scenarios with and without circular treatment processes, and the opportunities of applying new technologies to destroy PFAS wastes.

Approach/Activities. The six PFAS treatment train scenarios include two linear-process scenarios that PFAS are treated then the treatment wastes are transported off site for reactivation (scenario 1), or disposed of and incinerated off site (scenario 3). Scenario 2 is that GAC treatment waste is reactivated off site then the reactivated GAC returns back to the facility for reuse. And there are three scenarios containing emerging circular processes with very limited or no off-site treatment waste transportation and management. These circular processes include on-site AIX regeneration (scenario 4), on-site destruction of treatment wastes (scenario 5) and on-site foam fractionation (scenario 6). The evaluation of these scenarios is based on actual operation and cost data and the treatment systems have been operated ranging from 2 to 7 years. PFOS and PFOA influent concentrations, flow rates, frequency of changeout, capital and annual operational costs, and sustainability were used to evaluated compare the cost benefits of different scenarios based on million gallons of water treated and based on each gram of PFAS treated. The study also evaluated the impact of growing regulations (setting MCL and CECLA listing of PFOS and PFOA as hazardous substances) on the life cycle costs.

Results/Lessons Learned. Thirteen full-scale PFAS treatment system data were collected for evaluating scenarios. These treatment systems treat combined PFOS and PFOA concentrations ranging from 25 ppt to 15,000 ppt with years of operation from 2 to 7 years, and flow rates from 75 to 700 gpm. All of these treatment systems meet the regulatory criteria for discharge or distribution, however, the changeout strategy can vary from facility to facility. For instance, the facilities used for scenario 2 change out the GAC media when any measurable PFAS are detected in the effluent of lead vessel. This can increase the changeout frequency and OPEX comparing to systems which change out the media when only regulated PFAS exceed the criteria. GAC and S- AIX have been applied to a wide range of PFOS and PFOA concentrations and flow rates. S- AIX is generally higher on OPEX than GAC based on million gallons of water treated and per gram of PFAS treated. However, S- AIX has lower changeout frequency and will likely be less impacted by the increased costs of media and waste management due to future growing regulations. For those three scenarios using emerging technologies, they have been applied to higher PFOS and PFOA influent concentrations. They are economically and technical comparable to scenarios 1 through 3, except regenerable AIX scenario. The waste management costs are evaluated per scenario and will be presented justifying the future considerations of PFAS treatment using emerging technologies.