Aclarity

PFAS Destruction for the Waste Management Industry

Foam Fractionation:

Foam fractionation is a separation technology used to remove substances from a liquid based on their attraction to the air-liquid interface of foam bubbles. It is particularly useful for separating organic compounds with surfactant properties from an aqueous solution. PFAS compounds are attracted to air-liquid interfaces and can be separated from water by up to 99% or higher using this technology.

With foam fractionation, the dense foam generated can concentrate the PFAS by 300X to 3000X or higher and reduces the volume of water containing PFAS by the same concentration factor. This high concentration factor greatly improves the economics of PFAS destruction technologies which can efficiently perform on high concentration PFAS streams.

The water stream leaving the foam fractionation system is 99% PFAS-free and can be sent to standard industrial or municipal wastewater treatment processes prior to discharge.

Pilot and Technology Overview:

An Aclarity landfill client operating a foam fractionation system for the separation of PFAS in their leachate was seeking alternatives to solidifying the foamate liquid containing the PFAS and disposing of it back in the landfill. Electrochemical oxidation can destroy PFAS compounds at high concentration levels and was a candidate for evaluation on this process.

The concentration of measurable PFAS compounds in the foamate generated at site was measured to be 41.4 mg/L (41.4 million ng/L) by EPA Method 1633.

The Aclarity process works by using a combination of direct electron transfer at the electrodes in the electrochemical oxidation reactors, and by the production of oxidizing radicals, which work together to break carbon-fluorine bonds and "unzip" the PFAS compounds to render fluoride ions (F-) and carbonate species (CO_2, HCO_3 , CO_3^{2-}).

Aclarity applied its proprietary multi-reactor electrochemical oxidation process to the foamate, and reduced total PFAS from 41.4 mg/L down to 0.02 mg/L, a reduction of **greater than 99.9%**, which surpassed the requirements of the application.

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PROJECT RESULTS

EPA Method 1633 PFAS results showed consistent destruction of total 1633 PFAS throughout two separate runs, as shown in Figure 1 below.

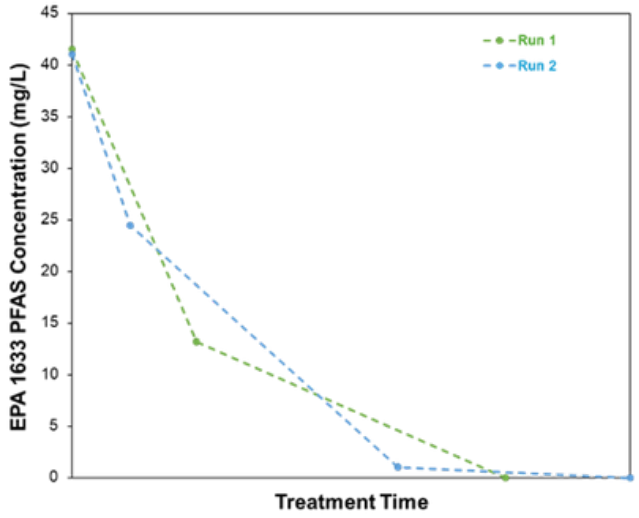

Figure 1

PFAS analysis by EPA Method 1633 showed destruction of each of the PFAS compounds detected in the foamate, as shown for Run 2 in Figure 2 below. The lighter color indicates increased treatment time.

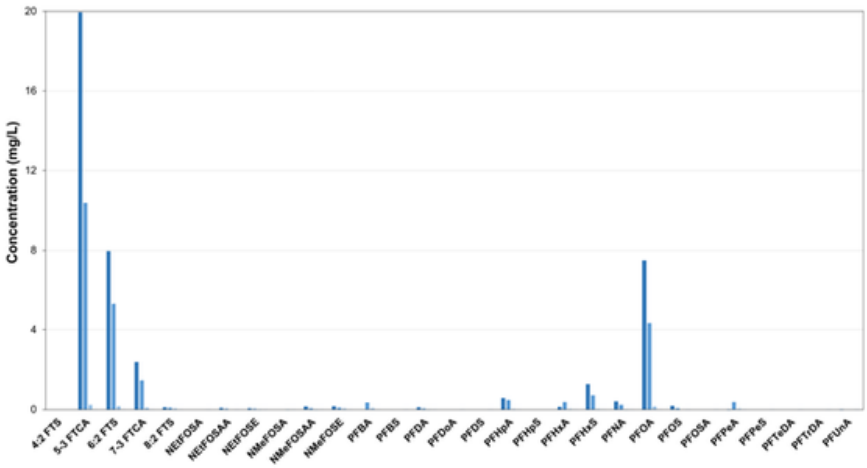

Figure 2

KEY TAKEAWAYS

- Aclarity's low energy EOx technology provides consistent destruction of PFAS in foam fractionation concentrate by attacking the C-F bonds which make PFAS so stable over time in the environment.

- Aclarity's modular design allows for successful scale-up of PFAS destruction to fit necessary volume and destruction needs

- Verifying the actual destruction of PFAS by monitoring fluorine conversion from organic to inorganic during the process provides assurance that these harmful chemicals are being destroyed and not converted to other organo-fluorine compounds.

Project Results

The major PFAS compound in the leachate and foamate, the fluorotelemer 5:3 FTCA used in stain repellent upholstery and carpet treatments, was reduced by over 99.9% in both runs. This level of destruction efficiency met the requirements for running the Aclarity process in a closed loop treatment scheme with foam fractionation, providing an economical destruction alternative to solidification and landfill disposal step.

In correlation with the unzipping hypothesis mentioned above, many PFAS destruction technologies will see increases in short-chain PFAS species, as longer chain species are destroyed. Aclarity's technologies is able to achieve overall destruction of these compounds, as demonstrated with the EPA Method 1633 results.

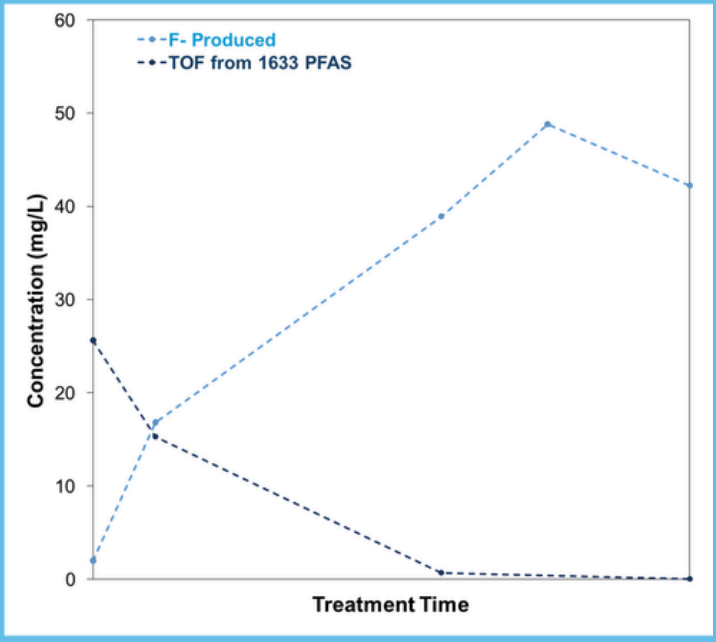

Figure 3

The PFAS reduction confirmed by the Method 1633 testing is promising, but it is also important to confirm the PFAS compounds were completely destroyed and not converted into other dangerous compounds that are not detected by the 1633 analysis. A fluoride ion-selective electrode (ISE) is used to measure inorganic free fluoride over time during the destruction test. If PFAS destruction is occurring, the free fluoride level in the water undergoing treatment should rise to a level which correlates to the initial free fluoride concentration in the water (about 2 mg/L in this case) plus the total organic fluorine associated with the PFAS levels measured by Method 1633 as well as any organo-fluorine compounds not detected using Method 1633.

In Figure 3 (left), the free fluoride ion increase during treatment is shown in light blue with lines to guide the eyes. The total organic fluorine (TOF) calculated from the 1633 PFAS destruction is plotted as well in dark blue and due to their being precursors and additional non-1633 PFAS, the F- generated is a higher concentration.

Figure 4

The Aclarity process also breaks down other organic compounds in the foamate as the PFAS destruction is occurring. This is observed by the color (and odor) change in samples captured during the test period shown in Figure 4. The overall reduction of organics provides benefits for downstream processes, or potentially for the stream returning to the foam fractionation process, by reducing the organics loading.

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