

WATER TREATMENT TECHNOLOGIES FOR PFAS: CURRENT AND NEXT GENERATIONS

March 31st 2022 – Maine Sustainability and Water Conference Baxter Miatke, P.E. Water Engineer, Arcadis Portland, Maine

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PFAS in Maine

OUTDOORS > Posted November 23, 2021 Updated November 24, 2021

Maine issues 'do not eat' advisory for deer harvested near PFAS-contaminated fields in Fairfield area

The state says deer taken in the Fairfield area have high levels of PFAS, the 'forever chemicals' that pose potential health risks.

Maine delegation calls for federal aid for PFAS crisis



(WABI) By Morgan Sturdivant Published: Mar. 15, 2022 at 6:12 PM EDT

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BANGOR, Maine (WABI) - Maine's congressional leaders are calling for more federal help with the PFAS crisis and say affected Mainers need immediate income replacement while unable to sell their products and longer-term supports to help them recover.

Both Senators Susan Collins, R-Maine, and Angus King, I-Maine, and Representatives Chellie Pingree, D-Maine, and Jared Golden, D-Maine, say they are urging the USDA to fully utilize all existing programs and authorities to provide additional assistance to farms affected by PFAS contamination.

They addressed the USDA secretary in a joint statement. The delegation said in part:

"We cannot overstate how devastating this situation is for the affected farmers and their families. In addition to extreme financial hardship, they are also facing the potential health risks associated with being exposed to these forever chemicals. **Environment and Outdoors**

'Complete crisis' as PFAS discovery upends life and livelihood of young Maine farming family

Maine Public | By Kevin Miller Published February 7, 2022 at 6:30 PM EST

The fight against 'forever chemicals' in Maine

PFAS are being found at farms, landfills, and even in wells.



Author: Associated Press Published: 1:12 PM EST February 19, 2022 Updated: 8:15 AM EST February 21, 2022 **A C**

MAINE, USA - *EDITORIAL NOTE: VIDEO CREATED 02-18-2022

Maine lawmakers are going to consider setting aside more funding to fight "forever chemicals" as an increasing number of farms across the state have been found to be contaminated.

The group of chemicals known as PFAS has been found in hundreds of farm sites where sludge or papermaking waste containing the toxins have been spread. PFAS also are being found in wells and landfills.

PFAS in Maine: 2022 Outlook: "Every day we are learning more"



PFAS in Maine

BON BANGOR DAILY NEWS

Old Town landfill shows how tough Maine's 'forever chemical' problem is to solve



by Sawyer Loftus February 14, 2022 Updated February 15, 2022

"Unfortunately, the technology just does not exist at this point in time to effectively remove PFAS from the discharge, from leachate or from wastewater treatment that is discharged," she said. "Casella is willing to spend money when the technology is proven and when it will ultimately enhance the operation and the management of landfill."

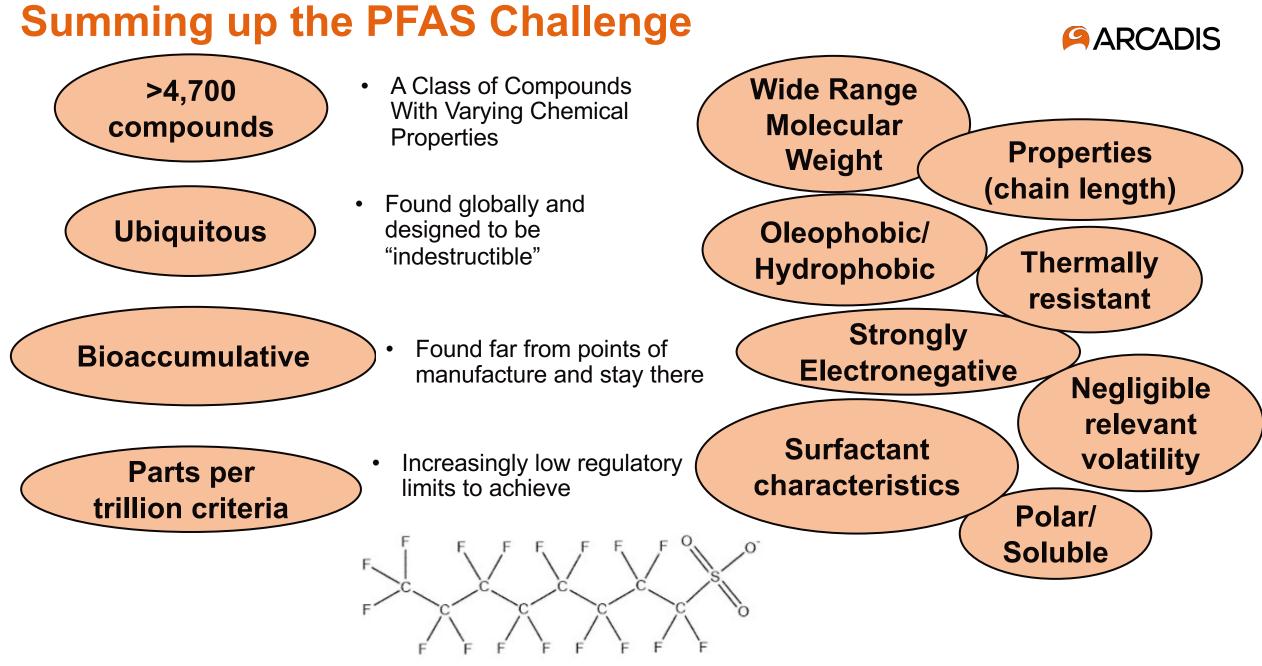


Briefing for the Joint Standing Committee on the Environment and Natural resources

January 31, 2022

Melanie Loyzim, Commissioner Susanne Miller, Director Bureau of Remediation & Waste Management Brian Kavanah, Director Bureau of Water Quality

> MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION Protecting Maine's Air, Land and Water







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No 's	silver bullet	for PFAS			

The PFAS remediation market is potentially huge. But the science, regulation and technology in this area still have a long way to go. Will Hatchett reports

22 September 2020 / Insight, North America, United States

NO SILVER BULLET FOR WASTEWATER TREATMENT OF PFAS

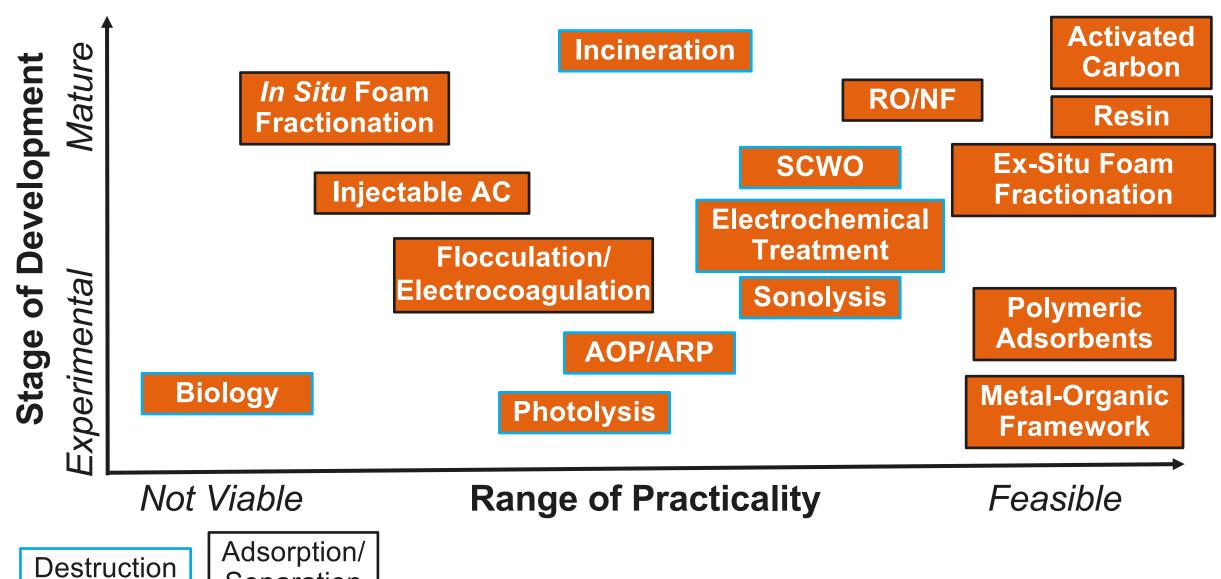
December 1, 2020

Treatment technologies for PFAS are rapidly evolving, but there is no feasible, large-scale treatment that is 100% effective in destroying PFAS or that is cost-effective for ratepayers. Upstream solutions like pollution prevention, product substitution and the like present a holistic, longterm and sustainable solution.

PFAS Water Treatment Technologies

Separation







Granular Activated Carbon (GAC)

Applicability:

- Effectively removes PFOS/PFOA from water (>90%)
- Certain types of carbon appears to perform better (i.e. bituminous)
- Low PFOS/PFOA concentrations; low flow rates with compatible geochemistry (low organics, low hardness, low PFAS, etc.)

Limitations:

- Effectiveness decreases as carbon chain length decreases; manage with longer empty bed contact time (EBCT)
- Competition with other natural organics and other contaminants





GAC in Maine

Kennebunkport and Wells Water District to Remove PFAS with Evoqua's Granular Activated Carbon (GAC) System

May 21, 2018 08:00 AM Eastern Daylight Time

PITTSBURGH--(BUSINESS WIRE)--The Kennebunkport, ME, Kennebunkport & Wells Water District (KKWD) will remove perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) from its water source using an Activated Carbon System from Evoqua Water Technologies (NYSE:AQUA).

Kennebunkport and Wells Water District to Remove PFAS with @Evoqua 's Granular Activated Carbon System

Tweet this

PFAS is a category of man-made chemicals that have been widely used to make products because of their stain-resistant, waterproof and/or nonstick properties, but are not safe for consumption beyond certain levels.

In 2016 PFOS and PFOA were detected in the Kennebunk River Well (KRW) at levels of 50 parts-per-trillion (ppt). Although the well contained less than the Environmental Protection Agency's (EPA) recommended combined limit of 70

ppt, officials decided against further use of the well without a treatment system for the compounds, and closed the well as a precautionary measure.













Ion Exchange Resin

Applicability:

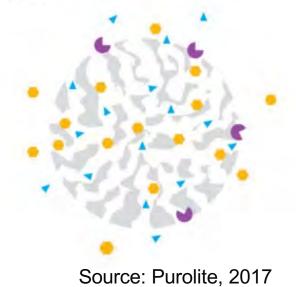
- Primary Treatment- Adsorption
- Negatively charged ions of PFAS are attracted to the positively charged anion resins
- Lower EBCT than GAC (2 5 min); smaller equipment footprints

Limitations:

- Rapid Small-Scale Column Testing (RSSCT) not viable for scale-up due to resin properties
- Predictive modeling and/or pilot-scale recommended to gather design parameters
- Extremely sensitive to site-specific geochemistry may require pre-treatment

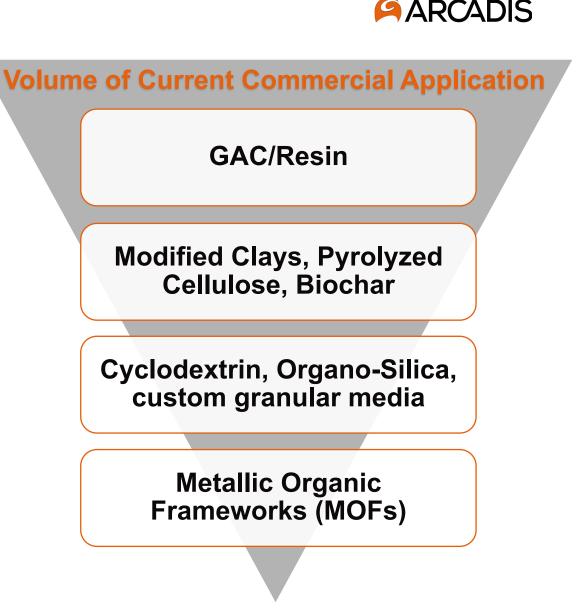


In this graphic, larger molecules (purple figures) are excluded from entry into the resin due to pore size. Smaller hydrophabic molecules are adsorbed onto the surface (orange figures), while the hydrophilic small molecules (blue figures) freely flow through the structure of the resin.



PFAS-Relevant Adsorbents

- GAC/Resins: Current "de facto" IRM adsorbents
- Modified clays (FluoroSorb®), pyrolyzed cellulose, biochar – available, competing with GAC/resin for PFAS relevance
- Cyclodextrin (CycloPure®), Organo-Silica (PQ-Osorb®), customized granular media (Puraffinity®) – promising but experimental
- MOFs, hydrogels, and two-phase composites – somewhat esoteric still, but huge potential adsorption capacities



Membranes

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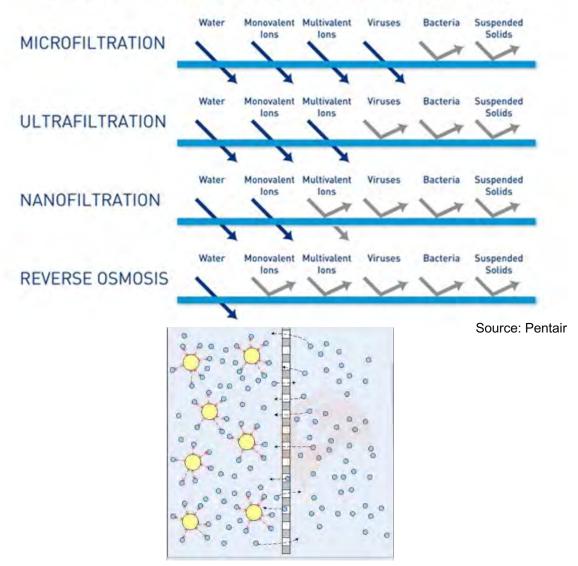
Applicability:

- Most effective removal of long and short chain PFAS
 - Nano-filtration (NF) >95%
 - Reverse Osmosis (RO) >99%
- Inefficient NF removal of short chain PFAS
- Effective for high-quality effluent and re-use applications

Limitations:

- Susceptible to fouling requiring pre-treatment
- Reject ratio can be 10%-35% and impractical for high-capacity systems
- Rejection depends on both the PFAS compound and type of membrane molecular weight cut-off (MWCO)
- Potentially high capital and O&M costs

TYPE OF MEMBRANES AND CHARACTERISTICS





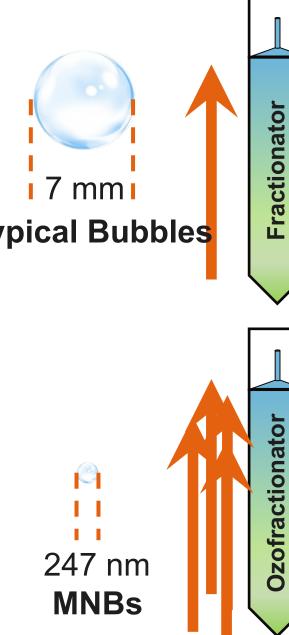
NF/RO Membranes



Source: Suez Titan Series Data Sheet- For Visualization

Foam Fractionation

- Fractionation uses bubbles to separate PFAS from the aqueous solution
- Gases (air and ozone) can vary to optimize bubble surface area and stability and create micronano-bubbles (MNBs) ranging from 10s nm to 10s µm
- Volume of foam target is less than 1% of the raw influent (will vary depending upon initial water quality)
- Potential for significant cost savings in disposal volumes







Target Structural Collapsing Foam – Optimized Fractionate Flow

(Hu and Xia 2018)

Fractionation

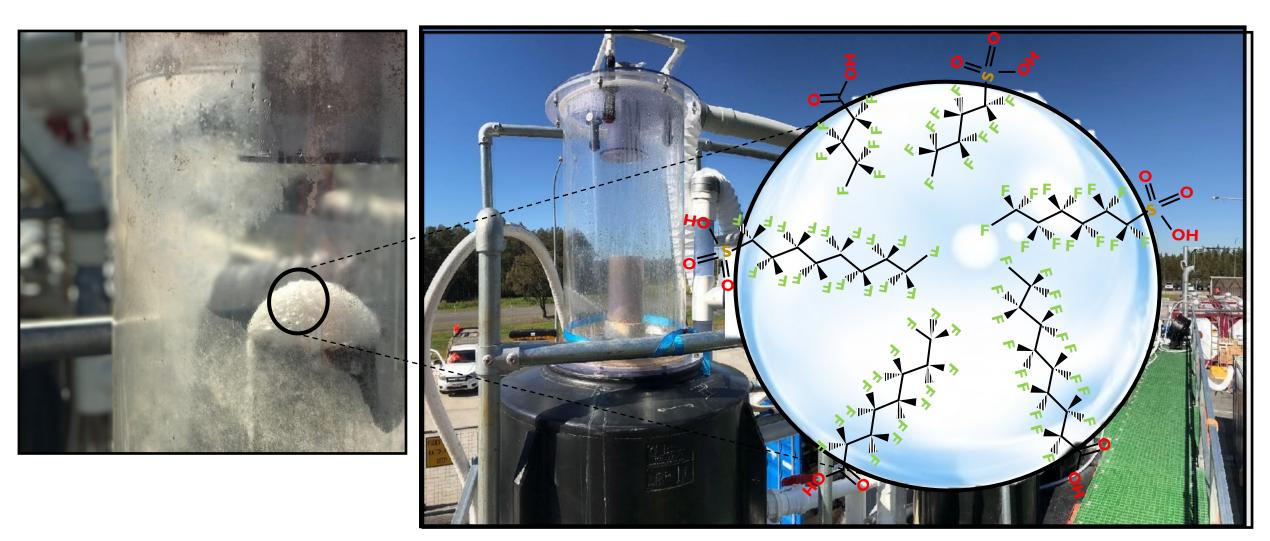


Photo Source: Evocra 2017



Fractionation Becoming More Commercially Available



Anson Madison Sanitary District in Maine

AMSD PFAS Treatment System

- PFAS is not treated via standard wastewater secondary treatment technology
- Additional tertiary treatment is necessary
- Proposed at AMSD Foam fractionation system followed by activated carbon

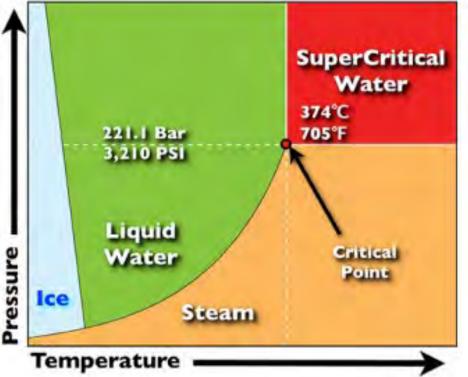






Supercritical Water Oxidation

- Demonstrated effectiveness within the radiological industry
- Viability for PFAS under development, particularly concentrated waste streams



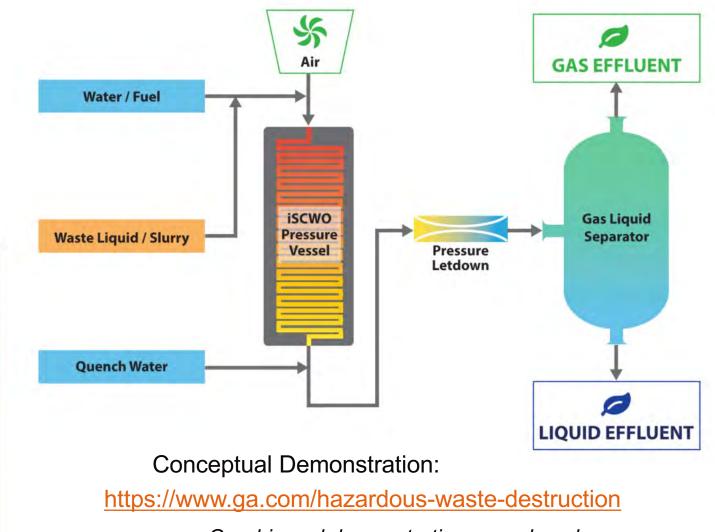
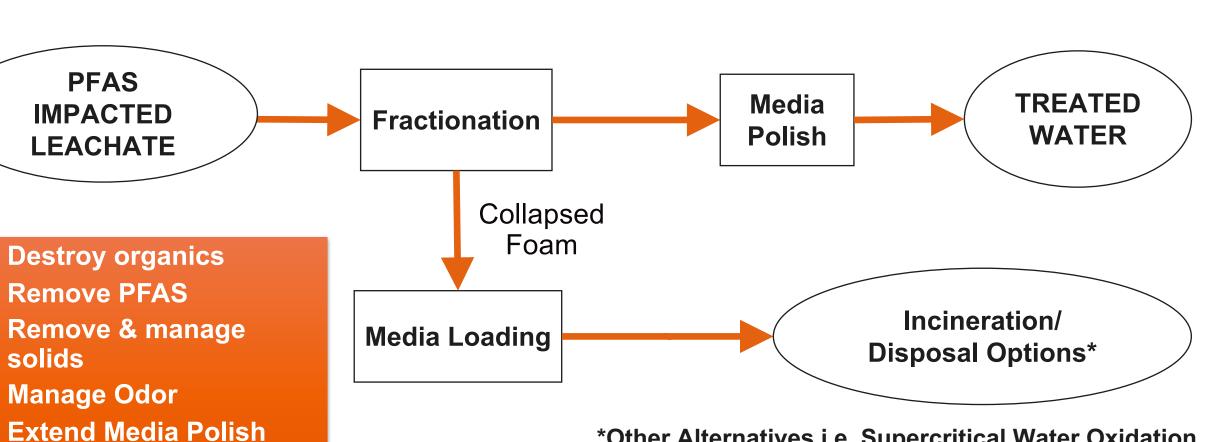


Image credit: Jonathan Kamler EPA Brief Graphic and demonstration reproduced from General Atomics (with permission) (McDonough et. al 2022)

Example of PFAS Treatment Train



*Other Alternatives i.e. Supercritical Water Oxidation

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solids

Performance

Reduce Waste Disposal

Volumes and Cost

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Research and Development Pipeline

- Sub-micron powdered activated carbon (SPAC) Ceramic Membrane Filtration (CMF)
- Synthetic Adsorbents (Osorb / PQ-Osorb)
- Destruction of PFAS
 - Sonolysis
 - eBeam
 - Electrochemical Destruction
- PFAS Cleaning Agents and Solvents
 - Arcadis FluoroFighter™



Source: Arcadis

OCTOBER 22, 2021 | PRESS RELEASE

Arcadis launches new cleaning agent to remove PFAS from fire suppression systems

Research and Development Matters



Commercialization

of TOP Assay

2016



projects (academic/industrial

partners)



Innovative and first to market solutions in collaboration with partners

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2022

PFAS Liquid Treatment Quick Take-Aways



- PFAS defy conventional remediation engineering
 - do not biodegrade
 - nearly impractical to chemically oxidize
 - has minimal removal through phase changes
 - energy-intensive to destroy
- Current state of the practice is a combination of treatment technologies
- Goal is to concentrate PFAS for energy-intensive destruction

ADSORPTION

SEPARATION/ CONCENTRATION

DESTRUCTION

ARCADIS

Thank You!



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PFAS in Maine: 2022 Outlook: "Every day we are learning more"

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