PFAS Treatment and removal using specialized coagulants for polluted waters and for the decontamination of firefighting and other equipment

ESAA Conference

December 2025

Presented by
Malika Bendouz, Ph.D.

Presentation Agenda

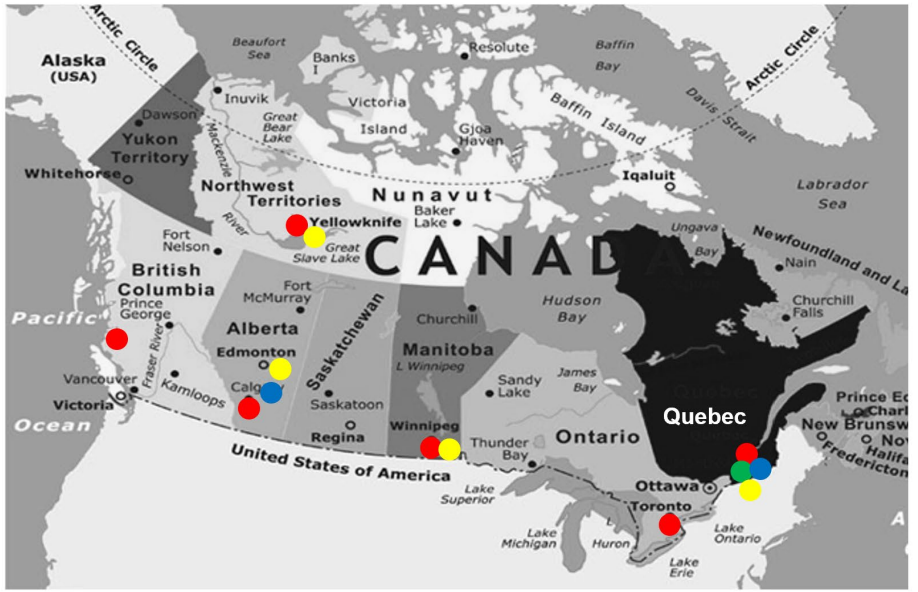
- About us
- PFAS background
- PerfluorAd® technology
- Bench and field scale tests
- PerfluorAd® PLUS technology
- Conclusion
- Questions

About us

- Chemco is a Nationwide 100 % own and operated Canadian company founded in 1988, specializing in providing chemical products and solution to the Environmental and Industrial sectors.

- **Main Divisions:**
  - **Environmental**
  - **Aeronautics:** ChemR
  - **Thermal Exchange Fluids**

Chemco Warehouse locations



Warehouse

- Quebec, Warehouse
- Toronto, Warehouse
- Winnipeg, Warehouse
- Calgary, Warehouse
- Yellowknife, Warehouse
- Richmond, Warehouse

Production Plant

- Saint-Augustin-de-Desmaures, QC

Liquid bulk storage

- Trois-Rivières, QC
- Kuusamo, AB

Railcar Transloading Facility

- Westroc, MB
- Calumar, AB
- Enterprise, NWT
- Saint-Augustin-de-Desmaures, QC

Excellence and Science Through Our Proud Suppliers and Partners

ADVANCED OXIDATION TECHNOLOGY (AOT) *Since 2005*

EVONIK Leading Beyond Chemistry *Since 2005*

BIOCONSERVACION

CARBONE CANADA INC. *Since 2014*

CARUS®

EthicalChem An Ethical Solutions, LLC Division *Since 2016*

Redox Tech

ChemCarb Sorption

SiREM *Since 2017*

Höganäs *Since 2018*

intrapore *Since 2023*

cornelsen *Since 2024*

Our Services

CANADIAN LEADER IN ENVIRONMENTAL SOLUTIONS

Specialized Products

- Chemical Oxidation
- Chemical Reduction
- Co solvent-Surfactant soil Washing
- Enhanced Bioremediation
- Permeable Reactive Barrier Amendments
- Metals Stabilization
- Activated Carbon Sorption Technologies
- PFAS Innovative Treatment Solutions

Training & Education

Technical and Design Support

Field-Proven Technologies

Expert Technical Team

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R&D and Treatability Laboratories

Field Support & Logistic

Mixing and Handling Equipment

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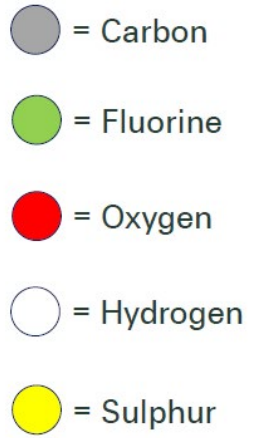
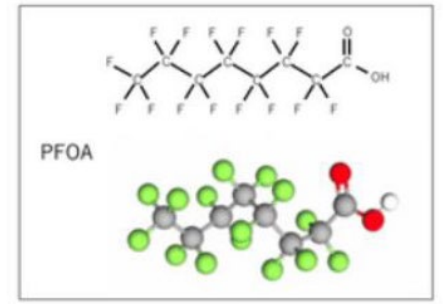
PFAS: background

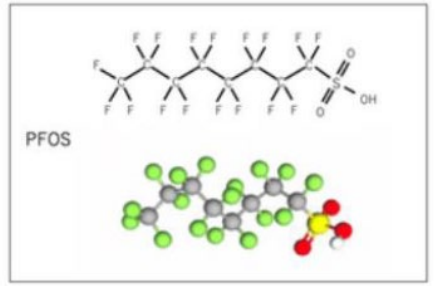
Per- and Polyfluoroalkyl Substances (PFAS)

- Group of man - made chemicals resistant to heat, water, and oil
- Thousands of compounds including the two sub - categories:
  - Perfluorooctanoic acid (PFOA)
  - Perfluorooctanesulfonic acid (PFOS)

- **Nonbiodegradable**
- presence of **the strongest bonds in chemistry :** fluorine and carbon atoms**(C-F bond)**
- **Environmental persistence**
- **Long chain vs. Short chain**
- **higher water solubility of short-chain**
- **Toxic, to both humans and wildlife, with Potential carcinogens effects**

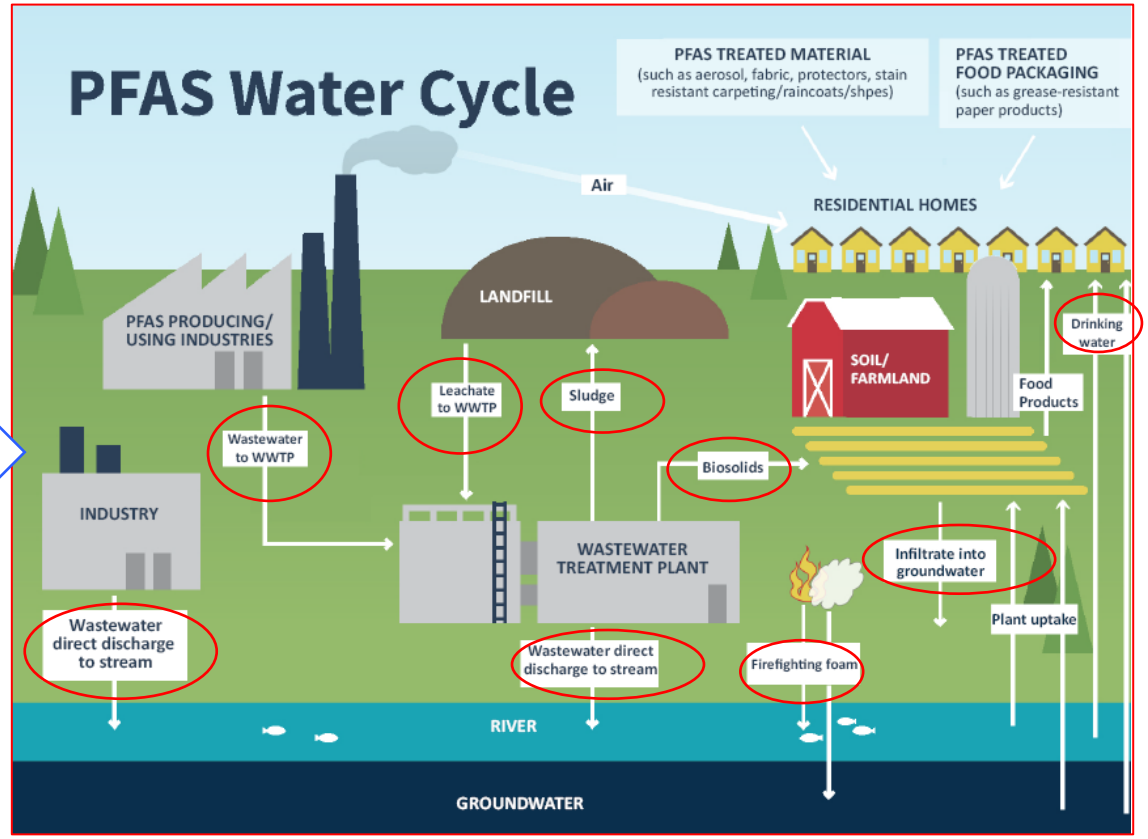






Where are PFAS used?

Where PFAS can be found?



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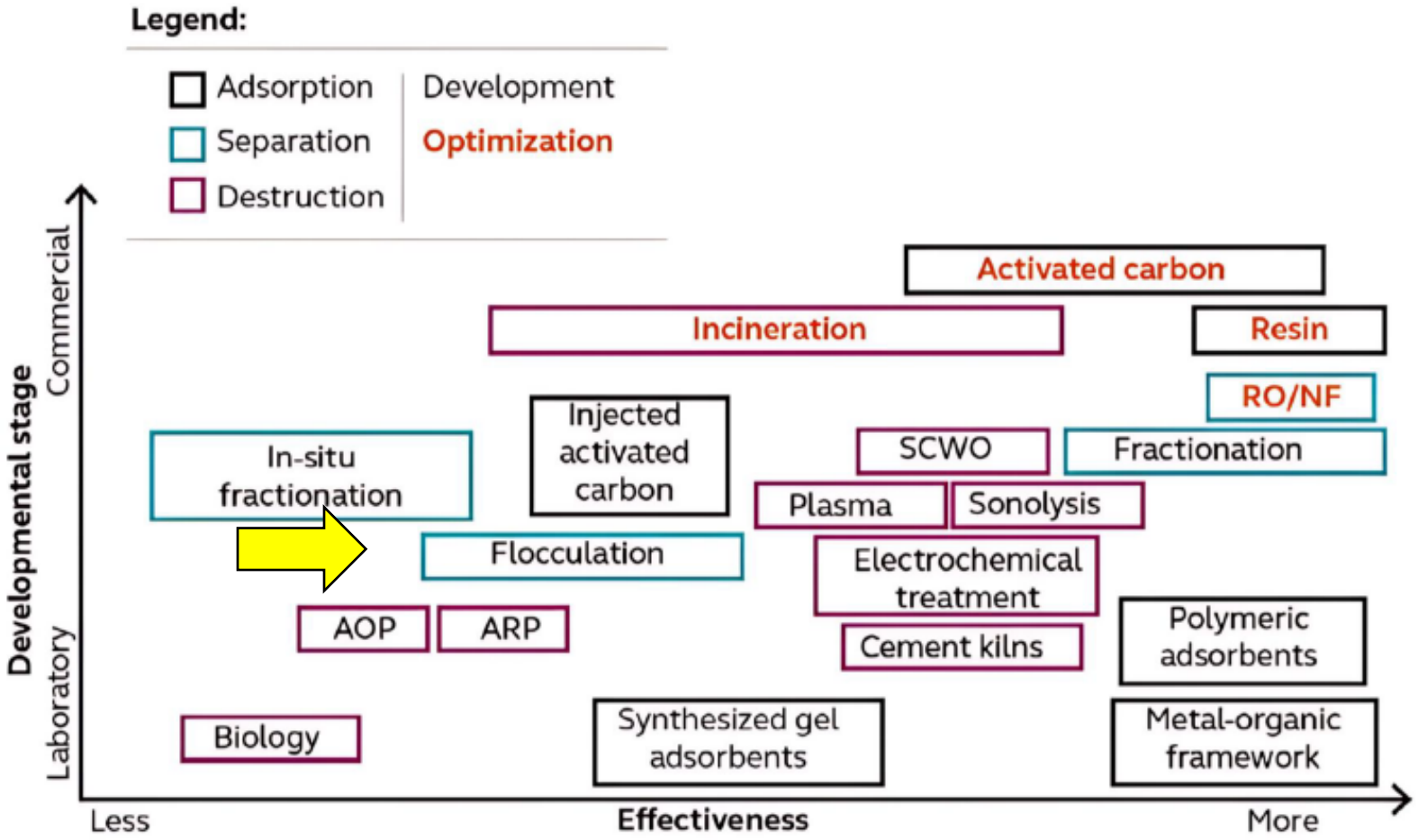
Conventional PFAS water treatment/ considerations /Limitations



Caption: PFAS Water Treatment Technologies (Arcadis 2022)

Conventional PFAS water treatment/ considerations /Limitations

- **The Problem:**

Conventional processes, such as adsorption on activated carbon or ion-exchange resins, as well as biological and oxidation processes are inefficient and costly for the **HIGH PFAS levels complex water conditions**, as is the case with Firefighting waters that may contain many other organic substances at high concentrations.

Conventional processes limitations:

- ✓ High volume of spent media
- ✓ Short chain PFAS are highly mobile and more difficult to be removed using GAC or ion exchange resin
- ✓ Extensive pretreatment often required to remove competing solutes
- ✓ Biological and oxidation processes can actually increase short chain PFAS levels in the effluent..
- ✓ Overall high costs for removing small mass of contamination (down to trace ppt levels)

Highly PFAS contaminated water treatment/**The Solution**

- **Cornelsen** Umwelttechnologie GmbH, Essen/Germany, has developed **PerfluorAd**® technology, a highly efficient process
- For the treatment of waters and surfaces highly contaminated with PFAS.
- PerfluorAd® is a specialised coagulant which binds with dissolved PFAS compounds employing electrostatic and hydrophobic interactions.
- Unlike activated carbon or resin, PerfluorAd® is a precipitation technology. It is an effective technology for removing PFAS compounds from surfaces as well as treating PFAS contaminated waters.

PerfluorAd® technology

PerflourAd®

Simple & Effective PFAS treatment

Dose | Mix | Remove

Sustainable:

Safe - based on chemistry found in nature, & food chain ingredients.

Low waste — the PFAS sludge is very low volume.

Biodegradable — PerfluorAd® breaks down biologically, to harmless chemicals according to OECD 301B

Effective:

Effective – The precipitation process removes up to 99% of most long Chained PFAS.

Enhanced short chain removal rates can be achieved by combining PerfluorAd and PerfluorAd Plus

Versatile:

Effective in High PFAS concentration waters & waters with a complex background.

Shelf Life & Storage - PerfluorAd® can be stored in closed containers for 6 months.

Stirring may be required before use.

International:

Listed with the following Registries:

Australia (AIIC), Canada (DSL),
EU (EINECS/ELINCS),
USA (TSCA)

Manufacturered in Germany & the USA

*3 **Founding Principles of PerfluorAd:***

Not to add harm to the environment

Made from readily available ingredients

Simple & safe to use

PerfluorAd
The PFAS Solution

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St-Augustin-de-Desmaures, QC G3A 0B3

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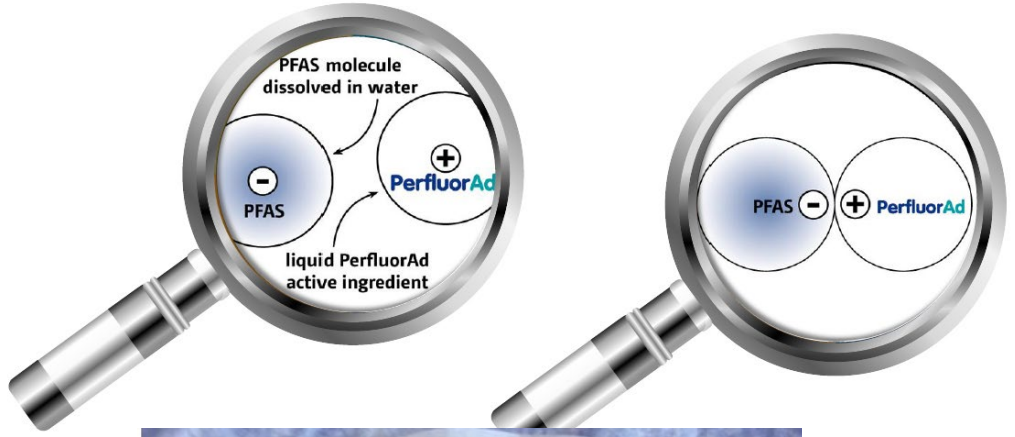
PerfluorAd® technology for PFAS treatment

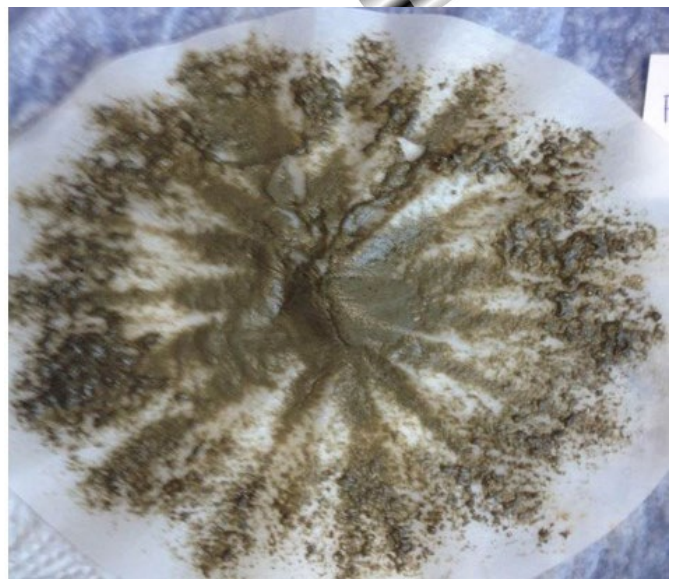
- **The active ingredient PerfluorAd® was developed from 2008 and patented in 2014**
- **PerfluorAd® offers <u>an adsorption free PFAS solution</u> that works in many types of water, but especially well in complex waters and waters with high PFAS concentrations –opposite to conventional treatment methods.**
- **PerfluorAd® precipitation of PFAS can be used:**
  - As stand alone PFAS treatment;
  - Added to an already existing mixing/flocculation/precipitation plant;
  - As a pre-treatment step, can be followed by adsorption by Activated Carbon / Ion Resin or Foam Fractionation.

PerfluorAd® technology for PFAS treatment

- The liquid active ingredient forms **bonds** with the PFAS contaminant, leading to precipitation and flocculation of the PFAS compounds as insoluble mass.
- The rate of PerfluorAd® dosed can be adjusted at any time to the raw water conditions to achieve the desired treatment.
- Can be used together with “standard” flocculation chemicals such as Ferric , PAX etc. to combine PFAS removal and particle / suspended solids removal.

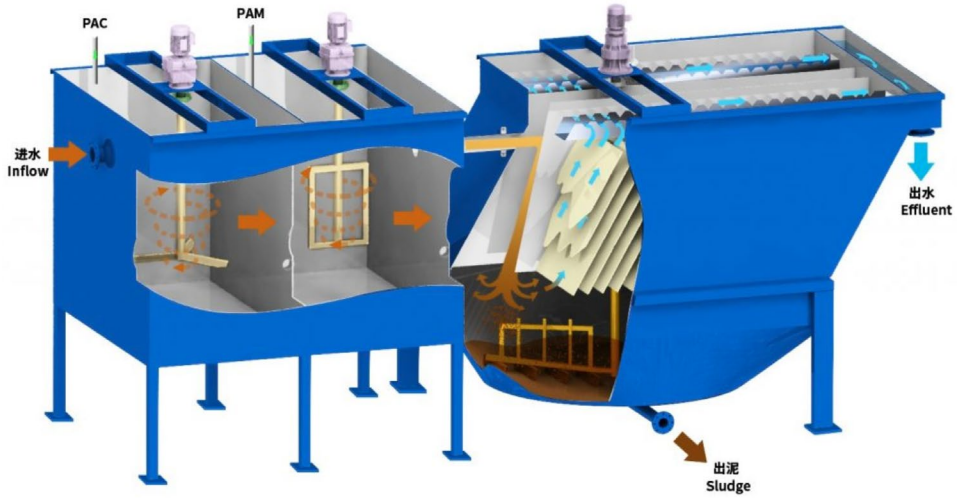
Water charcteristics	Effect on performance
pH low or high	**No detrimental effect**
High salinity	**Minor negative effect**
High organic background	**No or increased effect**
High surfactant loading	**No negative effect to slight benefit**

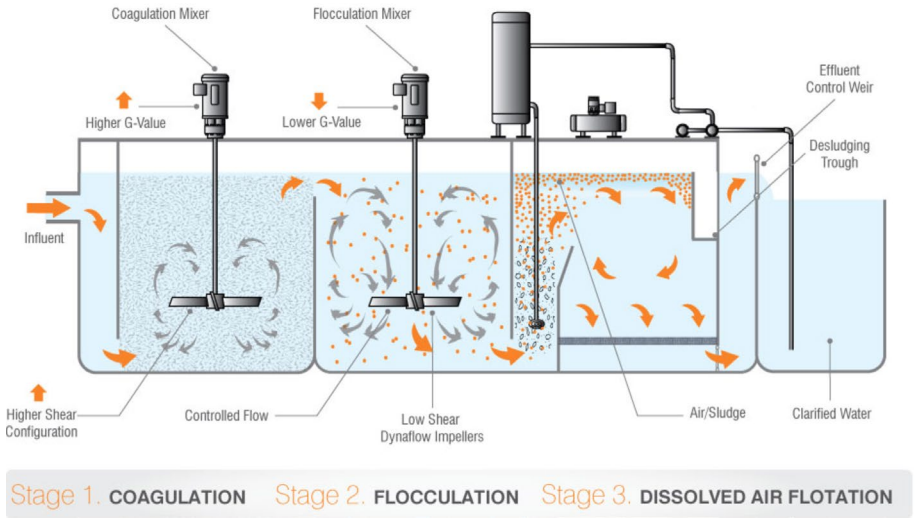




PerfluorAd® technology for PFAS treatment

- **Application** in typical **existing** industrial water treatment **plant** using flocculation & mixing
- **Low capex** as most plant already exists
- Typical in industries such as O&G where PFAS is also often found.
- **DAF (Dissolved Air Flotation)** can **remove** the **PFAS flocs.**
- In some cases, flocs can be settled in lamella settler installations.
- Existing coagulants utilized, to minimize on additional chemical supply.





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PerfluorAd® technology for PFAS treatment

- **Addition** to **soil washing plants.**
- Soil wash plants already have complete systems for water treatment integrated in process.
- It **already uses flocculation precipitation** to remove **suspended solids** from wash water stream
- Adding PerfluorAd to the wash-water side stream treatment keeps PFAS levels in the wash water down.

PerfluorAd® technology Bench scale and Field tests

PerfluorAd® technology for PFAS treatment

Full scale treatment using **PerfluorAd** to treat waste water at **net 300 m3/hr.**

- Pre-existing industrial waste water treatment plant utilizing flocculation & DAF.
- Main PFAS species PFOS, 6:2FTS.
- *Flows vary between 225 -650 m3/hr; Average flow 300 m3/hr.*
- **Water** contains **high** amounts of **solids** and **petroleum hydrocarbons.**

PFAS substance	Influent Concentration	Removal rate PerfluorAd 15 mg/l	Removal rate PerfluorAd 45 mg/l
PFOA	20	51%	83%
PFOS	430	98%	99%
PFHxS	85	73%	96%
6:2 FTS	210	33%	74%
PFHpS	20	99%	99%
PFPeS	20	76%	93%
PFHpA	22	18%	50%
PFHxA	62	5%	11%
PFPeA	94	0%	0%
PFBS	25	24%	52%
PFBA	46	0%	0%
Sum of PFAS	**1034**		

PerfluorAd® technology for PFAS treatment

Data from landfill leachate treatment trial , using different PerfluorAd® concentrations

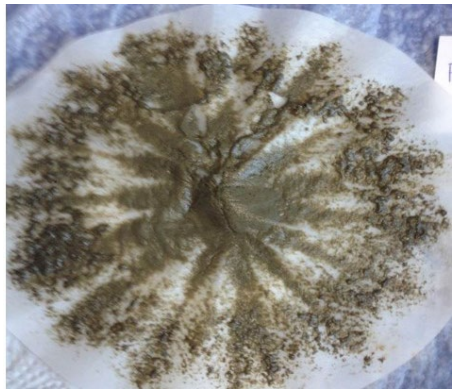
- **Landfill water**, complex chemistry, elevated pH.
- No pre-treatment.
- PerfluorAd in combination with standard flocculation precipitation chemicals to maximise flocculation precipitation of PFAS flocs.
- Removal of all suspended solids.
- **Inclined belt filter** used to **de-water settled floc waste**, (PFAS & non-PFAS floc).

	Type of water	Test no.	Test 1	Test 2	Test 3	Test 4
	PerfluorAd	0	25 mg/l	50 mg/l	75 mg/l	100 mg/l
	FeCl3	0	42 mg/l	42 mg/l	56 mg/l	56 mg/l
Parameter	unit		Removal Rate	Removal rate	Removal rate	Removal rate
PFOS	ng/l	260	>99%	>99%	>97	>99%
PFOA	ng/l	660	49%	73%	82%	85%
PFHxS	ng/l	110	73%	>99%	>99%	>99%
6:2 FTS	ng/l	200	30%	60%	75%	80%
PFBS	ng/l	7700	16%	43%	62%	72%
PFHpA	ng/l	470	7%	47%	66%	66%
PFHxA	ng/l	1900	11%	5%	32%	32%
PFPeA	ng/l	2100	0%	0%	14%	5%
PFBA	ng/l	820	0%	0%	11%	0%
Sum Total PFAS	ng/l	13440	11 250	8 920	6 340	5 800
Removal rate	%		16%	34%	53%	57%
Total PFAS Remaining	ng/l		1 800	3 032	3 360	3 306
DOC	mg/l	280	290	300	270	280
TOC	mg/l	290	300	300	290	280
pH Value		8,5				
Conductivity	mS/cm	3,84				

Mass of waste floc generated

Data from groundwater treatment at 6 sites

- **Residue weight is dewatered**, not dried.
- Dewatering by **bag filters** or **inclined belt filter**.
- 6 projects, **varied background chemistries**



		Nuremburg Airport	Sigmaringen	Sinzheim	Munster	Cologne	Dusseldorf
Flowrate	m3/hr	7.2	10.8	3.6	14.4	10.8	54.0
PFAS (19) influent	ng/l (ppt)	**700 000**	**10 000**	**2000**	**80 000**	**2000**	**30 000**
PFAS (19) effluent	ng/l	**41 000**	**<1000**	**<1000**	**<1000**	**<1000**	**<1000**
PerfluorAd dose	mg/l	40	25	10	60	10	20
PerfluorAd consumed	kg/day	6.91	6.48	0.86	20.72	2.59	25.90
Residue generated	**kg/day**	**2.4**	**1.8**	**0.2**	**4.8**	**1.8**	**9.0**
Operating days		2000	250	200	1500	500	350

Operating days is up to the point data was taken, some projects continue

PerfluorAd® technology for PFAS treatment

Treatment of PFAS & other organic contaminants from Nuremburg airfield groundwater

- Groundwater surrounding fire training area with historic use of AFFF
- **Additional contaminants: CHC's, BTEX, Arsenic. DOC**~10mg/l; **Iron** ~25mg/l.
- The co-contaminants meant that carbon was even less efficient than would be the case if only PFAS was present.

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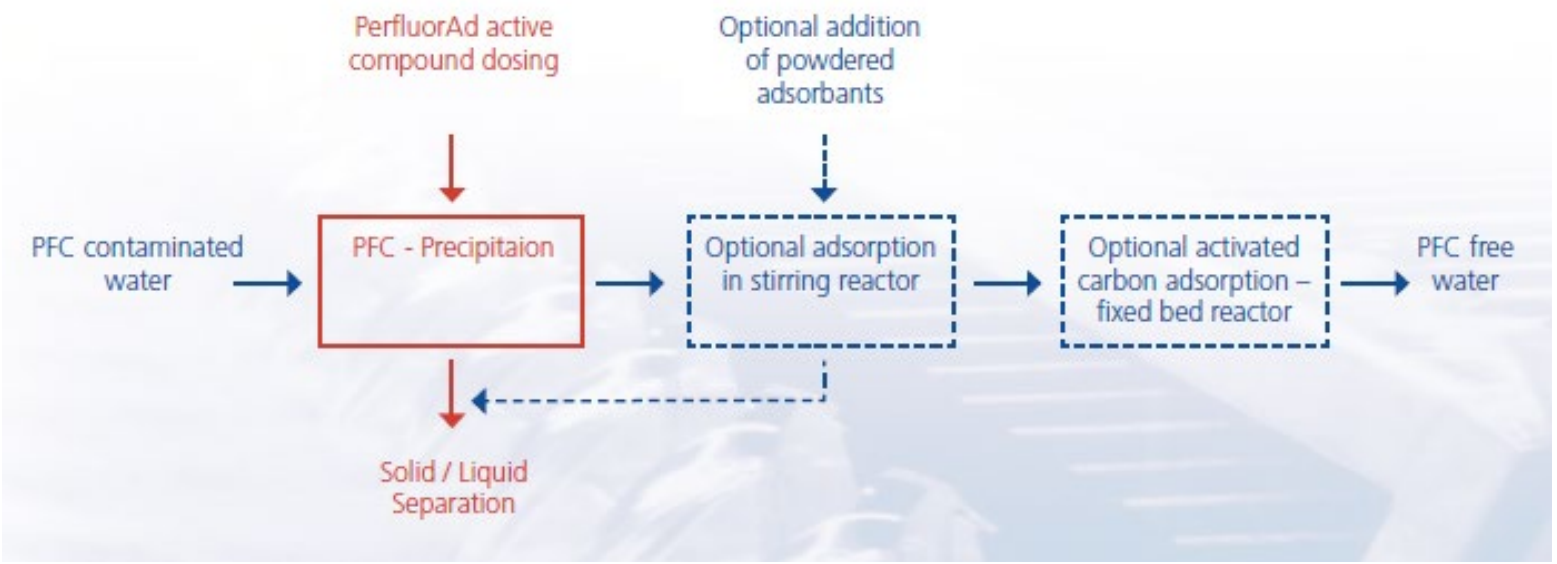
PerfluorAd® technology for PFAS treatment

Treatment of PFAS & other organic contaminants from Nuremburg airfield groundwater

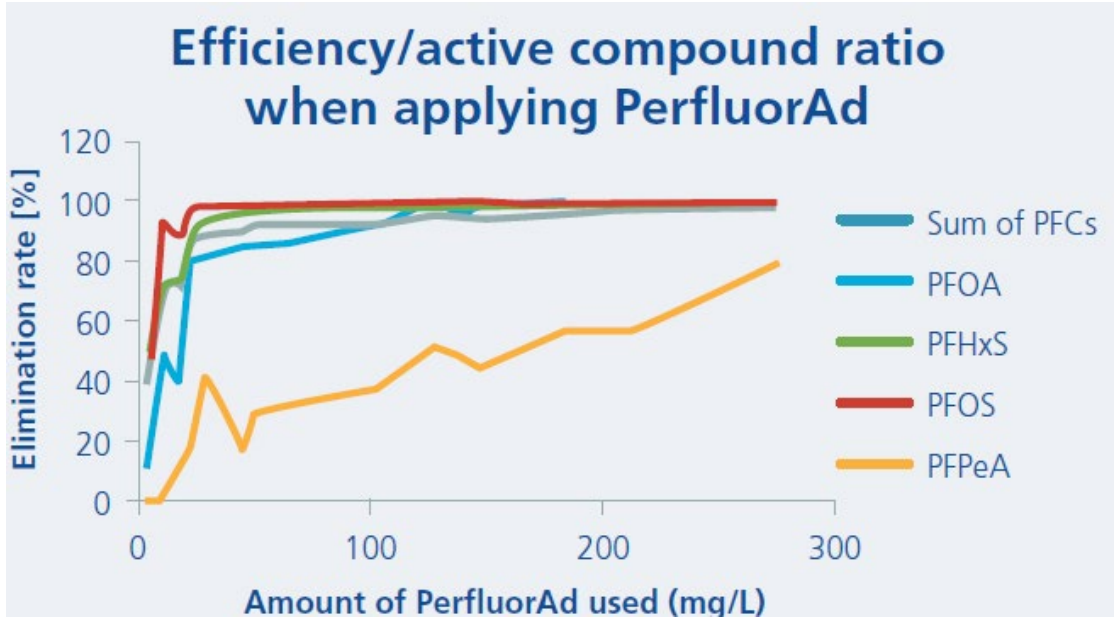
- At time of project, Germany still referring PFAS as PFC
- Bulk removal of PFAS by PerfluorAd, polishing stage by activated carbon.

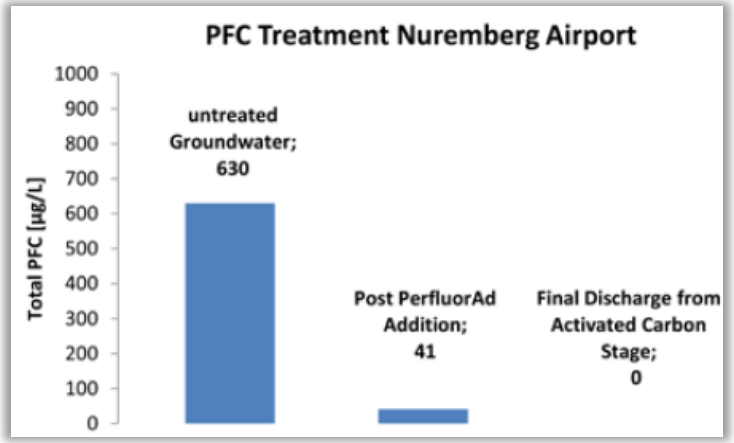


PerfluorAd® technology for PFAS treatment

Treatment of PFAS & other organic contaminants from Nuremburg airfield groundwater

- Dosing rate of 40mg/l found to be most effective to meet project aims
- **93%** of **PFAS removed** by PerfluorAd.





		Nuremburg Airport
Flowrate	m3/hr	7.2
PFAS (19) influent	ug/l	700
PFAS (19) effluent	ug/l	0
PerfluorAd dose	mg/l	40
PerfluorAd consumed	kg/day	6.91
Residue generated	kg/day	2.4

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PerfluorAd+

PerfluorAd+®

A flocculation additive for short chain PFAS, to be used in combination with PerfluorAd

What removal rates can be expected ?

- **PerfluorAd Plus (PerfluorAd+)** used together with PerfluorAd offers increased short Chain PFAS removal
- **Enhances removal** rates for **PFOA, 6:FTS** and **PFBS**
- **Major removal increase** can be achieved for **PFHpA, PFHxS, PFPeA** and **PFBA**
- Can achieve overall PFAS removal rates of up to 80 – 95% depending on water and PFAS signature
- Readily available chemistry.

PFAS substance	Expected removal rates PerfluorAd	Expected removal rates PerfluorAd Plus
PFDA	Up to 99,9%	Up to 99,9%
PFNA	Up to 99,9%	Up to 99,9%
PFOS	Up to 99,9%	Up to 99,9%
PFHxS	Up to 99,9%	Up to 99,9%
PFOA	Up to 85%	Up to 99,9%
6:2 FTS	up to 80%	Up to 99,9%
PFHpA	up to 65%	Up to 97%
PFHxA	up to 30%	Up to 95%
PFPeA	up to 20%	Up to 70%
PFBS	Up to 70%	Up to 97%
PFBA	Up to 10%	Up to 60%

Sustainability

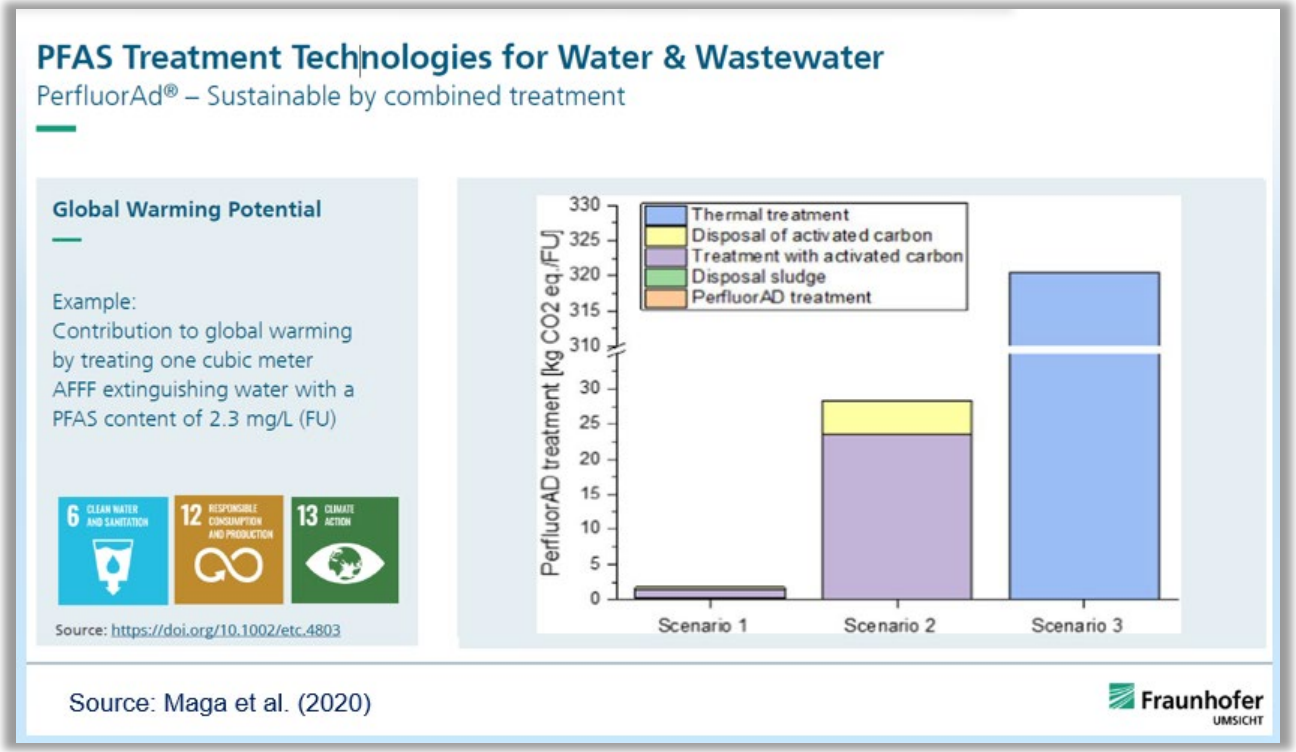
Study undertaken to assess global warming potential of treatment method

Environmental Assessment of Various End-of-Life Pathways for Treating Per- and Polyfluoroalkyl Substances in Spent Fire-Extinguishing Waters

Daniel Maga, Venkat Aryan,* and Stefano Bruzzano

Fraunhofer Institute for Environmental, Safety, and Energy Technology (UMSICHT), Oberhausen, Germany

- PerfluorAd demonstrated a significant impact reduction in all assessment criteria
- **Reduction** in **waste** mass leads to largest **saving** in **CO2 footprint**
- **Ongoing work** with **destruction technology developers** to seek more efficient end destruction processes.



Bench Scale Trials

To evaluate possible performance of PFAS removal for PerfluorAd

Key to proper evaluation & establishment of optimal dose rate.

- Simple tests. Simple equipment.
- Global availability via partner companies.
- Typically, 10 litres sent for tests.
- 5 litres ‘OK’ if simple water.

CAPEX and OPEX of the PerfluorAd® technology

CAPEX for PerfluorAd

- As PerfluorAd can be used as a stand alone treatment, or be used in already existing systems**, CAPEX** can be as low as zero
- Refitting of existing treatment plant with chemical dosing pumps: 15 000 – 35 000 $ will cover most flow rates

OPEX

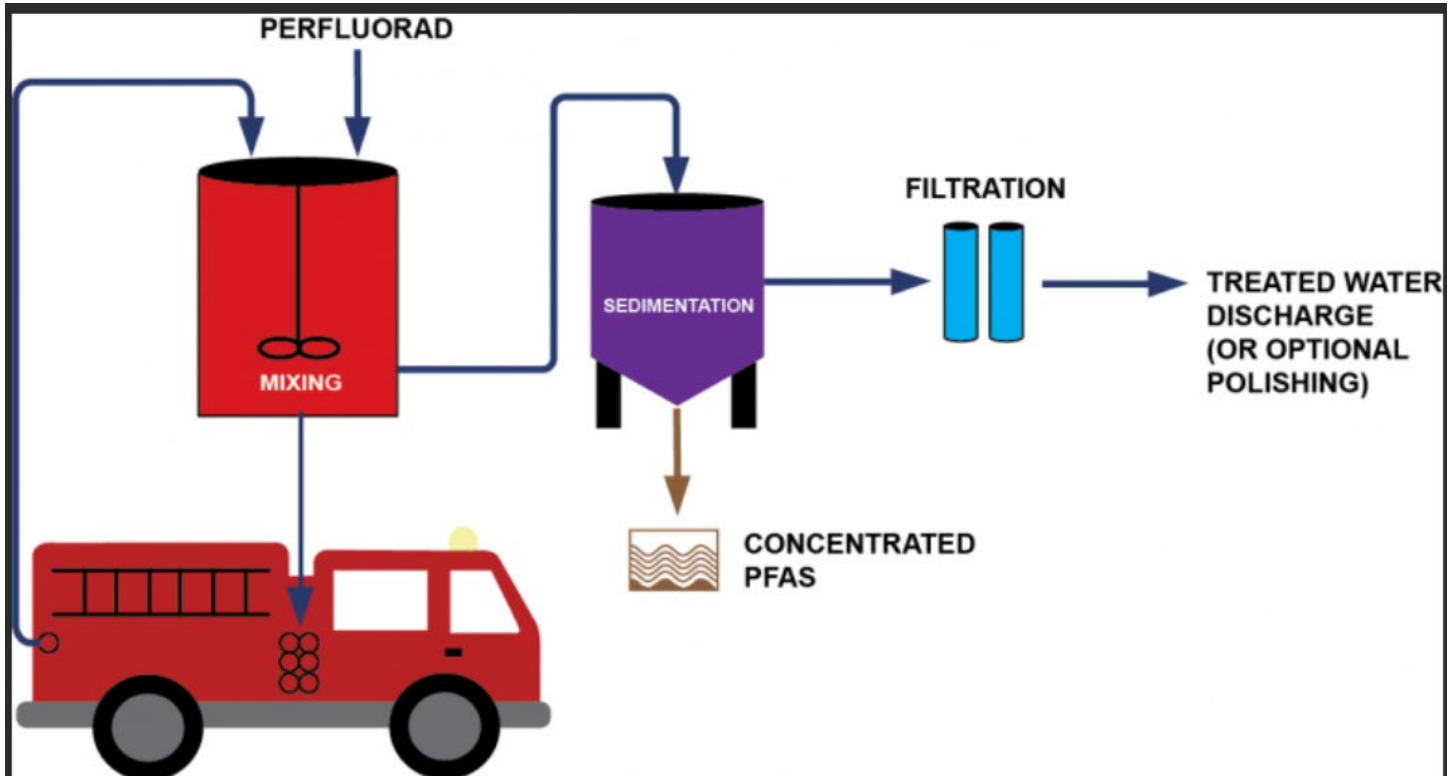
- PefluorAd in combination with standard flocculation precipitation products and service (not including waste disposal)
  - 10 mg/l – 100 mg/1
  - 0,7 $/m3 – 7 $/m3

Mobile PFAS decontamination of AFFF systems

cornelsen Re:Think Water

TRS Group Accelerating Value

US & Canada (surface decontamination)



		Pre-rinsing		Final / post rinsing	
	Sample	Pre-Rinse	Sample 1	Final	Sample 2
	Lab	Element	GBA	Element	GBA
	Lab ID	22/20838	22522666-001	22/20840	22522666-002
CAS nr.	Abbv.	ng/l	ng/l	ng/l	ng/l
375-22-4	PFBA	36,000	6,500	<50	<10
2706-90-3	PFPeA	26,230	9,900	<50	10
307-24-4	PFHxA	210,420	60,000	<50	14
375-85-9	PFHpA	7,150	2,700	<50	<10
335-67-1	PFOA	48,110	12,000	1.6	<10
375-95-1	PFNA	670	<1000	<50	<10
335-76-2	PFDA	3,990	<1000	<50	<10
2058-94-8	PFUnA	1,080	<1000	<50	<10
307-55-1	PFDoA	3,940	<1000	<50	<10
375-73-5	PFBS	9,170	2,200	<50	<10
355-46-4	PFHxS	63,690	11,000	<50	<10
375-92-8	PFHpS	560	<2000	<50	<10
1763-23-1	PFOS	320,420	110,000	12	16
335-77-3	PFDS	630	<5000	<50	<10

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Conclusion

- ✓ Liquid derived from plant-based fatty acids
- ✓ Low dosage requirement
- ✓ **PerfluorAd+** is NOW available for the PFAS short chains
- ✓ Low volume of micro flocs (sludge) will be generated
- ✓ Micro floc is biodegradable – stable for 24 hrs
- ✓ Ferric chloride could improve removal efficiency in complex water
- ✓ Large scale application tested in Europe , US and commercially available in CANADA
- ✓ Only simple mixing process is required
- ✓ Low reagent cost

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Thank you for your attention !!
Questions ?!?

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