



# DESOTEC<sup>®</sup>

Sustainable mobile  
filtration solutions

## Breaking the Cycle: The Power of Activated Carbon in PFAS Removal and Destruction

Johan Craeye, CTO, DESOTEC

# Outline| Compliant and effective PFAS removal

## Application

- What influences performance:
- PFAS type and concentration
  - Activated carbon characteristics
  - Monitoring and filter setup
  - Influence of the water



## Compliance

What is the POP regulation?  
How do we help our customers stay compliant?



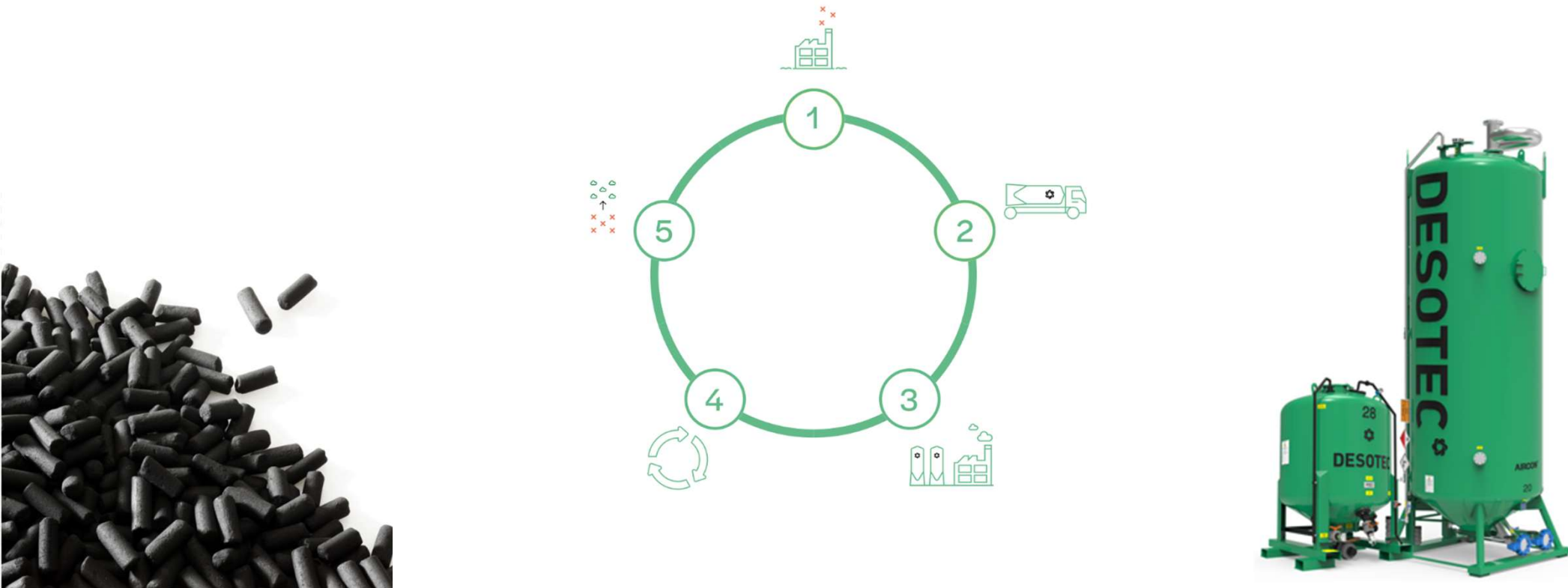
## PFAS & reactivation

What happens during activated carbon reactivation?  
How can it effectively destroy and mineralize PFAS?



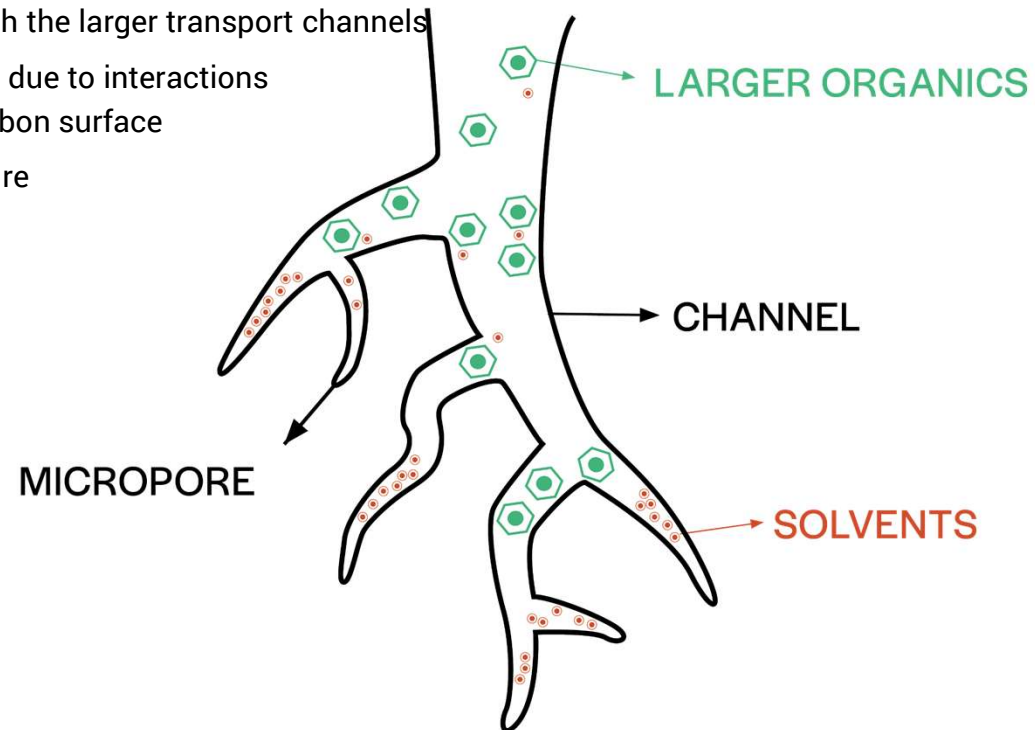
# DESOTEC in a nutshell

We are an **international environmental services company** that helps protect the planet with sustainable mobile filtration solutions based on activated carbon for the purification of liquids and gases



# How does activated carbon remove PFAS effectively?

- the most frequently applied technology for PFAS removal from water
- It traps PFAS molecules in its pores, effectively removing them from liquids and gases
- Activated carbon has a network of pores with varying sizes, creating an extensive surface area
- The PFAS molecules and their solvents, such as water, move through the larger transport channels
- When the PFAS molecules reach the smaller pores, they are trapped due to interactions such as Van der Waals forces between the contaminant and the carbon surface
- This adsorption process allows activated carbon to efficiently capture PFAS.

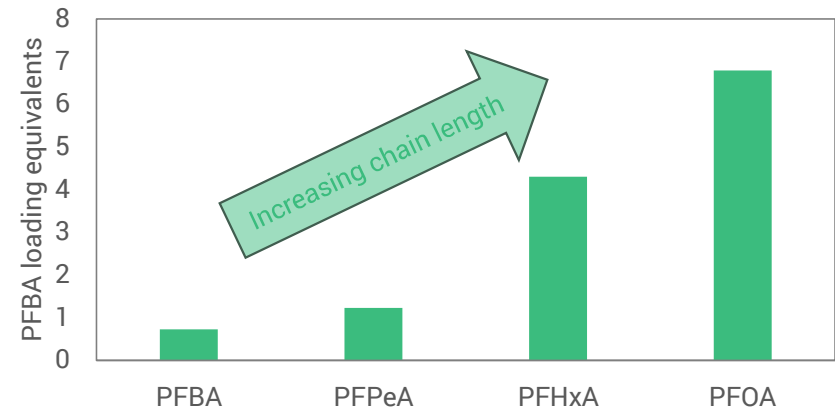


# Solution lifetime: Influence of PFAS

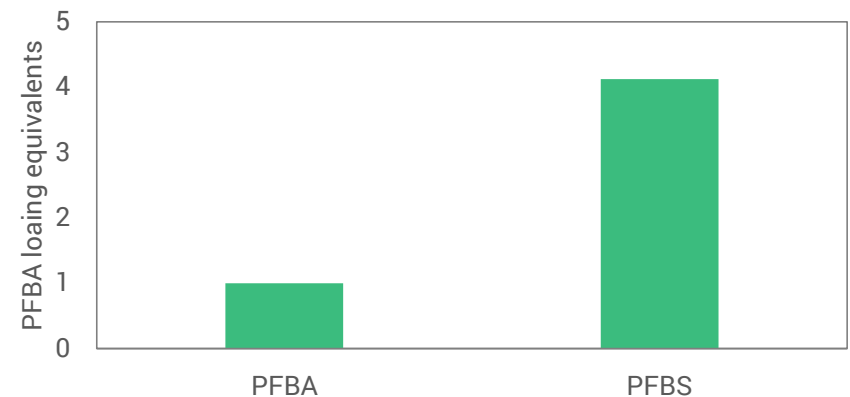
## Influence of PFAS types, concentrations and discharge limits

- Increased loading with increasing hydrophobicity:
  - Higher adsorption for higher PFAS chain length
  - Higher adsorption for sulfonates vs carboxylates
- Influence of PFAS concentrations:
  - Increased concentrations:
    - Increased loadings
    - Faster saturation and reduced lifespan
    - Longer contact times required
  - Lower concentrations:
    - High removal efficiencies over a prolonged timeframe
- Impact of discharge limits:
  - Decrease in required effluent concentrations can require optimization:
    - Extended contact times
    - Multi-stage filtration including polishing step

PFAS loading on activated carbon



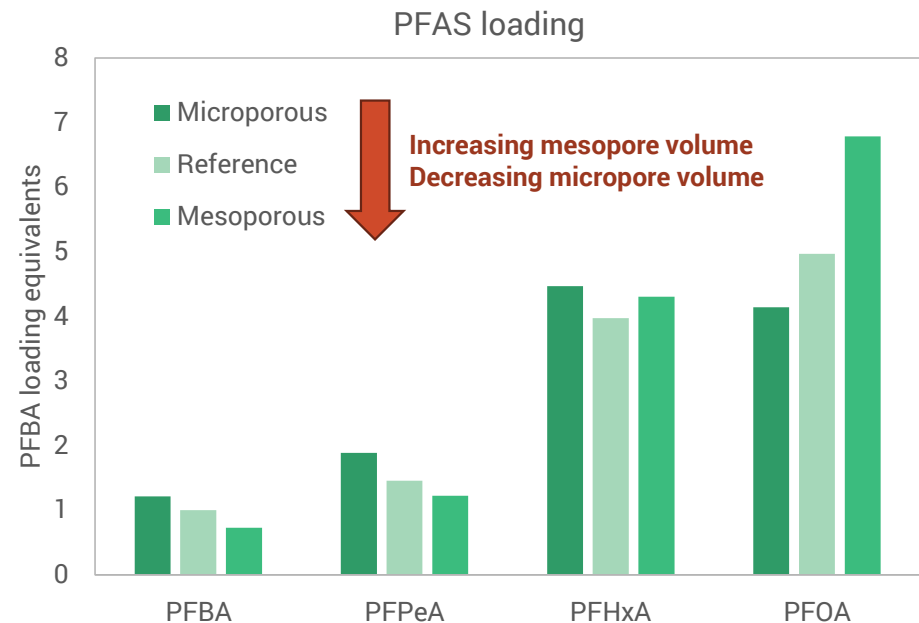
PFAS loading on activated carbon



# Solution lifetime: Influence of carbon type

## Influence of activated carbon characteristics

- Micropores:
  - Ideal adsorption sites for smaller PFAS molecules
- Mesopores:
  - Improve diffusion and avoid pore blocking
  - Offer adsorption sites for larger pfas molecules
- High surface area, with a balanced pore structure, improves adsorption efficiency





# Solution lifetime: Influence of configuration

**Case study:** end-of-pipe PFAS removal on a central Waste Water Treatment installation from a cluster of Chemical Production facilities

Total Waste Water flow: 50 m<sup>3</sup>/h.

Total PFAS concentration: 300 ng/l, of which 160 ng/l PFOS.

June 2023: discharge limit for total PFAS went down from 500 ng/l to 100 ng/l and for PFOS from 100 ng/l to 20 ng/l.

Customer used already the mobile activated carbon solution with 2 filters in serie to be compliant on  
Total Organic Carbon discharge limit of 100 mg/l.



# Solution lifetime: Influence of configuration

- **Influence of monitoring and filter configuration**

Case study: end-of-pipe PFAS removal on a central Waste Water Treatment installation from a cluster of Chemical Production facilities

DESOTEC's plug & play solution for a 50 m<sup>3</sup>/h challenge:

2 streets in parallel of each 2 MOBICON filters in serie containing each 17 m<sup>3</sup> of AC.



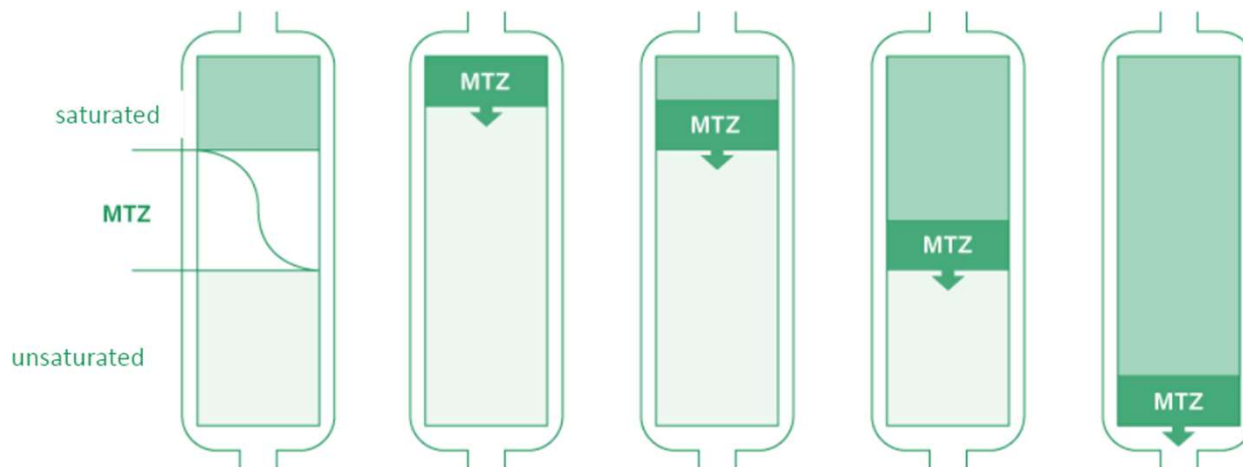
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# Solution lifetime: Influence of configuration

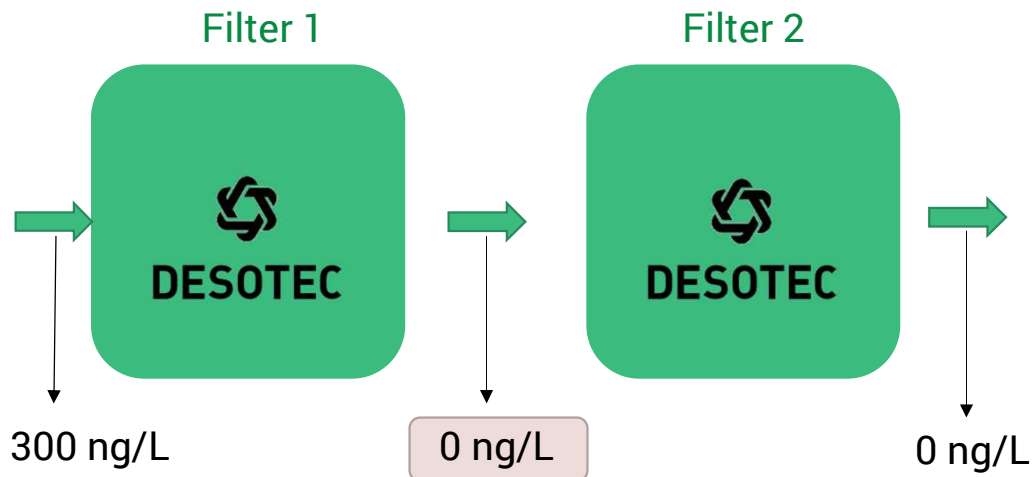
- **Influence of monitoring and filter configuration**
  - Mass transfer zone (MTZ):
    - Adsorption front moving through the carbon bed
    - Saturated carbon upstream of the MTZ
    - Fresh carbon downstream of the MTZ
    - When the MTZ reaches the end of the carbon bed, the filter capacity is completely exhausted



# Solution lifetime: Influence of configuration

Case study:

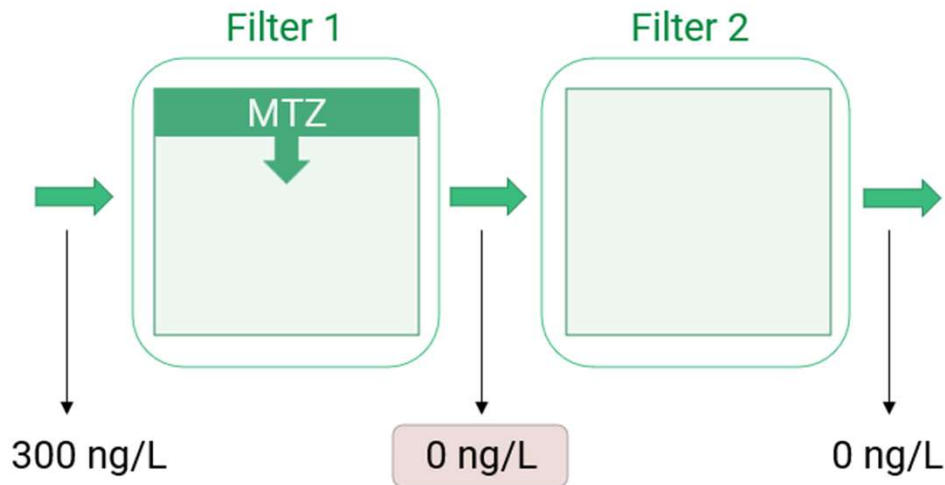
- Lead time to analysis result 5-10 days
- Detection limit = discharge limit!
- Solution:
  1. Measure between filters to prevent exceeding discharge limits
  2. Lead lag configuration for maximal carbon usage



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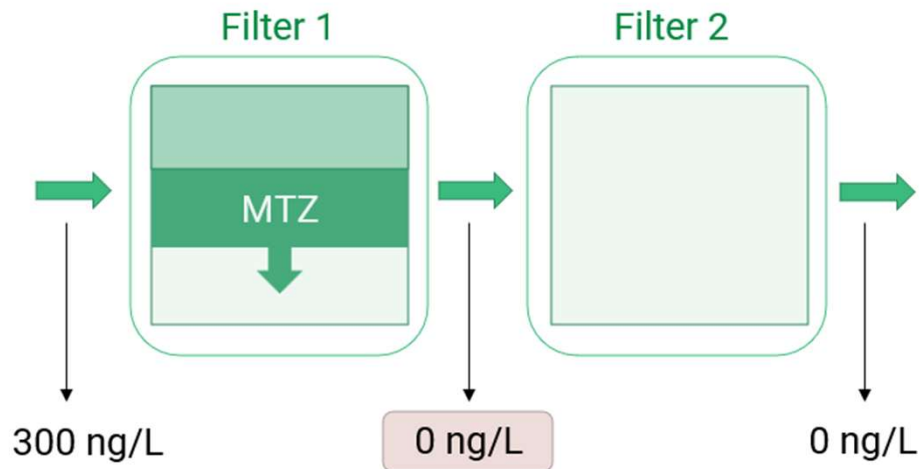
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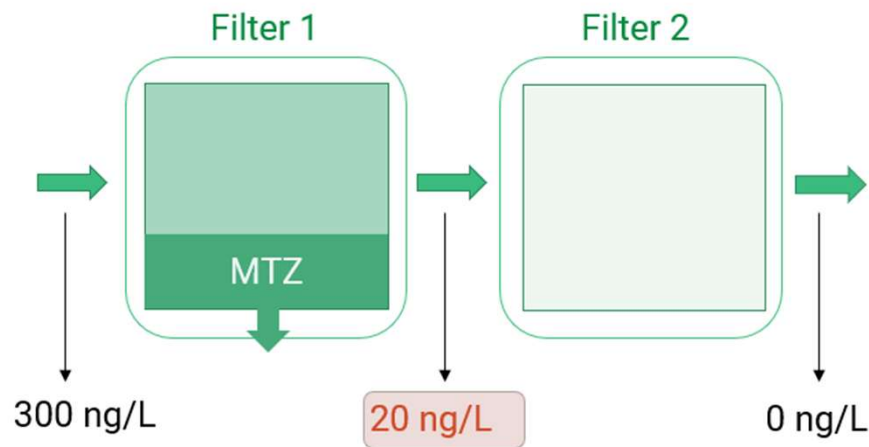
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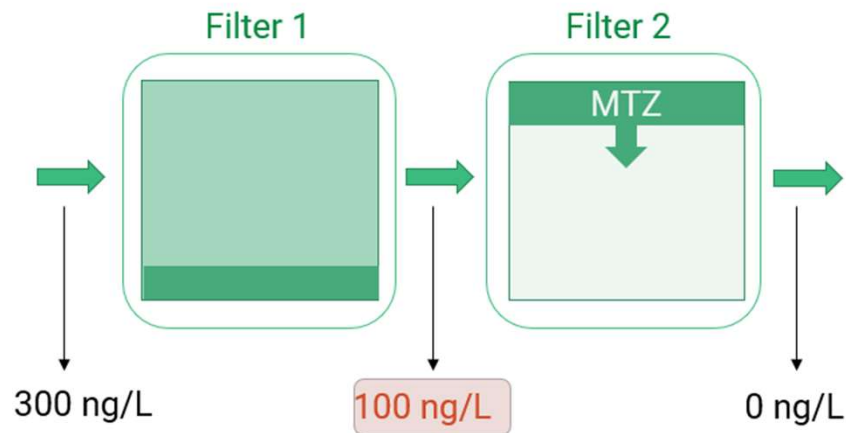




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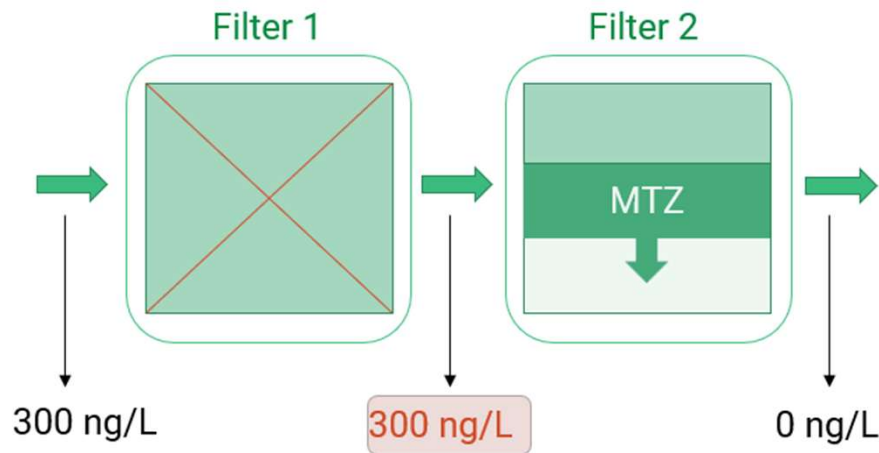
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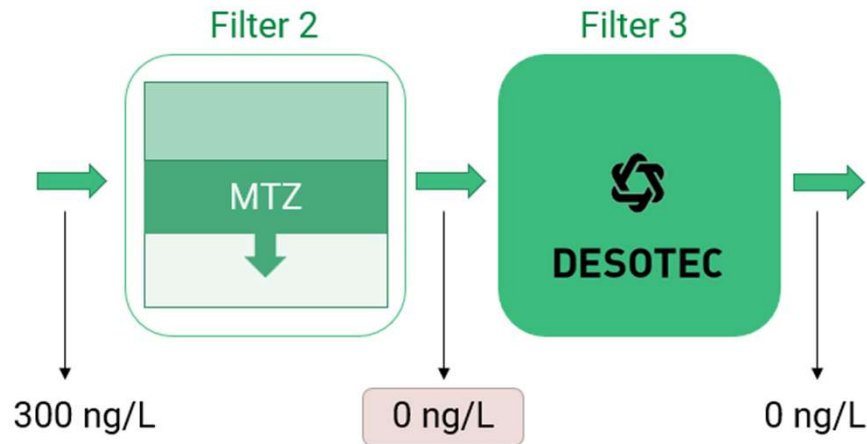
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Result: treated water was compliant throughout the project



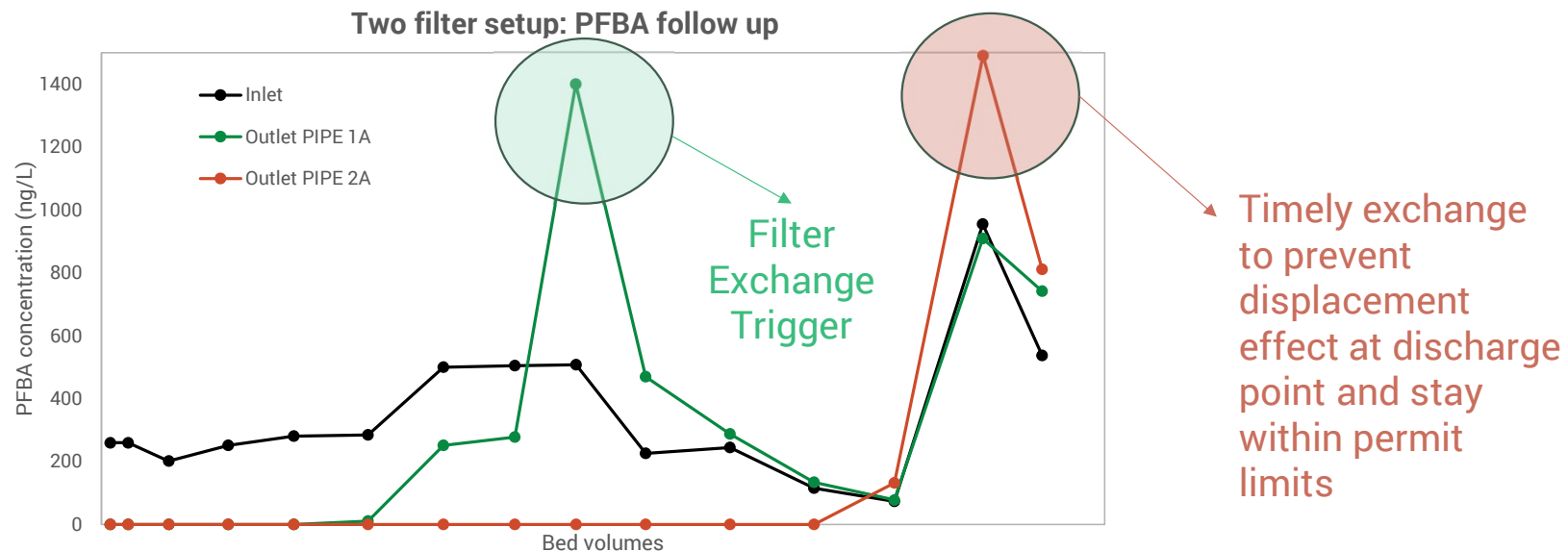
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# Solution lifetime: Influence of matrix

- **Influence of water matrix:**

- Impact of dissolved organic matter:
  - Competition for adsorption sites: reducing overall adsorption capacity
  - Pore blocking: preventing access to micropores. Mesoporous carbons are less susceptible
  - Displacement effect

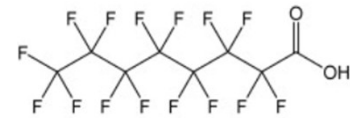


# Solution lifetime: Influence of matrix

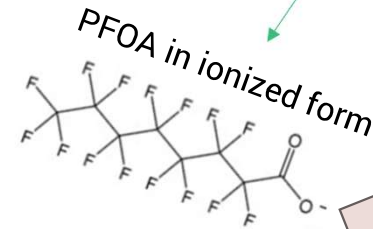
- **Influence of water matrix:**

- Impact pH:
  - Many PFAS show pH dependent ionization
    - At low pH (acidic conditions): neutral form dominant = higher loadings
    - At high pH (alkaline conditions): ionized form = reduced capacity
  - Activated carbons have pH dependent surface charge (PZC, point of zero charge)
    - Below PZC (acidic conditions): overall positive surface charge  
Enhancing electrostatic interactions between negatively charged PFAS
    - Above PZC (alkaline conditions): overall negative surface charge  
Creating electrostatic repulsion
  - Conclusion: Optimal adsorption in neutral to slightly acidic range
- Impact of water hardness and ionic strength (conductivity)
  - High ionic strength can affect charge interactions and competition for adsorption sites

PFOA in neutral form

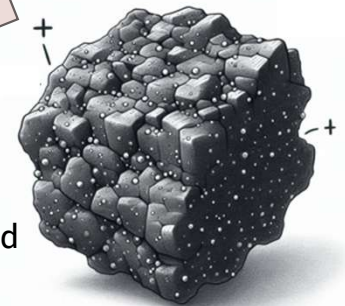


pH > 3,5



Enhanced  
electrostatic  
interaction

Positively charged  
carbon surface





# PFAS and POP regulation

- **Regulation (EU) 2019/1021 of the European Parliament and of the Council of 20 June 2019 on persistent organic pollutants (POP)**

bans or restricts the production and/or use of POPs in the European Union.

The regulation is intended to protect human health and the environment through specific control measures that:

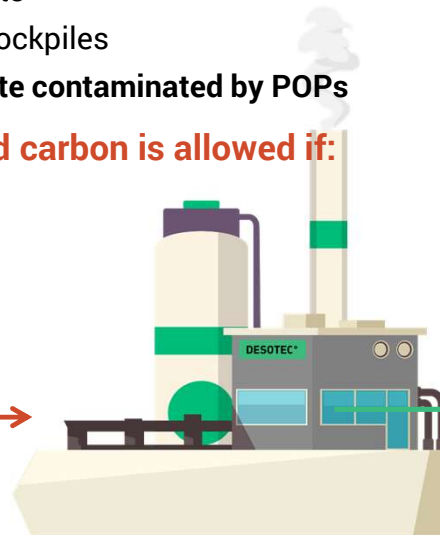
- Prohibit or restrict the production, marketing, and use of POPs
- Minimize environmental release of POPs by-products
- Ensure the safe management of restricted POPs stockpiles
- **Regulate the proper disposal of POPs waste or waste contaminated by POPs**



- **Thermal reactivation/recycling of spent activated carbon is allowed if:**



PFHxS < 1 mg/kg  
PFOA < 1 mg/kg  
PFOS < 50 mg/kg



**Reactivated carbon**

# Measuring PFAS on spent carbon



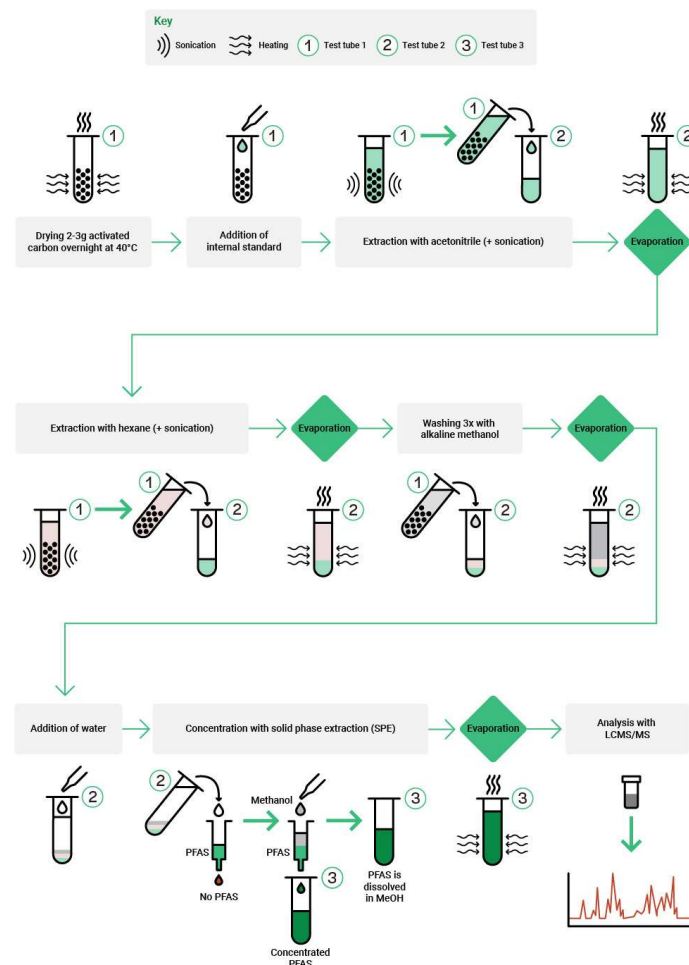
Challenge to comply with POP regulation:  
Not possible with existing methods to accurately extract and detect PFAS on spent carbon



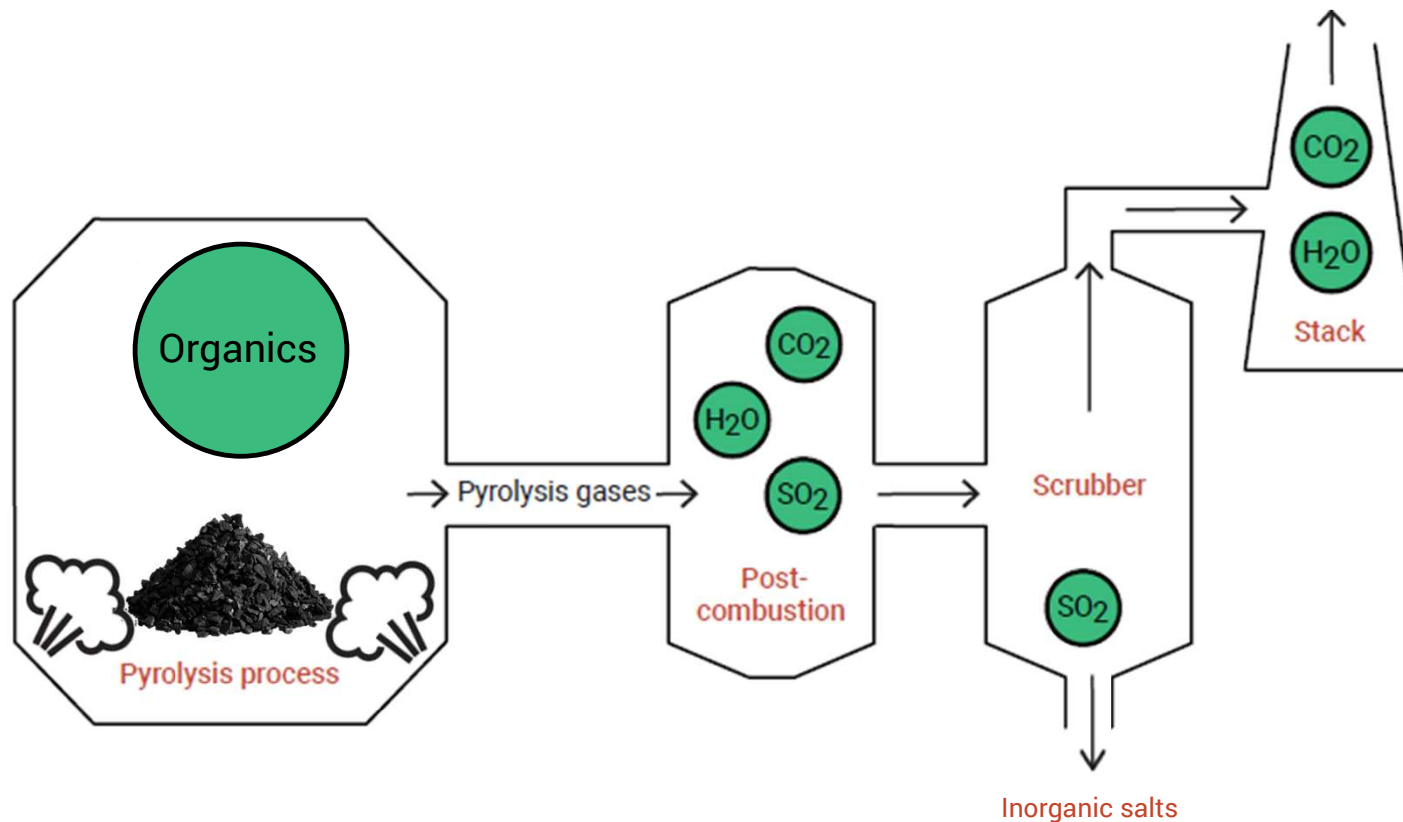
DESOTEC's solution:

1. New method developed in collaboration between DESOTEC and VITO
2. After extensive validation, the method was incorporated in DESOTEC's acceptance framework using an in-house LC-MSMS
3. It has now been officially included in the Flemish Compendium for the Monitoring of the Environment (CMA). This means it is recognized as a standardized method for regulatory compliance and environmental monitoring in Flanders.

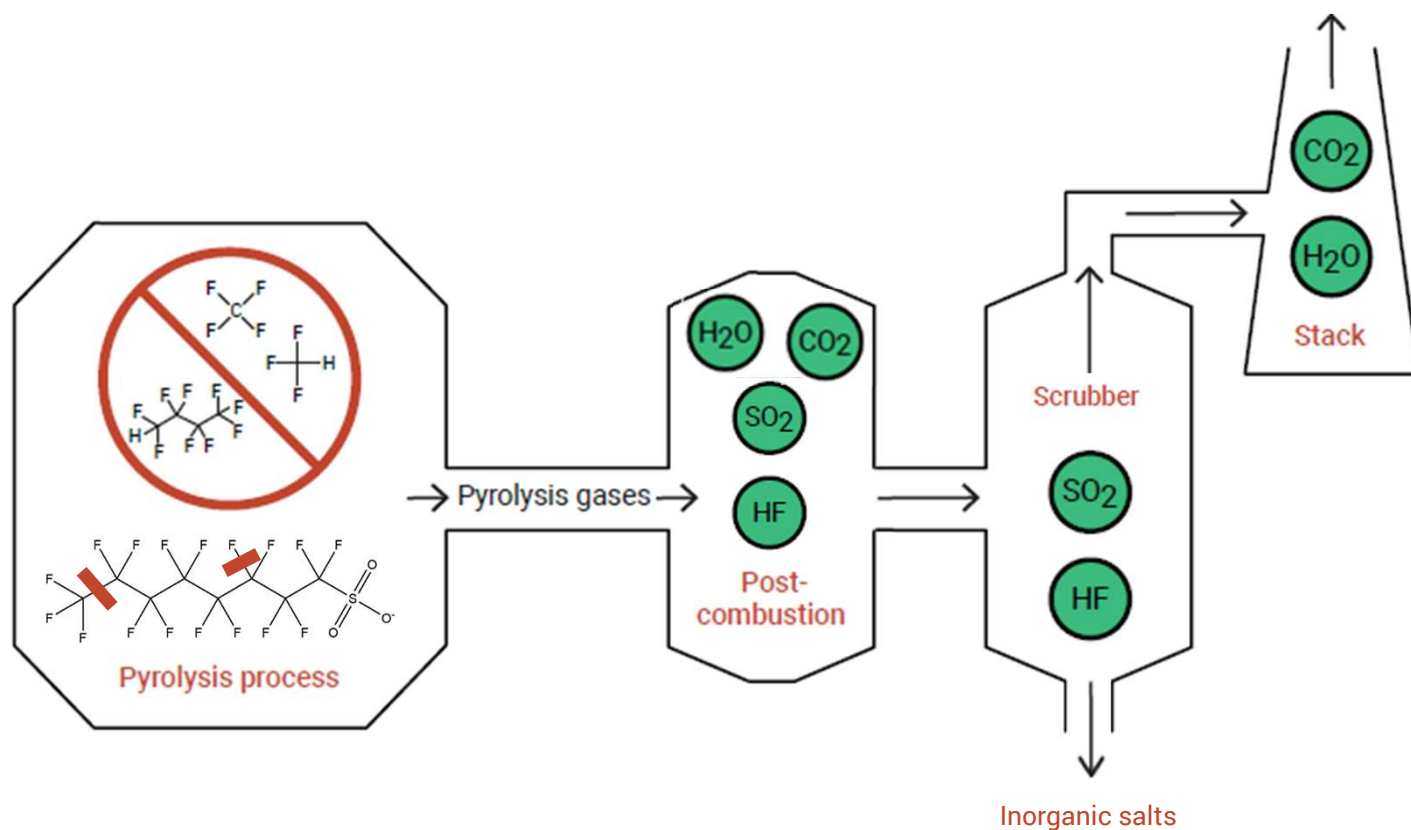
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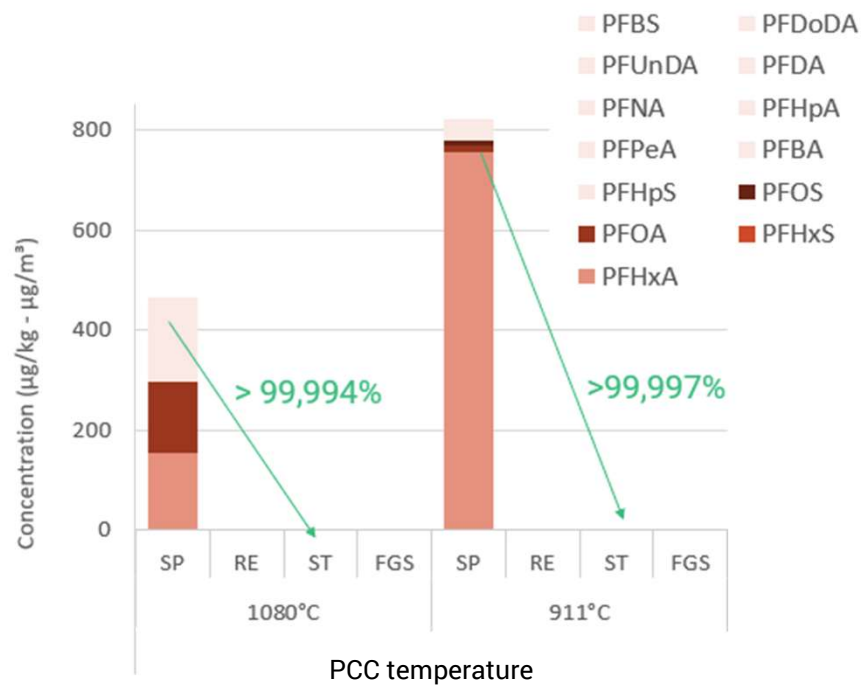
# Reactivation of activated carbon



# Mineralization of PFAS during reactivation

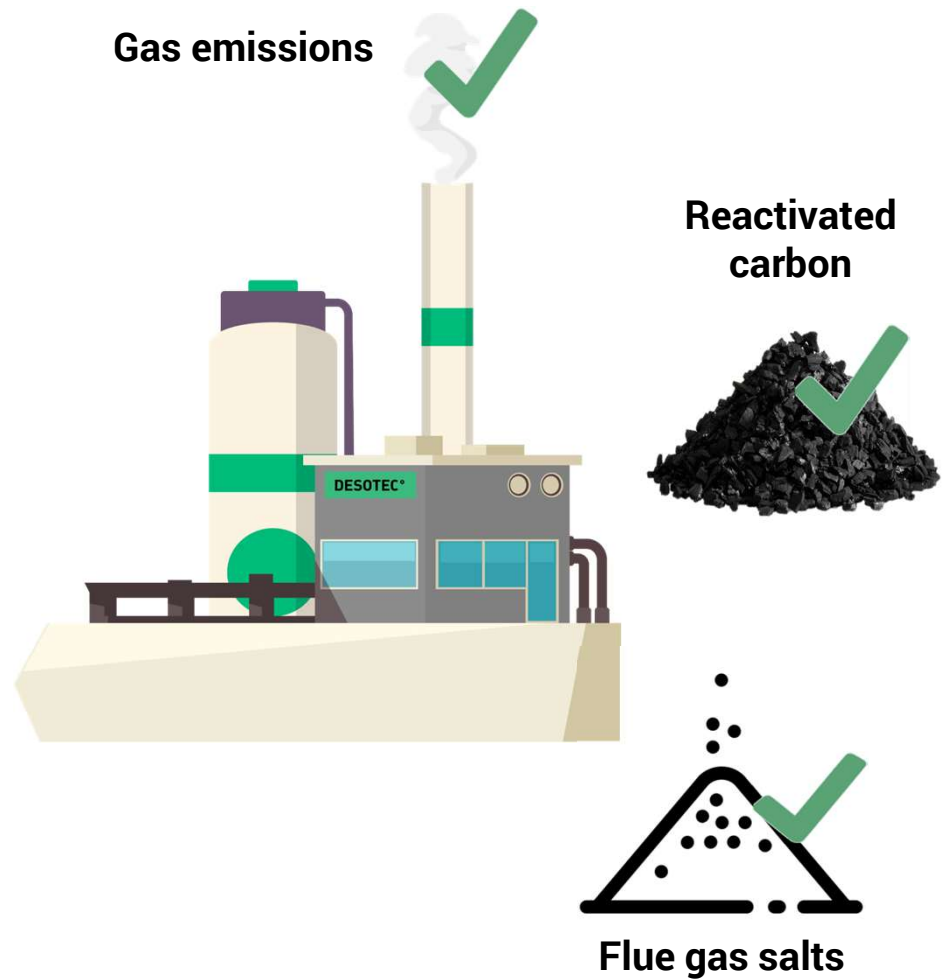


# Effective destruction during reactivation



SP = Spent carbon  
 RE = Reactivated carbon  
 ST = Stack  
 FL = Flue gas salts

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# Conclusions

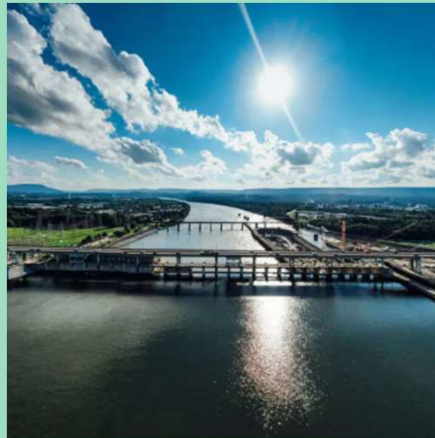
## Effective removal

Combining performant products with extensive application knowledge



## Compliant & sustainable solutions

POP compliant recycling by reactivation



## Effective destruction

Extensive measurements on the reactivation installation show destruction below detection limit and indicate mineralization of PFAS

