PFAS and PFOS The forever chemicals

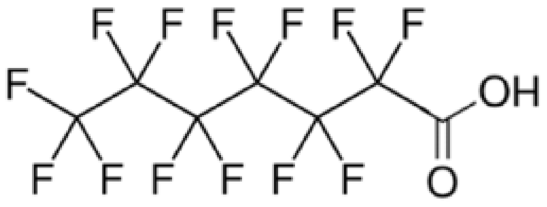
IVL Svenska Miljöinstitutet

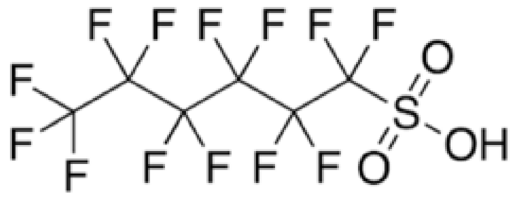
- Sweden’s leading research organisation for applied environmental and sustainability research

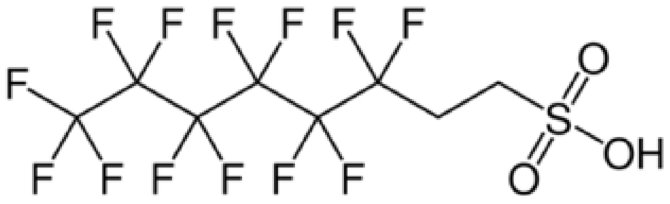
What makes PFAS special?

PFAS = extremely stable fluorinated substances

- Contains very strong carbon–fluorine bonds (–CF_2– / –CF_3)
  - Among the strongest chemical bonds known
- Highly persistent — they essentially do not degrade naturally.
- water- and oil-repellent
  - Provides functionality even at very low concentrations







Consequence:

- Technically useful — but difficult to control
- Mobile and bioaccumulative

PFAS analysis — an overview

Targeted analysis

- For specific, known PFAS with available analytical standards

Examples of broad-spectrum methods

- TOP-assay
- Extractable organic fluorine, EOF
- Total fluorine, TF

The regulatory landscape is changing rapidly

- Proposed broad PFAS group restriction under REACH (≈ 10 000 PFAS)
- Stricter environmental quality standards for surface water (PFAS25 expressed as PFOA-equivalents)
- Phase-out of PFAS in firefighting foams, with a transition period
- Review of PFAS in plant protection products
- Impact assessment of proposed soil guideline values

Punktkällor

- Fire training sites
- Industrial processes
  - Hard Chrome plating
  - PFAS containing materials
  - Process chemicals
- Landfills and leachate
- Plant protection products

Sekundära källor

- Stormwater
- Wastewater treatment
- Drinking water production

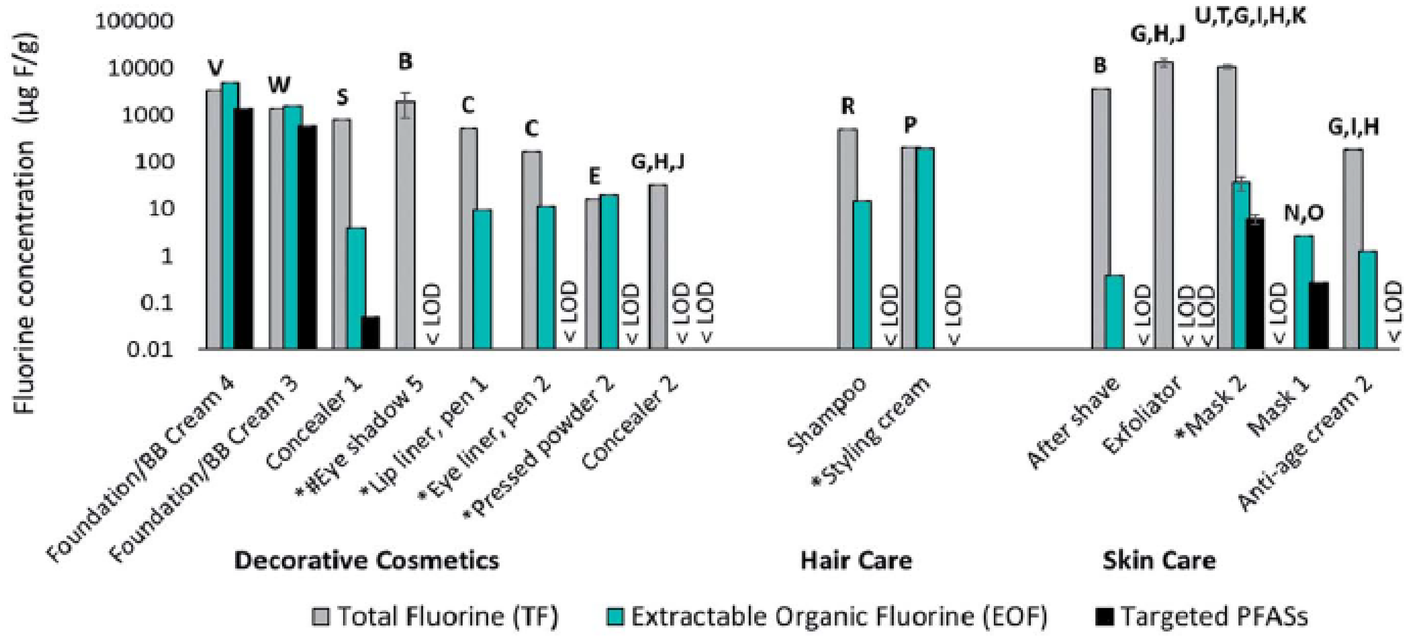
Diffusa Källor

- Atmospheric transport and deposition
- Consumer-related PFAS sources
- Biological and food-chain-related sources

Products and point sources

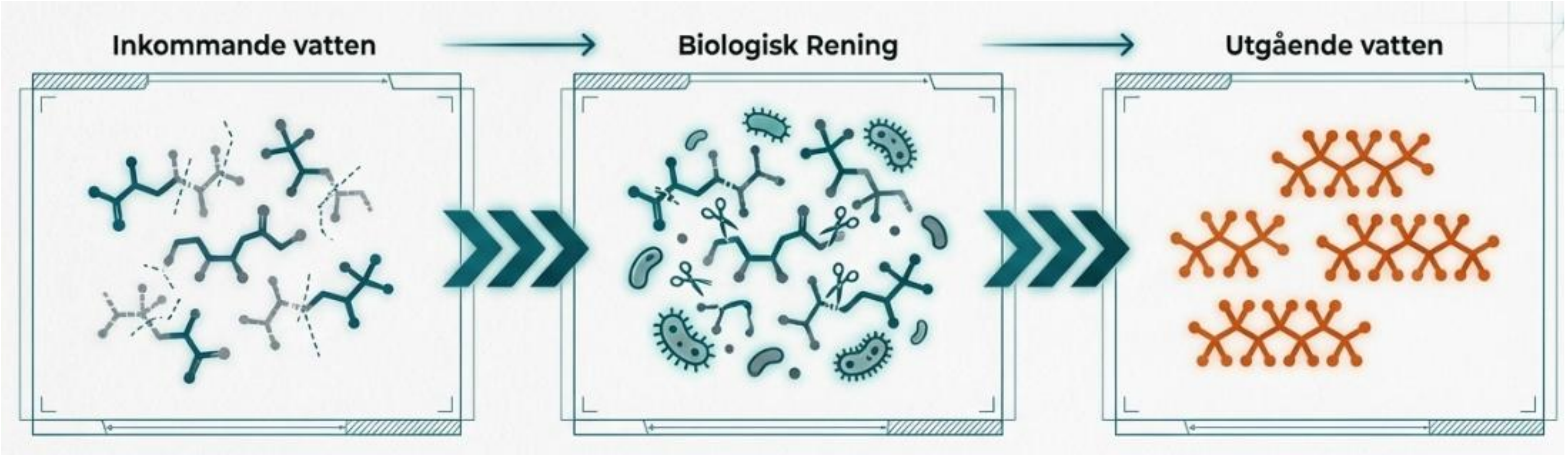
– where many problems begin

Same product, three different views of PFAS content



Today's biological treatment does not address the PFAS problem

PFAS tend to pass through, transform and recirculate rather than be removed



- No robust, general PFAS removal is observed
- Concentrations of some PFAS increase
- Internal recirculation via sludge and foam is an important factor

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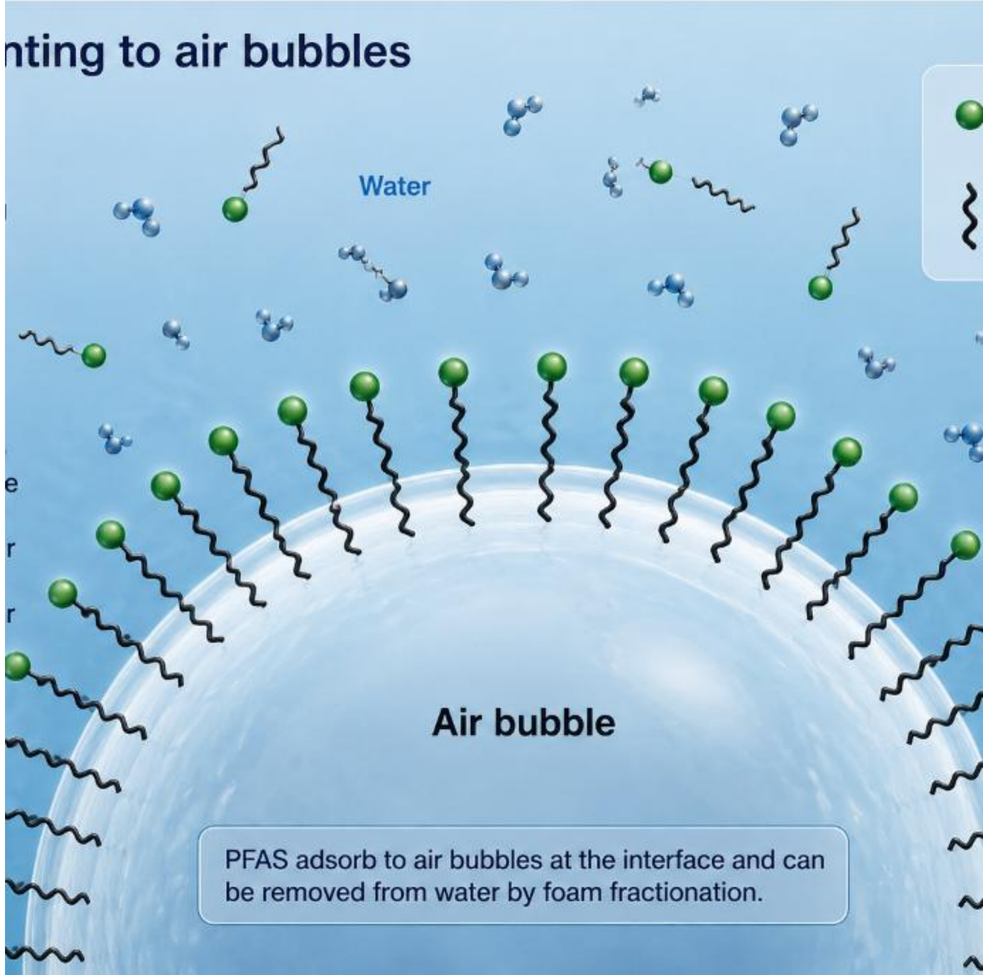
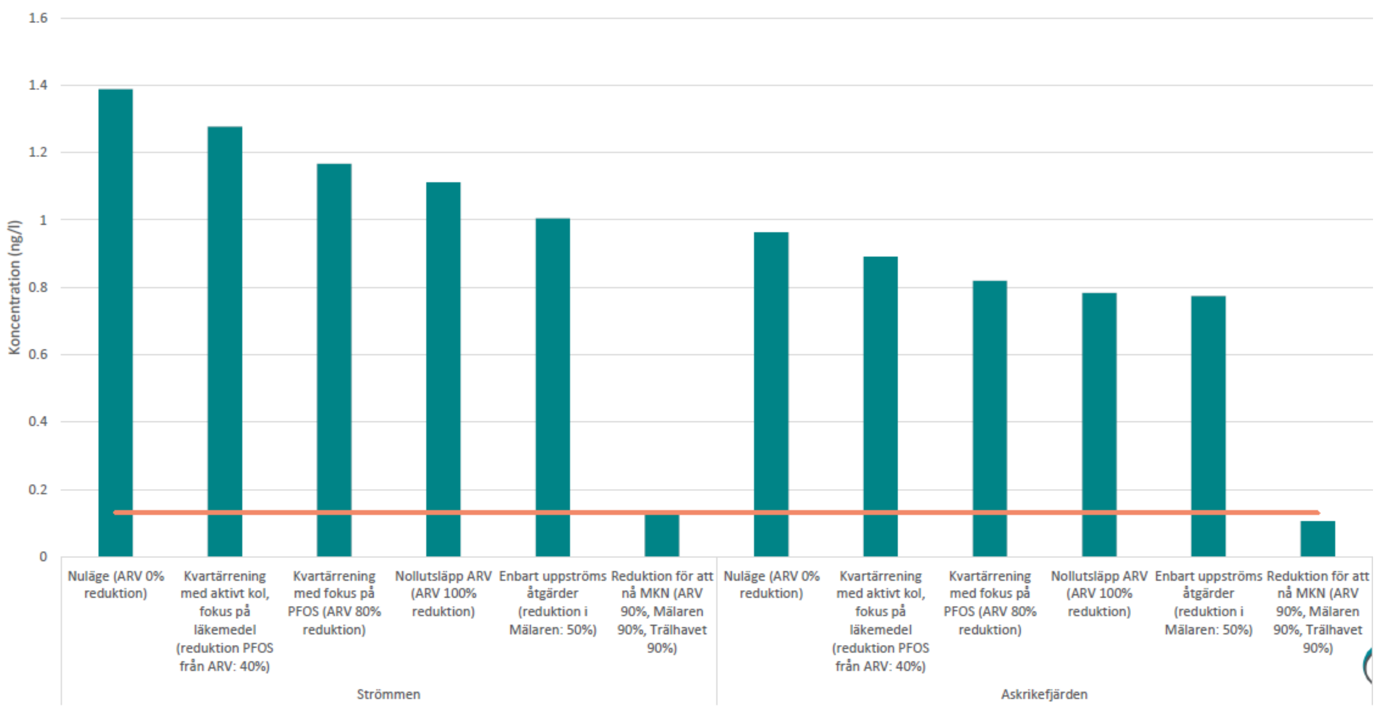
PFAS removal from wastewater by foam fractionation

- Municipal wastewater treatment plants are a significant pathway for PFAS emissions. The revised EU Urban Wastewater Treatment Directive introduces requirements for micropollutant removal and PFAS monitoring, although no specific PFAS removal target has yet been set. Conventional treatment cannot effectively remove PFAS from water and sludge. Ion exchange and activated carbon are effective, but costly and resource-intensive, with limited capacity and lifetime.



Treatment performance at the plant does not necessarily translate into reduced impact in the recipient

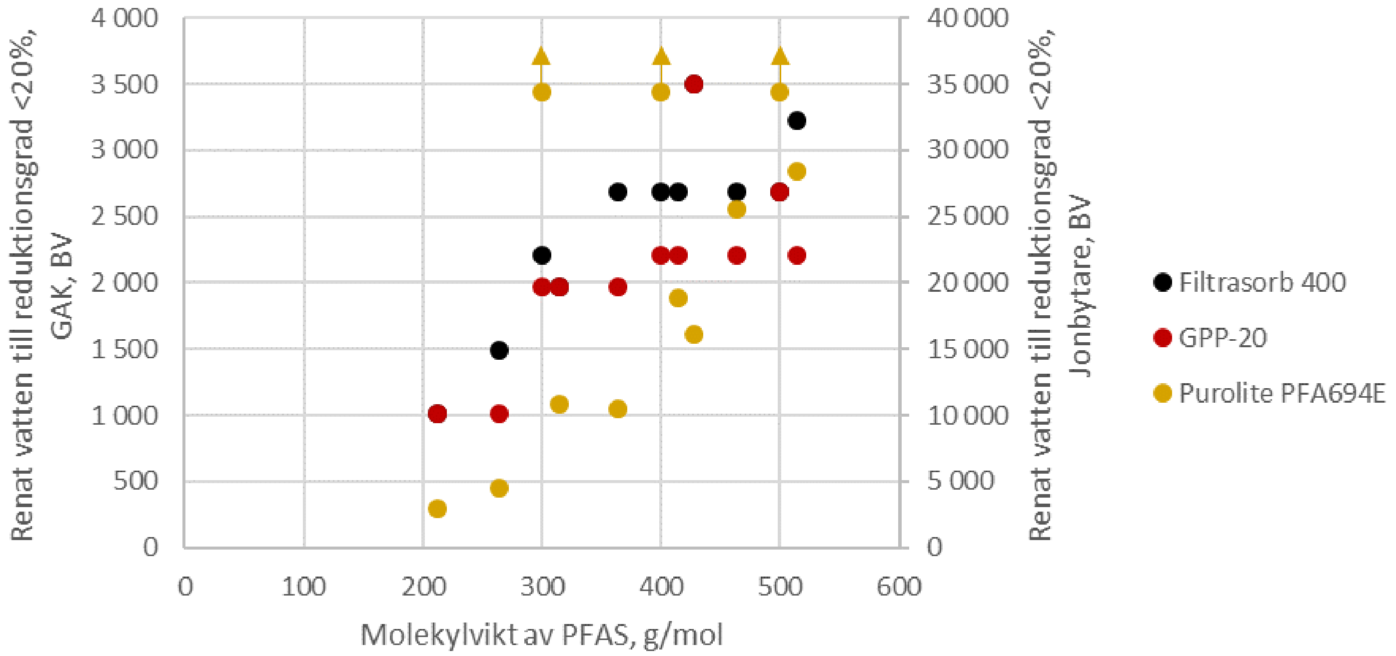
For PFOS, upstream inputs are a major driver of the overall load



- Modelled PFOS load: Lake Mälaren 63%, Trälhavet 21%, WWTPs combined 14%
- Modelled PFOS: WWTPs account for 14% of the load; current WWTP removal is 0%
- Therefore, upstream inputs are a major driver of PFOS concentrations in the receiving water body

Treatment technologies exist — but performance varies

Chain length, water matrix and treatment objectives determine the most suitable approach

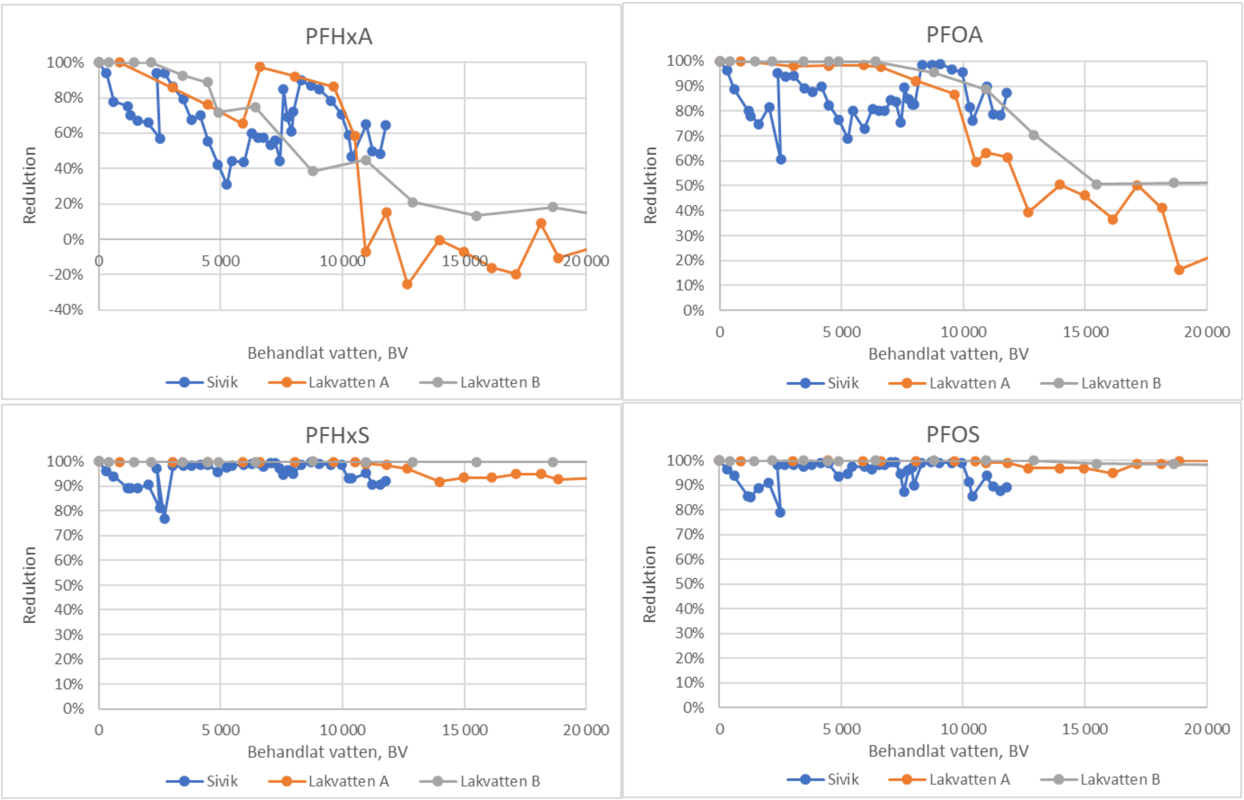


- Short-chain PFAS are more difficult to remove than long-chain PFAS
- Foam fractionation, GAC and ion exchange showed the greatest potential in B2412

Källa: Rapport B 2412 Rening av PFAS-förorenat vatten från avfallsanläggningar

PFAS treatment can be effective — but requires robust operation

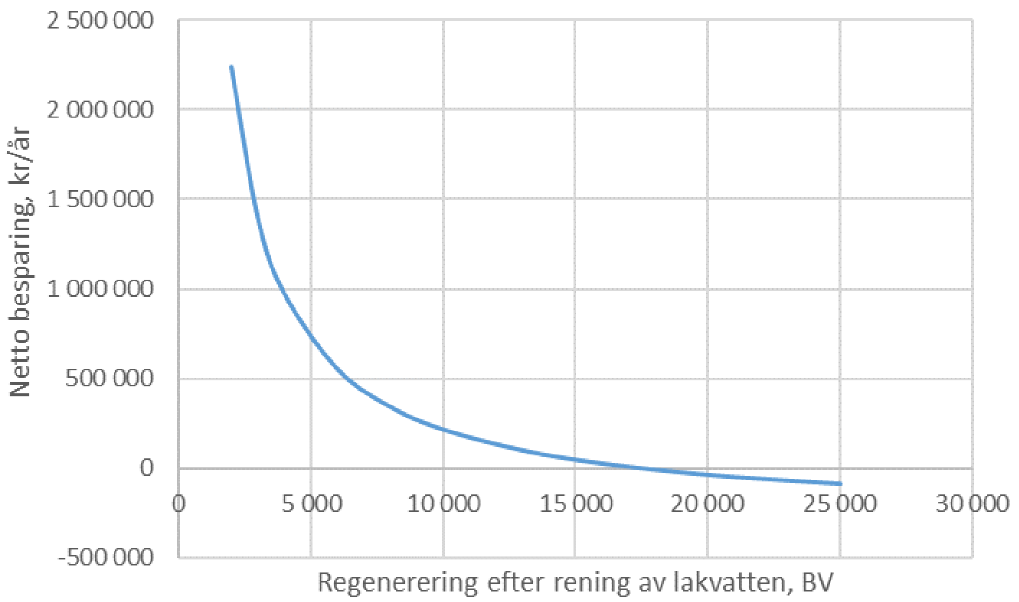
Upflow operation was evaluated and shown to be cost- and resource-efficient during the study period. However, hydraulic performance and systematic follow-up are important to ensure reliable treatment performance.



- At Sivik, the average PFOS reduction was 94% during the trial period, maintained after treatment of 14,300 BV
- The study estimated that treatment costs could be almost halved compared with conventional pre-treatment
- The risk of ion exchange resin or microplastic losses must be addressed

Resource-efficient PFAS water treatment

Regeneration of ion exchange resin



- Regeneration is effective, but recovering the regeneration solution is essential for economic viability
- Regeneration becomes more attractive as requirements tighten and the resin needs to be replaced more often; otherwise, single-use operation may still be justified

Current status and next steps

- Continued interest in exploring new matrices and industry sectors
- Improved efficiency, with reduced economic and climate impacts
- Identification of sources and source tracking
- Research has so far focused mainly on separation, while increasing attention is now being directed towards destruction and combined separation/destruction approaches
- Adaptation to upcoming regulatory requirements: EQS PFAS25

Recommendations and next steps - A coordinated and long-term approach to PFAS

- Limit environmental impact
- Minimise human exposure
- Combine remedial and preventive measures
- Strengthen existing environmental and chemicals management with a clear focus on PFAS

Address known high-risk areas

- Fire training sites, PFAS-containing firefighting foams and extinguishing agents → technical barriers and treatment solutions
- Clarify roles and responsibilities
- Map PFAS dispersion in surrounding soil and water
- Identify potential point sources, including chemicals and materials

Develop a stronger knowledge base

- Expanded sampling across different matrices, including PFAS 21/25, ultra-short-chain PFAS and broad-spectrum analysis
  - Water sampling to identify potential sources
- Long-term monitoring time series
- Assessment of potential local diffuse sources

What can IVL contribute?

- Mapping and analysis
- Risk assessment and remediation planning
- Pilot trials for treatment and remediation
- Strategic support
- Coordination and stakeholder engagement

Four guiding principles

- Reduce PFAS at the source
- Understand how PFAS spreads
- Go beyond standard analytical packages
- Apply treatment where it has the greatest impact

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Tack!

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PFAS are not one substance — but a large group of chemicals

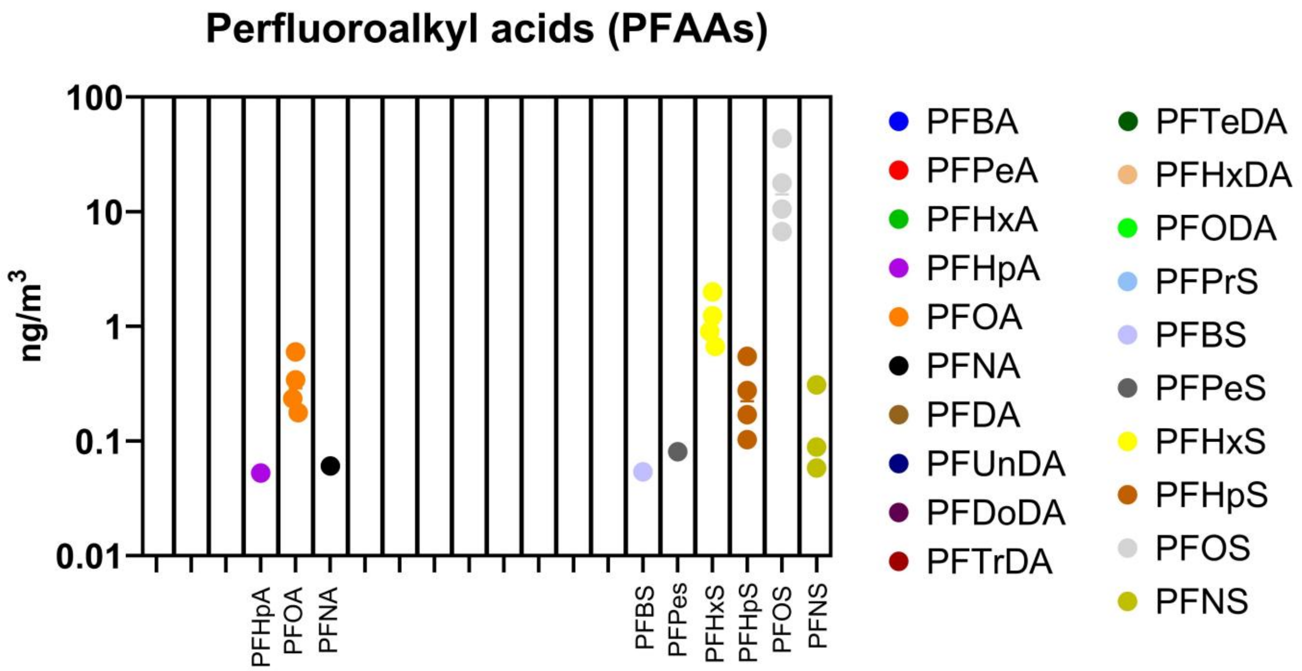
- 7 million substances under the new definition (2021)
- Main subgroups
  - Polymers, e.g. PTFE/Teflon, PVDF
  - Non-polymers, e.g. PFOS and PFOA — among the most stable groups
- Long-chain and short-chain PFAS
  - Ultra-short-chain PFAS – e.g. TFA!
- Precursors → can be transformed into stable PFAS

Summaparametrar

- PFAS4
- PFAS11
- PFAS21
- PFAS25

PFAS are enriched at the air–water interface

Elevated concentrations occur where air is bubbled through water in wastewater treatment plants



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Targeted analyses show only the tip of the iceberg

Targeted PFAS analysis accounts for only a small fraction of EOF