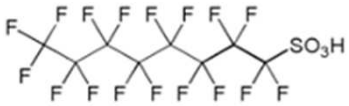


Effects of enhanced removal of micropollutants on PFAS

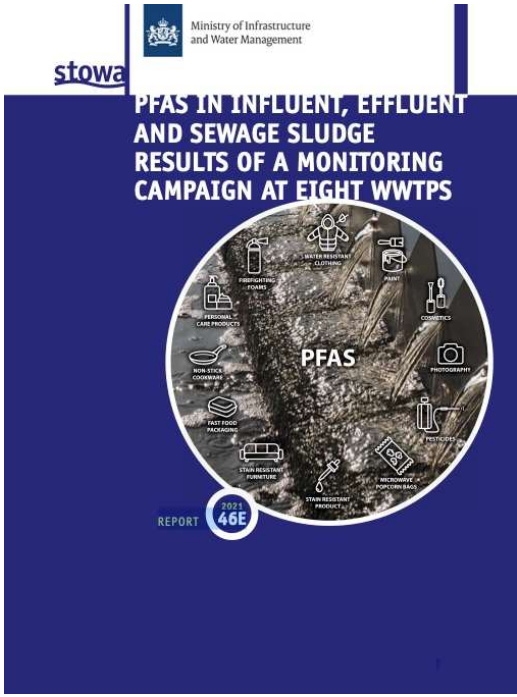
First results of a monitoring campaign

Anja Derksen, AD eco advies

Contents

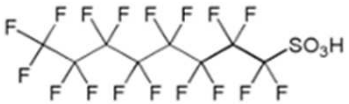
Background and motivation

- Conclusions monitoring campaign ‘PFAS in WWTPs’ (a.o.):
  - PFAS hardly removed
  - Apparent increase of PFAS in WWTPs:
    Non analysed (unknown) PFAS precursors in the influent are transformed in the WWTP to analysed (known) precursors and stable PFAS with a short chainlength (C4 – C8)
- How do enhanced techniques for removal of micropollutants deal with PFAS?
- Sampling in parallel with antibiotica resistence project

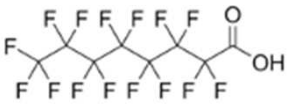


STOWA report 2021-46E: https://www.stowa.nl/publicaties/pfas-influent-effluent-and-sewage-sludge-results-monitoring-campaign-eight-wwtps

What are PFAS and PFAS precursors?

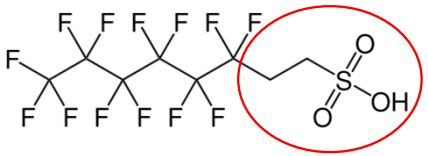


PFOS

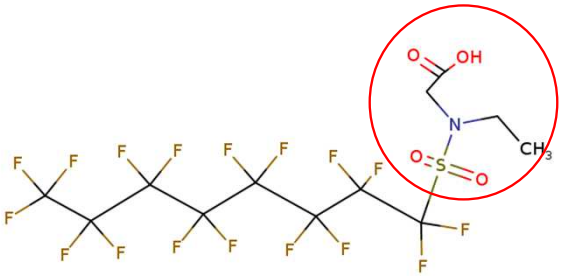


PFOA

Stable PFAS: completely fluorinated ‘tail’, different ‘heads’
Due to full fluorination very poorly degradable



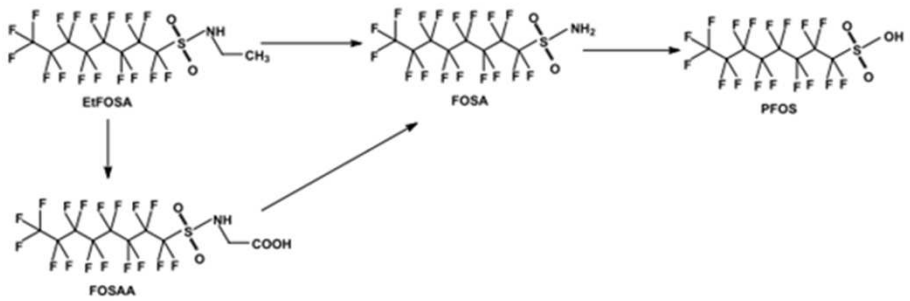
6:2 FTS



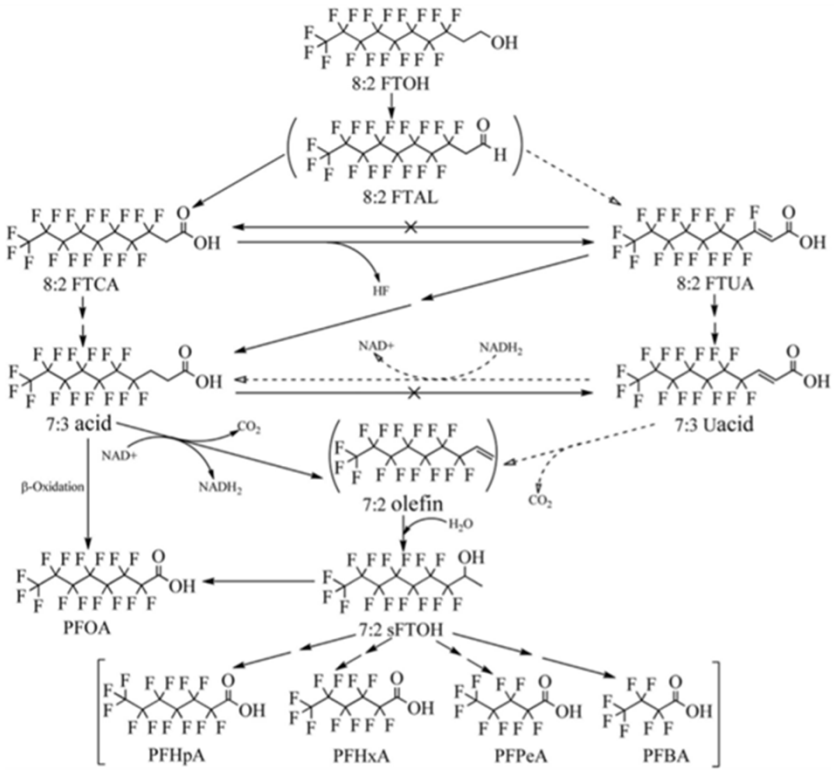
N-EtFOSAA

Precursors: (un)completely fluorinated ‘tail’,
‘Heads’ with nitrogen, sulfate or similar included, degradable

Degradation of PFAS precursors

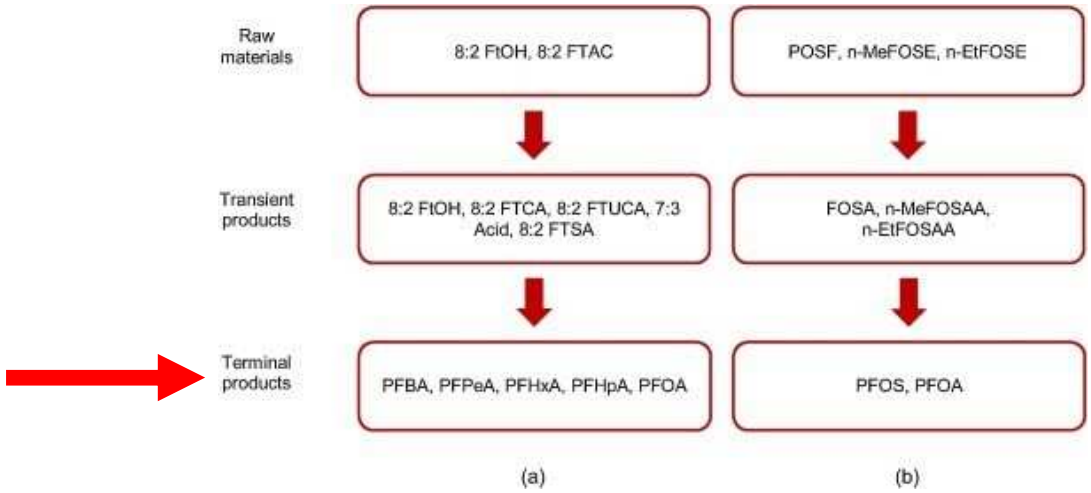


from simple



to very complex

Degradation of PFAS precursors



In all cases stable
PFAS (C4 - C8) are formed!

What about smaller PFAS (<C4)?
Hardly investigated so far!

Alternative analytical methods needed to measure unknown PFAS precursors: TOP analysis

Goal

To increase knowledge about:

- Removal of PFAS and PFAS precursors by advanced water treatment techniques
- The presence of PFAS and PFAS precursors in WWTP effluents
- The presence of ultrashort PFAS (<C4) in WWTP effluents (*new*)
- The applicability of the Total Oxidizable Precurors (TOP) analysis to monitor (un)known PFAS precursors (*new*)

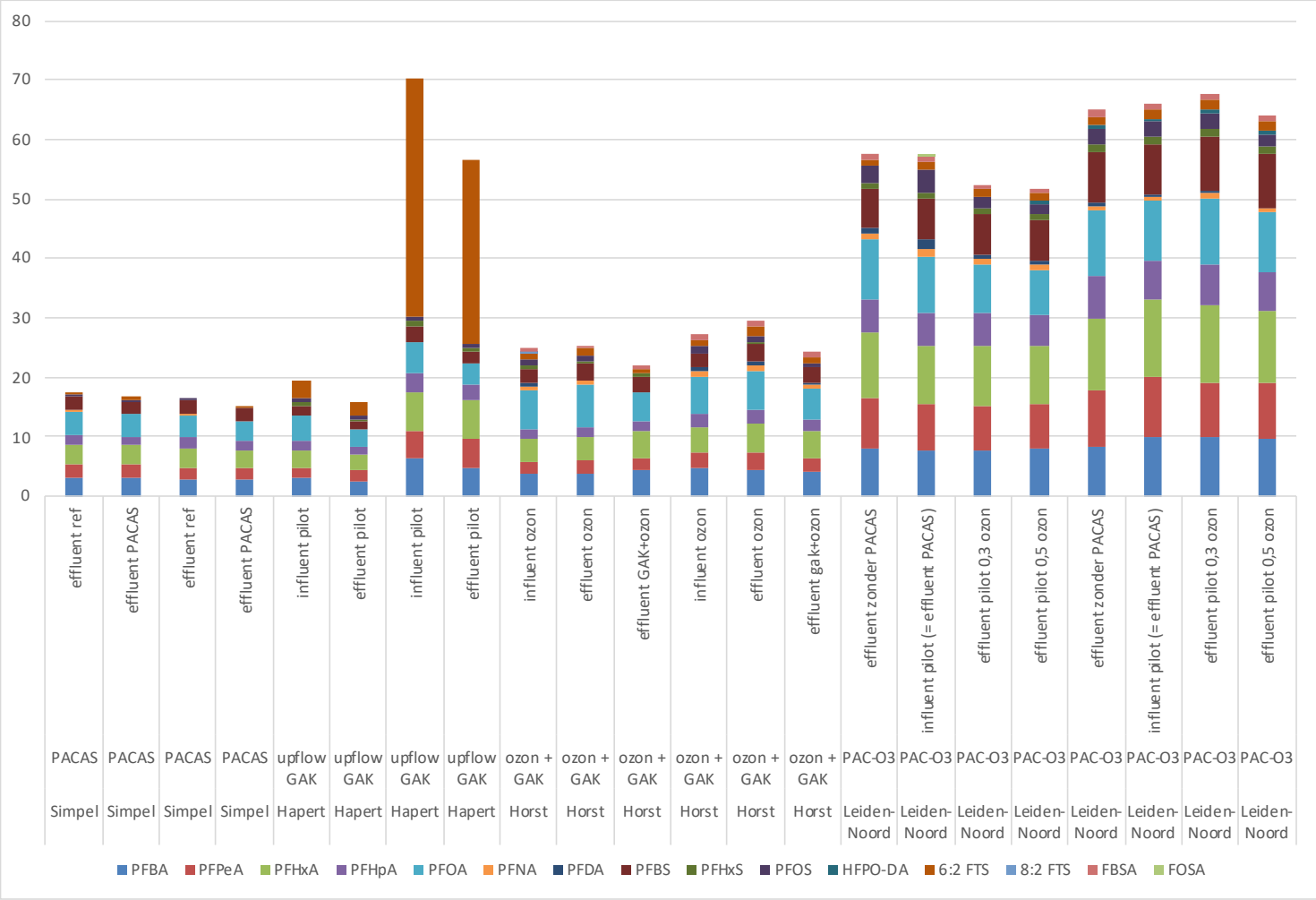
First results

- 6 WWTPs, 6 techniques
  (PACAS, upflow GAK, ozon+GAK, PAC-O3, ozon+filter, NF+UV)
- First glance of results of additional pilots (7 WWTPs, 8 techniques)
  (PACAS, BODAC, GAK-O2, AdOx, Dex-filter, ozon, BO3-B, NF+UV)
- Only regular analysis and ultrashort chains
- Beware, conclusions are not generic
  - Number of samples and locations is limited
  - PFAS fingerprint is different for each WWTP

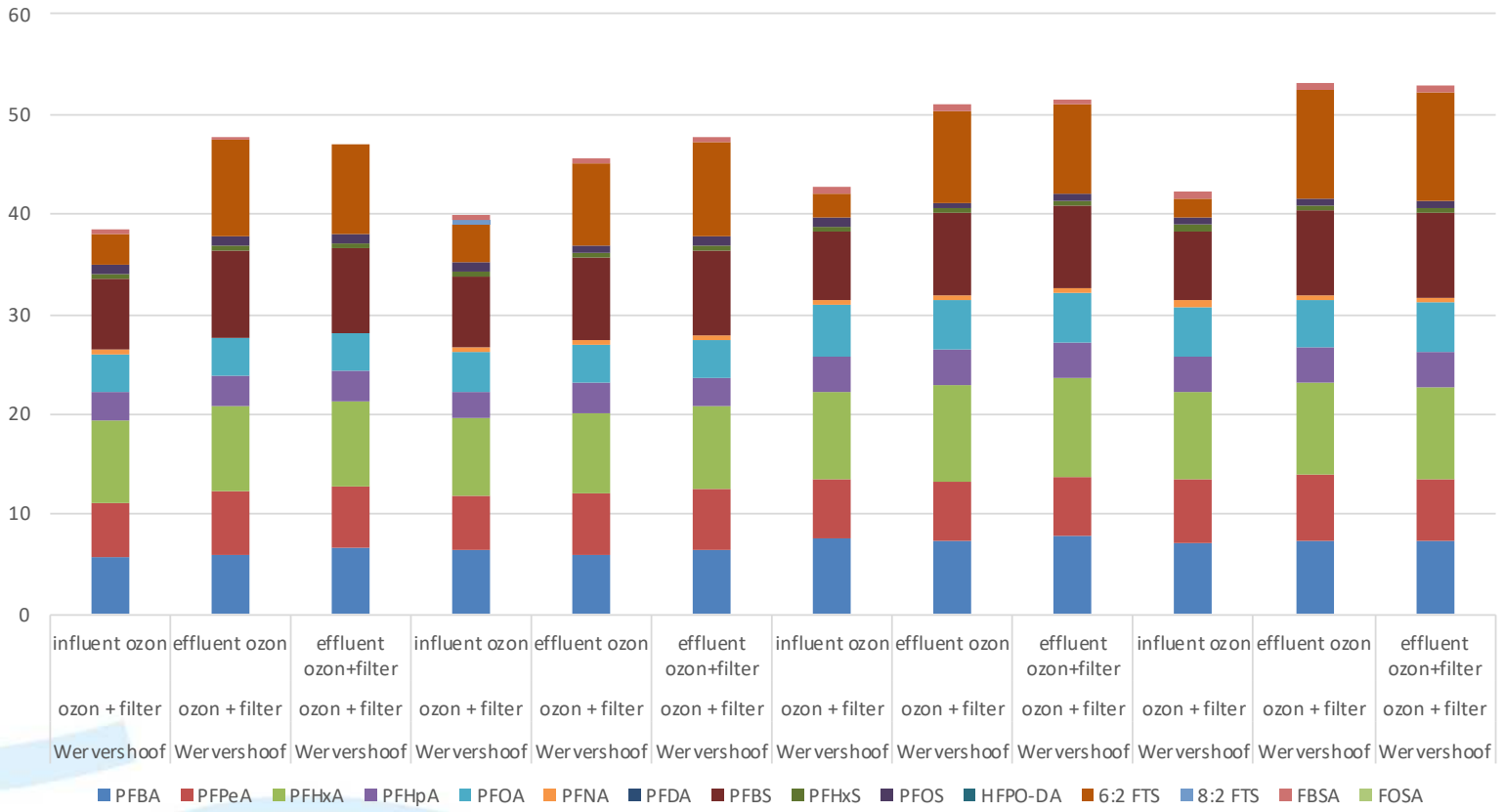
Spoiler alert

- Most additional treatment techniques do not remove PFAS
- At WWTP Wervershoof (ozon) increase of 6:2 FTS
- At WWTP Asten (NF+UV) decrease of all PFAS at finest NF
- At WWTP Hapert and WWTP Asten variations in concentrations in regular effluent observed

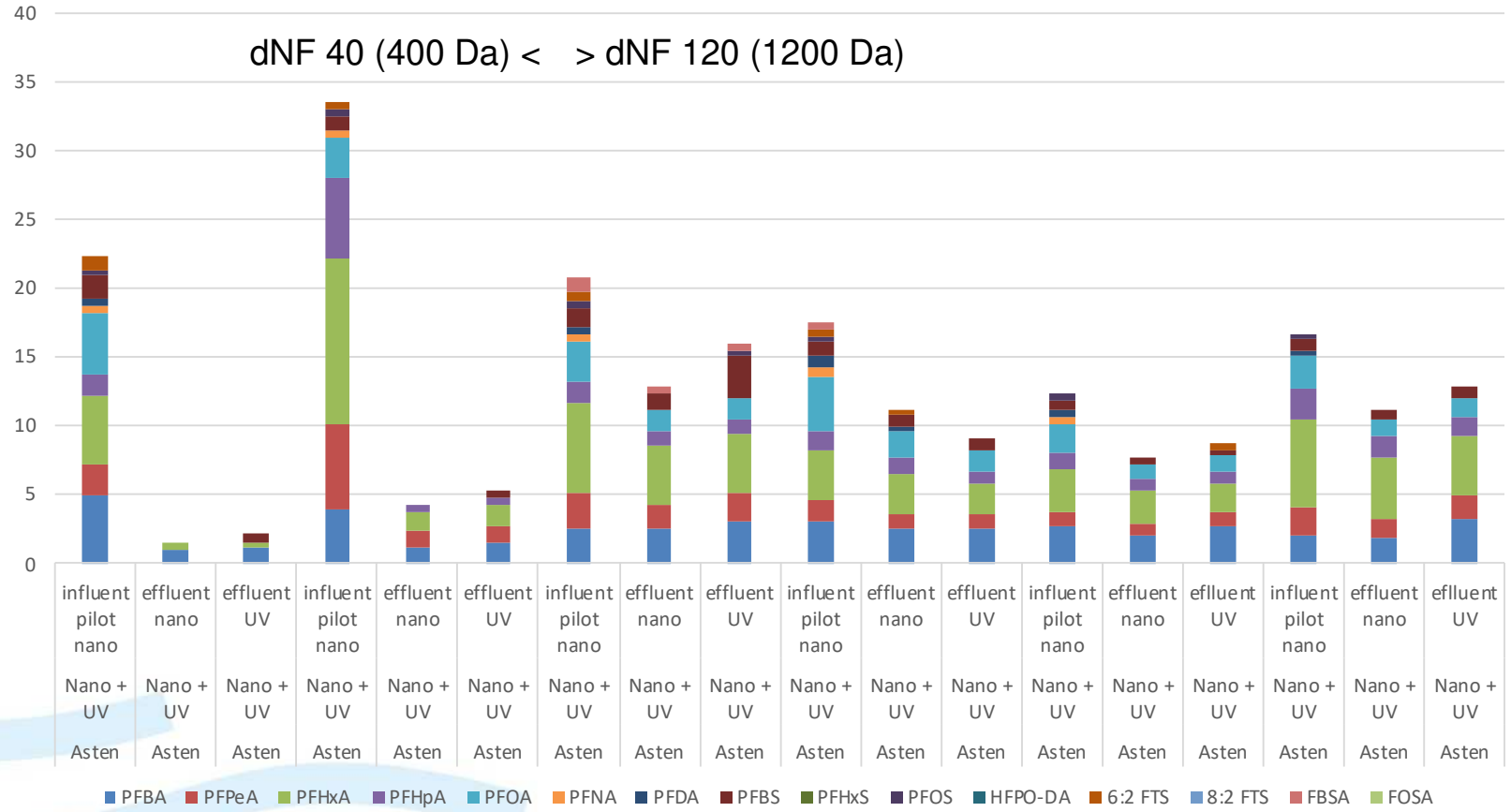
Concentrations (ng/l)
(from left to right influent, effluent, day 1, day 2 and so on)



Concentrations Wervershoof (ng/l)

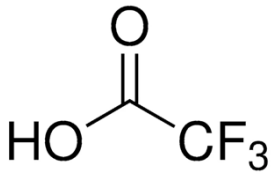


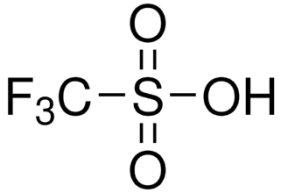
Concentrations Asten (ng/l)



Ultrashort chains

- Only TFA (trifluoroacetic acid) and TFMS/F3-MSA found
- Results very comparable to regular PFAS
- ‘TFA is the new PFOA’:
  - Still little investigated but almost everywhere present in high concentrations (<DL – several µg/l)
  - Also emitted by Chemours
  - Very mobile and persistent, hard to remove
  - Degradation product of PFAS precursors? Natural occurrence?
  - Risks?
- TFMS/F3-MSA: very little known about





Expectation techniques

- Activated carbon: especially effective for longer chainlenghts, PFCA's <C8, PFSA's <C6 poorly removed, precursors?
- Ozon: attacks double carbon…..?
  Degradation of precursors exspected. Possible increase of other precursors and short chainslengths
- Nanofiltration: membrane <90 Da wil remove most PFAS
  (stable PFAS have a molecular size of approx. 200 – 500 Da)

✓ confirmed

First glance at other pilots

- New: also branched PFOA, PFOS and PFHxS analysed
  Branched PFOA and PFOS not to be ignored at some locations
- Ozon: confirms results of Wervershoof or no clear effect
- NF+UV (Asten): in between NF membrane gives in between removal
- AdOx and Dex-filter: some removal
- Techniques based on activated carbon: mostly little effect but needs to be studied in more detail for branched PFOS and some precursors

Outlook

- All pilots and demo’s have been sampled
- Results for two more techniques to be expected
- Results of Total Oxidizable Precursors (TOP) analyses to be expected
- Further processing of data
- WWTPs will be ranked based on PFAS emission factors
  (mg PFAS/PE150 per year)
- Overall report in Q1 2024

Take home messages

- Most additional treatment techniques do not remove PFAS
- Some techniques may even increase PFAS concentrations, especially when PFAS precursors are present in the regular effluent
- Filtering techniques seem to remove PFAS to some extend, NF with fine membranes being the most promising
- Two ultrashort chain PFAS have been found in effluent: TFA (~ µg/l) and TFMS/ F3-MSA (up to ~ 40 ng/l)

Thank you for your attention!

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stowa

Ministry of Infrastructure and Water Management

Tackling Micropollutants in Wastewater
Results of the Dutch Innovation and Implementation Program

November 8 and 9 2023
Aquatech Amsterdam