



Removal of perfluoroalkyl acids from the drinking water production chain

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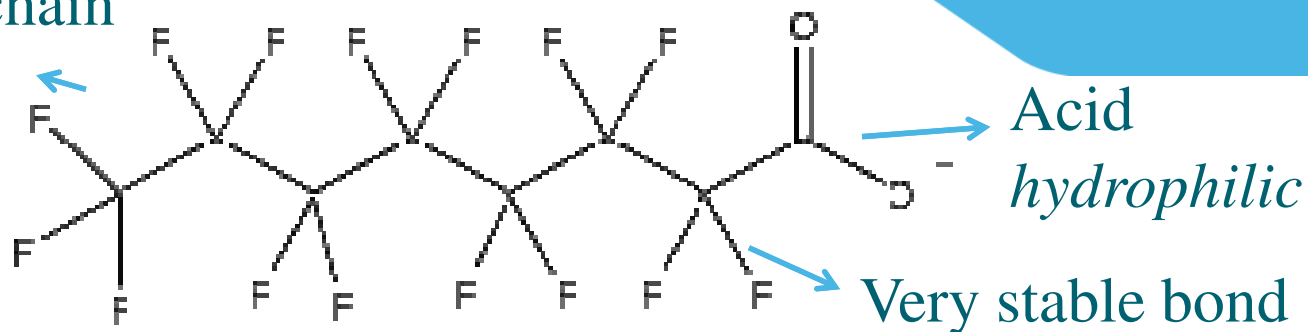
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Outline

- Introduction
- Sources of PFAS to groundwater
- Behavior of PFAS in drinking water production
- Conclusions

Perfluoroalkyl acids - properties

Fully fluorinated chain
hydrophobic



Perfluorooctanoic acid (PFOA)

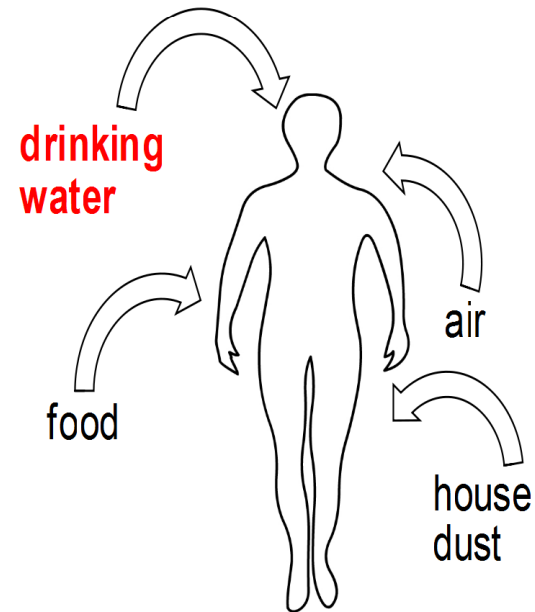
- Chain length varies $n_{\text{CF}_2} + \text{F} = 3$ to 17
- Very persistent, possibly bioaccumulative and toxic.
- Water solubility: 9.5 g/L \rightarrow high!
- Multiple uses

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Introduction

- PFAA in environmental compartments
 - Surface water, biota, air
 - Human serum
- Exposure pathways
(denHollander, 2010)
 - Drinking water
(Vestergren, 2009)



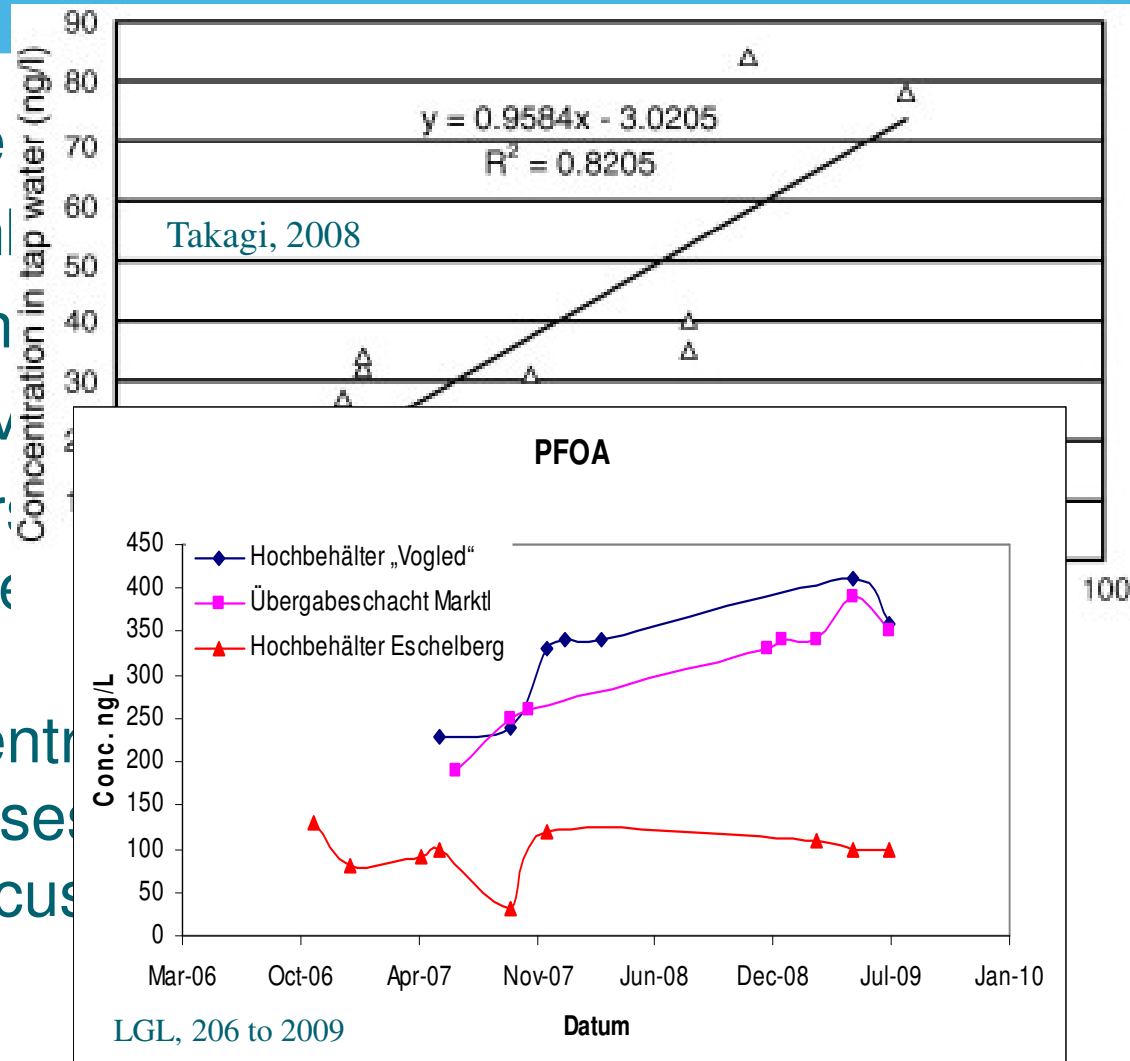
Introduction

Perfluoroalkyl acids in drinking water: Sources, fate and removal.

- Sources: to groundwater and surface waters
- Fate: During treatment
- Removal: Affinity adsorption

Introduction

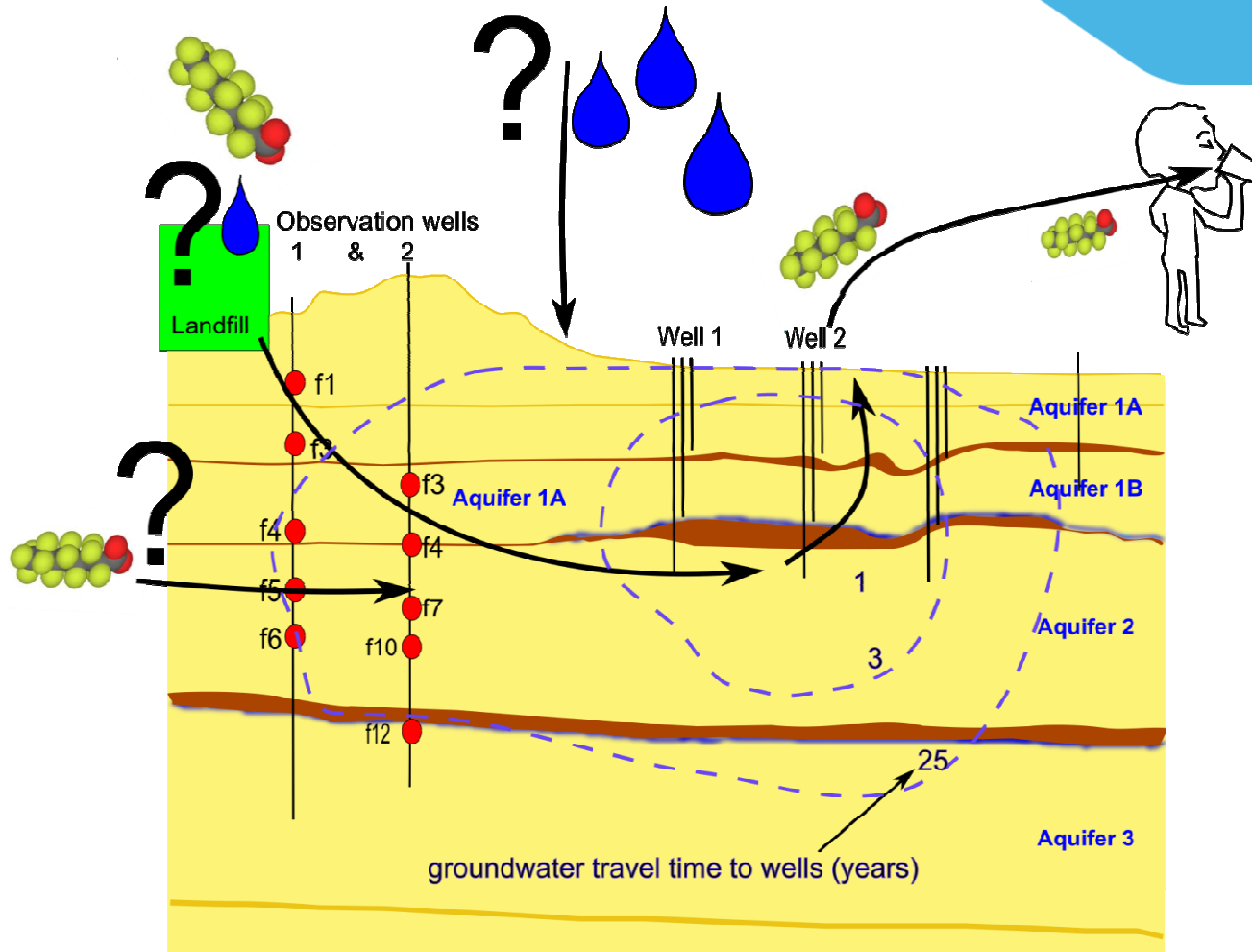
- PFAA in surface
- Surface vs. Drinking
- Background concentration
 - low ng/L level
- In surface waters: high concentrations
- Unknown concentrations
- Info mainly focused on
- Info does not focus on



Sources to groundwater

- Low concentrations in general (ng/L)
- Much less info available
- Sources
 - fire fighting practise
 - Landfills
 - Producing/using companies
- Drinking water treatment less thorough

Case study



Groundwater: Case study

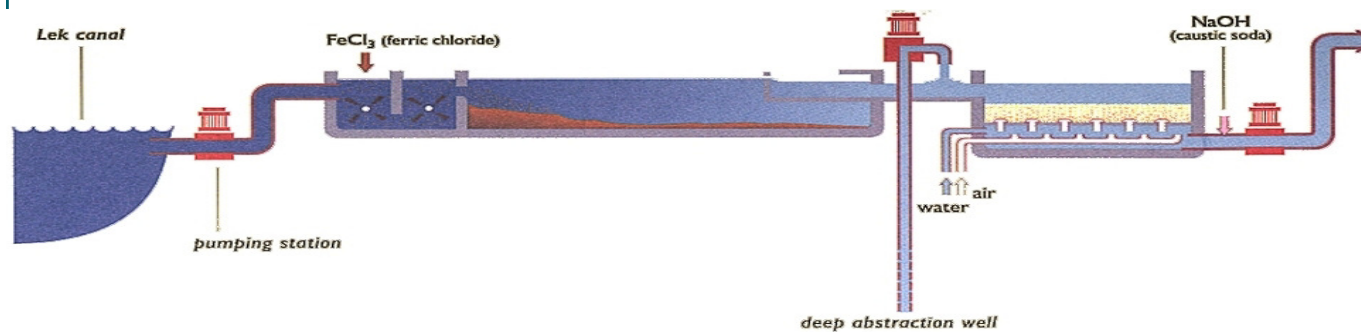
- Chain length dependent behaviour
 - PFOS not mobile
- Point source: Landfill
- Diffuse source: Rainwater
- PFOS mobility
- Removal from groundwater...?

Fate: During treatment

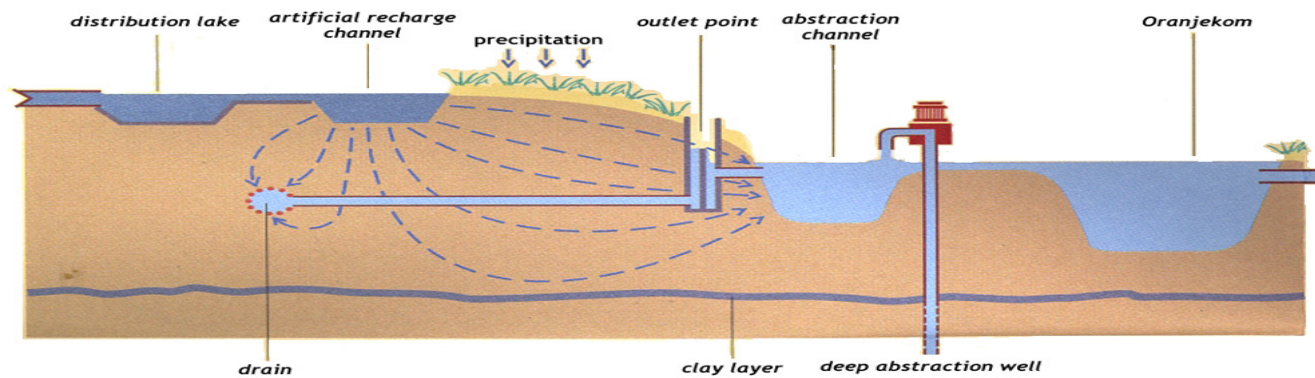
- Drinking water production of Amsterdam
- Two sampling rounds
- Hydrological retention time taken into account
- More than 60 samples analyzed in duplicate over two seasons



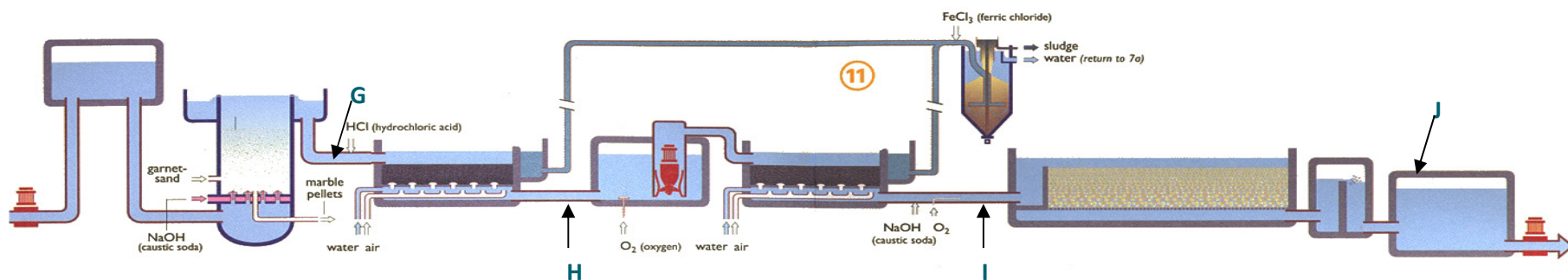
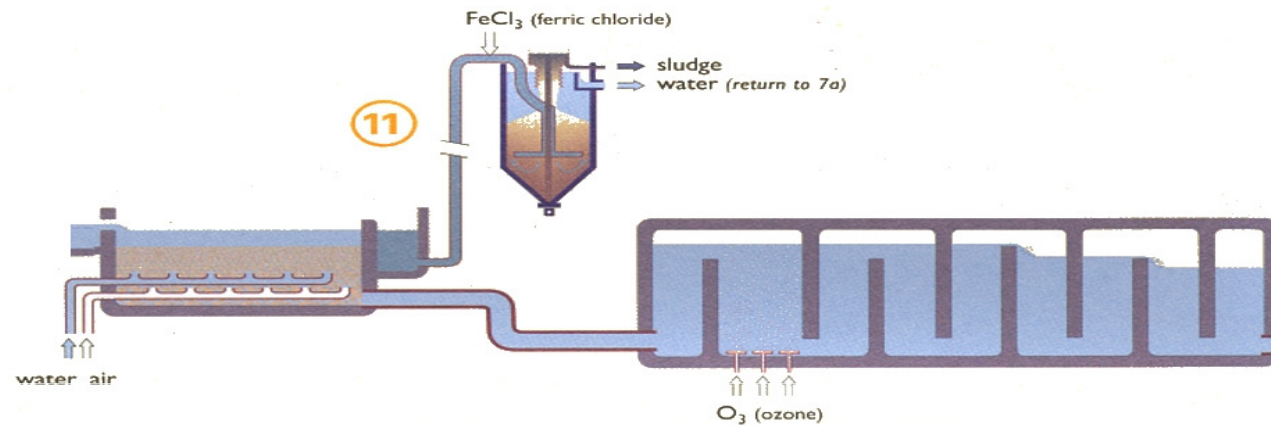
Drinkingwater treatment



*Drinking
Water
Production
from river
Rhine water
in NL
with sampling
points*

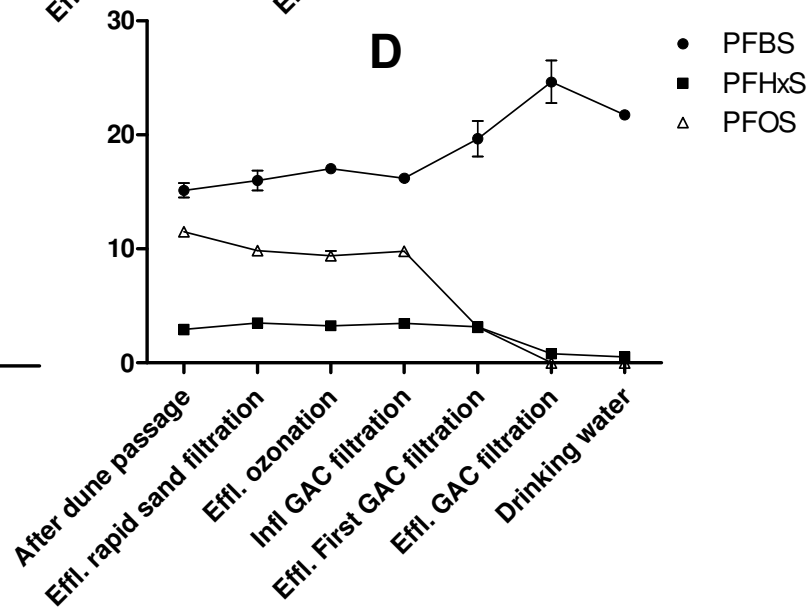
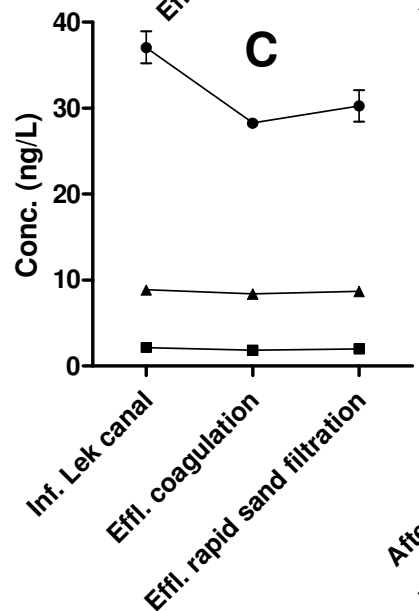
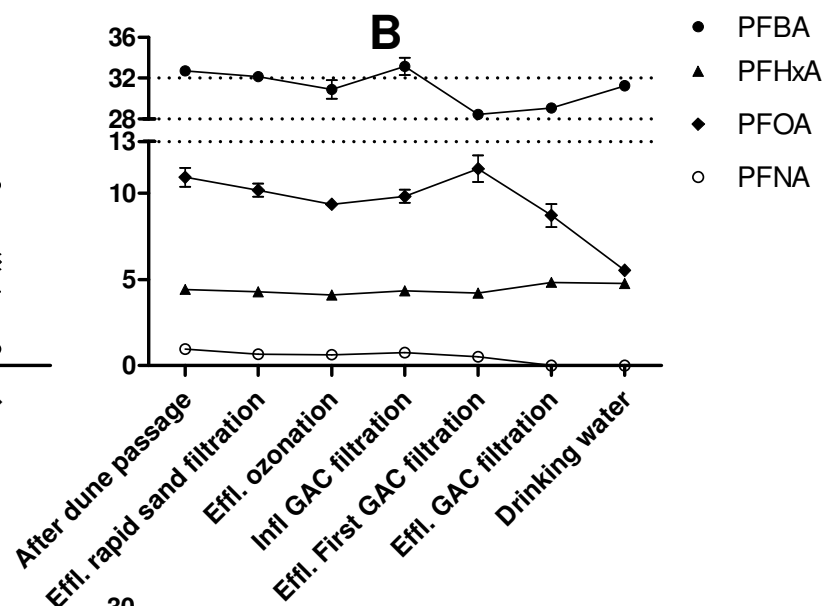
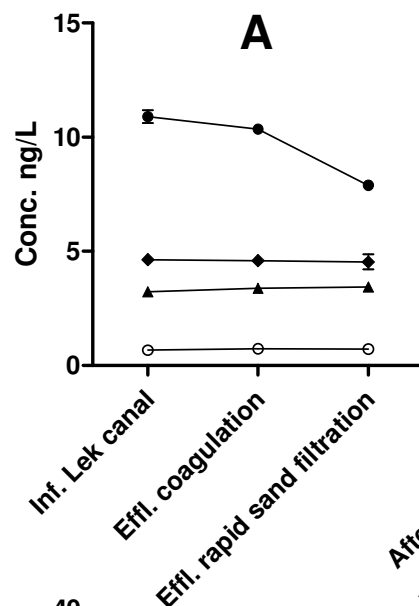


Drinkingwater treatment



PFAA

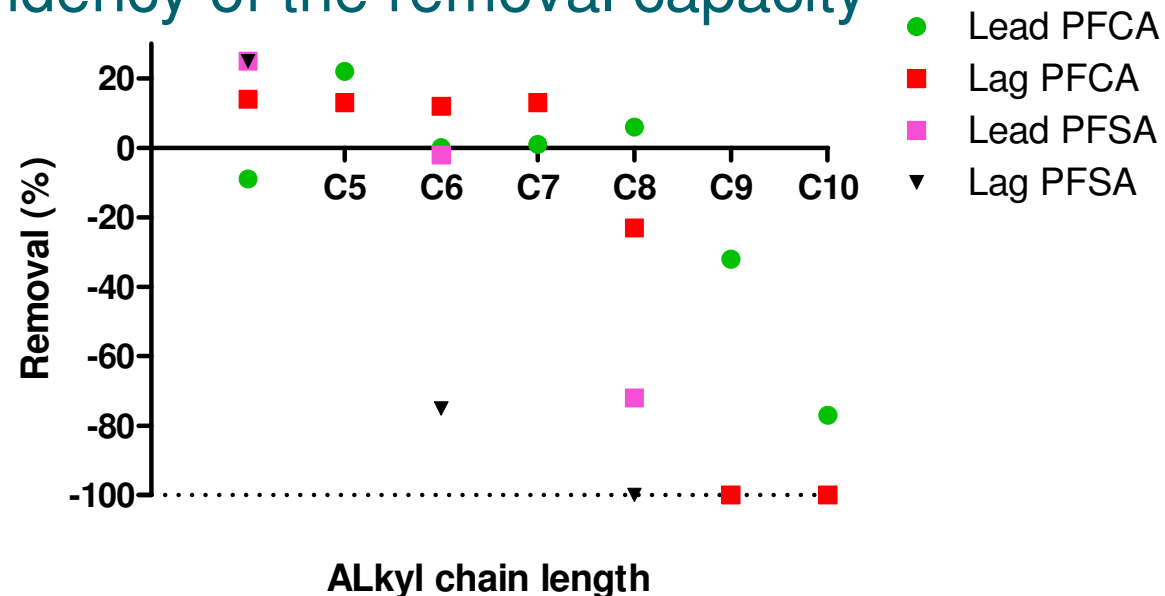
- Similar to the surfactants in the product
- PFAA/
- P
- P
- (in raw water)



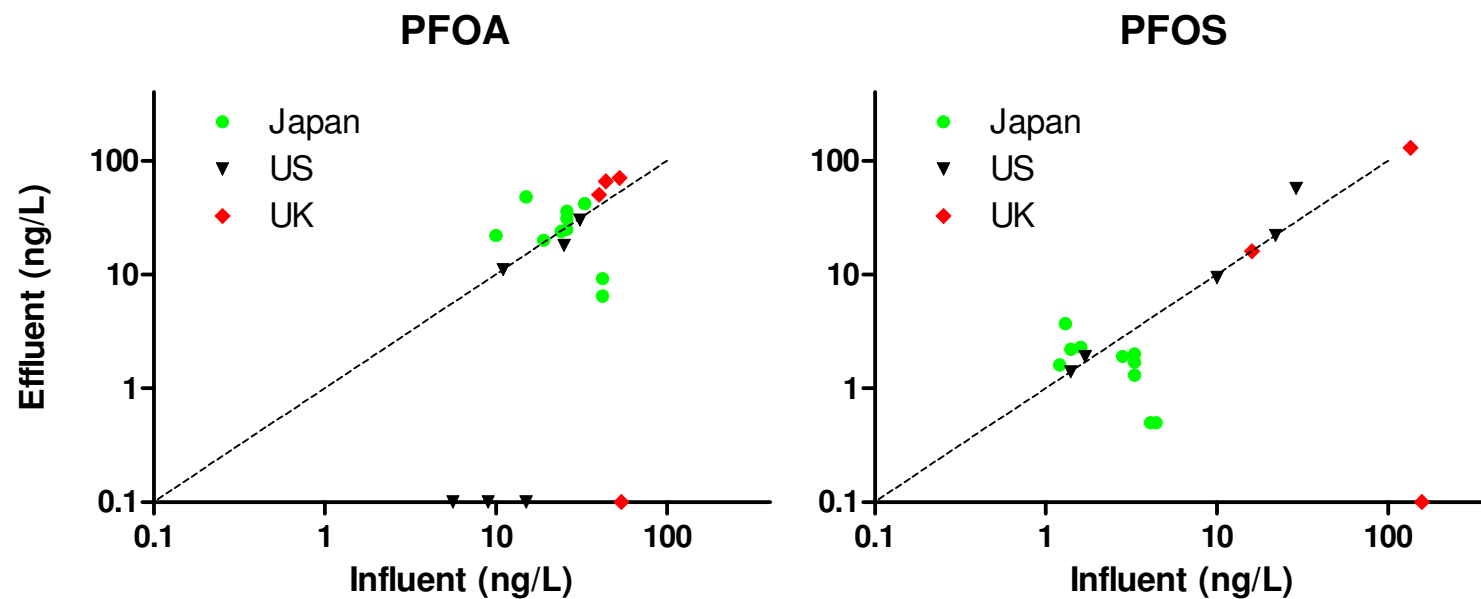
Results 2

GAC filtration

- No removal of PFAA throughout the purification process except for GAC filtration.
- No removal of $\leq C8$ carboxylic acids and $\leq C5$ sulfonic acids
- Filter age dependency of the removal capacity



In a broader perspective



Conclusions

- From all tested processes only GAC removes PFAA
- No removal of short chained PFAA
 - PFBS which is used PFOS substituent
 - PFHxA which is partly replacing PFOA
- Margins to existing guidelines are large
 - 300 ng/L PFOS + PFOA
 - PFBA 7000 ug/L (Wilhelm, 2010)



Acknowledgments

- EU project PERFOOD (KBBE-227525)
- TTIW Wetsus
- BTO
- Wellington Laboratories

