

PFAS – 3rd International Congress
June, 4, 5 & 6, 2024 - Paris

New developments and advances in treating PFAS-contaminated soil and water

Nicolas Etard

Michael Linke, Hans-Georg Edel

Züblin Umwelttechnik GmbH
Germany · France · Switzerland · Italy

www.zueblin-umwelttechnik.com



ZÜBLIN
WORK ON PROGRESS

Content

- 1 Introduction
- 2 PFAS soil treatment
- 3 PFAS water treatment
- 4 Summary



Our PFAS treatment plants for water and soil

- Efficient and economical
- Over 60 plants since 2009



Former refinery – hydraulic barrier, 200 m³/h

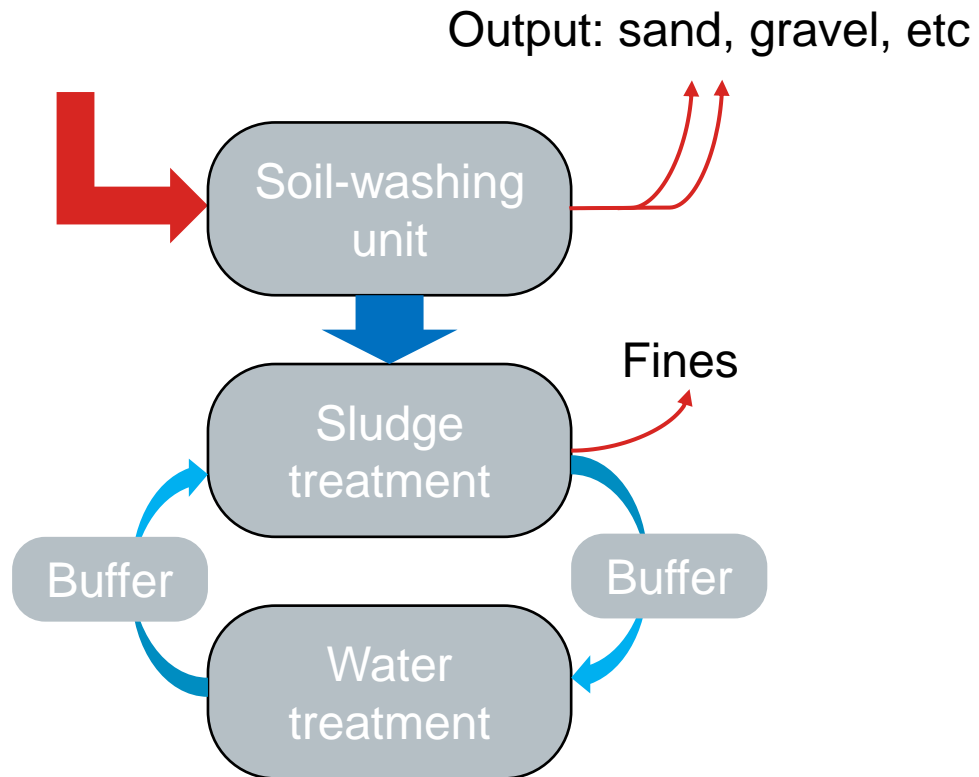


Airport – soil washing plant, 2.000 t/day

PFAS soil treatment

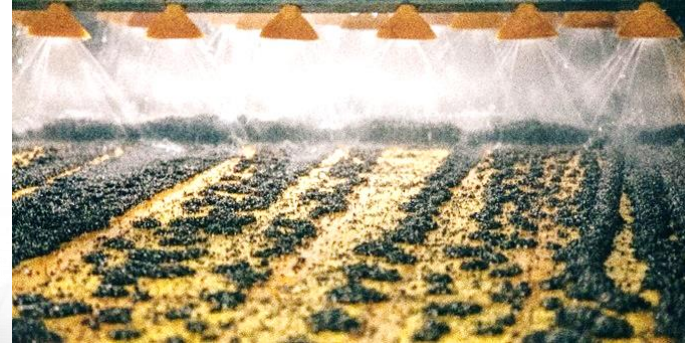
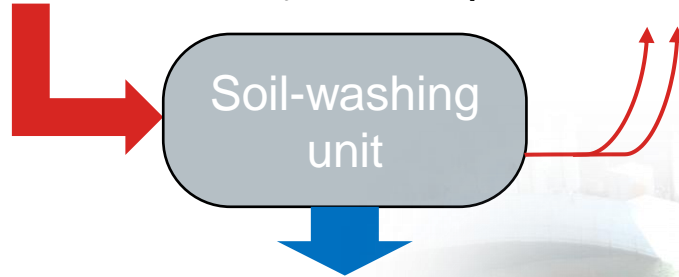


PFAS soil washing – at a glance



Soil washing – core element 1/3

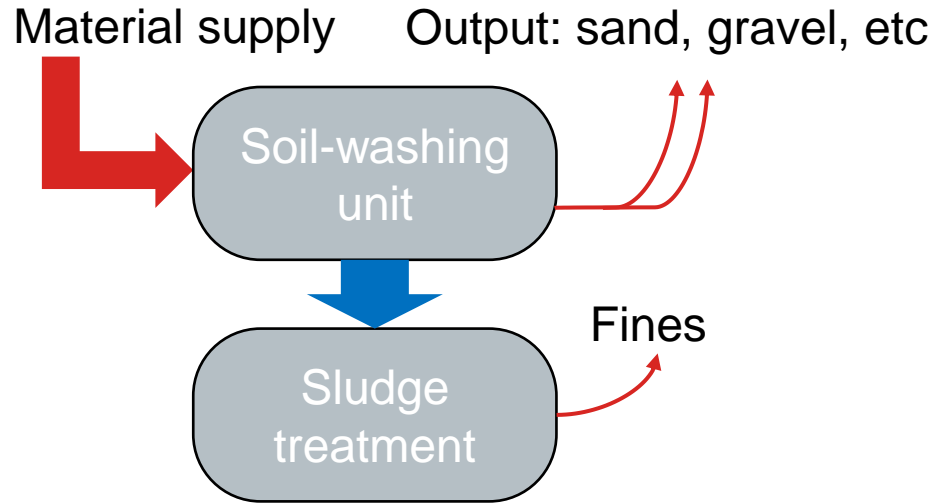
Material supply Output: sand, gravel, etc



Soil-washing unit

- Classification (screens, hydrocyclones, etc)
- Transfer of PFAS to the washing water

Soil washing – core element 2/3



Soil-washing unit

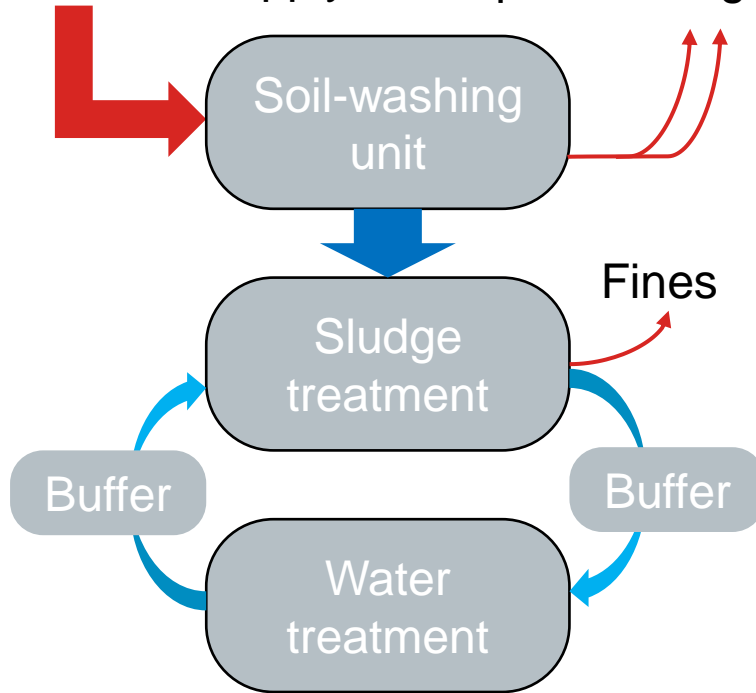
- Classification (screens, hydrocyclones, etc)
- Transfer of PFAS to the washing water

Sludge treatment

- Dewatering & washing fine fraction

Soil washing – core element 3/3

Material supply Output: sand, gravel, etc



Soil-washing unit

- Classification (screens, hydrocyclones, etc)
- Transfer of PFAS to the washing water

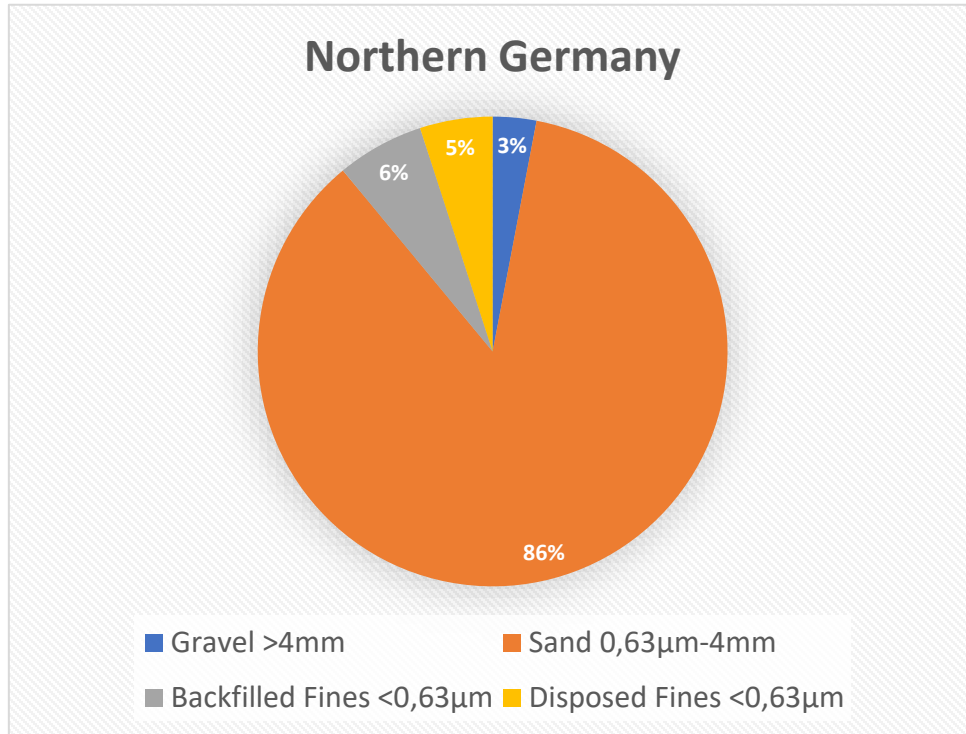
Sludge treatment

- Dewatering & cleaning fine fraction

Water treatment

- Removal of PFAS by activated carbon
- Buffer tanks

Interim balance (status: May 2024)



Optimised soil treatment

- 50-75% of the fines are treatable
→ increased backfilling rate 90% → 95%

Output-material

- Soil washed, 02/23 – 05/24 220.000 t (100%)
- Backfilled on-site 209.000 t (95%)**
 - Gravel (> 4 mm) 6.600 t (3%)
 - Sand (< 0,63 µm - 4 mm) 189.200 t (86%)
 - Fines (< 0,63 µm) 13.200 t (6%)
- Landfill
 - Disposed Fines (< 0,63 µm) 11.000 t (5%)

Operation data

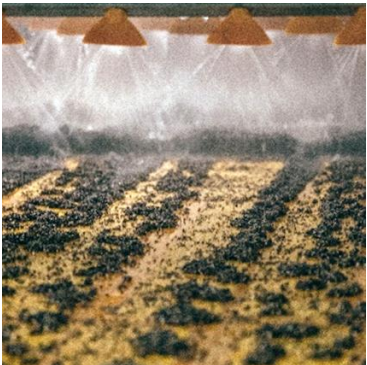
- Throughput soil: 2.000 t/d
- Flow rate washing water: 200 m³/h
- Costs: 60 EUR/t
- Output c_{PFAS} (2:1 eluate): <0,1 µg/L
<1,0 µg/L

Operation is optimisation



Reduce complexity

- PFAS-Analysis:
focus on main substances
Identification of critical factors
of the input material
- Adapted operation



Reduce water demand

- Degrees of freedom
- Water: the more, the better...
but the higher the costs



Use laboratory experiments

- Selection & dosage of
precipitation & flocculation aids
- Optimisation of the washing
result

Soil washing test – technical scale



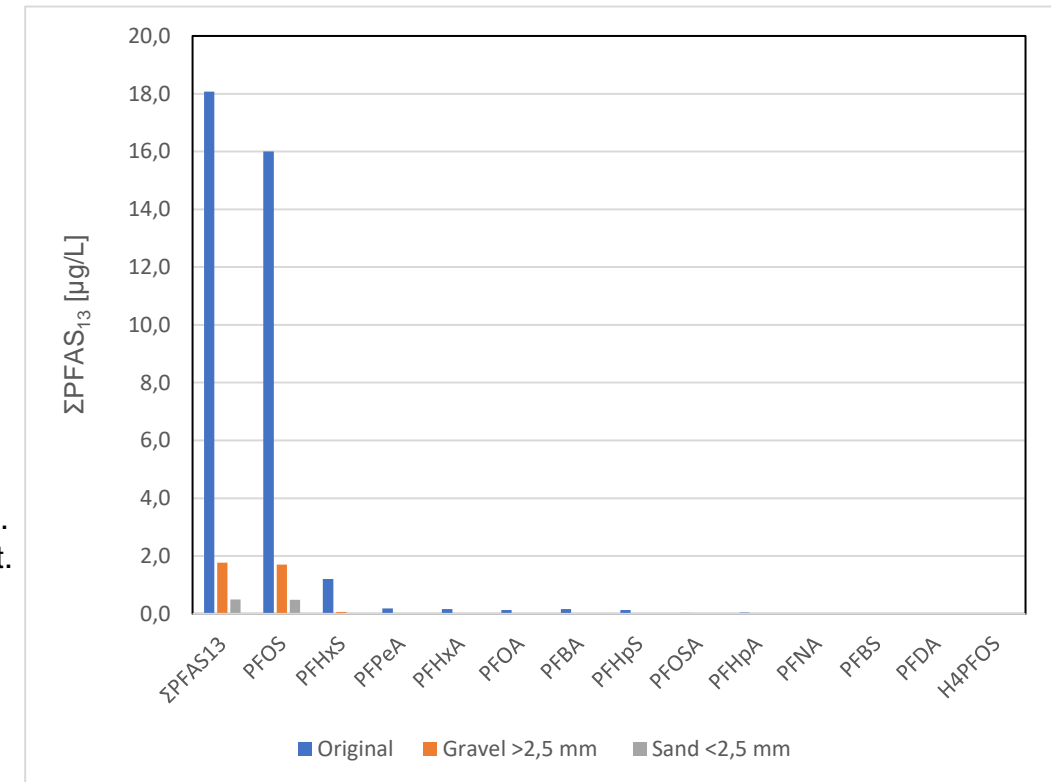
Soil washing plant, multi-stage, technical scale



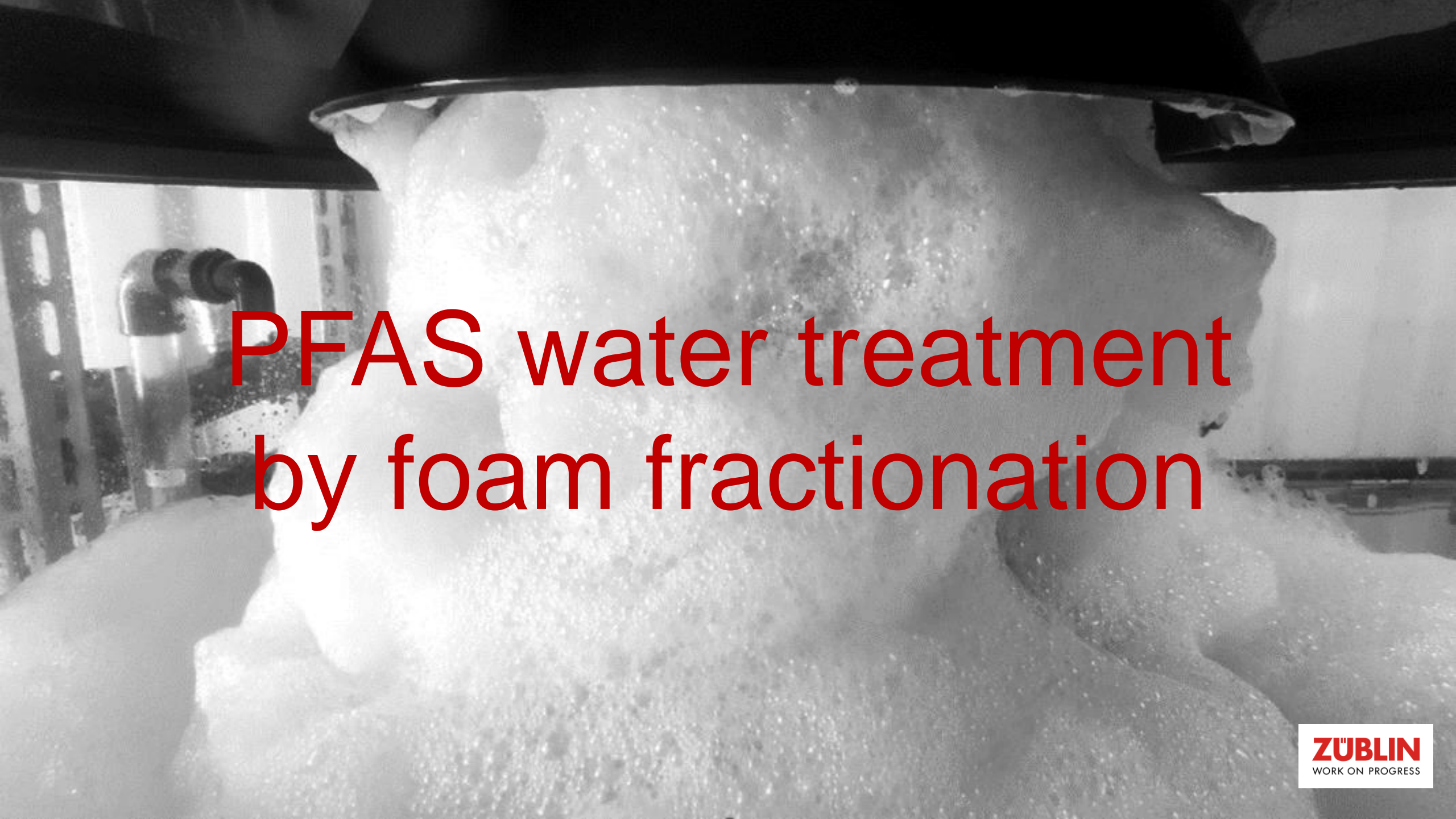
Gravel (> 2,5 mm), 11.0% wt. Sand (< 2,5 mm): 63.8% wt.
Fines (< 0,63 µm): 24.5% wt.



Organics: 0.7% wt.



→ This soil material is very easy to wash



PFAS water treatment by foam fractionation

Relevant water treatment methods



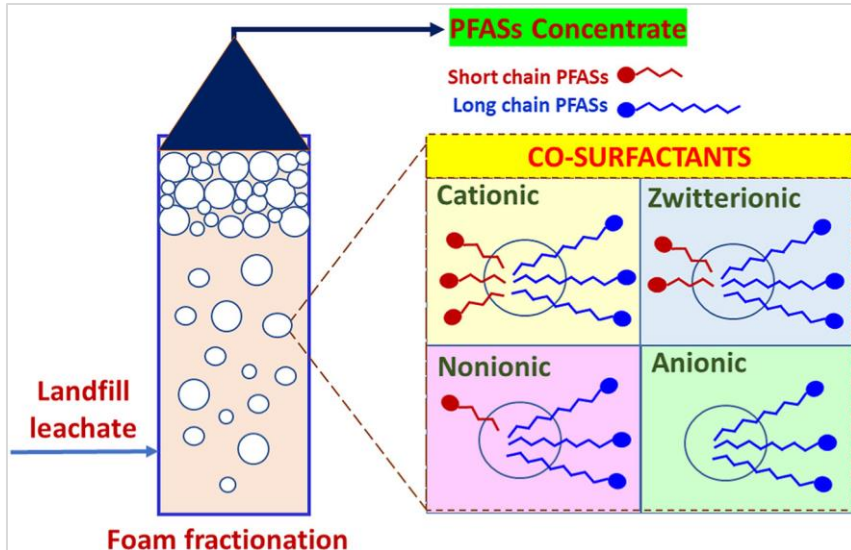
Treatment methods

- Activated carbon adsorption
- Ion exchange
- Foam fractionation
- Membrane process

Aqueous media

- Groundwater
- Leachate
- Extinguishing water
- Process water

Foam fractionation - basics



Source: Vo P et al. (2023)

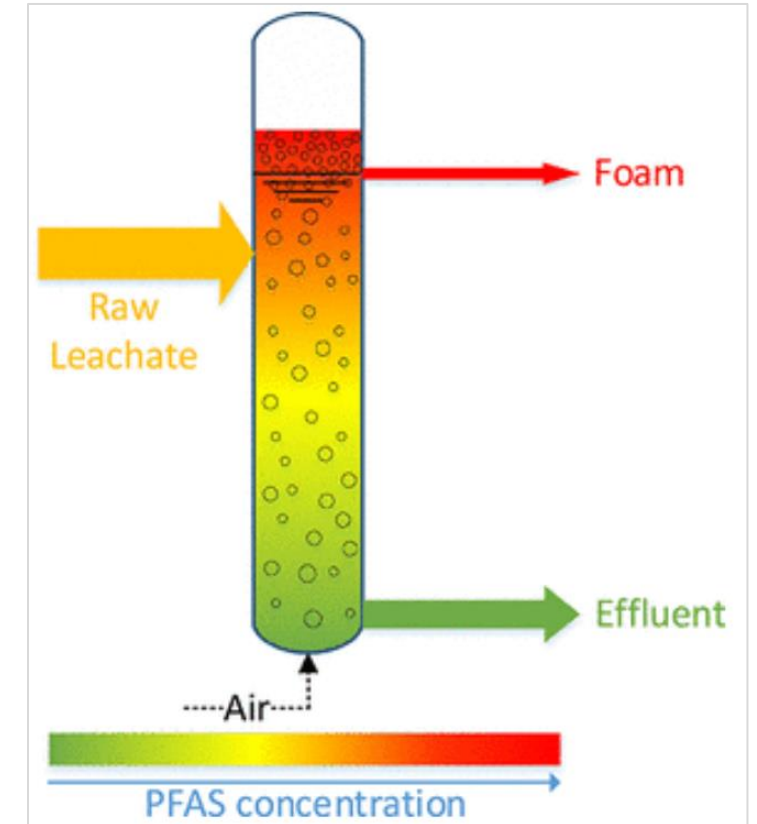
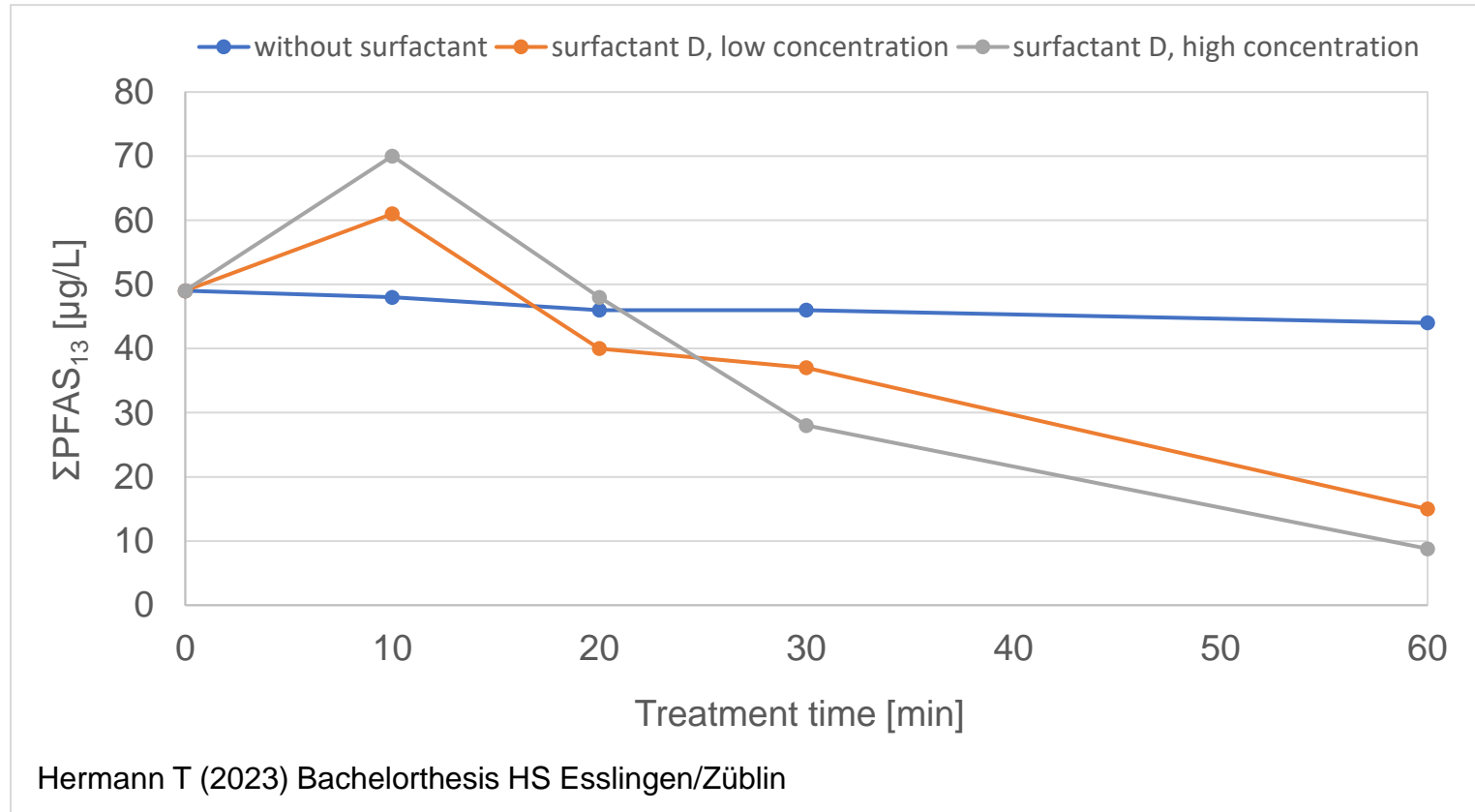
Foam fractionation

- First patent in 1918, Wilhelm Ostwald
- Adsorption of surface-active compounds on the hydrophobic surface of gas bubbles
- Separation of the foam, removal of the surfactants

Application

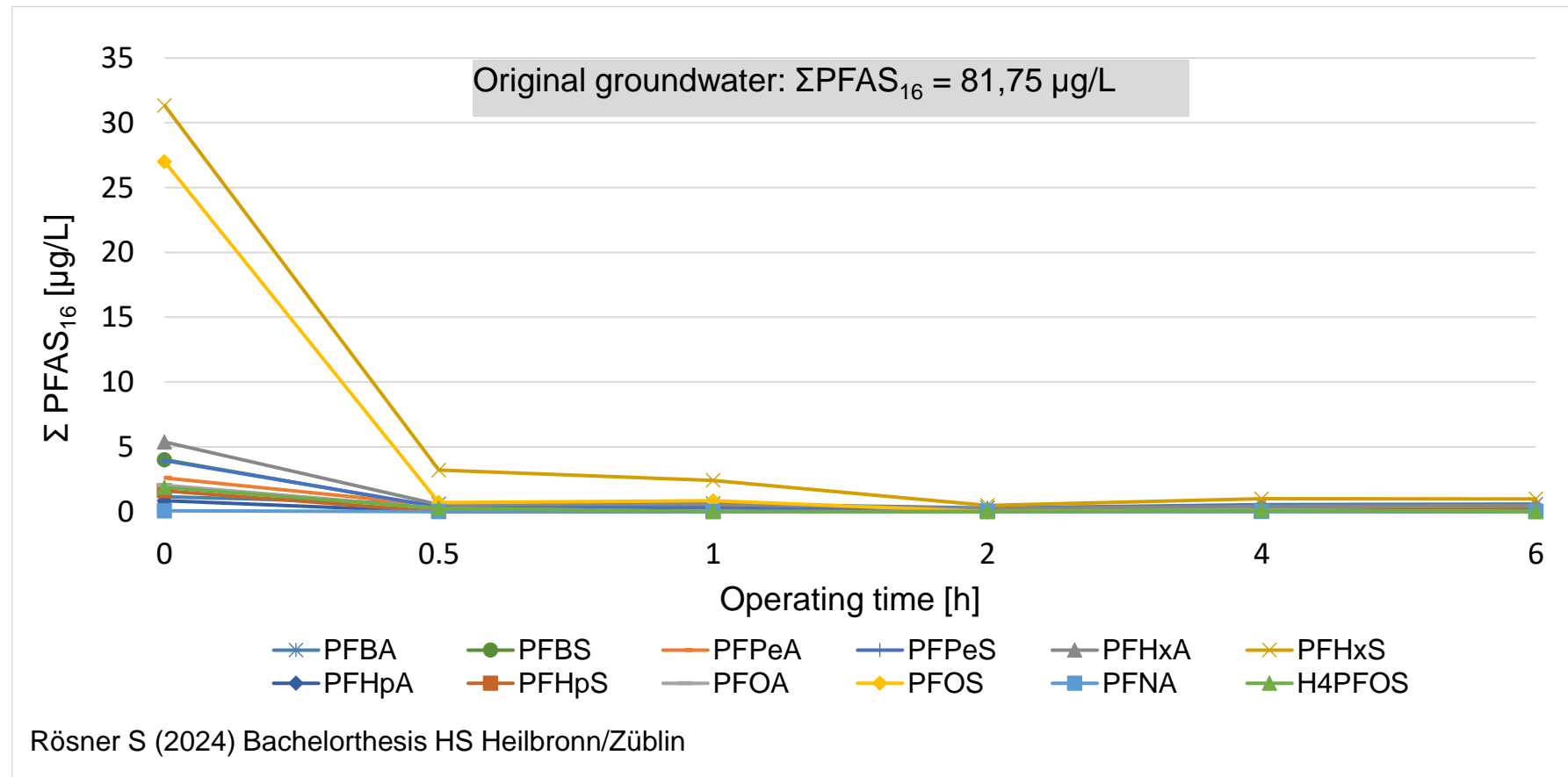
- Protein separation
- Fish farming
- PFAS removal

Foam fractionation - leachate



Source: Smith SJ et al. (2022)

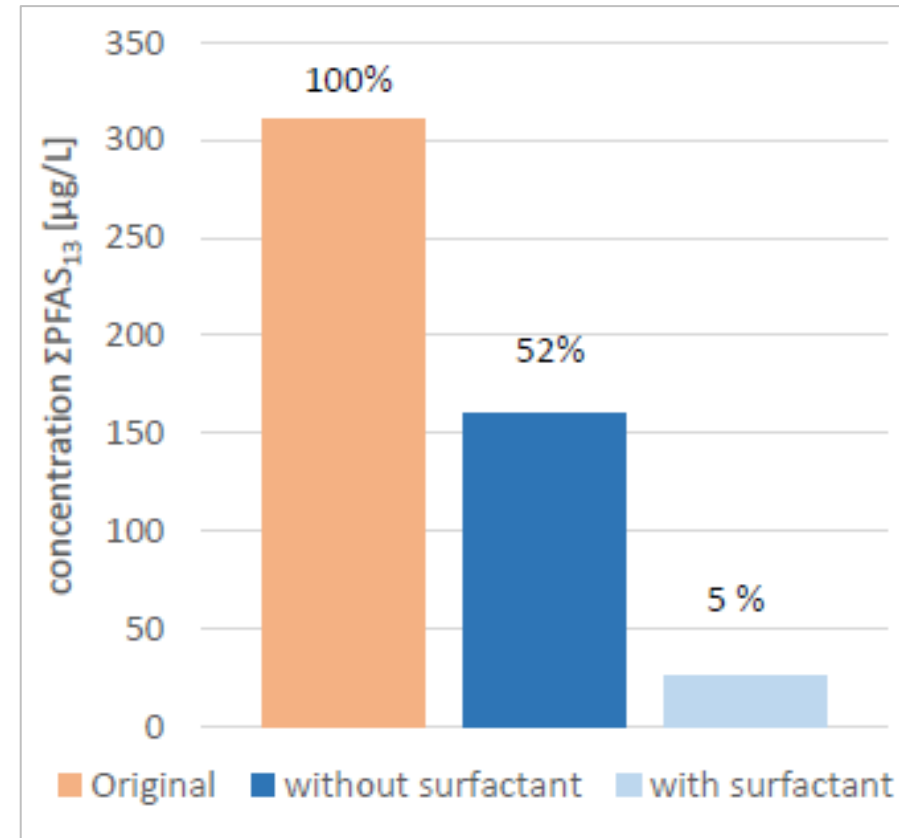
Foam fractionation - groundwater



Foam fractionation – extinguishing water

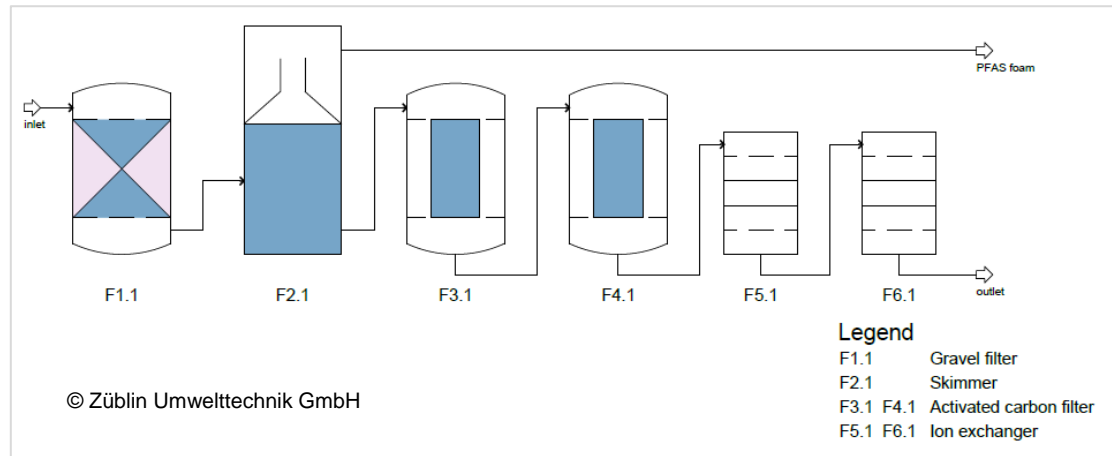


Sprinkler system - foam fractionation unit



Foam fractionation - treatment performance

Combined treatment procedure



Foam fractionation

- high PFAS concentrations
→ PFAS load reduction

Activated carbon adsorption

- low PFAS concentrations
→ polishing

Ion exchange (option)

- low PFAS concentrations, short-chain PFAS
→ polishing



Summary and outlook

PFAS soil washing

- The only economically feasible cleaning method on large scale
- Even a viable tool treating the fine fraction
- Heterogeneous input material with varying contaminant load and soil structure requires constant optimisation of operation
- Tests on laboratory and technical scale serve for reliable planning

PFAS foam fractionation

- Suitable and reliable method for removing high PFAS concentrations
- Application for aqueous media:
 - leachate
 - groundwater
 - extinguishing water
 - process water
- Combination with GAC adsorption and/or IEX
 - economical operation
 - low target values in the nanogram range

→ Ongoing research/development leads to further advances in PFAS treatment technologies

Any questions?

Thank you for your attention!

Nicolas Etard

Phone +33 6 35 83 78 51

E-Mail: nicolas.etard@zueblin.de

Dr. Michael Linke

Phone +49 7145 9324-208

E-Mail: michael.linke@zueblin.de

Dr. Hans-Georg Edel

Phone +49 7145 9324-249

E-Mail: hans-georg.edel@zueblin.de

www.zueblin-umwelttechnik.com/fr

