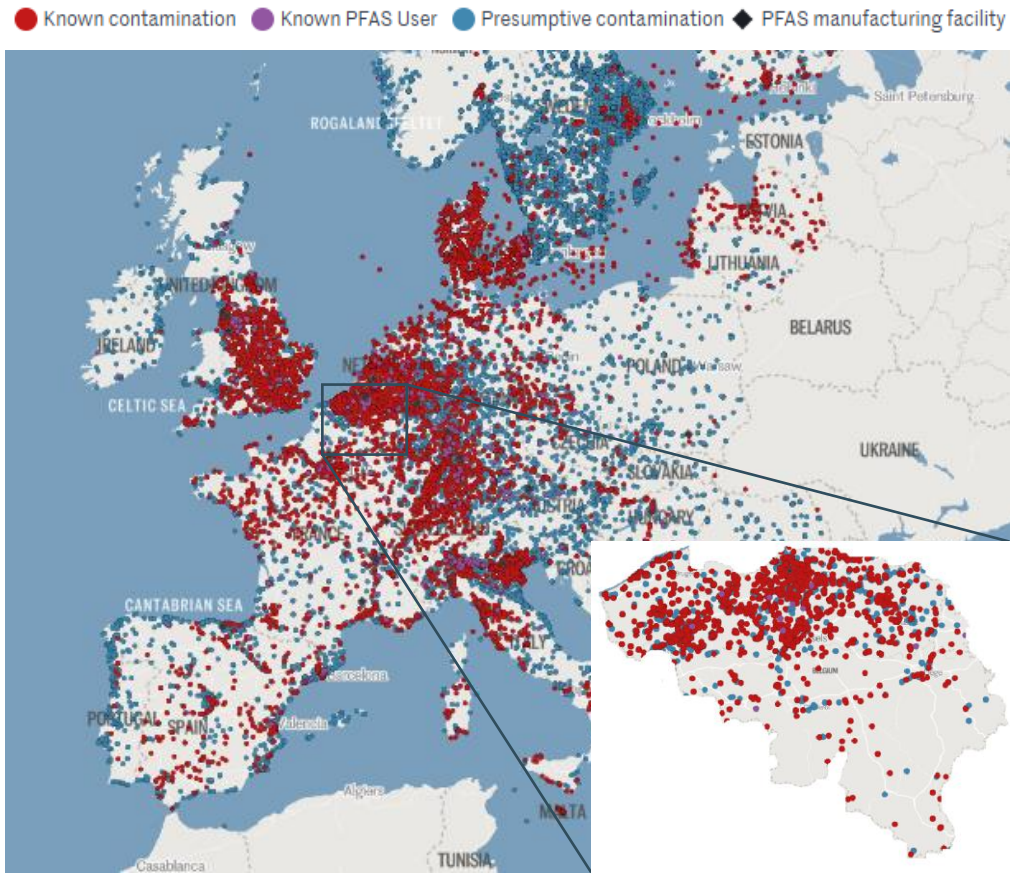
KU LEUVEN

Effect of soil characteristics and mobilizing chemicals on PFAA desorption during soil flushing

Arne Vangansbeke

Situation in Belgium



From *Le Monde: The Map of Forever Pollution in Europe (2025)*

Current remediation efforts?

Immobilization

Excavation

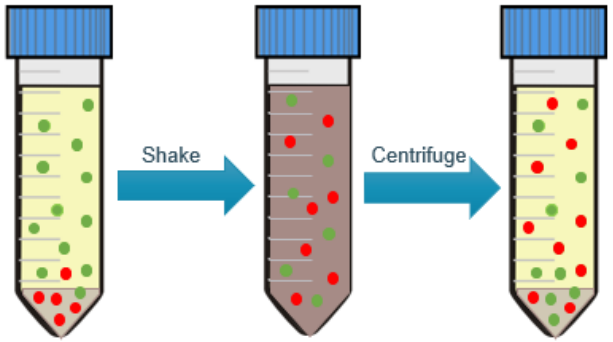
Combustion

Soil washing

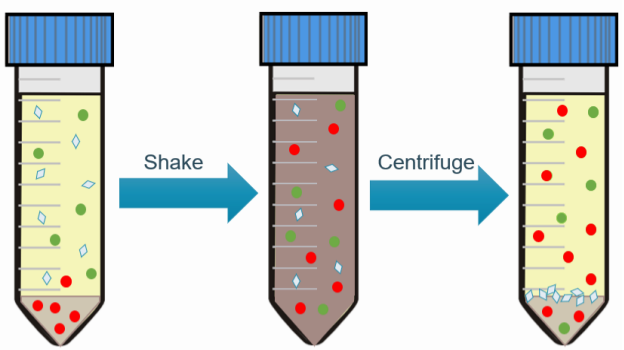
Faculty of Bioscience Engineering, Department of Earth and Environmental Sciences,
Division of Soil and Water Management

KU LEUVEN

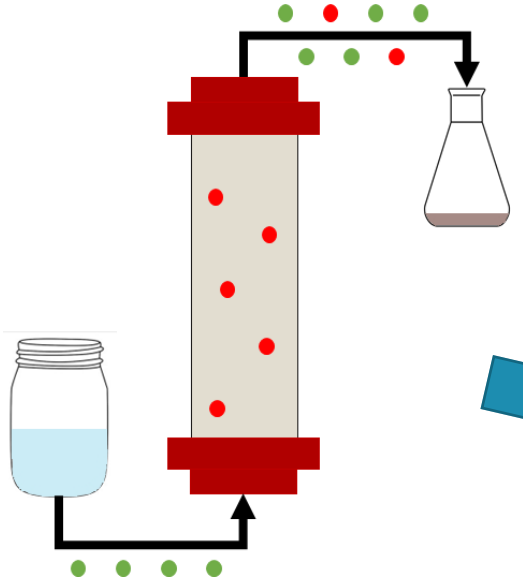
Research



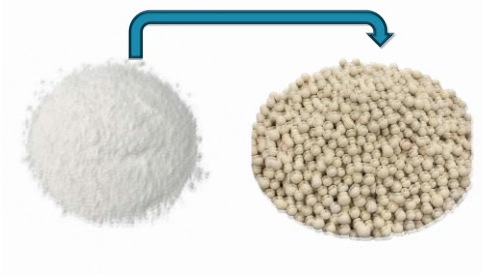
1.1) Batch experiments
- Dose?
- Shift in equilibrium?



2.1) Batch experiments
- Efficiency zeolite?
- Effect mobilizing chemicals?

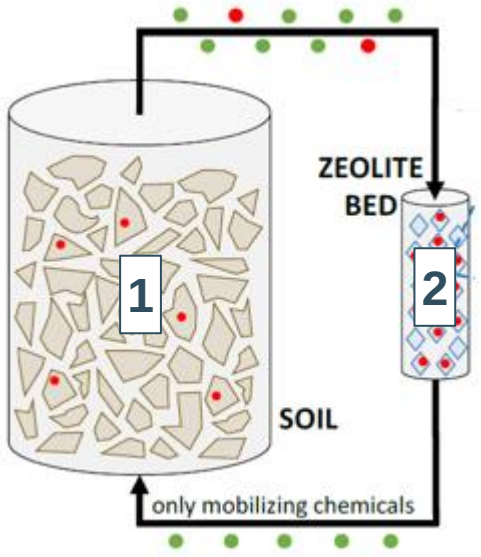


1.2) Column experiments
- Flow rate?
- Desorption kinetics?



2.2) Pelletization
- Efficiency loss for zeolite?

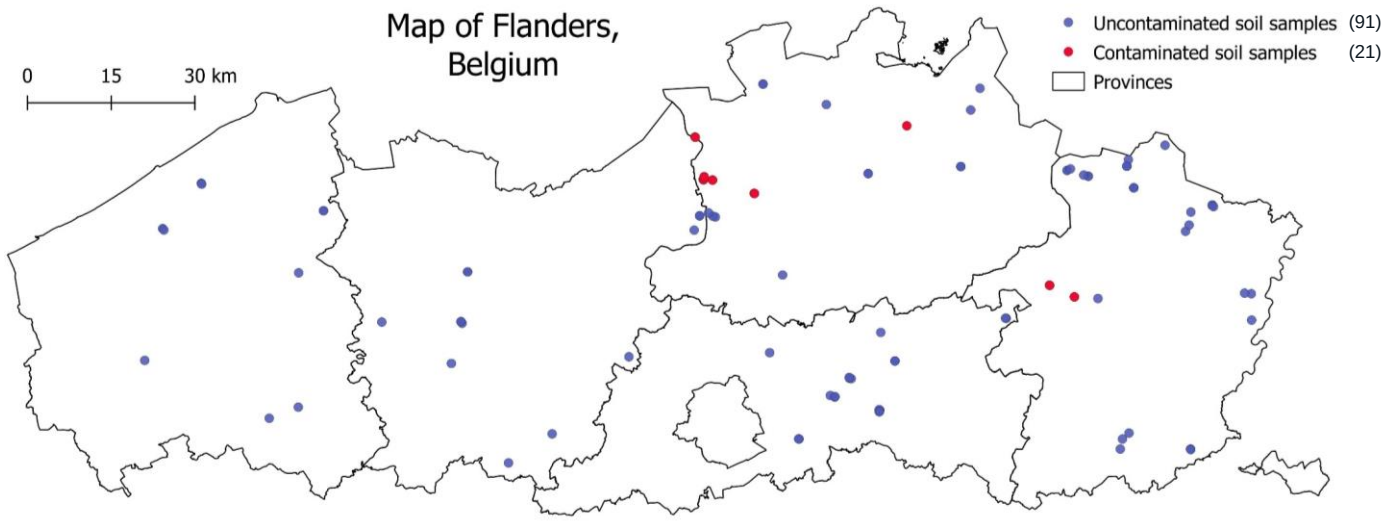
Mobilizing chemical = ●
PFAS = ● Soil = ▭ Zeolite = ◇



3) Closed-loop experiment
- Efficiency zeolite?
- Effect loop?

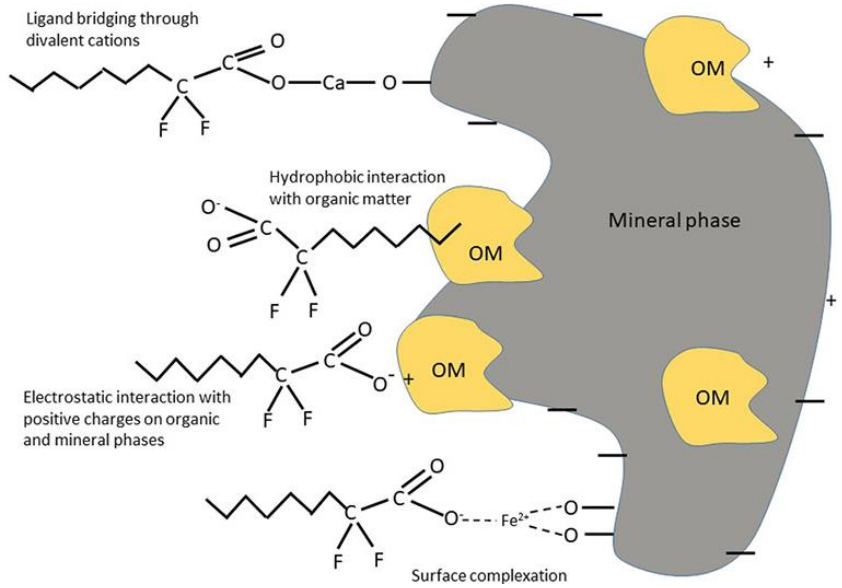
Van den Bergh et al. (2020), "Highly Selective Removal of Perfluorinated Contaminants by Adsorption on All-Silica Zeolite Beta". Published in Angewandte Chemie.

Research



From *Vangansbeke et al. (2025), "No discrepancy in solid-liquid distribution of perfluorooctanoic acid between field-contaminated and lab-spiked soils". Under review at EJSS.*

Contaminated soils	Minimum	Median	Maximum	Average
pH (-)	3.8	7.0	7.8	6.7
SOC (%)	0.1	2.1	7.0	2.1
Fe_{ox} (mg/kg)	620	2150	7300	2450
PFAS load (µg/kg)	15	370	53000	6150



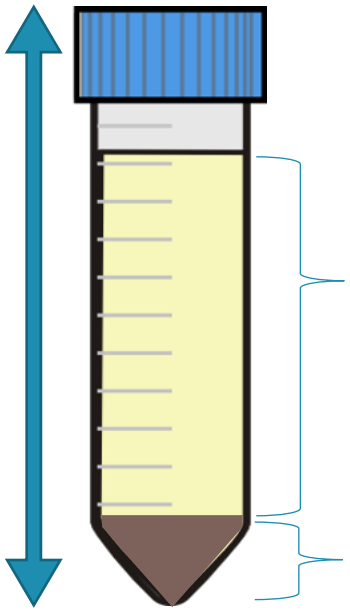
From *Li et al. (2018), "A critical analysis of published data to discern the role of soil and sediment properties in determining sorption of per and polyfluoroalkyl substances (PFASs)". Published in STOTEN.*

Group	Component	Abbreviation
Salt	Potassium sulfate	K_2SO_4
	Sodium sulfate	Na_2SO_4
	Sodium thiosulfite	$Na_2S_2O_3$
	Trisodium citrate	NaCitrate
Surfactant	Dodecylbenzene sulfonic acid	DBSA
	Sodium lauryl ether sulfate	SLES
	Triton CG-110	Triton
	Tween 60	Tween
	Empigen BB Detergent	Empigen

Faculty of Bioscience Engineering, Department of Earth and Environmental Sciences,
Division of Soil and Water Management

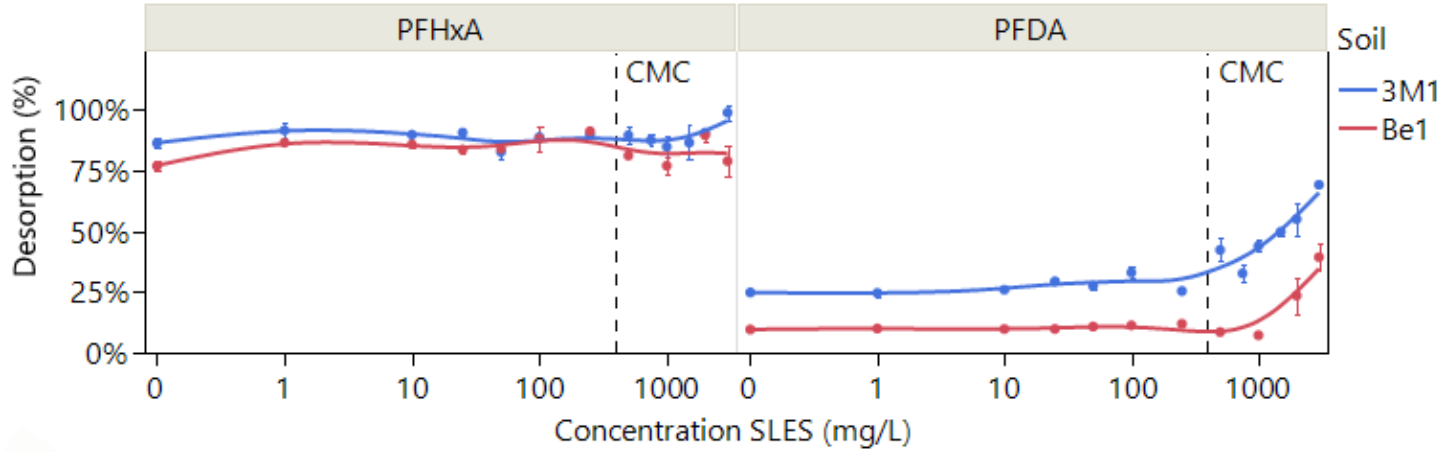
KU LEUVEN

1) Batch experiments



10 mL solution containing:
- 0.01 M $CaCl_2$
- 5 mg/L mobilizing chemical

2 g of soil



Concentration	Min	Max
Salts	1 mg/L	10 mg/L
Surfactants	1 mg/L CMC	…

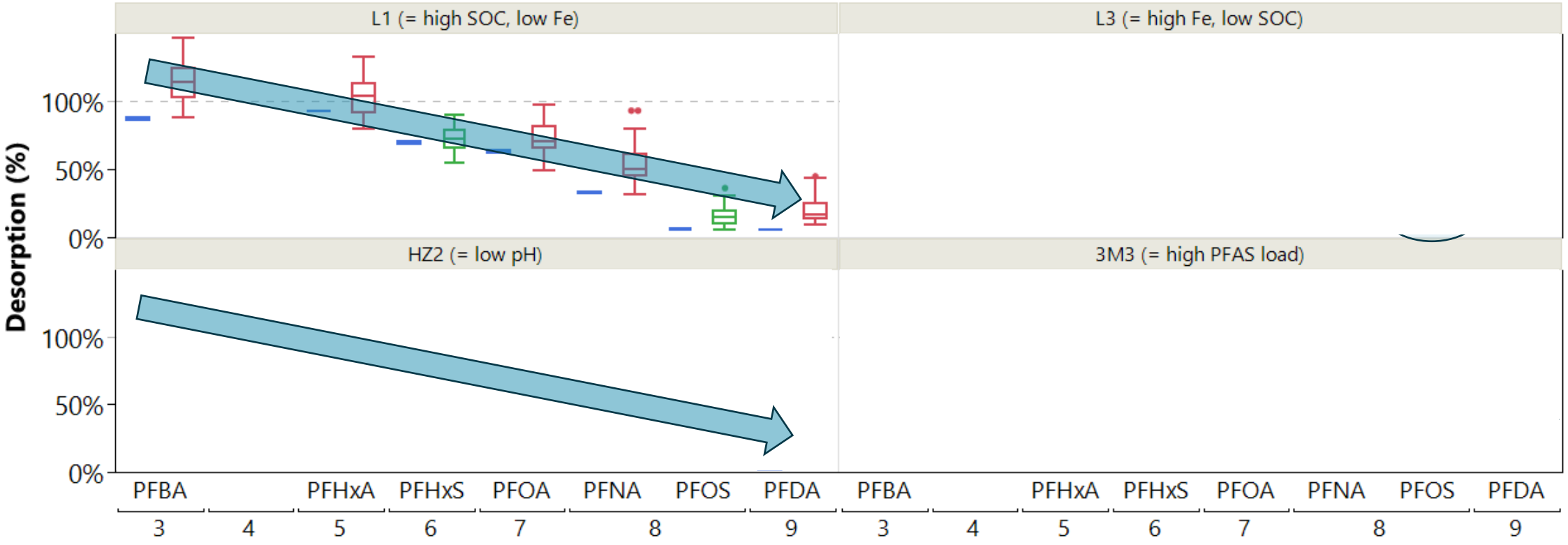
Contaminated soils	L1	L3	HZ2	3M3
pH (-)	7.0	7.3	**3.8**	7.6
SOC (%)	**5.9**	1.0	1.6	0.6
Fe_{ox} (mg/kg)	1700	**7300**	2500	2200
PFAS load (µg/kg)	3100	400	4600	**21500**

Faculty of Bioscience Engineering, Department of Earth and Environmental Sciences,
Division of Soil and Water Management

KU LEUVEN

1) Batch experiments

High potential for mobilizing chemicals, dependent on soil characteristics



$CaCl_2$ leaching (n = 2)

Washing solution (n = 56)

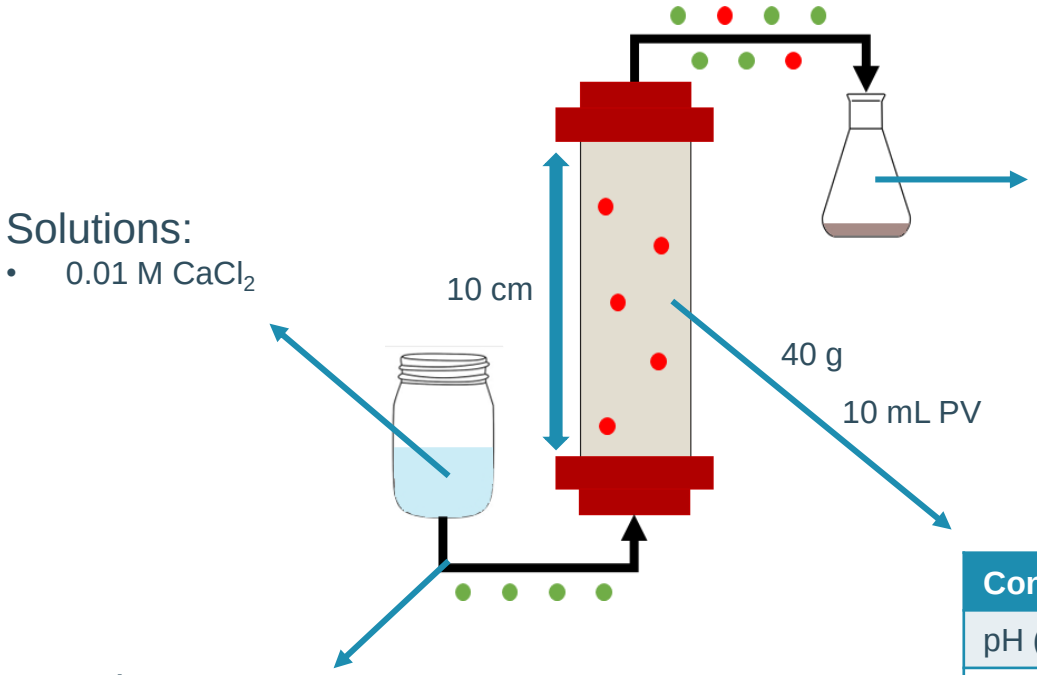
9 single solutions
16 binary mixtures
3 ternary mixtures

Faculty of Bioscience Engineering, Department of Earth and Environmental Sciences,
Division of Soil and Water Management

KU LEUVEN

2) Column experiments

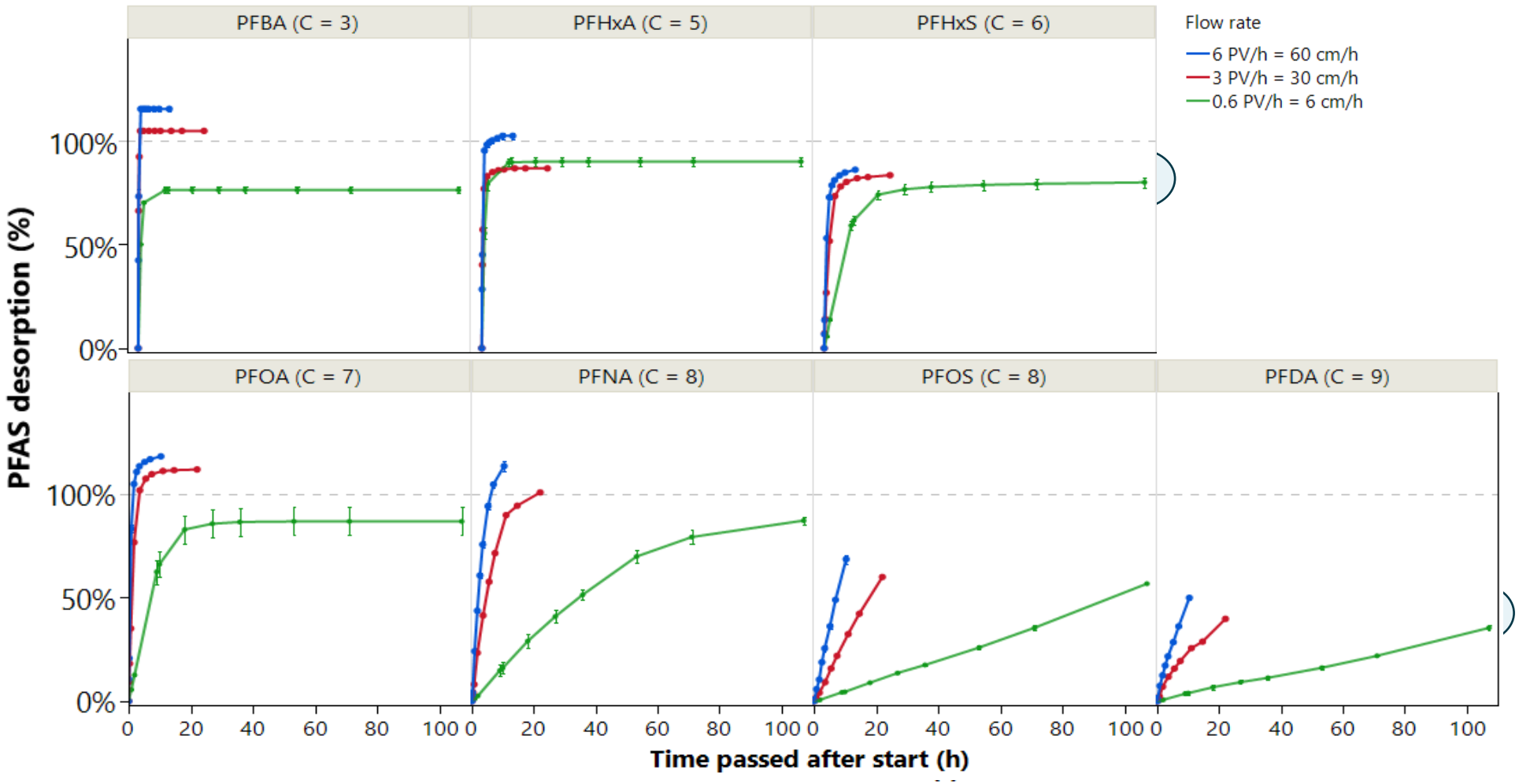
Flow rate experiment



Contaminated soils	Be2	Average
pH (-)	6.7	6.7
SOC (%)	4.2	2.1
Fe_{ox} (mg/kg)	3000	2450
PFAS load (µg/kg)	1200	6150

2) Column experiments

No effect of flow rate



Slower flow rate =

- Longer contact time with container
- Increased background noise

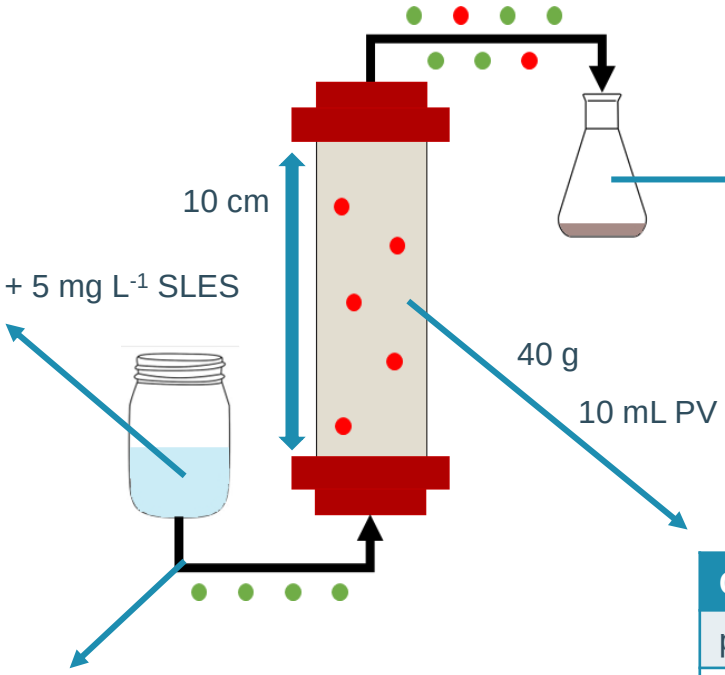
Fast flow rate =

- Not very realistic
- Only for sandy soils & in the lab

2) Column experiments

Solution experiment

Solutions:
- 0.01 M $CaCl_2$
- 0.01 M $CaCl_2$ + 5 mg L^{-1} DBSA
- 0.01 M $CaCl_2$ + 5 mg L^{-1} K_2SO_4 + 5 mg L^{-1} SLES



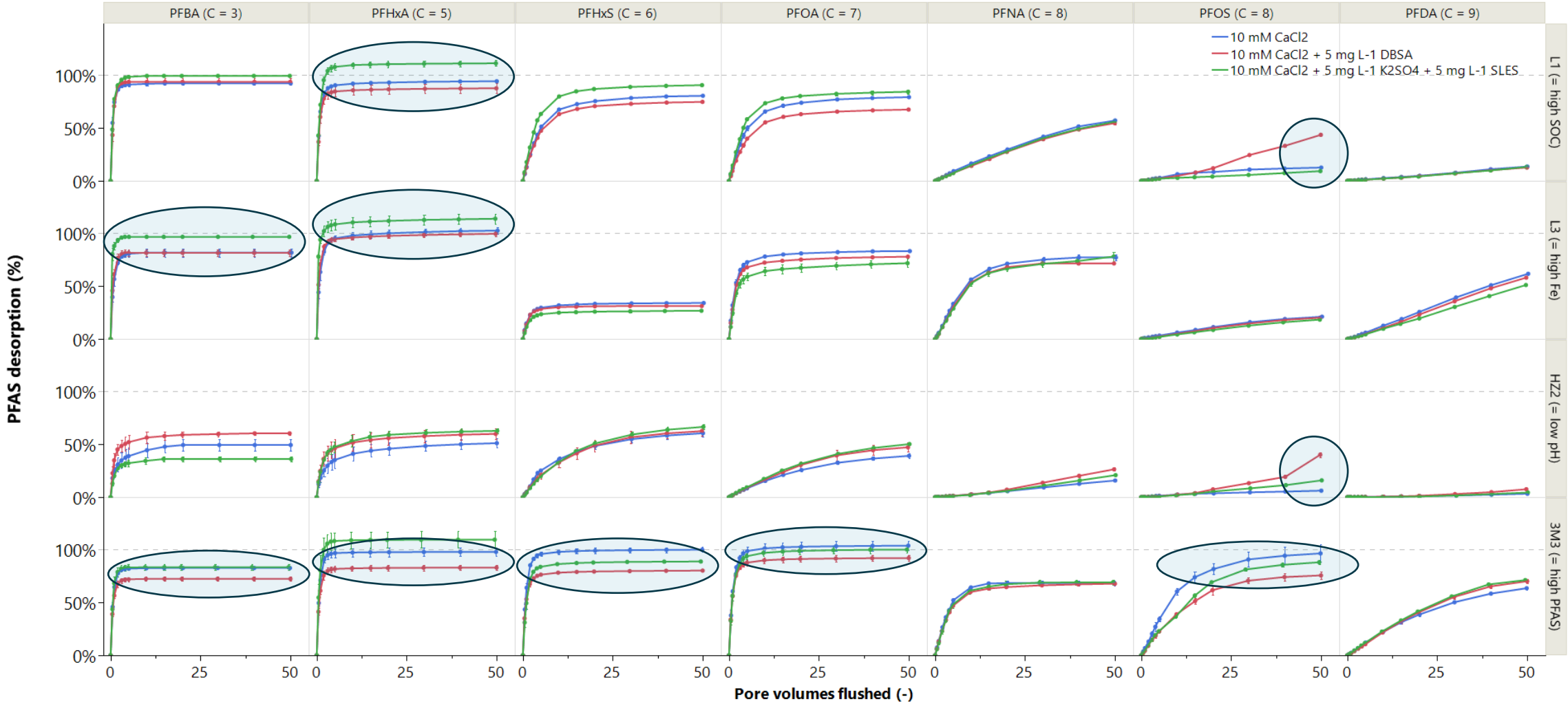
Sampling pore volumes
- From 0.5 → 50
- Removal of container

Flow rates:
- 6 PV/h = 60 mL/h

Contaminated soils	L1	L3	HZ2	3M3
pH (-)	7.0	7.3	**3.8**	7.6
SOC (%)	**5.9**	1.0	1.6	0.6
Fe_{ox} (mg/kg)	1700	**7300**	2500	2200
PFAS load (µg/kg)	3100	400	4600	**21500**

2) Column experiments

Limited effect of mobilizing chemicals

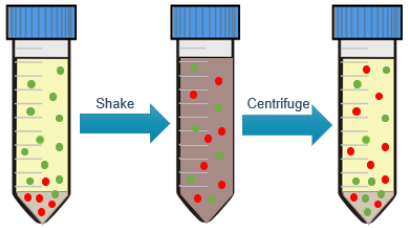


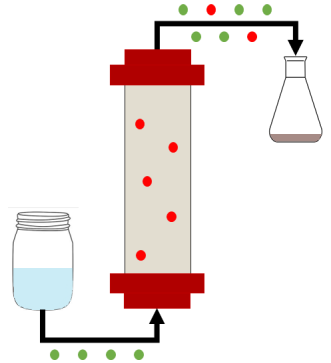
Faculty of Bioscience Engineering, Department of Earth and Environmental Sciences,
Division of Soil and Water Management

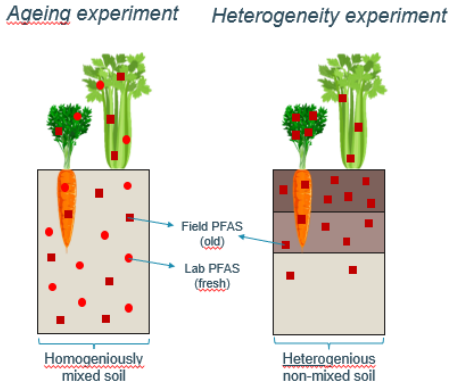
KU LEUVEN

Conclusion

- Batch experiments:
  - Mobilizing chemicals increase efficiency
  - Higher surfactant dose increases efficiency
  - Soil characteristics influence efficiency
- Column experiments:
  - Flow rate no effect
  - Mobilizing chemicals limited influence on efficiency
- Future research:
  - Closing the soil flushing loop
  - Uptake of PFAS by garden vegetables
  - Fingerprinting tool for environmental data







Thank you for your attention

More information? Questions?
arne.vangansbeke@kuleuven.be