



PVDF-GO modules

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- Hollow Fibers (HF) module type
- Experimental set-up
- Tested contaminants
- Removal of:
 - Ciprofloxacin
 - Mixture of 14 PFASs
 - Metals
- Conclusion
- Next experiments planned

HF modules: PDVF-GO 3,5%

18/05/2022 → 8 modules PVDF-GO 3,5%

25/07/2022 → 3 modules PVDF Neophil + 11 modules PVDF-GO 3,5%

Materials: **Graphil B3** PVDF-GO 3,5%

HF weight = 432 mg

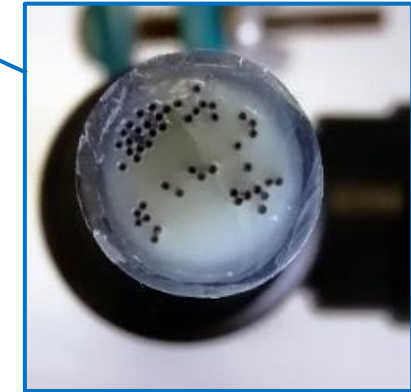
Weight of GO = 15,12 mg

Materials: **Neophil XS** PVDF

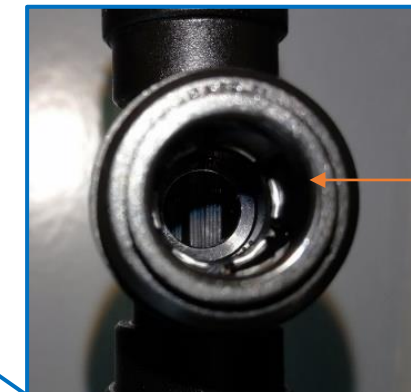
HF weight = 357 mg



48 fibers each, 26 cm length



Fiber edge

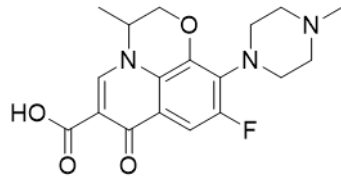


Ø 12 mm

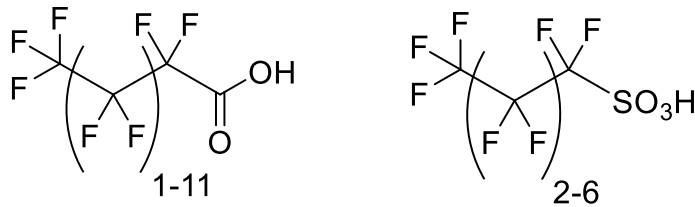
Fiber wall

Experimental set-up

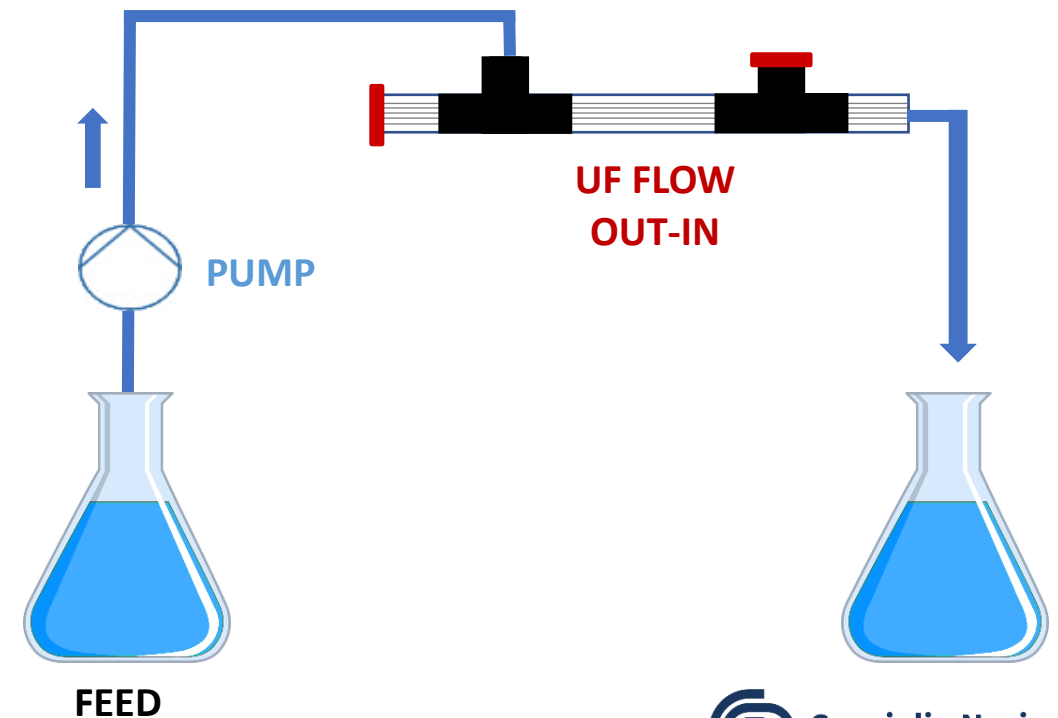
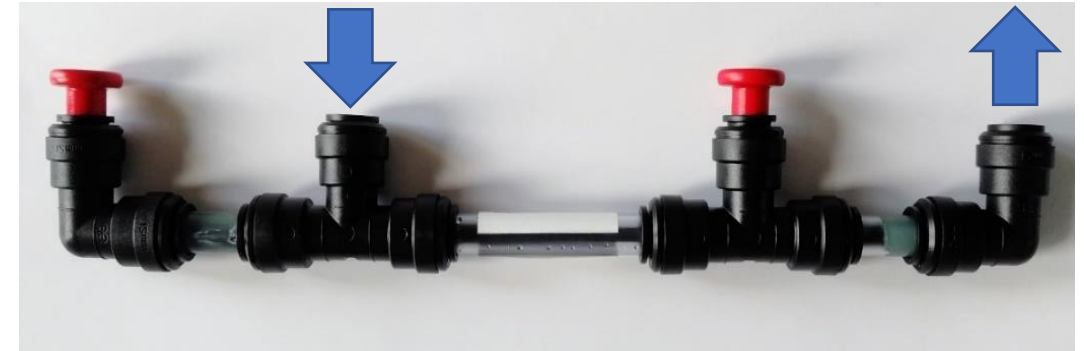
- **OUT-IN** modality
- Flow rate= 5 ml/min
- Washed with 2L of mQ water before use
- Tested on :
 - Ciprofloxacin (CIPRO), 5 ppm (tot V= 1L)



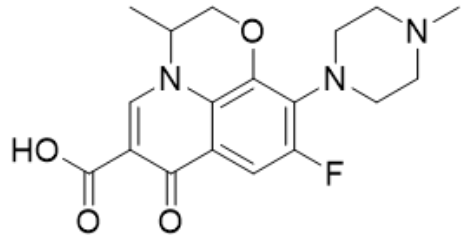
- Mixture of 14 PFASs (MIX14), 0,5 ppb each (tot V=1 L)



- Mixture of Heavy Metals, 100 ppb each (tot V= 3 L for PVDF-GO, 1L for PVDF)
Cd, Pb, U, AS(V), V, Cr (III), Ni, Cu



Results ofloxacin



Ciprofloxacin (CIPRO)

$C_{IN} = 5 \text{ ppm}$,

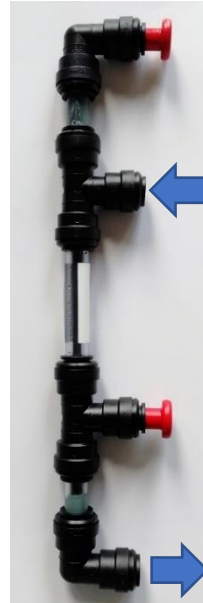
$V_{tot} = 1 \text{ L}$

Matrix: Tap water

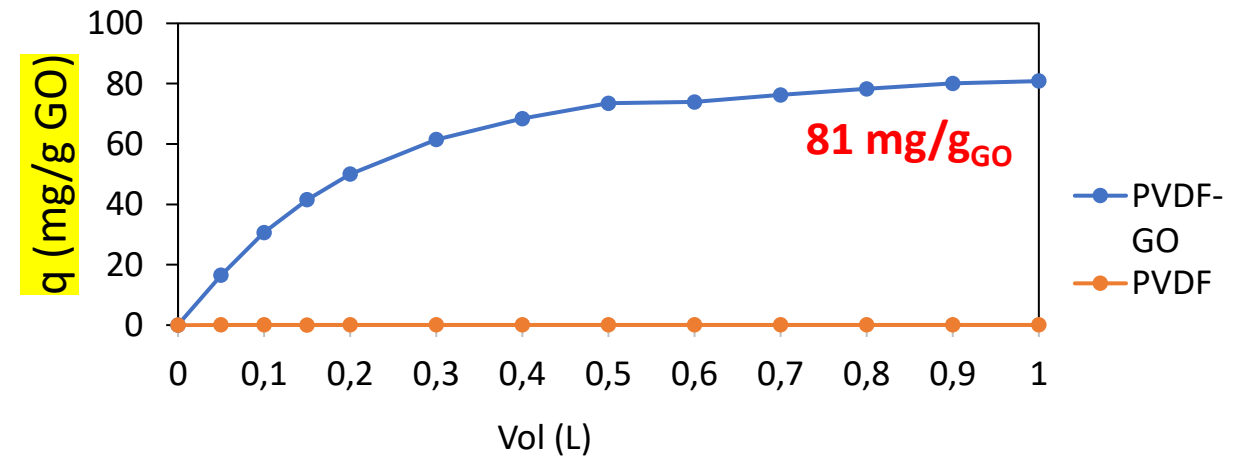
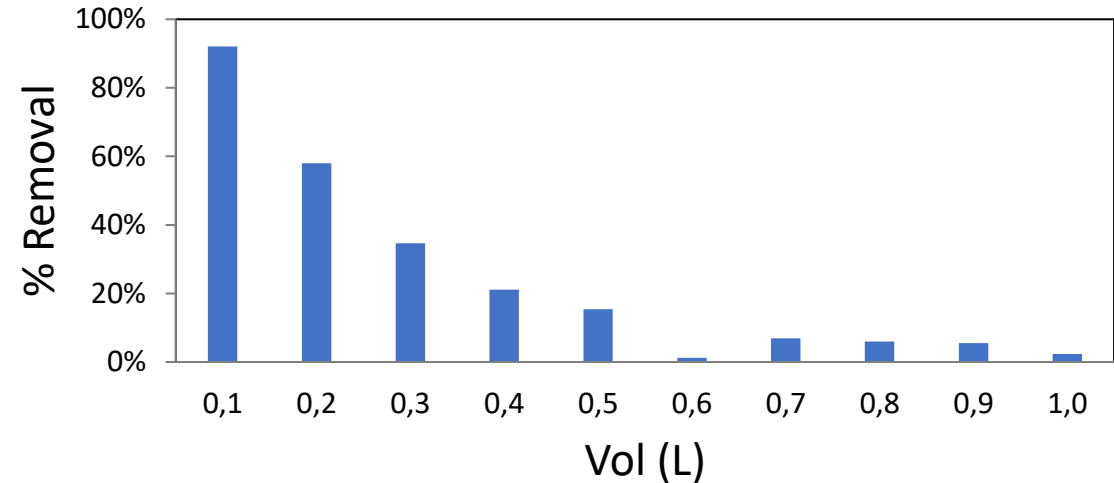
Flow rate: 5 ml/min

Configuration: OUT-IN

Tot ads CIPRO: 1,22 mg
Performance: 81 mg/g_{GO}



Removal of OFLOX by PVDF-GO



Note: the adsorption of CIPRO on PVDF is negligible

Results metals

Mixture of Heavy Metals

Cd, Pb, U, AS(V), V, Cr (III), Ni, Cu

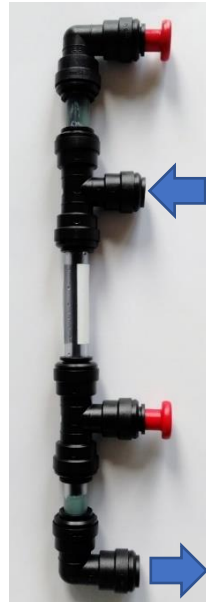
$C_{IN} = 100$ ppb each,

$V_{tot} = 3L$ for PVDF-GO, 1L for PVDF

Matrix: Tap water

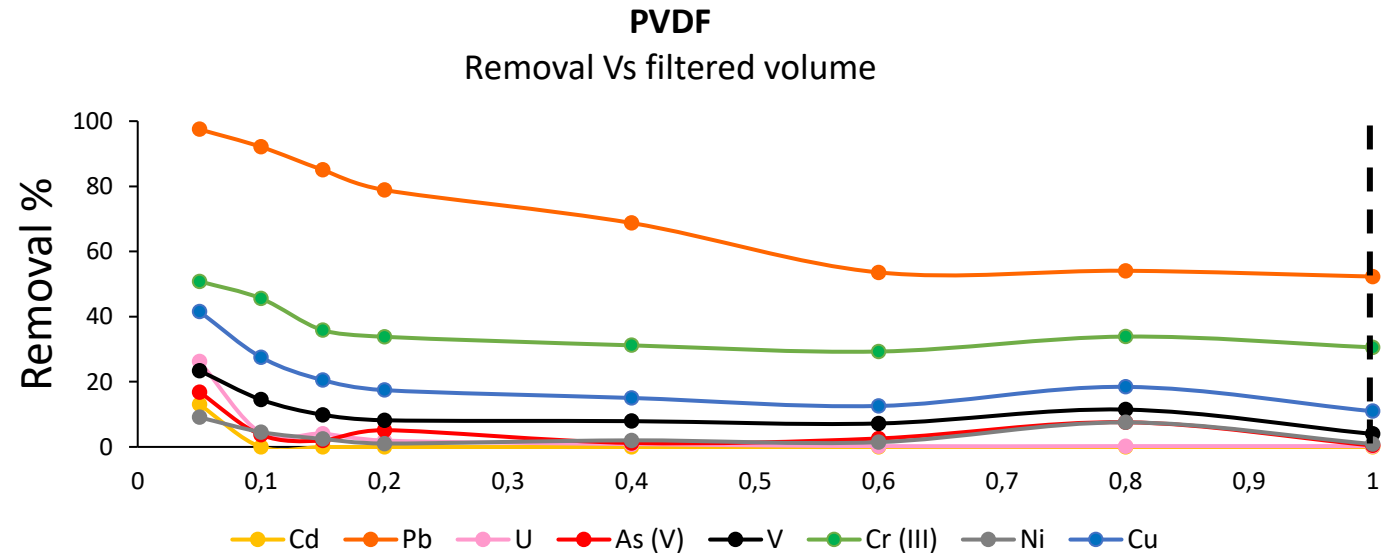
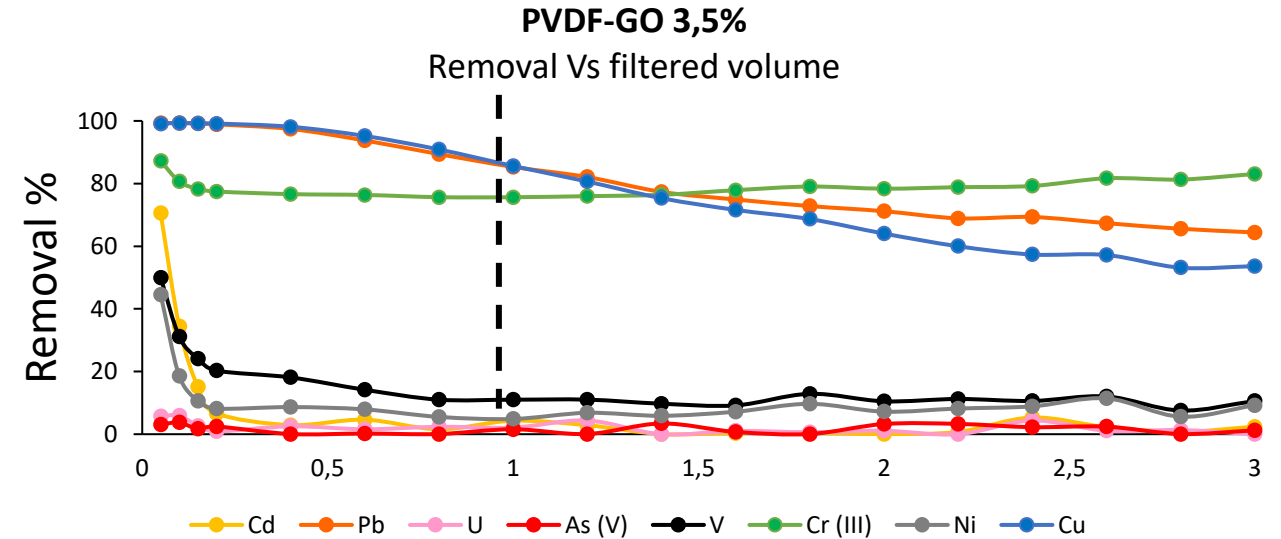
Flow rate: 5 ml/min

Configuration: OUT-IN

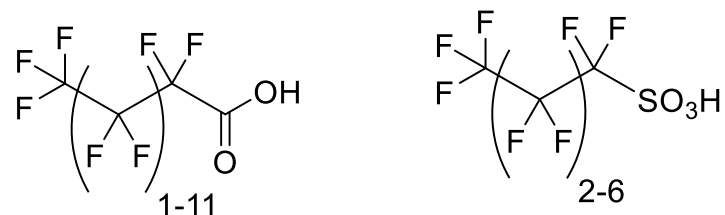


GO improves the removal of Pb, Cr(III) and Cu

	mg removed after 1 L		
	Pb	Cr (III)	Cu
PVDF-GO 3,5%	653	483	555
PVDF	581	265	147
Improvement	1.1	1.8	3.8



Results PFAS



Mixture of 14 PFAS (MIX14)

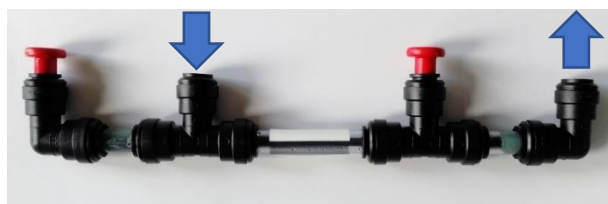
$C_{IN} = 0,5$ ppb each,

$V_{tot} = 1L$

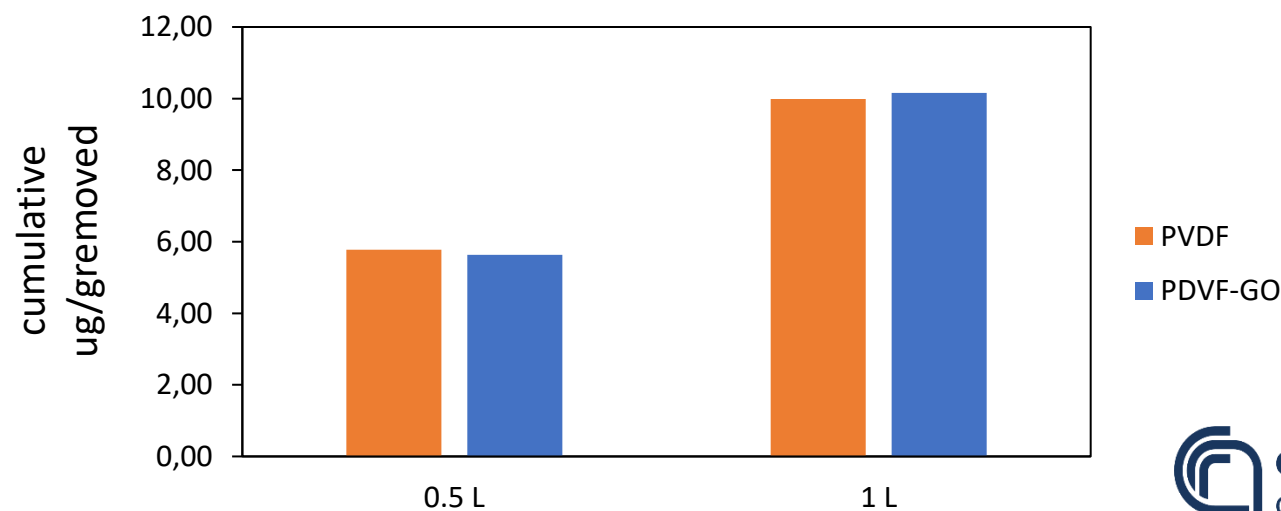
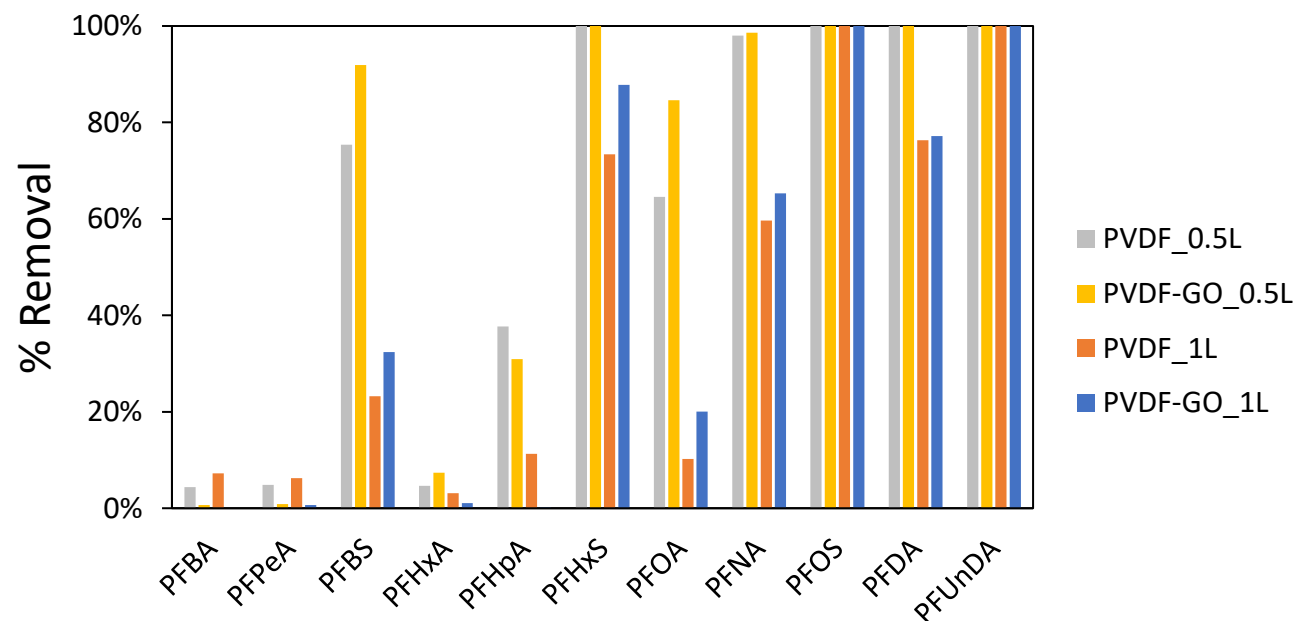
Matrix: Tap water

Flow rate: 5 ml/min

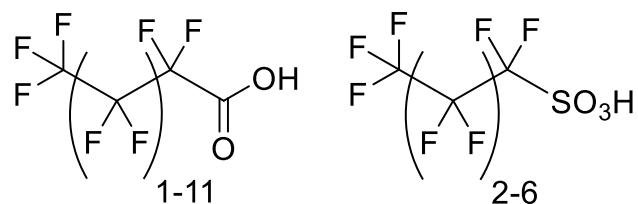
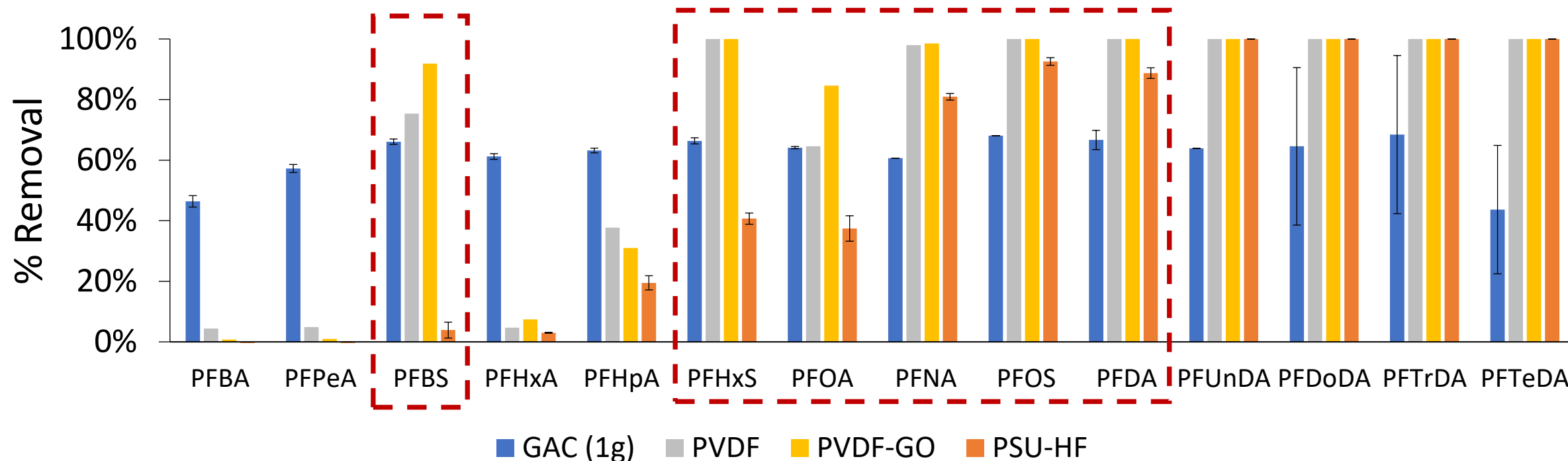
Configuration: OUT-IN



- No contribution of GO
- Adsorption performance drops after 0,5L



Results PFAS test: comparison between PSU, GAC (1g) and PVDF modules at 0,5 L



Mixture of 14 PFAS (MIX14)

$C_{IN} = 0,5 \text{ ppb each}$,
 $V_{tot} = 1L$
Matrix: Tap water
Flow rate: 5 ml/min
Configuration: OUT-IN

*PVDF and PDVF-GO showed better adsorption properties on **PFBS, PFHxS, PFOA, PFNA, PFOA, PFDA** compared to PSU and GAC.*

Conclusions

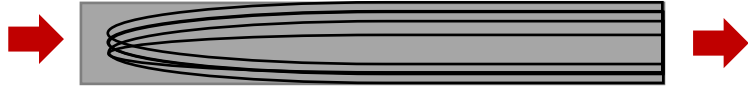
- **CIPRO** was removed with efficiency up to 2,8 mg/g (81 mg/g_{GO}) and only by GO doped modules.
- Longer PFAS (**PFHxS**, **PFNA**, **PFOA**, **PFDA** e **PFUnDA**) were removed with efficiency up to 90% by both PVDF and PVDF-GO, with saturation observed for most of PFAS (**PFBA**, **PFPeA**, **PFHxA**, **PFHpA**) after filtering 500mL of solution. **PFBS** and **PFOA** are removed up to 80% in the first 500 mL but after the removal drops at 20%. A removal of tot. PFAS up to 10 ug/g of fiber was found for both PVDF and PVDF-GO.
- **Pb**, **Cr(III)** and **Cu** are removed by PVDF-GO with efficiency in mg removed after 1L up to 1,1 (Pb), 8 (Cr), 3,8 (Cu) times higher than PVDF.



Some modules were clogged, and the filtration did not occurs as predicted.

Experimental Set-up

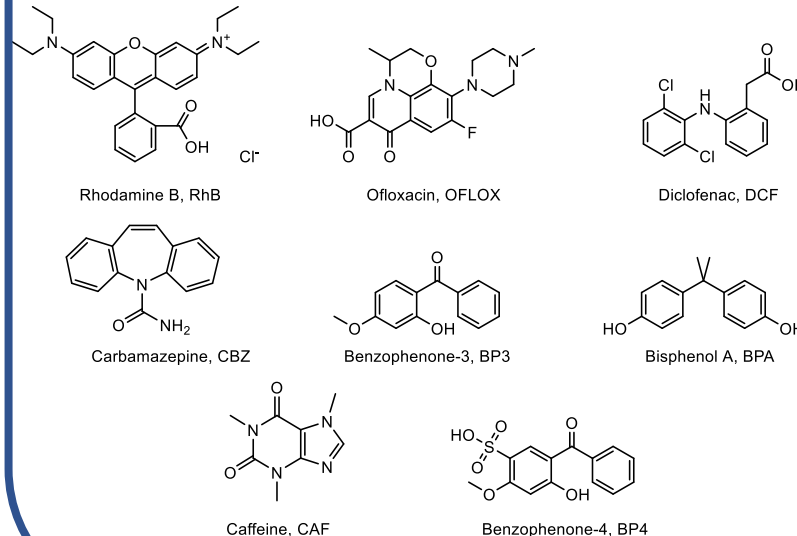
- Flow rate direction



- Matrix:** Tap water
- Flow rate:** 400 ml/min, washed at 1,1 bar for 10 minutes before use
- Sampling volume:** 250 mL, 500 mL, 750 mL, 1L, 1.5 L, 2 L, 3 L → until saturation
- Amount of material in the module:** 221 g of PVDF, 7,7 g of GO

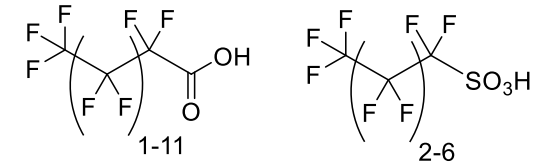
Exp 1:

Mixture of 8 organic contaminants
(MIX8, $C_{IN} = 0,5$ ppm each)



Exp 2:

Mixture of 14 PFAS
(MIX14, $C_{IN} = 0,5$ ppb each)



Exp 3:

Mixture of eight metals
($C_{IN} = 30$ ppb each)

Cd, Pb, U, As, V, Cr, Ni, Cu