PFAS

PER- AND POLY-FLUOROALKYL SUBSTANCES

Management of Environmental & Health Risks

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Evaluation of the efficiency of a two-stage reverse osmosis (RO) system for trifluoroacetic acid (TFA) retention applied to industrial wastewater treatment

Semi-industrial-scale case study

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Hazardous Waste Europe

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Veolia - Hazardous Waste Europe: a leading company in Europe

Treatment & valorization of hazardous waste

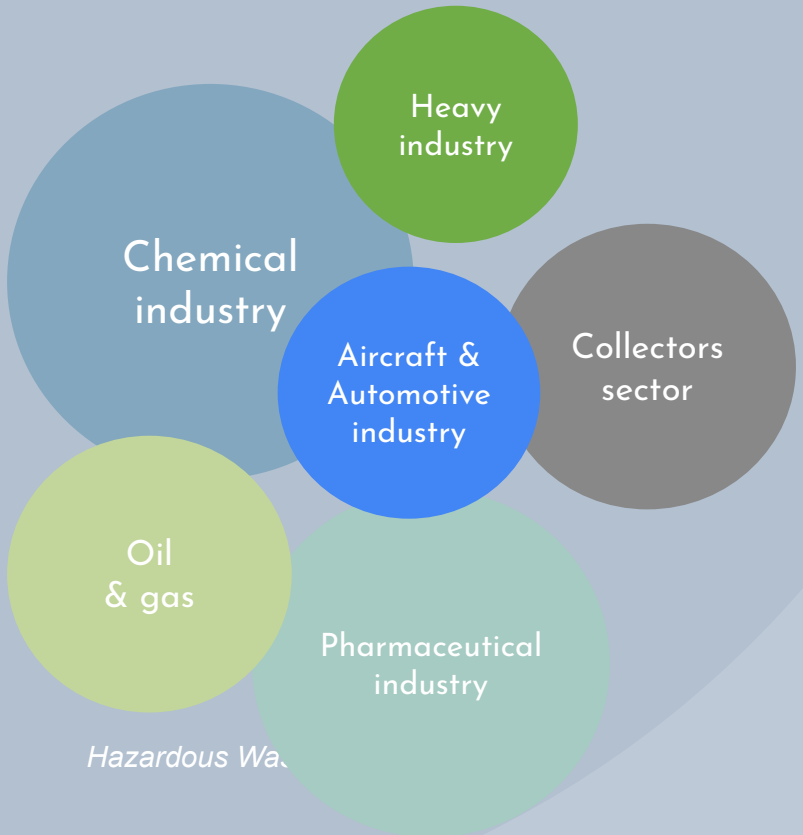
10 countries in Europe

more than 110 industrials sites

over 10 MT treated / year

Origins & Variety of the wastewaters

Variety of origins



Hazardous Wa

Variety of matrices and pollutants

Sludges
Water
Colloidal particles
Suspended particles
Oils & Fats
Soluble matter
Acids & Bases
Organic pollutants
Inorganic substances
PFAS

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Common Technologies used for PFAS retention

	Activated Carbon	IE Resin	Foam Fraction.	NF	RO
Organic pollutants	++	++	++	++	++++
Long-chain PFAS	++	++	+++	+	++++
Short-chain PFAS	+/-	++	+	-	++++
Ultra-short-chain PFAS	- -	+	- -	- -	?

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Can we run Reverse Osmosis with a high recovery rate to remove ultrashort-chain PFAS and especially TFA from pretreated hazardous waste ?

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Facility & methods

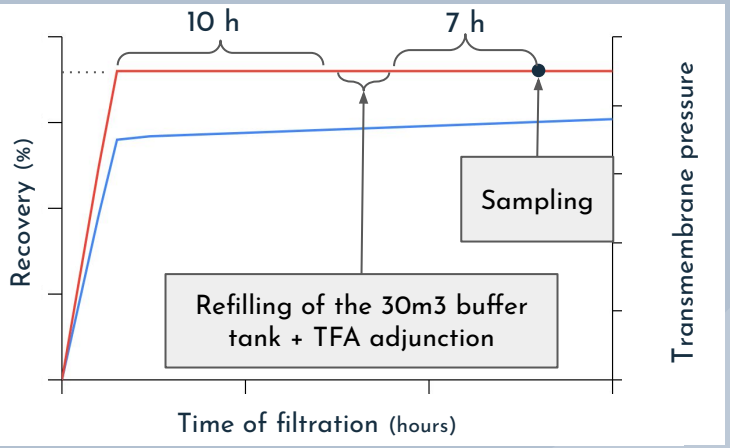
Perform long time trials using the daily plant effluent supplemented with increasing TFA concentrations ranging from 10 to 100 000 µg/L

Mobile processing unit

up to 47 polymeric spiral-wound membranes FilmTec™ SW30HRLE-370/34i

2 or 3 stages
Feed-and-bleed mode

3.0 $m^3 \cdot h^{-1}$ of feed flow rate
@ ambient temperature



- 10 h without TFA (rinsing)
- Refilling & Addition of TFA
- 7 h of filtering
- Sampling

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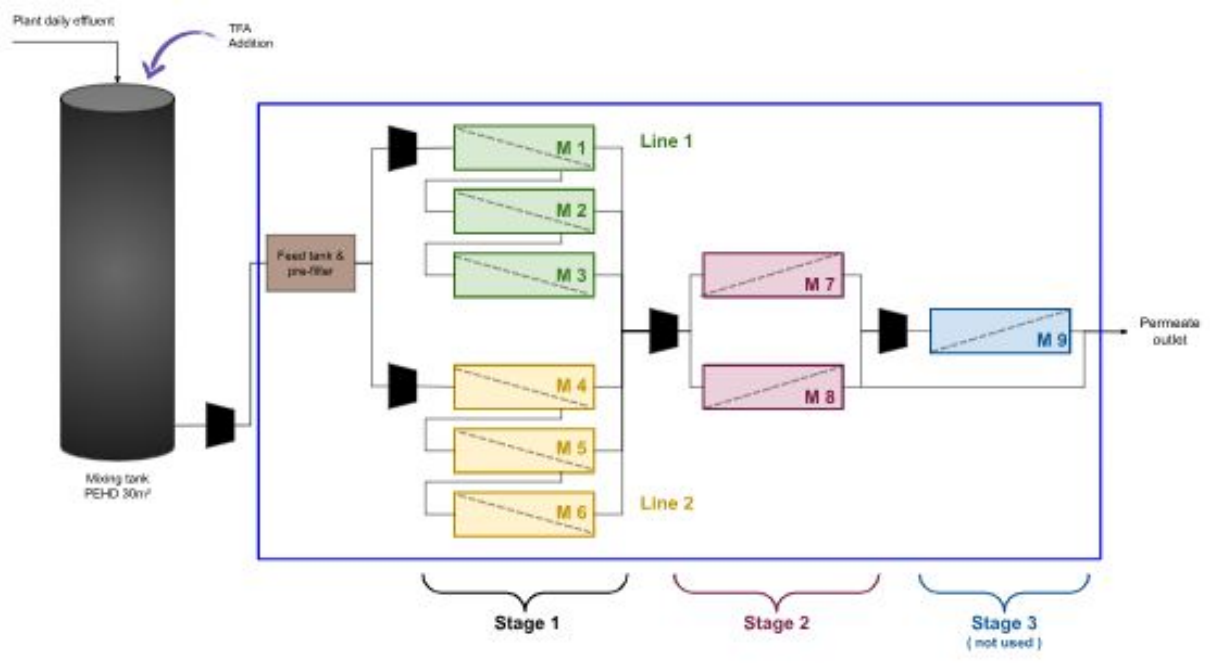
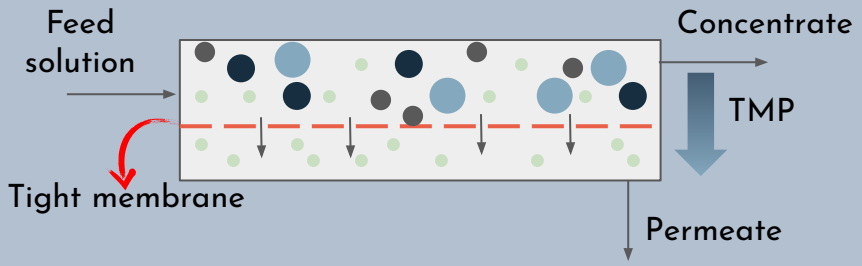
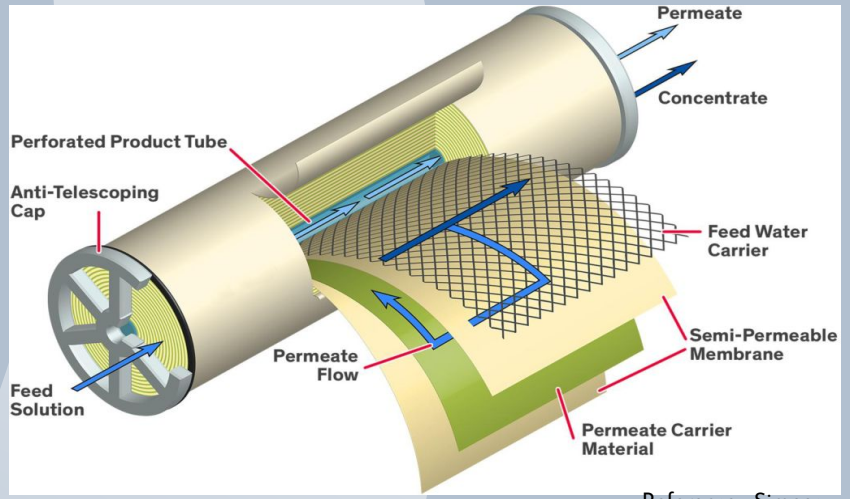
Reverse Osmosis unit : schematic set-up



Fundamentals of Reverse Osmosis





Reference : Simpec

Driving force

Pressure gradient = **TransMembrane Pressure**

$$Recovery = \left(\frac{Q_P}{Q_F}\right)$$

$$Rejection\ a_j = \left(1 - \frac{[a_j]_P}{[a_j]_F}\right)$$

$$Retention\ a_j = \left(1 - \frac{[a_j]_P}{[a_j]_C}\right)$$

$$Trans.\ a_j = \left(1 - Retention\ a_j\right)$$

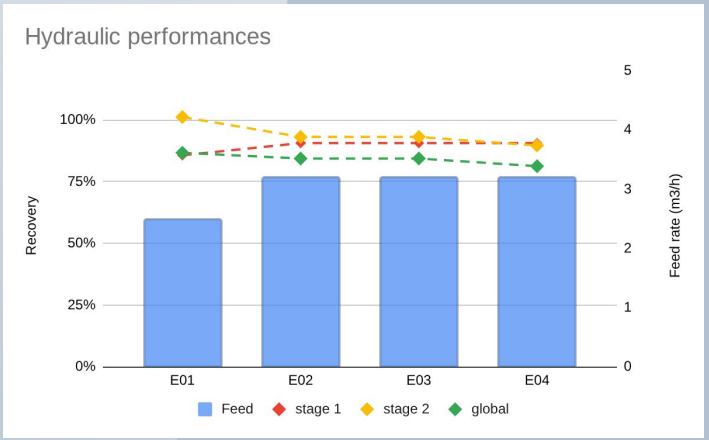
Q_p flow rate of permeate ($L \cdot h^{-1}$)
Q_F flow rate of feed solution ($L \cdot h^{-1}$)

$[a_j]_p$ concentration of molecule i in the permeate ($ng \cdot L^{-1}$)
$[a_j]_c$ concentration of molecule i in the concentrate ($ng \cdot L^{-1}$)
$[a_j]_F$ concentration of molecule i in the feed ($ng \cdot L^{-1}$)

Results

Hydraulic performances

Hydraulic performances					
Trial n°	Feed rate m3/h	Recovery stage 1	Recovery stage 2	Recovery global	PTM bar
E01	2,5	86%	101%	87%	22,3
E02	3,2	91%	93%	84%	29,2
E03	3,2	91%	93%	84%	29,2
E04	3,2	91%	90%	81%	33,1
Avrg	3,0	89%	96%	85%	26,9



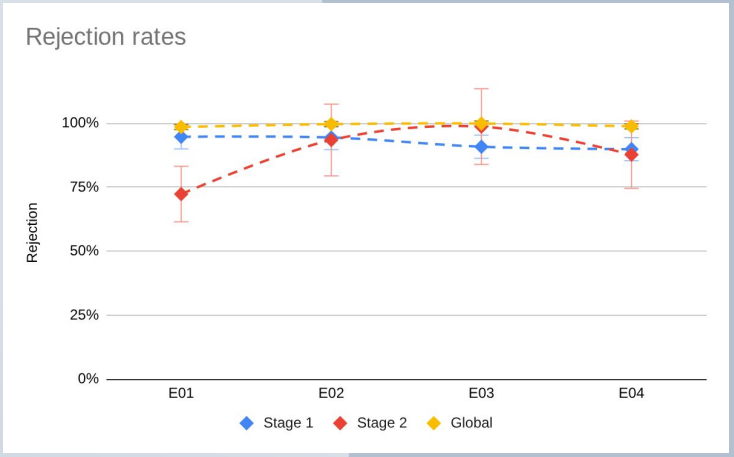
Results

TFA measurements

TFA Concentration								
Trial n°	Feed		Permeate Stage 1		Permeate Stage 2		Concentrate Stage 1	
	µg/L	+/-	µg/L	+/-	µg/L	+/-	µg/L	+/-
E01	10	1,50	0,53	0,12	0,15	0,03	45,9	6,9
E02	117	17,6	6,54	1,44	0,43	0,09	496,0	74,4
E03	910	137	83,7	18,4	1,1	0,2	4840	726
E04	65900	9885	6680	1470	822	181	521000	78150

Results

Rejection rates with increasing TFA concentrations



Rejection rates						
Trial n°	Stage 1		Stage 2		Global	
	%	+/-	%	+/-	%	+/-
E01	94,7%	2,0%	72,3%	12,2%	98,5%	0,5%
E02	94,4%	2,1%	93,4%	2,9%	99,6%	0,1%
E03	90,8%	3,4%	98,7%	0,6%	99,9%	0,05%
E04	89,9%	3,8%	87,7%	5,4%	98,8%	0,5%
Avrg	92,4%	2,8%	88,0%	5,3%	99,2%	0,3%

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Conclusion

- Stable performances over long time
- 90% TFA Rejection rate at each stage
- Rejection rate seems to be indépendant from the TFA concentration
- Overall Rejection rate 99% with a 2 stage system (99.9% or higher with a 3rd stage)

This study confirms that reverse osmosis is an effective technology for the retention of PFAS and, in particular, TFA, even at high and very high concentrations.

The results demonstrate the capabilities of reverse osmosis for treating hazardous waste contaminated with TFA, whether as a direct treatment or as a final treatment.

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