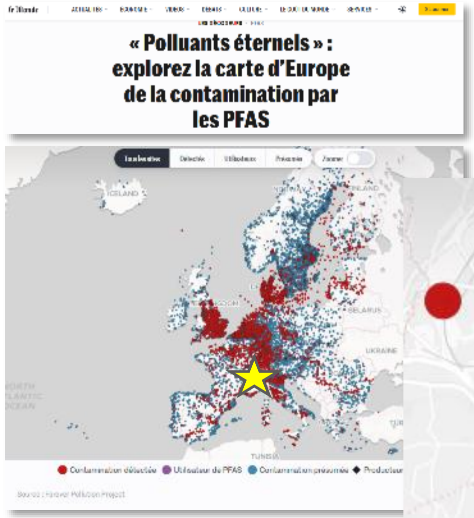
Trends of PFAS recorded in sedimentary archives upstream and downstream of the Lyon metropolis

Brice Mourier, Elie Dhivert,
André-Marie Dendievel, Philippe Marchand

14th International SedNet Conference 6–10 October 2025, Madrid, Spain

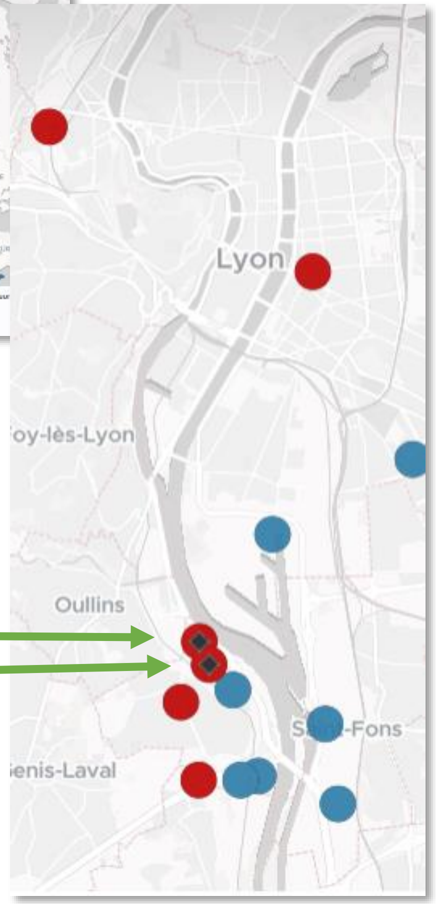
The issue of PFAS pollution in the south of Lyon - FR

- **Questions surrounding these compounds have emerged due to:**
  - Scientific research published in the 2010s (Babut et al.)
  - Journalistic investigation broadcasted on France 2 in 2022
  - A series of articles released by a consortium of international newspapers



- These investigations spotlight **the industrial complex** in Pierre-Bénite, **which has been producing fluorinated polymers**—and handling PFAS—since **the 1960s.**

- **According to historical data from the industry, liquid discharges included:**
  - Between 6.6 to 12.6 tons of PFNA
  - 15.6 and 31.2 tons of PFOA
  - 21 to 57 tons of 6:2 FTS
  - Surflon, foraflon…

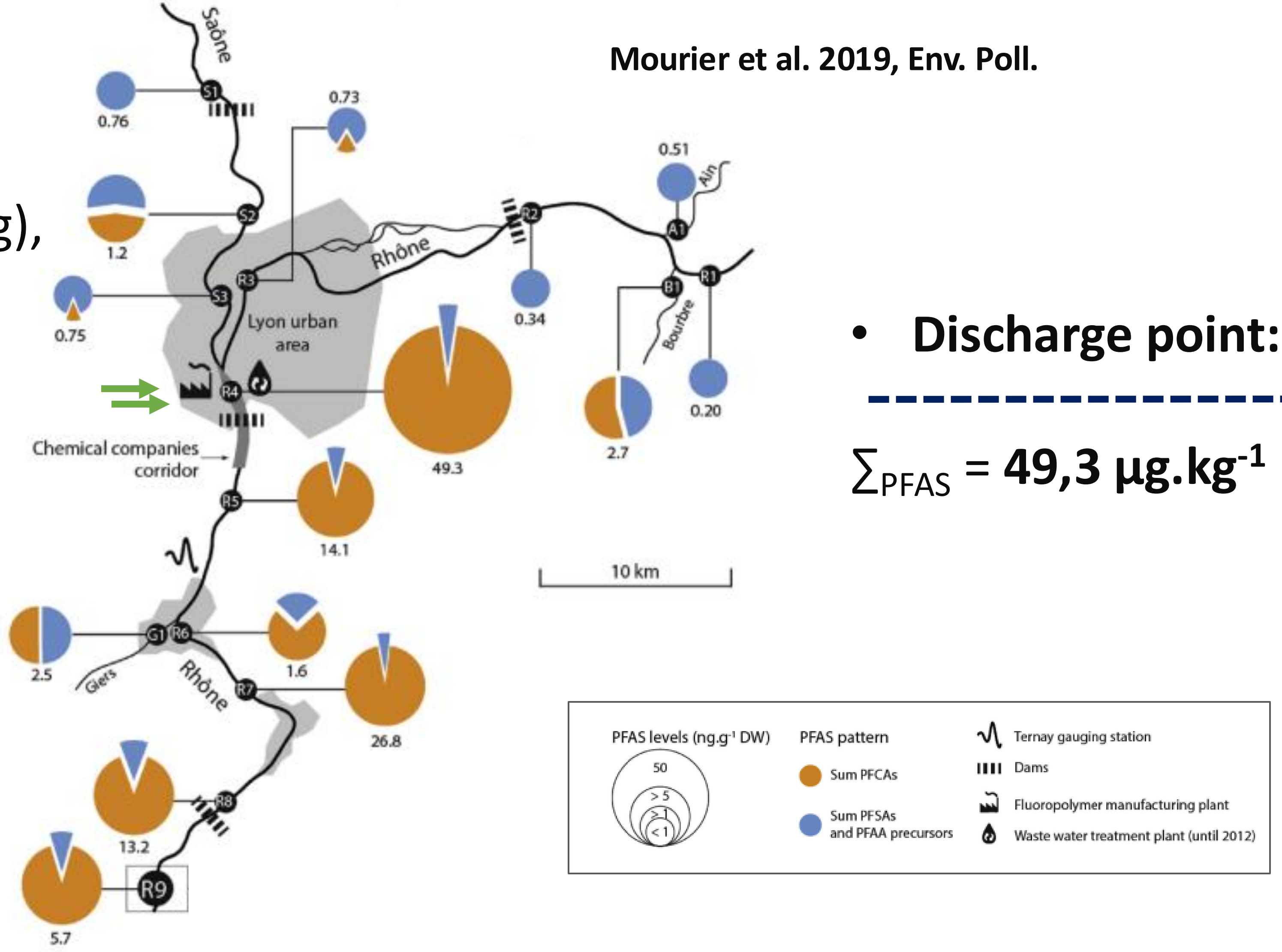


PFAS concentrations in surface sediments: upstream-downstream gradient

Mourier et al. 2019, Env. Poll.

- **Upstream:** Low total concentrations (0.19 to 2.6 µg/kg), with a high proportion of **PFSA**

- **Downstream:** Concentrations increase (X10), long-chain **PFCAs** dominate, particularly PFUnDA (C = 11) and PFTrDA (C = 13)

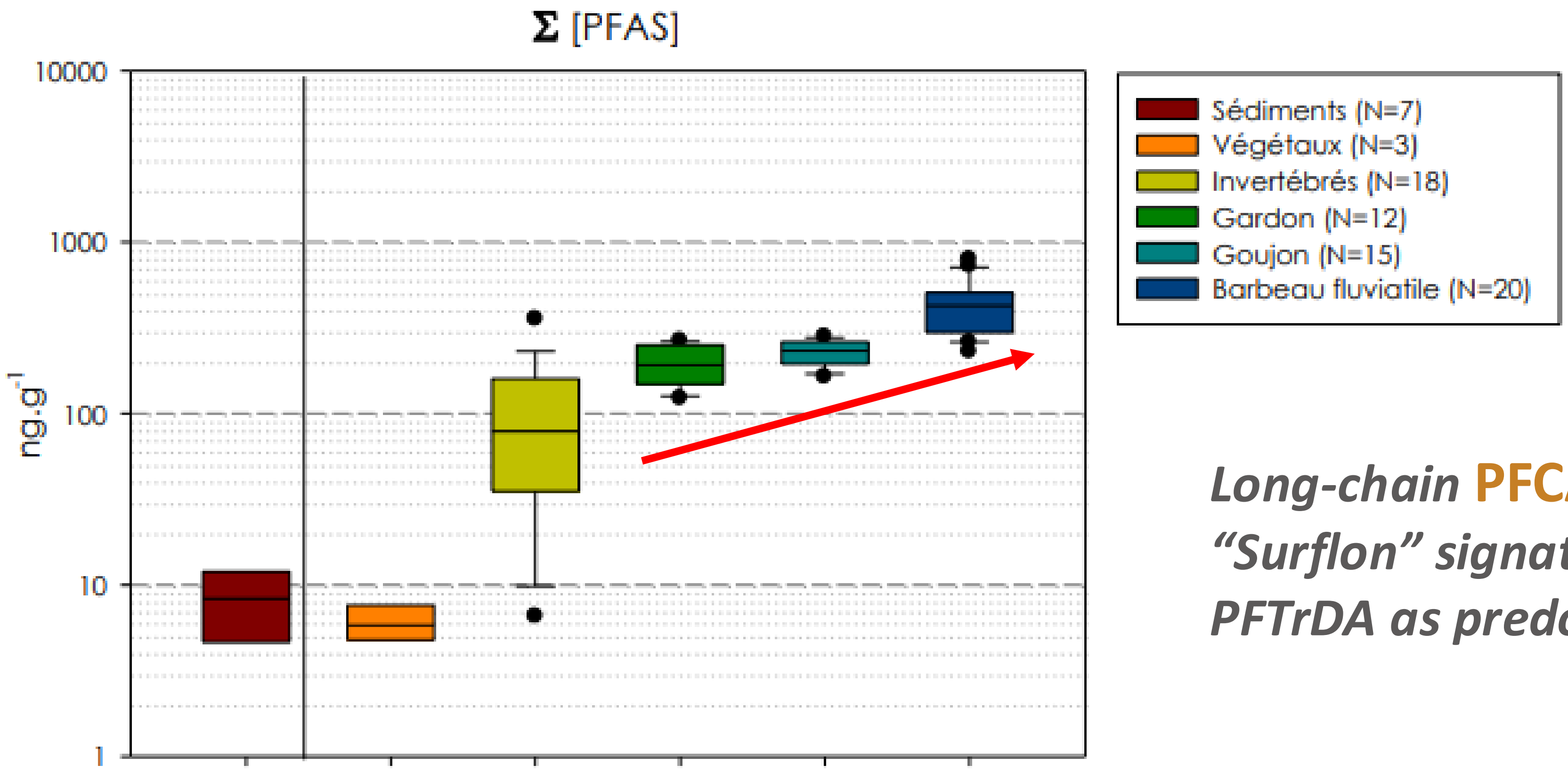


- **Discharge point:**

$\sum_{PFAS}$ = **49,3 µg.kg^{-1}**

Consequences: Transfer of PFAS between different biological compartments

PFAS concentrations by compartment (2012)
(sediments = ng/g dry weight; biota = ng/g fresh weight)



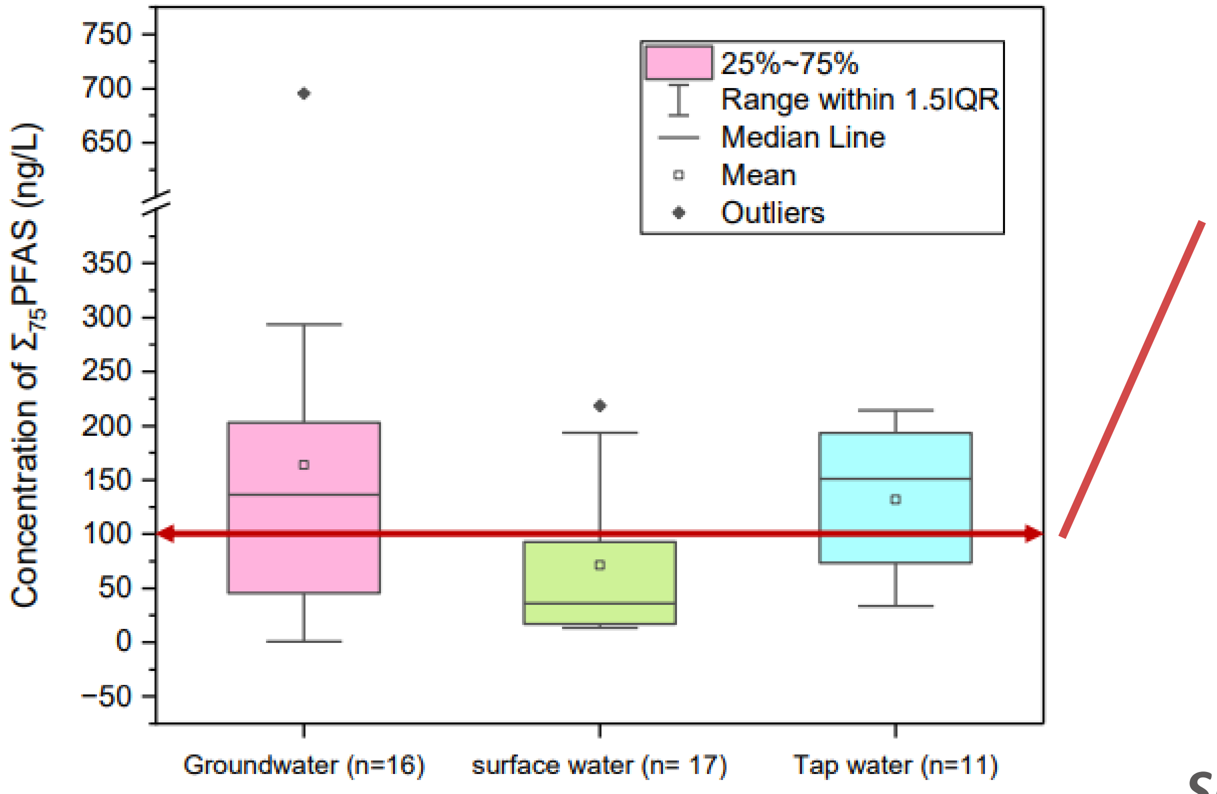
Work of M. Babut et D. Bertin (2014)

Accumulation in sediments, bioaccumulation in plants, and **biomagnification in the food chain**

Long-chain PFCAs dominate → typical "Surflon" signature, with PFUnDA and PFTrDA as predominant compounds in biota

Consequences: Degradation of water quality

Concentration de 77 PFAS dans l'eau de Lyon
(Échantillons collectés de février 2023 à Janvier 2024)



Teymoorian et al., ES&T Letters, 2025

Drinking water standard coming into effect in the EU in 2026 :
∑20 PFAS < 100 ng/L

The vast majority of samples would not be considered safe for consumption in the USA, Canada, Denmark...

Short-chain PFCAs (C4–C7) dominate:
PFHxA > PFPeA > PFBA > PFHpA

Observatoire
des Sédiments
du Rhône

Objectives

- Investigate PFAS trends in dated sediment cores collected at key locations to assess PFAS concentration variations and compound profiles
  - ➢ reconstruct the history of PFAS emissions, identifying periods of intense release and shifts in source types.

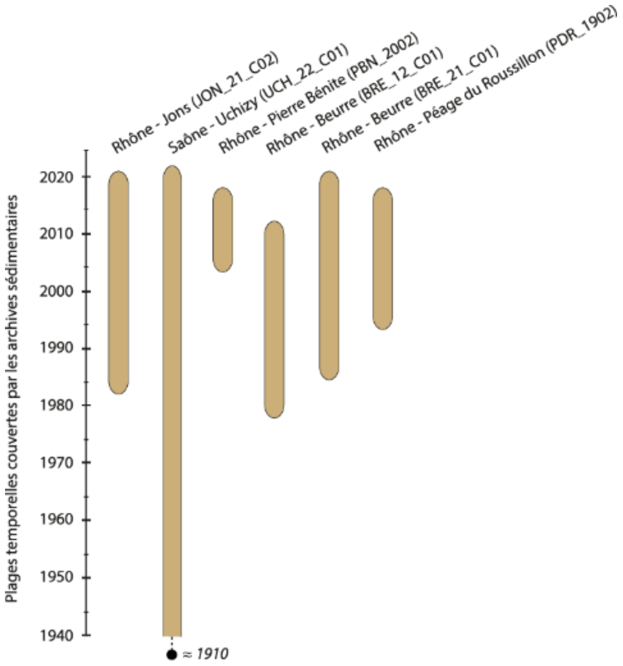
Methodology

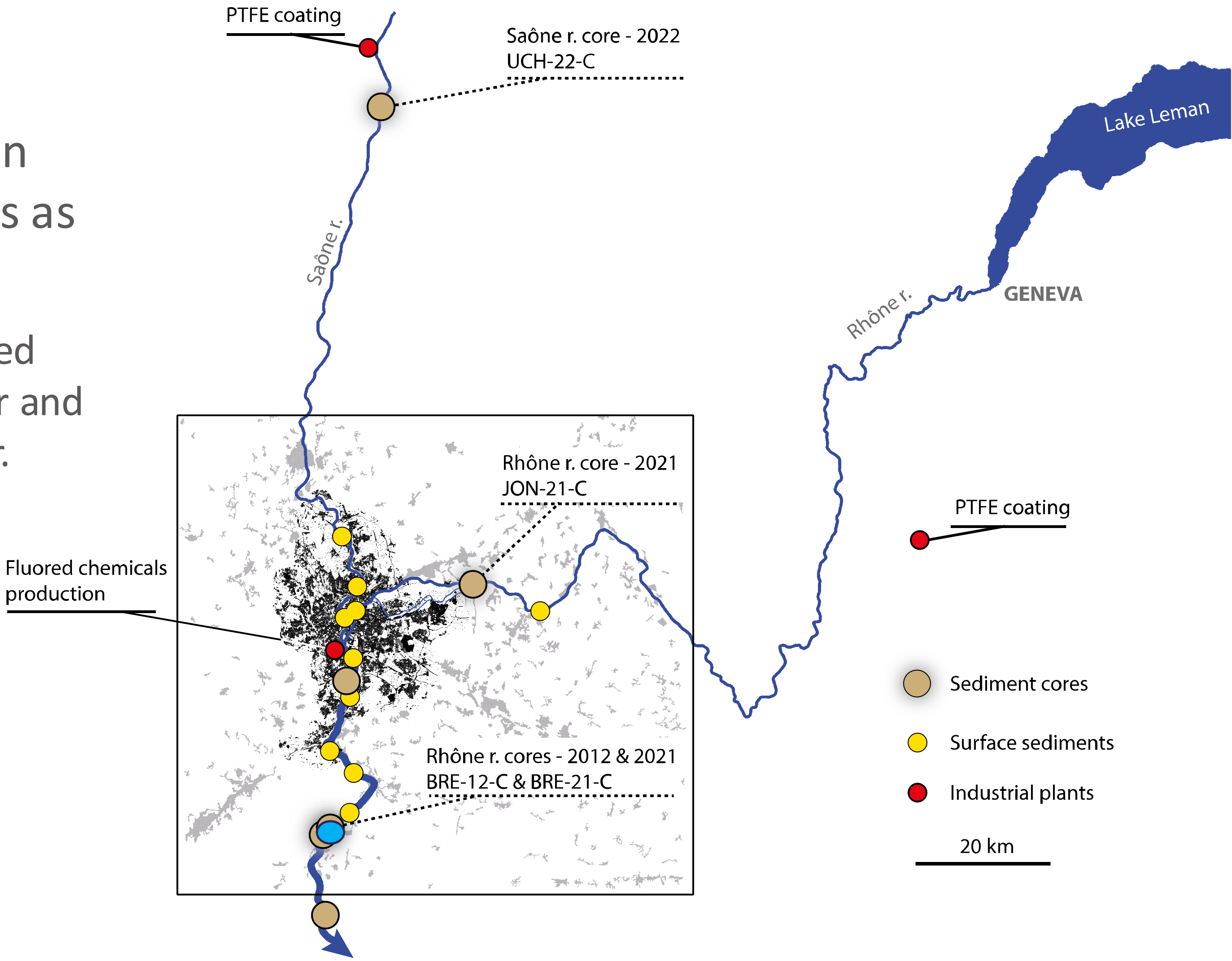
- Integrated approach combining sedimentology, geophysics, and environmental geochemistry;

- Targeted analysis of PFAS compounds and their precursors using liquid chromatography coupled with high-resolution mass spectrometry (LC-HRMS) conducted by specialized laboratories (EPOC Bordeaux, ONIRIS-LABERCA).

Sampling Strategy

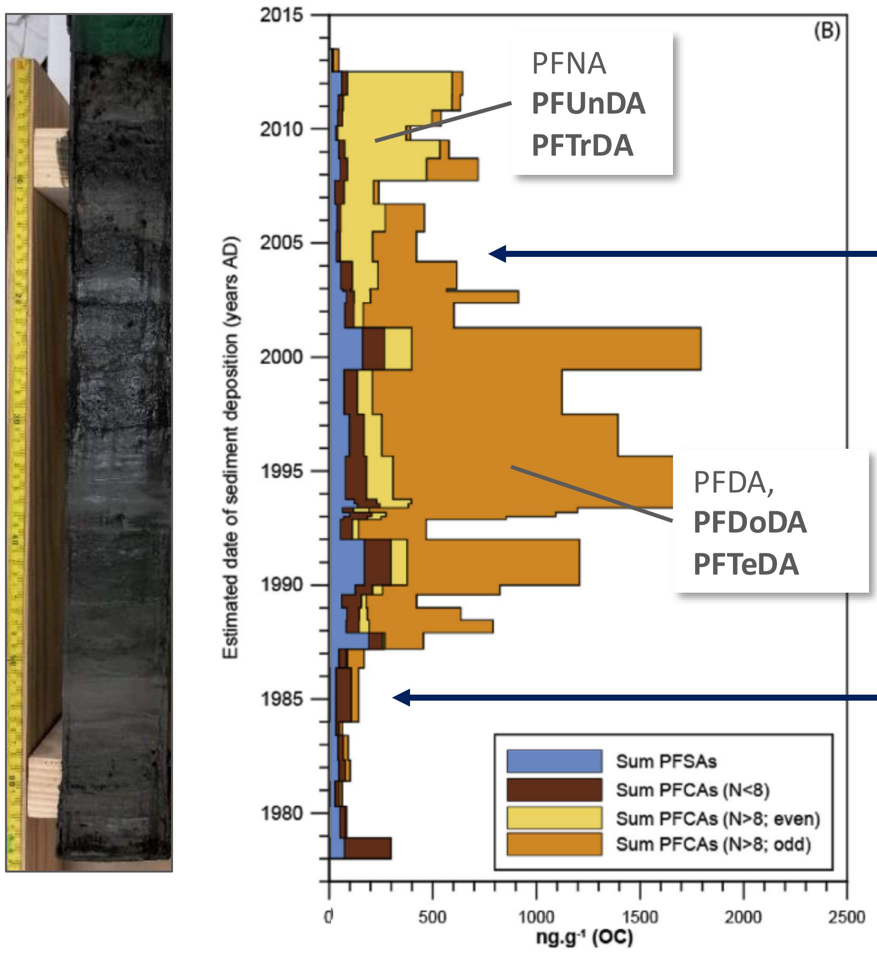
- Initiated in 2012 and expanded in 2021 and 2022 on impacted sites as well as reference sites.
  - ➢ PFAS trends have been documented since the 1980s in the Rhône River and since the 1950s in the Saône River.





2012 Sediment Archive – Indicator of liquid discharges and industrial process changes over more 30 yr.

BRE core: 34 km downstream indus.



The proportion of PFSA has remained relatively constant since the 1980s, while PFCA levels—especially long-chain compounds (C > 8)—show significant variation.

2003 : Shift in long-chain PFCA profiles (odd-numbered) – possibly linked to the commissioning of a new production unit?

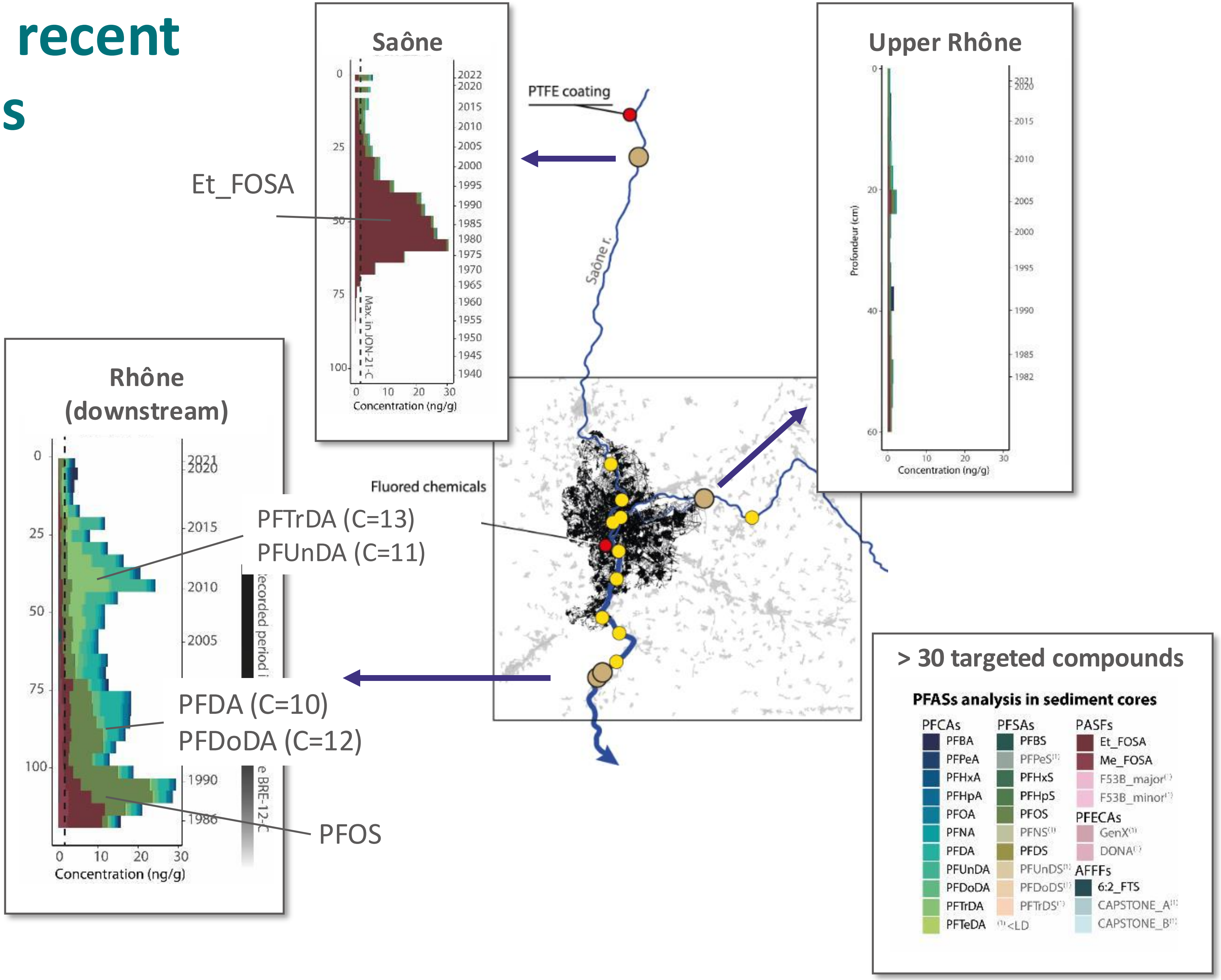
1990s : Peak PFAS concentrations, with a dominance of long-chain PFCAs (even-numbered).

1985 : Construction and expansion of workshops producing fluorinated polymers.

Mourier et al. 2019, Env. Poll.

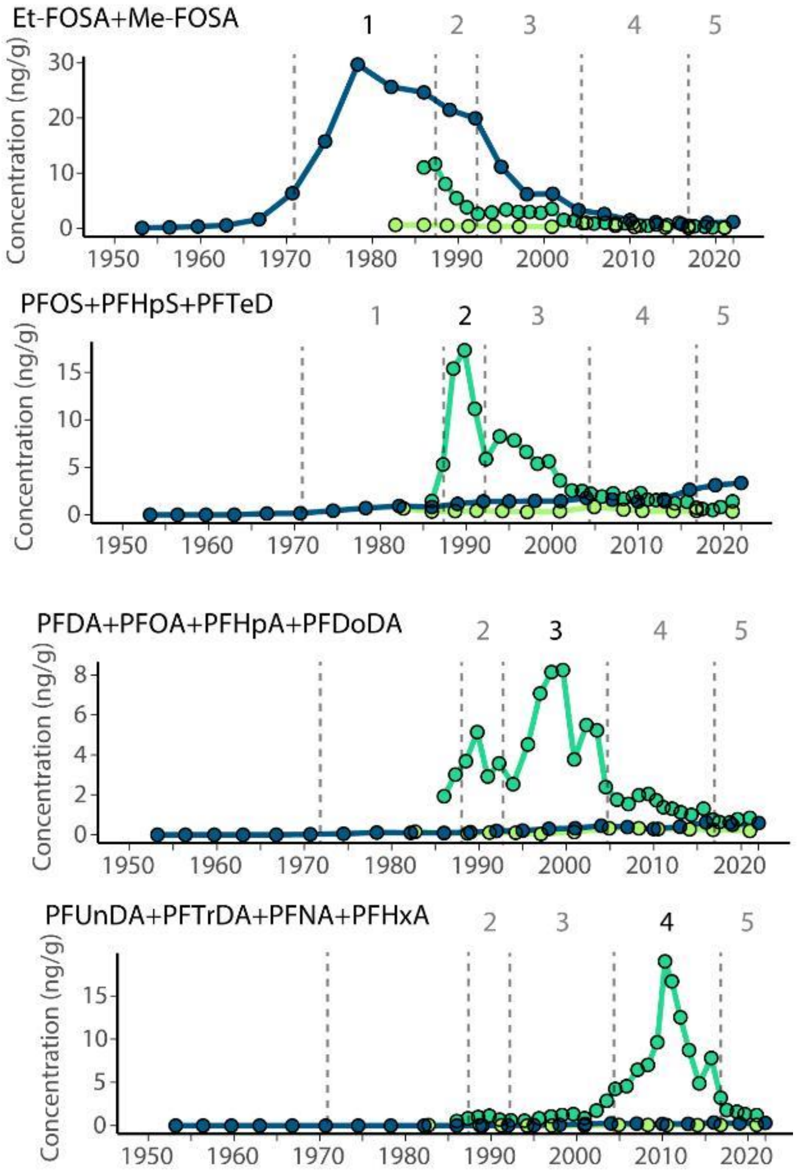
PFAS trends in recent sediment cores

- **Downstream of Lyon:**
  - Great diversity of compounds >LOQ
  - Multiple contamination phases with differing compound compositions : long chain PFCA
  - Confirmation of a recent pollution phase (odd-numb.)
- Higher contamination levels downstream of Lyon (10×) compared to the **upper Rhône**
- **Saône:** Older contamination phase, predominantly composed of PFOS precursors.



Establishg the causal link : attribution of contamination phases

- Phase 1 : **EtFOSA** (PFOS precursors)



Linked to industrial manufacturing in Tournus: treatment of kitchen equipment, first in aluminum, then in stainless steel.

- Phase 2 : **PFOS**

Hypothesis : PEH fire incident (200 m³ of firefighting foam); possible link to workshops on the industrial platform? Saône River?

- Phase 3 : **Long-chain PFCA** (even-numbered)

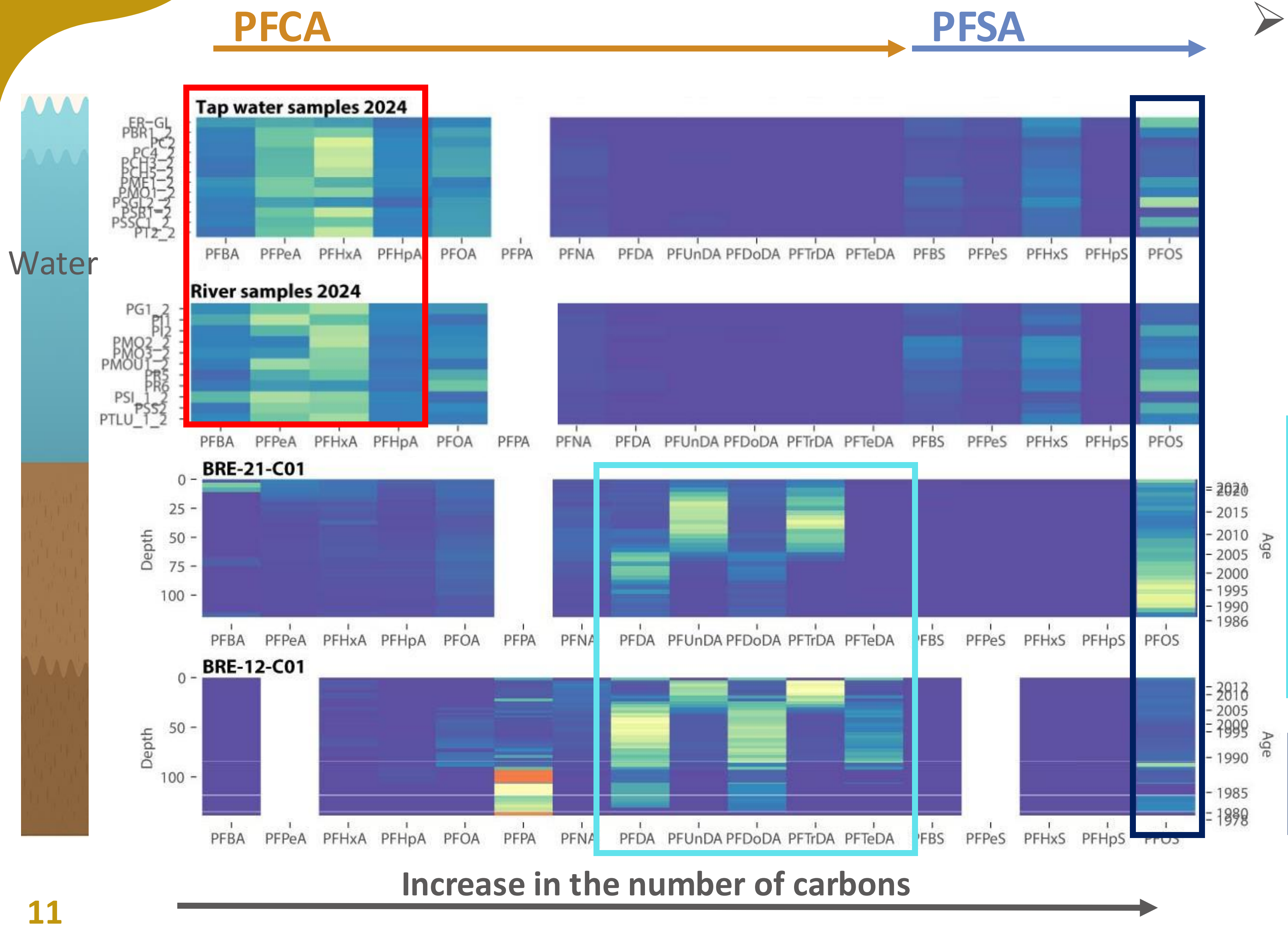
Workshops on the PB platform potentially compatible with PVDF – Foraflon® production. **Time range matches**, but compound composition is poorly documented.

- Phase 4 : **Long-chain PFCA** (odd-numbered)

Workshops on the PB platform. Characteristic of Surflon®, Time range (2003–2017) and compounds composition matches.

- ✓ ANSES 2022: Dust and soil data from the platform
- ✓ Arkema 2023 historical study (Surflon® composition)
- ✓ 2024 soil study by S. Sauvé (Université de Montréal)

PFAS signatures in water and sediment in the south of Lyon



➢ **Complex PFAS Liquid–Solid partitioning**

Water : short chain PFCAs, transformation of 6:2 FTS into stable transformation products : PFHxA > PFPeA > PFBA > PFHpA

Sediment : long-chain PFCAs, signature of Surflon, a fluorinated copolymer (PFUnDA, PFTrDA), and of other historical surface surfactants (PFDA, PFDoDA, PFTeDA).

PFOS : transformation of Et FOSA? firefighting foam?

Conclusion and implications

General downward trend, but the situation remains concerning

- **Persistence of long-chain PFCAs** in sediments poses a potential long-term threat to the ecological restoration of the river.
- A major challenge for **drinking water** supply systems: who should bear the cost of water treatment infrastructure to remove PFAS?
- Widespread exposure in human populations and biota: What is the elimination time following a reduction in exposure?
- There is a disconnect between the socio-political “crisis” around PFAS and the actual contamination levels—despite data being public and readily accessible.

Strengthen regulations on aqueous discharges from classified facilities

Prohibit PFAS by class to avoid regrettable substitutions

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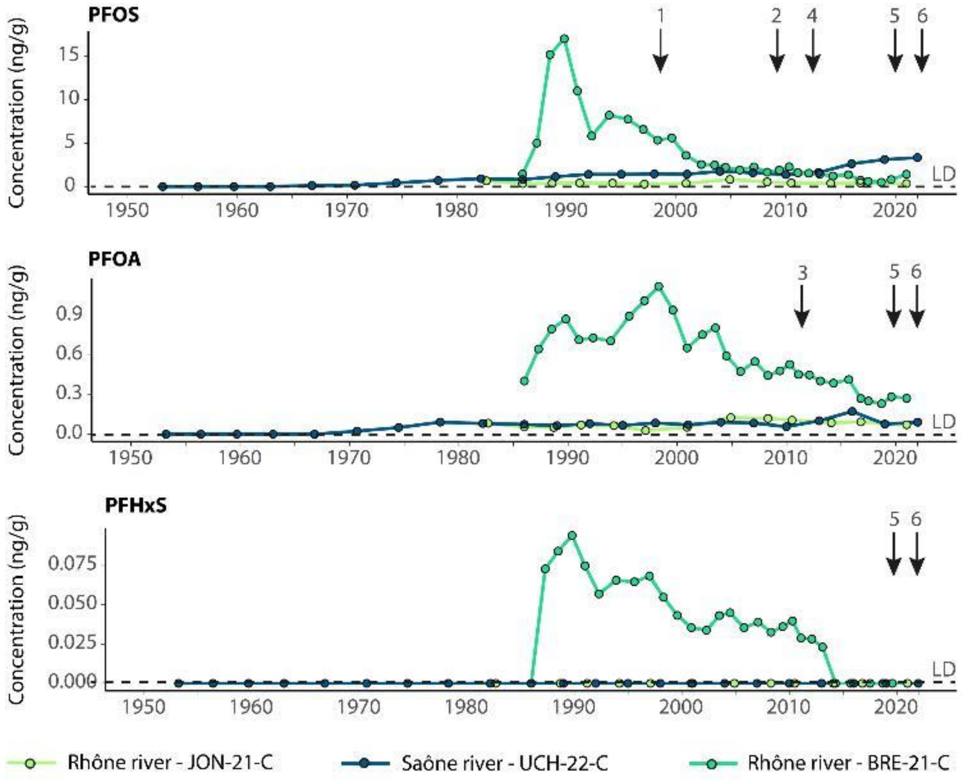
Tendances des composés fluorés réglementés

- Amélioration générale des niveaux de contamination
- Crise des PFAS tardive par rapport aux pics de contamination
- Tendances des PFAS globalement peu influencées par les règlementations : baisse amorcée avant



Dates de régulation des PFAS

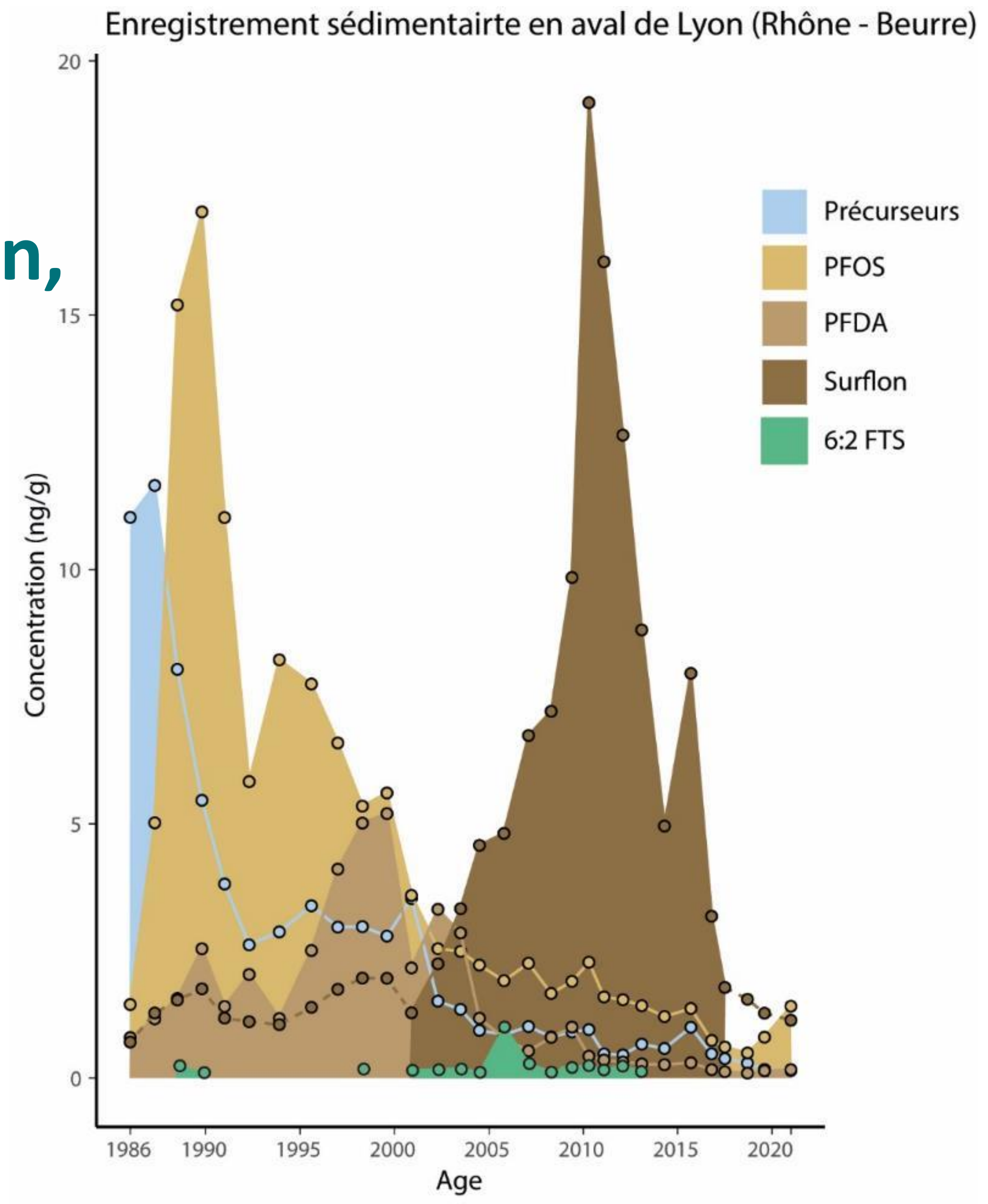
PFAS regulations
1 - 1998 - PFOS limitations in releases of classified industrial plants
2 - 2009 - PFOS inscription in the UE POP reglement
3 - 2011 - PFOA regulation in plastic materials in contact with foodstuffs
4 - 2013 - Environmental standards for the PFOS in waterbodies
5 - 2020 - Quality standards in drinking water for 20 targeted PFAS
- PFOA inscription in the UE POP reglement
6 - 2022 - Plan for the assesment and improvment of PFAS contaminations in the water ressource
- PFHxS inscription in the UE POP reglement

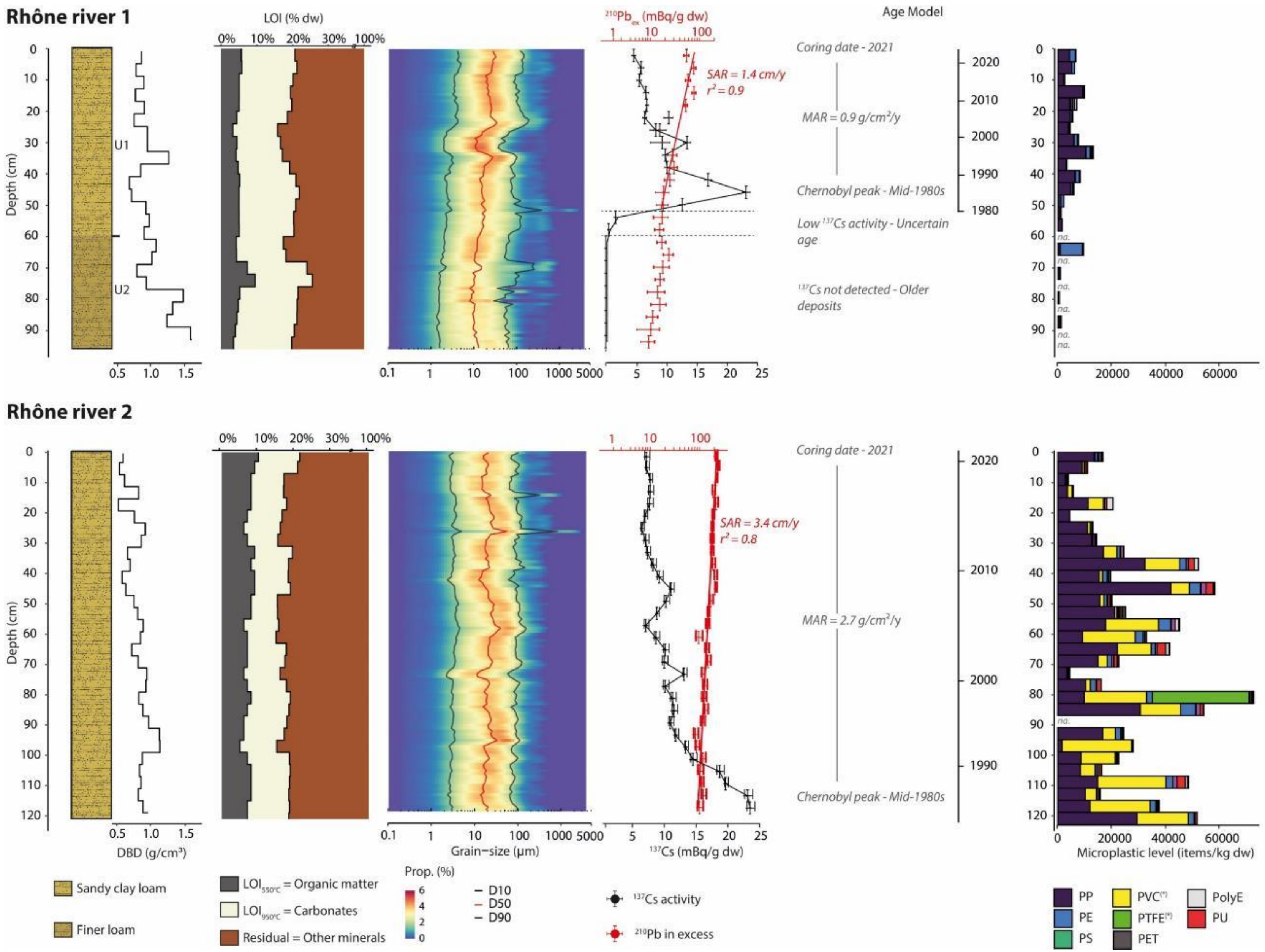
Evolution of PFAS downstream of Lyon, different contamination phases

Surflon* :

- 74% PFNA,
- 16-20% PFUnDA,
- 5% PFTrDA,
- <5% PFOA,
- <1% PFDA et PFDoDA,
- Puis 6:2 FTS

* Prevedouros et al. 2006;
Étude historique Arkema



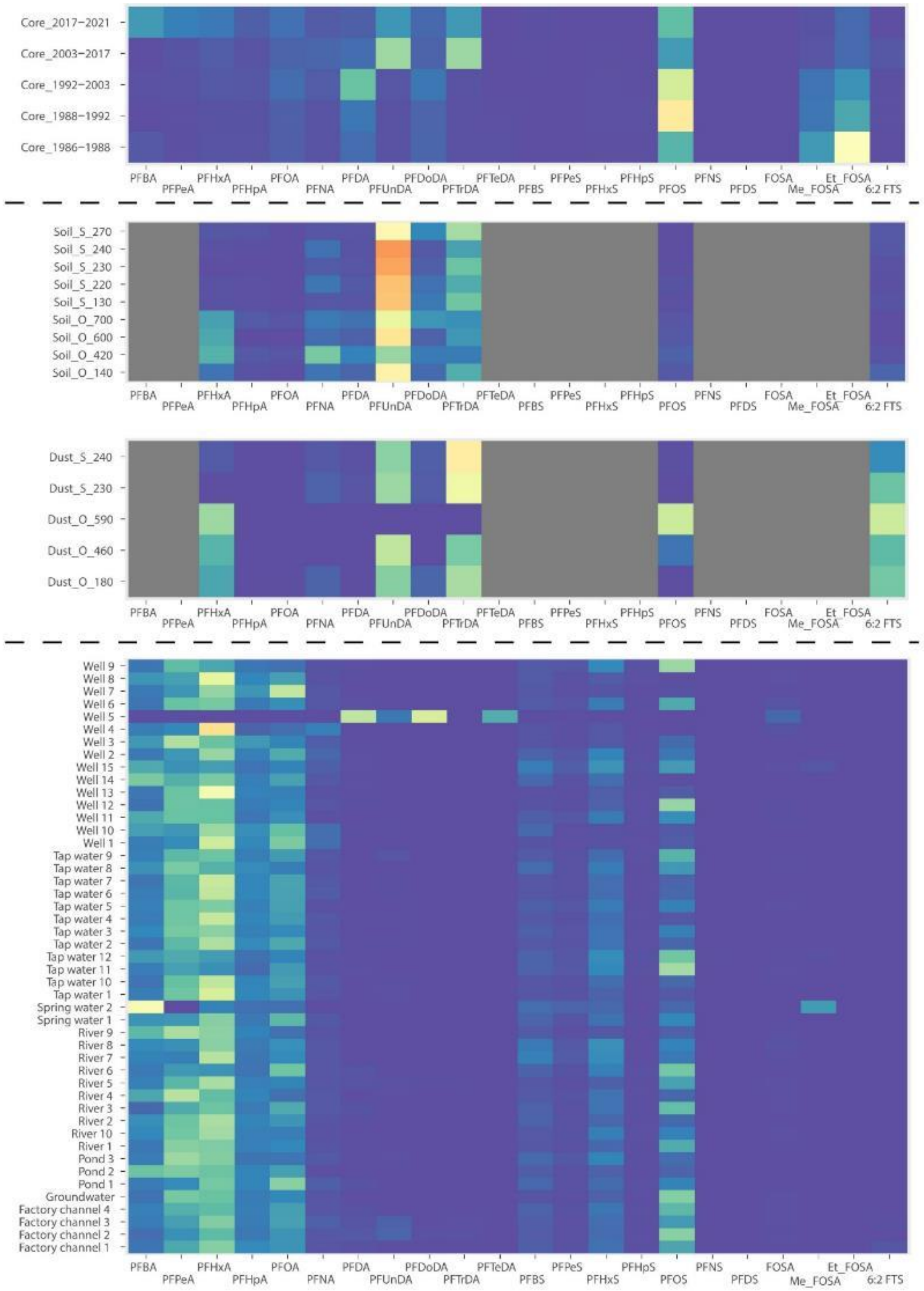

Rhône river 1
Rhône river 2
LOI (% dw)
Age Model
Coring date - 2021
SAR = 1.4 cm/y
$r^2 = 0.9$
MAR = 0.9 g/cm²/y
Chernobyl peak - Mid-1980s
Low ¹³⁷Cs activity - Uncertain age
¹³⁷Cs not detected - Older deposits
SAR = 3.4 cm/y
$r^2 = 0.8$
MAR = 2.7 g/cm²/y
Depth (cm)
DBD (g/cm³)
Grain-size (µm)
¹³⁷Cs (mBq/g dw)
²¹⁰Pbex (mBq/g dw)
Microplastic level (items/kg dw)
U1
U2
na.
Sandy clay loam
Finer loam
LOI550°C = Organic matter
LOI950°C = Carbonates
Residual = Other minerals
Prop. (%)
D10
D50
D90
¹³⁷Cs activity
²¹⁰Pb in excess
PP
PE
PS
PVC(*)
PTFE(*)
PET
PolyE
PU

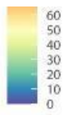
Profils de PFAS dans la région de Lyon

Carottes sédimentaires

Sols et poussières sur la plateforme industrielle

Eaux (Teymoorian et al., 2025)





Catégories		Composés	N° CAS	Carbone	Run 1	Run 2	Run 3
PFAA	PFCA	PFBA	375-22-4	4	0.03	1.35-2.12	0.15
		PFPeA	2706-90-3	5	-	-	0.05
		PFHxA	307-24-4	6	0.07	?	0.05
		PFHpA	375-85-9	7	0.01	0.06-0.07	0.01
		PFOA	335-67-1	8	0.11*	?	0.02
		PFPA	68412-68-0	8	0.02	1.18-1.43	-
		PFNA	375-95-1	9	0.01	0.06-0.07	0.02
		PFDA	335-76-2	10	0.01	?	0.02
		PFUnDA	2058-94-8	11	0.02	?	0.03
		PFDoDA	307-55-1	12	0.01	?	0.02
		PFTrDA	72629-94-8	13	0.01	?	0.05
		PFTeDA	376-06-7	14	0.03	?	0.05
	PFSA	PFBS	375-73-5	4	0.02	0.01-0.02	0.01
		PFPeS	2706-91-4	5	-	-	0.02
		PFHxS	355-46-4	6	0.02	0.03-0.04	0.02
		PFHpS	375-92-8	7	0.01	0.01-0.02	0.01
		PFOS	1763-23-1	8	0.01*	?	0.05
		PFNS	68259-12-1	9	-	-	0.01
		PFDS	335-77-3	10	0.01	0.01-0.02	0.02
		PFUnDS	749786-16-1	11	-	-	0.02
		PFDoDS	79780-39-5	12	-	-	0.02
		PFTrDS	791563-89-8	13	-	-	0.04
Precursor	PASF	FOSA	754-91-6	8	0.01	-	-
		N-Et-FOSA	2355-31-9	8	0.01	-	0.02
		N-Me-FOSA	2991-50-6	8	0.01	-	0.02
		F53B-major	756426-58-1	8	-	-	0.01
		F53B-minor	763051-92-9	10	-	-	0.01
	PFECA	GenX	13252-13-6	6	-	-	0.05
		DONA	919005-14-4	7	-	-	0.01
AFFF	FTS	6:2-FTS	27619-94-9	8	0.01*	-	0.1
		CAPSTONE-A	80475-32-7	13	-	-	0.05
		CAPSTONE-B	34455-29-3	15	-	-	0.25

TAB. 1 LIMITE DE DETECTION DES COMPOSES ANALYSES LORS DES 3 RUN ANALYTIQUE (*=LR, ? = LD INCONUE, - = NON ANALYSE)

Sediment core

Water samples