PFAS "The Forever Chemicals“
What they are and Why they are of concern

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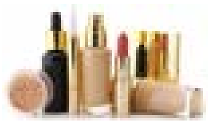
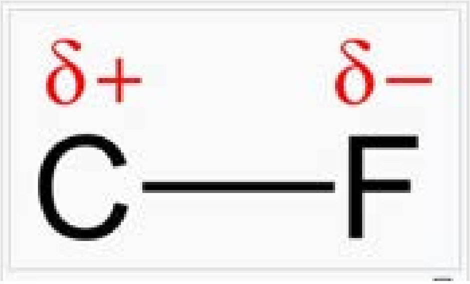
WHAT ARE THEY?



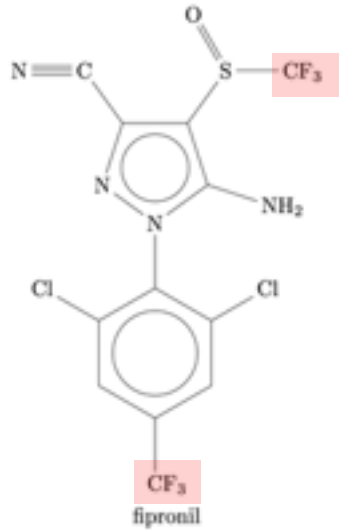


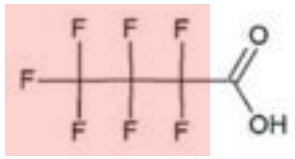
It is one of the strongest single bonds in the chemistry of carbon compounds

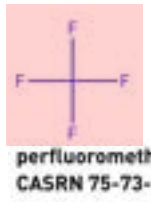
Inertia
Durability
Resistance

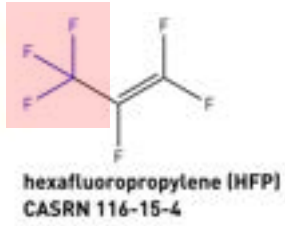
PFAS per- and polyfluoroalkyl substances

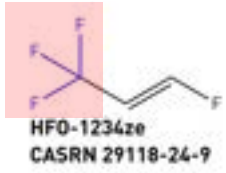
PFAS definition: "PFAS are defined as fluorinated substances that contain ***at least one fully fluorinated methyl or methylene carbon atom*** (without any H/Cl/Br/I atom attached to it), i.e., with a few noted exceptions, any chemical with at least a perfluorinated methyl group (−CF3)or a perfluorinated methylene group (−CF2−) is a PFAS". The "noted exceptions" refer to a carbon atom with a H/Cl/Br/I atom attached to it. (*OECD, 2021)*

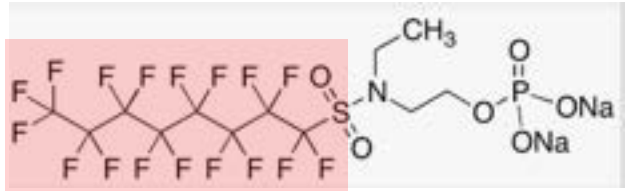


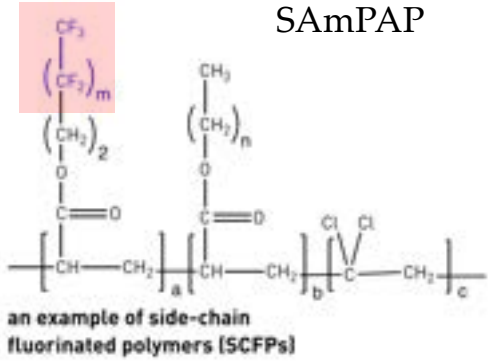






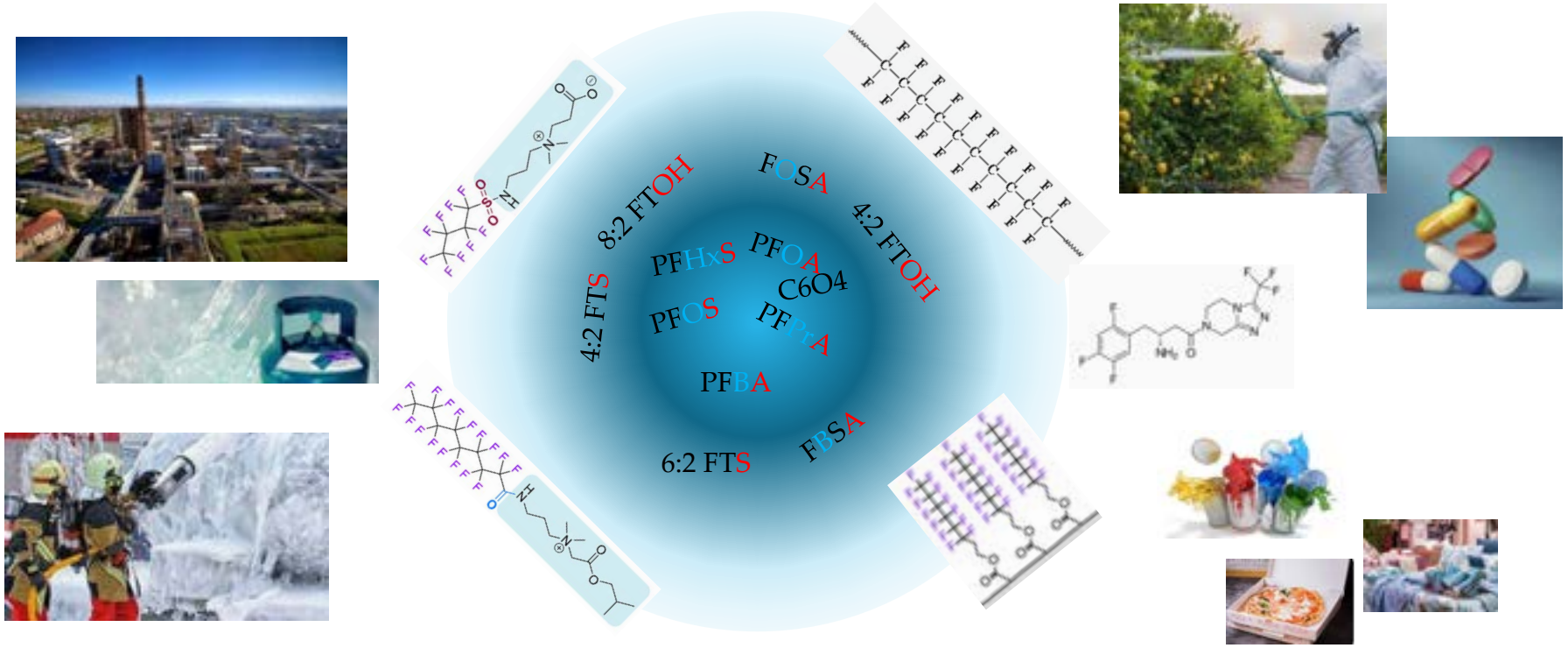






ARE THEY ALL FOREVER?

Common characteristic: they are persistent themselves or generate persistent chemicals in the environment.



PFAS classification

State of Matter

- Solid
- Liquid
- Gas

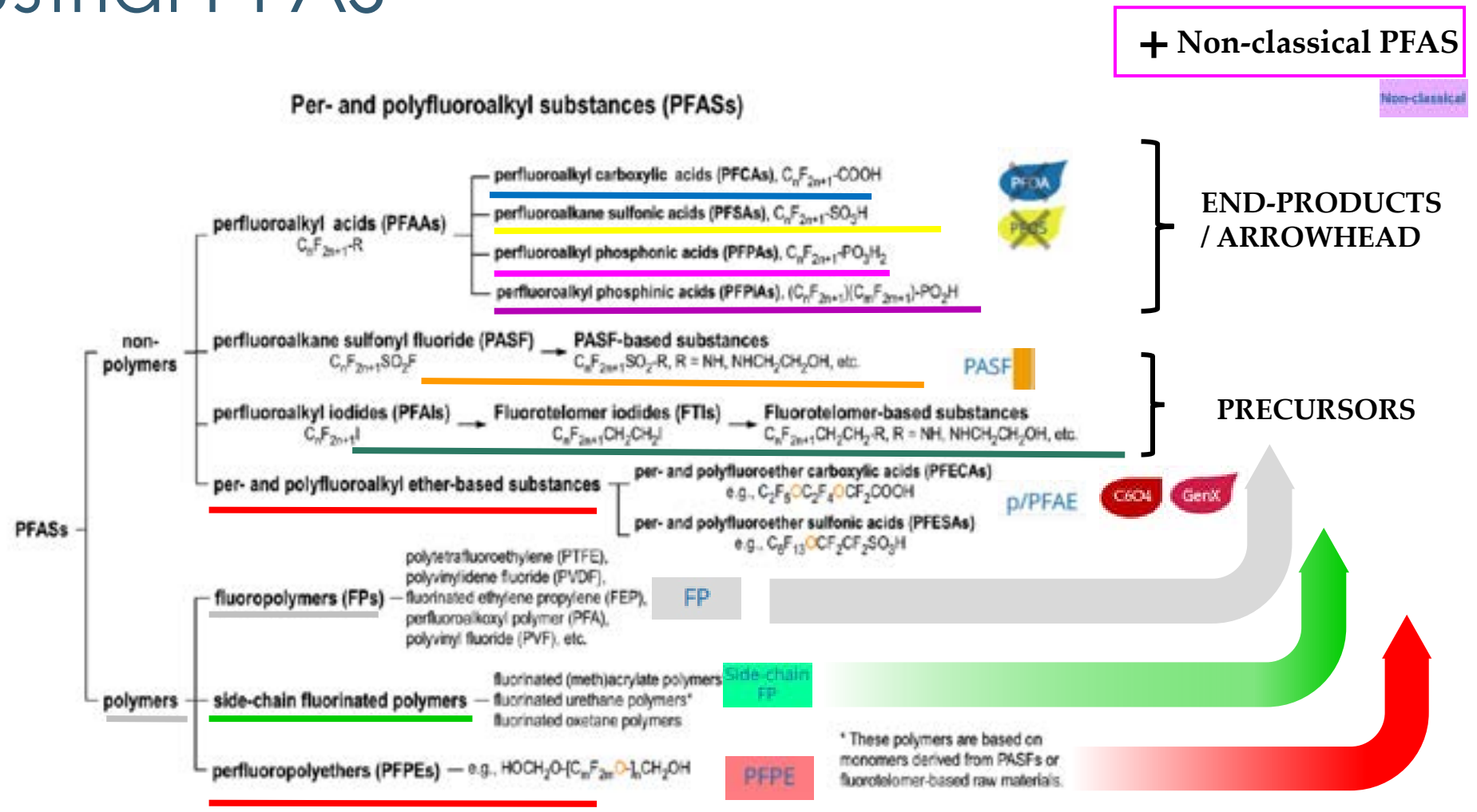
Uses

- Plant Protection Products
- Pharmaceuticals
- Industrial

Chemical nature

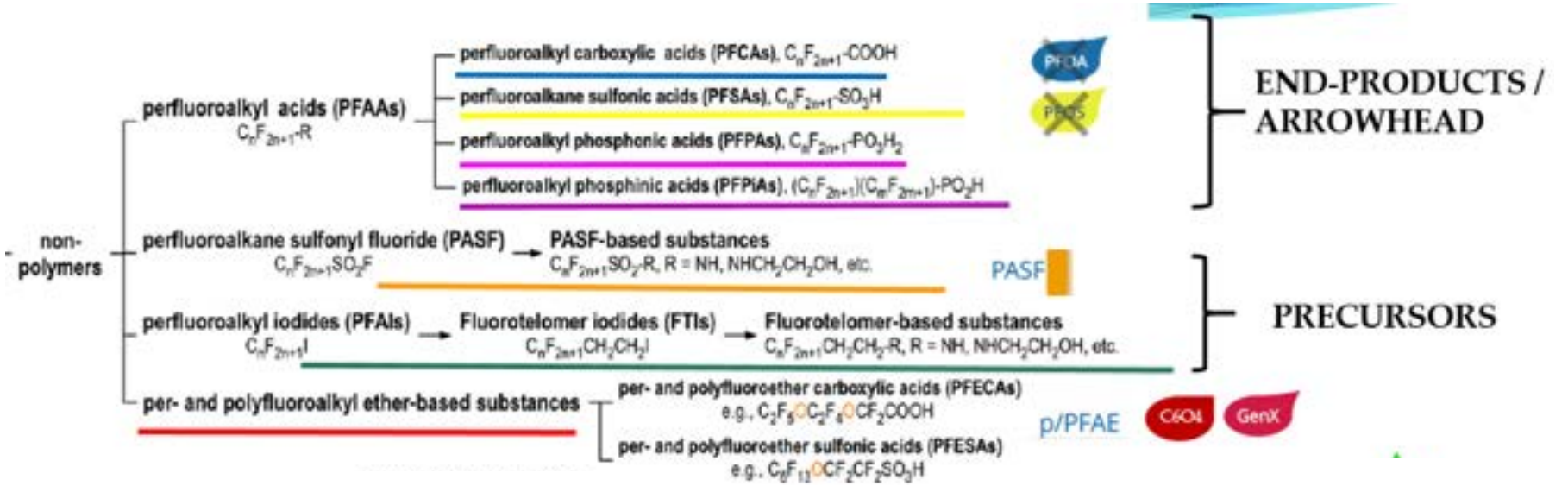
- Non-polymer
- Polymer (plastomers, elastomer, fluid)

Industrial PFAS

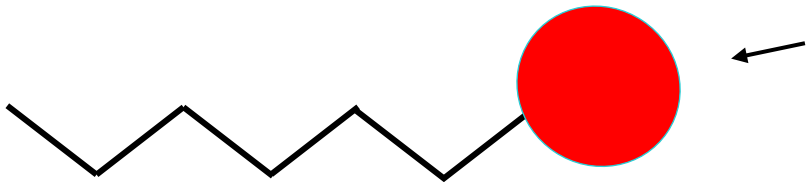


OECD, 2015. WORKING TOWARDS A GLOBAL EMISSION INVENTORY OF PFASS: FOCUS ON PFCAS STATUS QUO AND THE WAY FORWARD. OECD Environment, Health and Safety Publications Series on Risk Management No. 30.

Non polymeric industrial PFAS



PFAS Long vs Short and Ultrashort



Strong acids: COOH, SO_3H, CH2CH2 SO_3H, ….

Neutral or semi-neutral: SO_2NH_2, CH_2CH_2OH, SO2NHCH2CH3 ….

	Acidi perfluorocarbossicili			
	TFA	CF_3COOH	CF3 COOH	Ultrashort chain
	TFPrA	C_2F_5COOH	CF3 CF2 COOH	
C4	PFBA	C_3F_7COOH	CF3 CF2 CF2 COOH	Short chain
	PFPeA	C_4F_9COOH	CF3 CF2 CF2 CF2 COOH	
C6	PFHxA	$C_5F_{11}COOH$	CF3 CF2 CF2 CF2 CF2 COOH	
	PFHpA	$C_6F_{13}COOH$	CF3 CF2 CF2 CF2 CF2 CF2 COOH	Long chain
C8	PFOA	$C_7F_{15}COOH$	CF3 CF2 CF2 CF2 CF2 CF2 CF2 COOH	
	PFNA	$C_8F_{17}COOH$	CF3 CF2 CF2 CF2 CF2 CF2 CF2 CF2 COOH	
C10	PFDA	$C_9F_{19}COOH$	CF3 CF2 CF2 CF2 CF2 CF2 CF2 CF2 CF2 COOH	
	PFUnA	$C_{10}F_{21}COOH$	CF3 CF2 CF2 CF2 CF2 CF2 CF2 CF2 CF2 CF2 COOH	
	PFDoA	$C_{11}F_{23}COOH$	CF3 CF2 CF2 CF2 CF2 CF2 CF2 CF2 CF2 CF2 CF2 COOH	

PFAA
Long vs Short and Ultrashort

Acid
Fast elimination
NO bioaccumulable

Acid
Surfactant

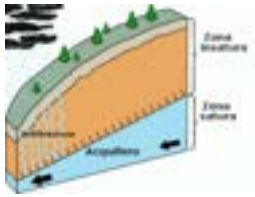
Surfactant
Slow elimination
Bioaccumulable-Biomagnificable

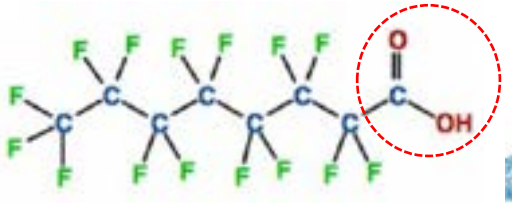
Acidi perfluorocarbossicili	
TFA	CF_3COOH
TFPrA	C_2F_5COOH
PFBA	C_3F_7COOH
PFPeA	C_4F_9COOH
PFHxA	$C_5F_{11}COOH$
PFHpA	$C_6F_{13}COOH$
PFOA	$C_7F_{15}COOH$
PFNA	$C_8F_{17}COOH$
PFDA	$C_9F_{19}COOH$
PFUnA	$C_{10}F_{21}COOH$
PFDoA	$C_{11}F_{23}COOH$

Ultrashort chain

Short chain

Long chain





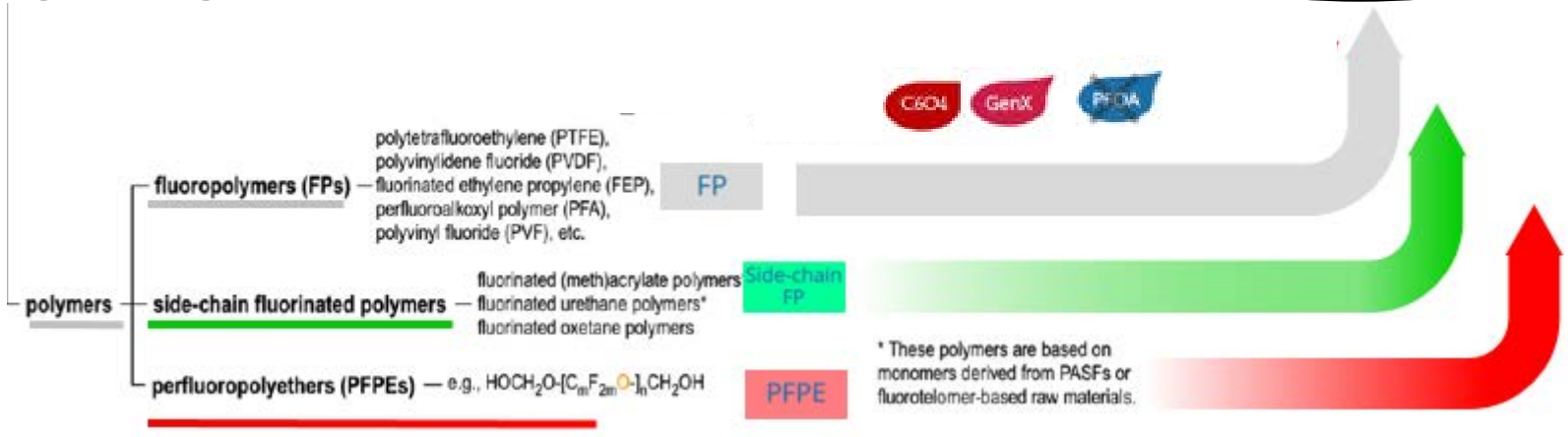
PFOA - perfluorooctanoic acid

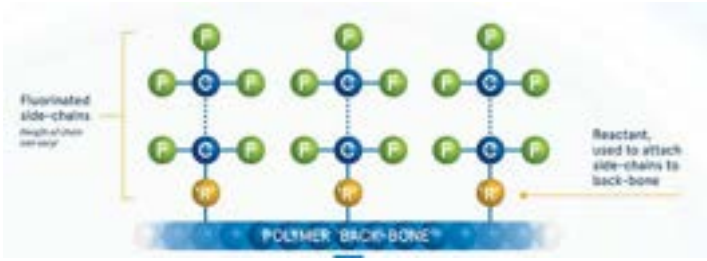
Unintentionally or intentionally added fluorocompounds (up to 5%)

Polymeric industrial PFAS

They act as long-term sources of PFAA in the environment

IMPURITIES
REACTION PRODUCTS
+
DEGRADATION PRODUCTS





In 2000, up to about 50% of POSF used for acrylate and urethane SCFPs vs ca 3% of POSF for producing fire-fighting foams

In 2006 about 80 % of the n:2 fluorotelomers manufactured (including all SCFPs)

Significant release of SCFPs and other PFAS during the application of commercial formulations and the processing of treated materials into articles (3M 1999: 10-25% loss, in the case of fiber, textile and leather) and during the use and disposal of treated articles.

REACH registered volumes

Figure 5: Proposed categorisation scheme of PFASs and relative registered volumes.

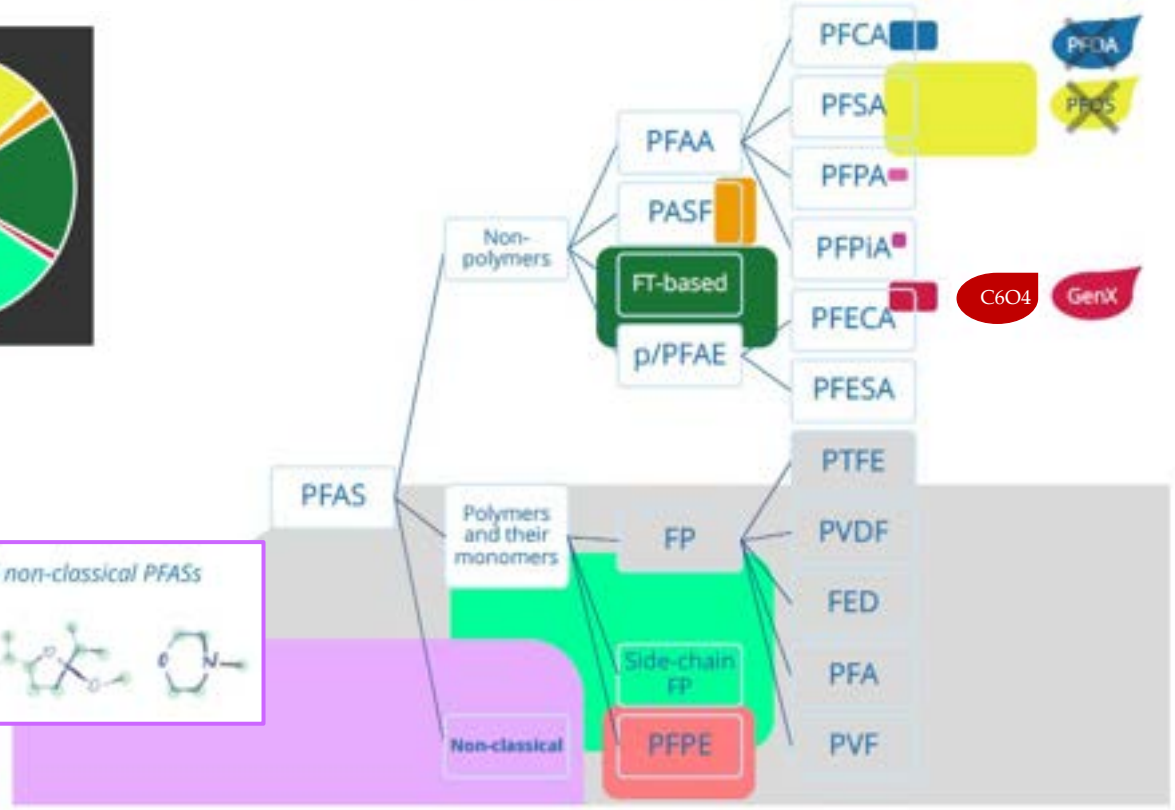


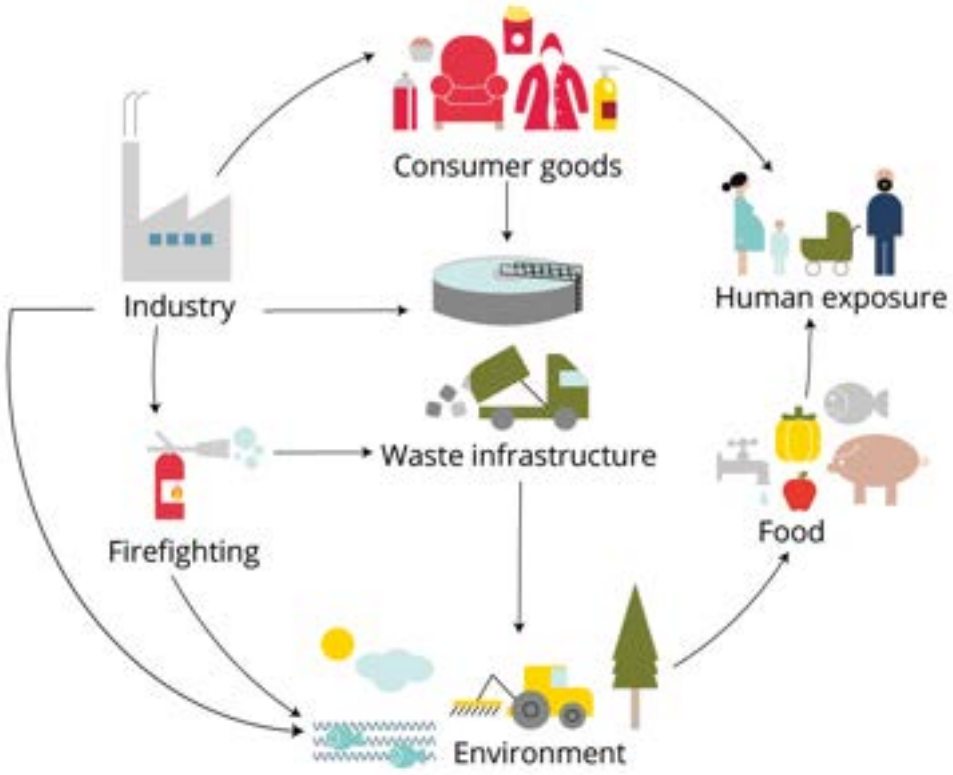
Figure 7: Structures of selected non-classical PFASs

Wietor, J.-L., 2021. PFASs – Avoiding the streetlight effect An overview of the current situation in the EU. European Environmental Bureau

Fluoropolymer market sales is estimated to be approximately 330 000 MT in 2021 (*Korzeniowski et al. 2022, DOI: 10.1002/ieam.4646*)

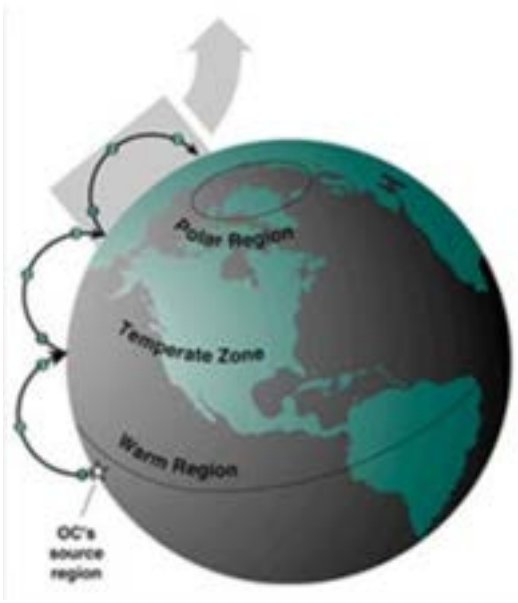
WHY ARE THEY OF CONCERN?

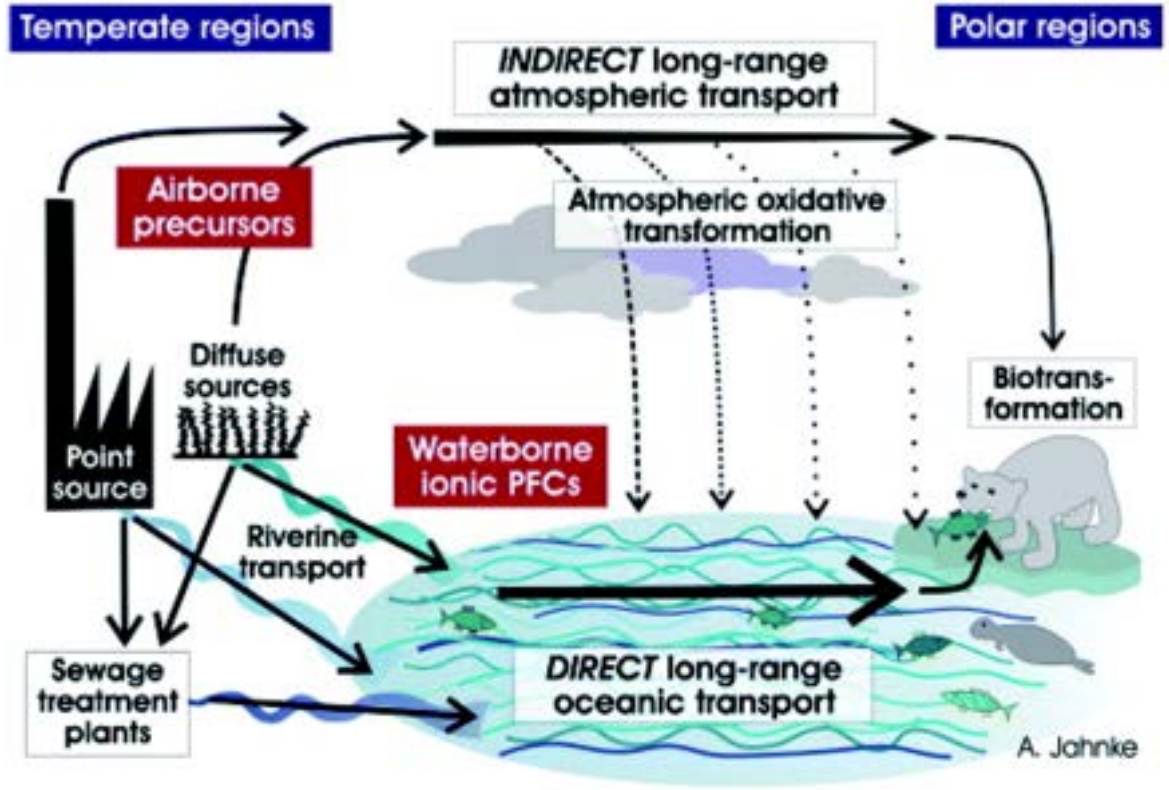
- Release into the environment occurs at all stages: production, use, disposal
- Persistent (they or their end -products)



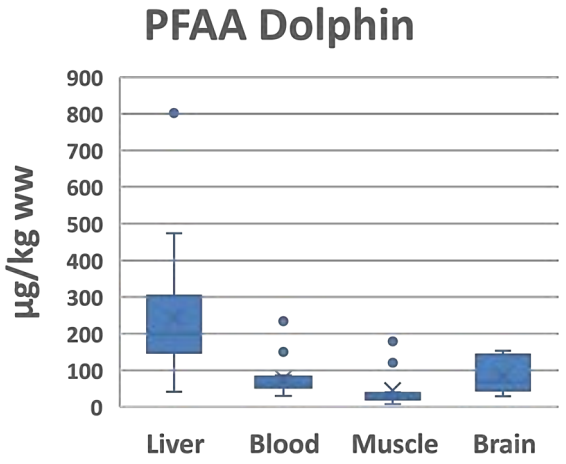
WHY ARE THEY OF CONCERN?

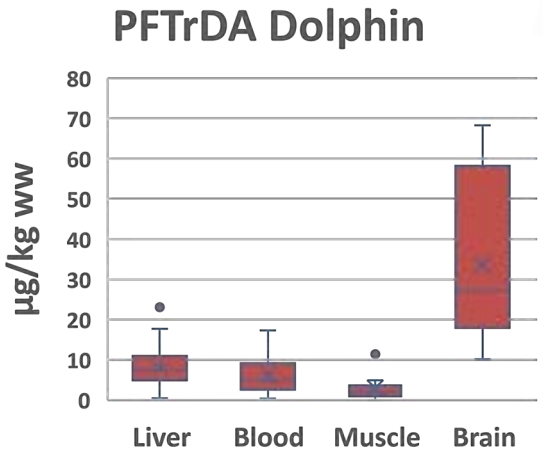
- Global transport (atmospheric or oceanic transport, LRT)

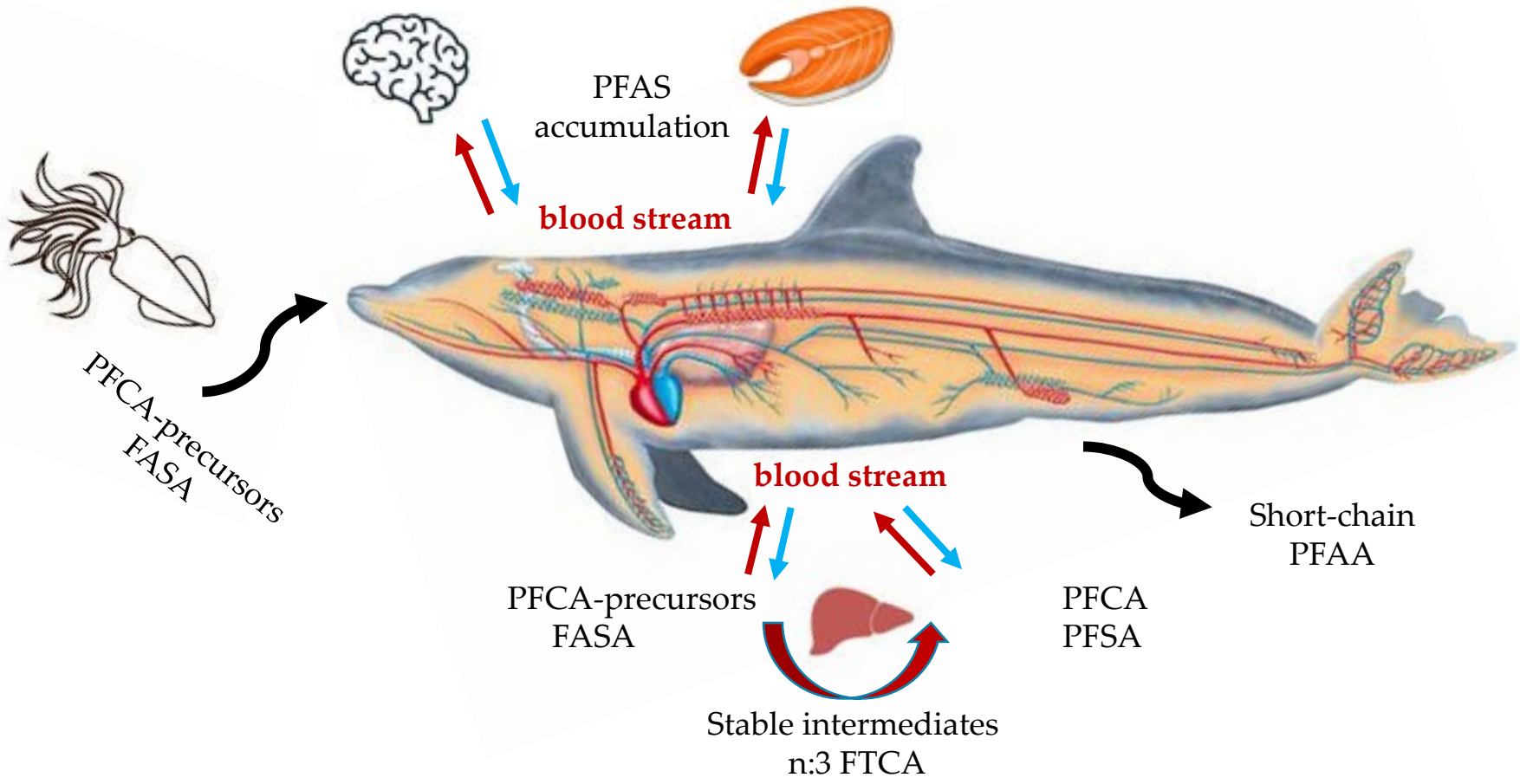




Dolphin: PFAS uptake and tissue distribution







WHY ARE THEY OF CONCERN?

- Bioaccumulative (PBT)
- Mobile (PMT)

Low exposure

Slow elimination
BIOACCUMULABLE
(precursors and long chain)

High exposure

Fast elimination
(ultrashort and short chain,)

High internal concentration

Endocrine disruptor

Carcinogenic

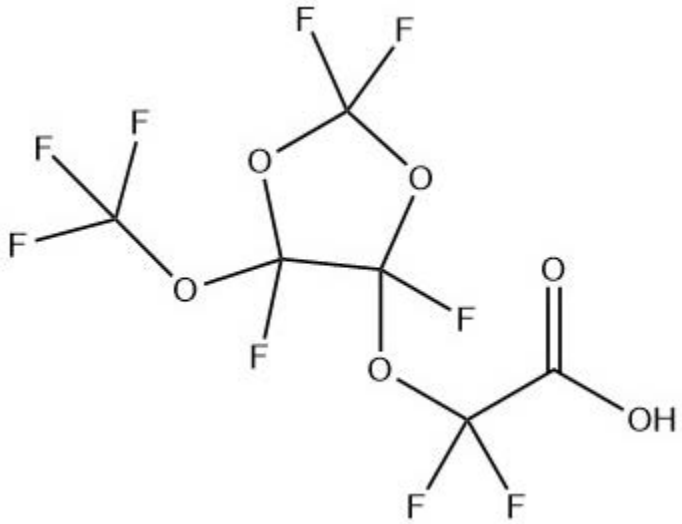
Toxic to reproduction

…….

Regrettable substitution: C6O4 fluorinated PFOA alternative

C6O4 (F-Dioxin or cC6O4)

P5MeODIOXOAc: Perfluoro([5-methoxy-1,3-dioxolan-4-yl]oxy)acetic acid (cas 1190931-41-9)



It was registered in ECHA by Solvay Specialty Polymers Italy S.p.A (potassium, ammonium and acid form) and by Miteni (ammonium and acid form)

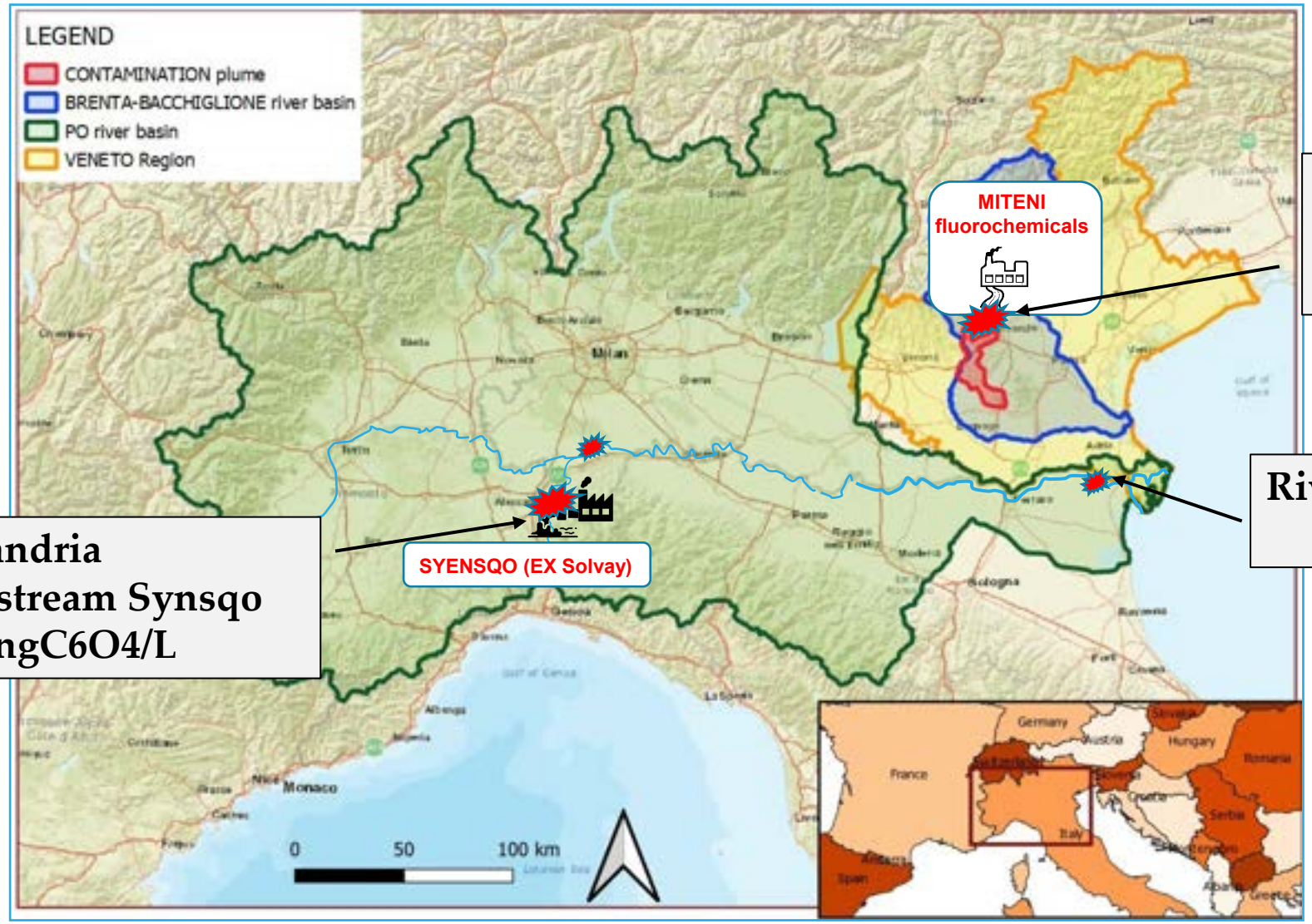
- short-chain PFECA
- not bioaccumulable in aquatic organisms
- very persistent
- highly mobile

efsa
European Food Safety Authority

EFSA J. 2014, 12(6):3718

"According to the applicant, the substance cC6O4, ammonium salt, is used as an emulsifier/dispersing agent during the polymerization process of fluoropolymers such as tetrafluoroethylene homopolymer and others."

C6O4 2019

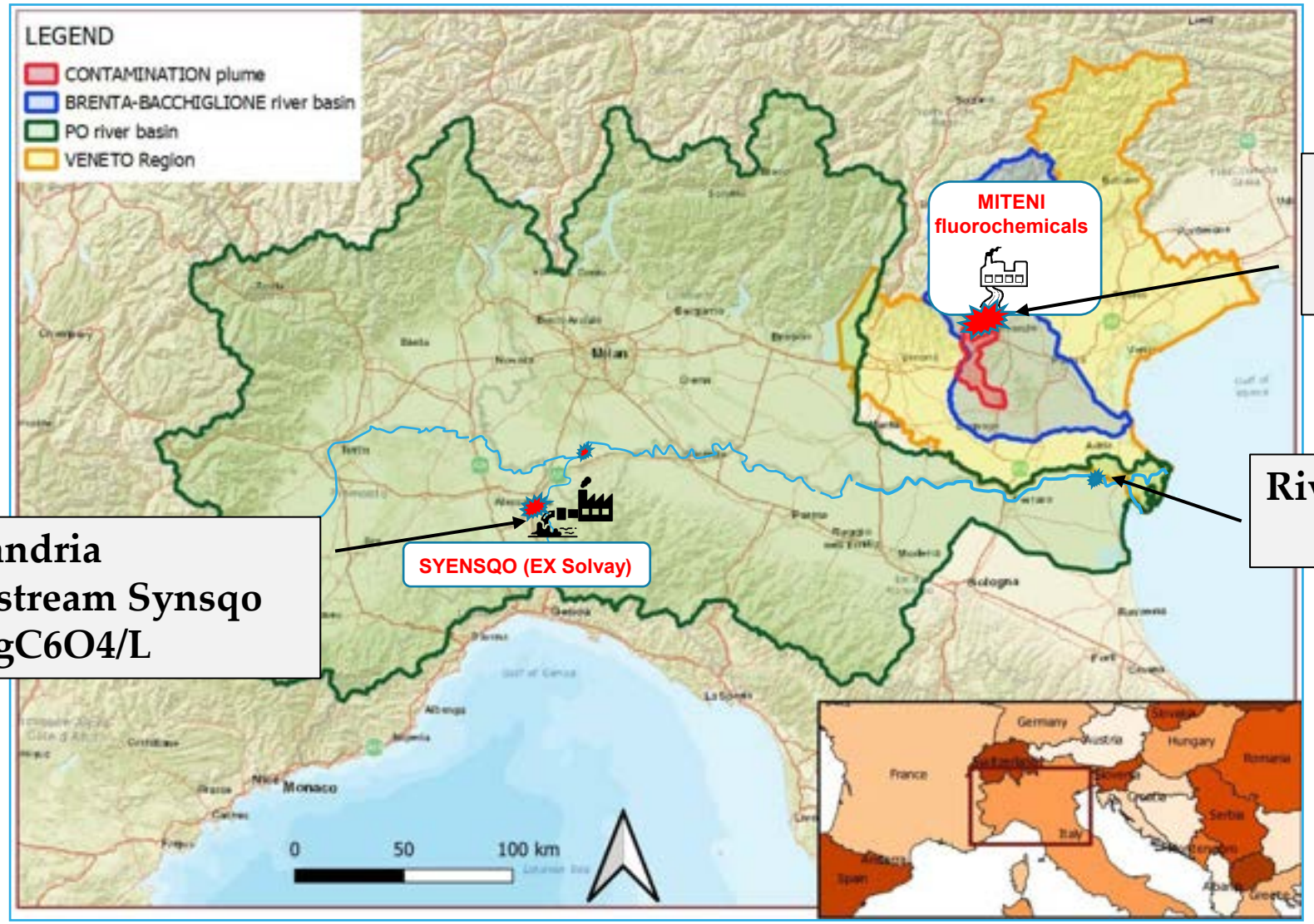


Trissino (Miteni)
groundwater
33-3300 ngC6O4/L

River Po (basin closure)
40-291 ngC6O4/L

Alessandria
Bormida downstream Synsqo
200-52000 ngC6O4/L

C6O4 2022



Trissino (Miteni)
groundwater
33-3300 ngC6O4/L

River Po (basin closure)
< 40 ngC6O4/L

Alessandria
Bormida downstream Synsqo
54 -524 ngC6O4/L

C6O4 2021-2022

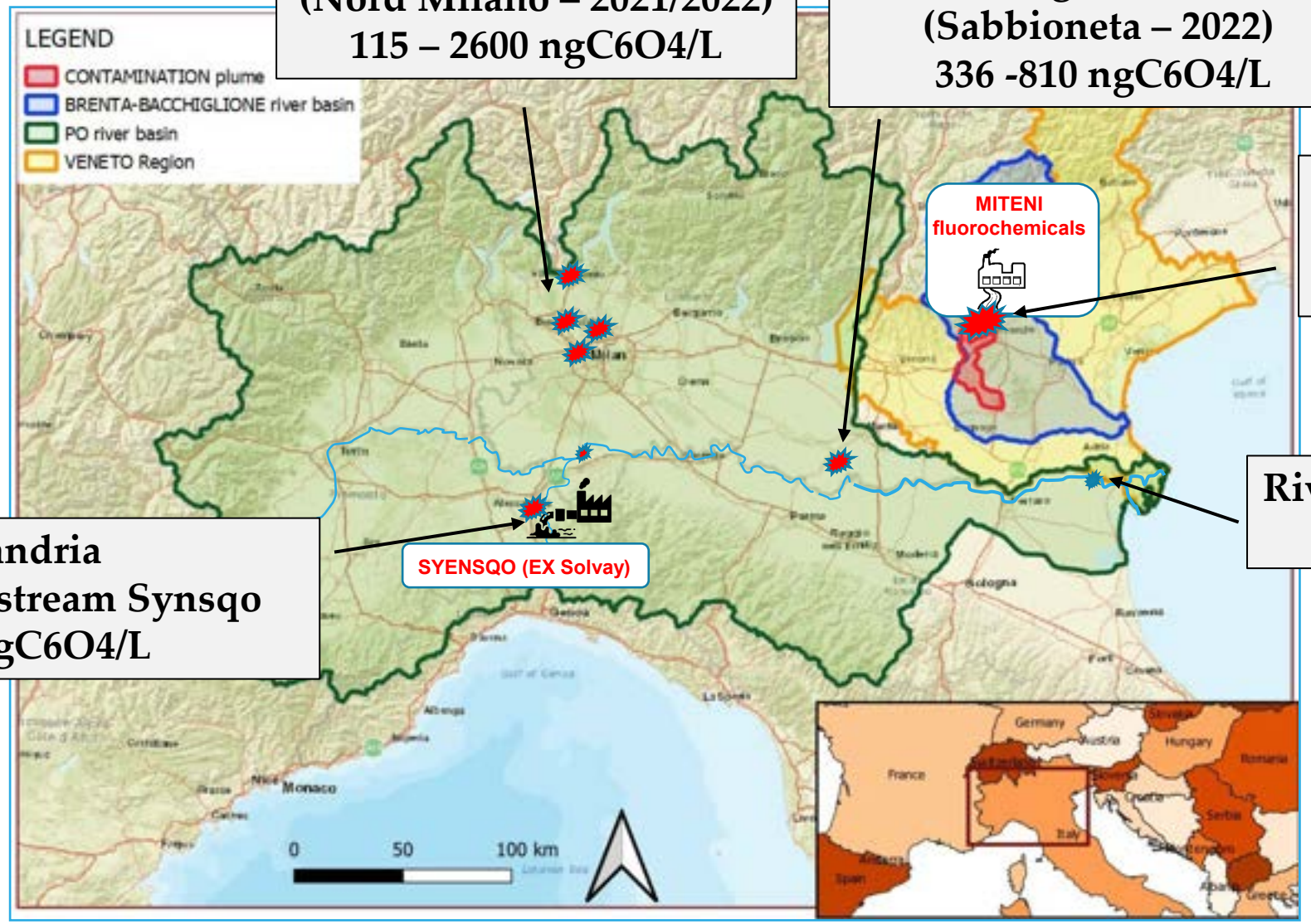
Terrò -Seveso
(Nord Milano – 2021/2022)
115 – 2600 ngC6O4/L

Canale Dugale Casumenta
(Sabbioneta – 2022)
336 -810 ngC6O4/L

Trissino (Miteni)
groundwater
33-3300 ngC6O4/L

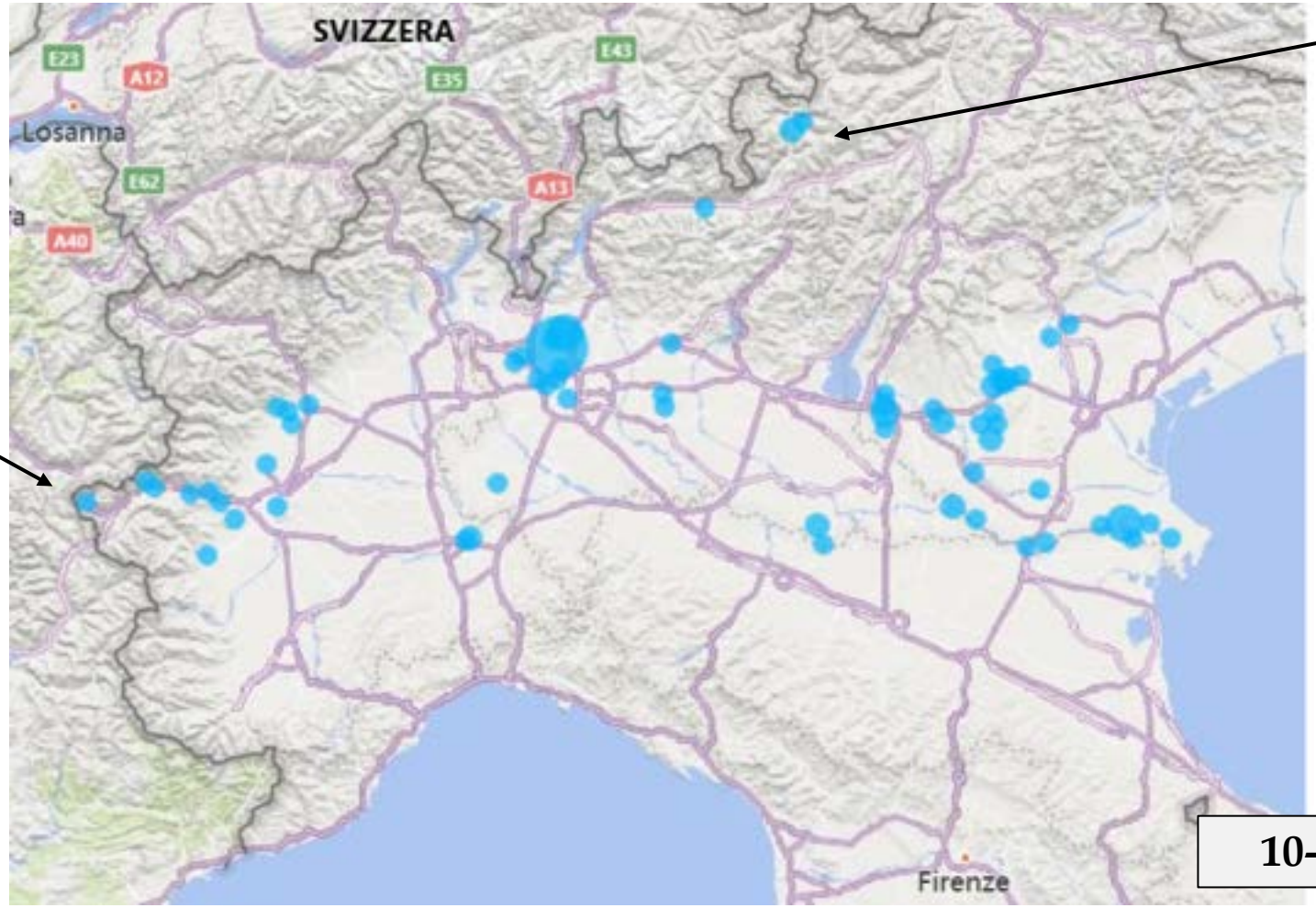
River Po (basin closure)
< 40 ngC6O4/L

Alessandria
Bormida downstream Synsqo
54 -524 ngC6O4/L



C6O4 River, Groundwater and Drinking water 2021-2022

Valdisotto
(1100 m asl)



Bardonecchia
(1300 m asl)

10- 2600 ngC6O4/L

Environmental sources

- Chemical industry
- Surface treatment industries (textile, tanning, furniture industry, construction……)
- Waste (especially industrial)
- Fire-Fighting Foams
- Fluorinated refrigerant gases Pesticide and Pharmaceutical (TFA)

The cyclical problem of PFAS disposal

- Industrial waste but also consumer products and various materials discarded in landfills leach PFAS over time.
- Wastewater treatment can transform PFAS and increase measurable PFAS concentration.
- Incineration of PFAS wastes can release toxic air pollutants and greenhouse gases.

Disposal of PFAS-containing wastes creates repeated cycles of contamination.

IRSA CNR

erica VALORE PER L'AMBIENTE

Waste Management Europe