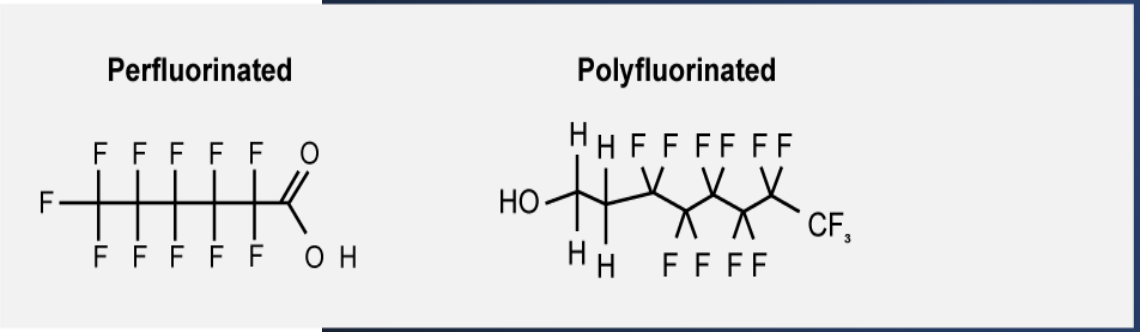
PFAS – Challenges and Policy Options

Dr. Timothy Randhir
Professor and Director
Massachusetts Water Resources Research Center
University of Massachusetts, Amherst.

University of Massachusetts Amherst

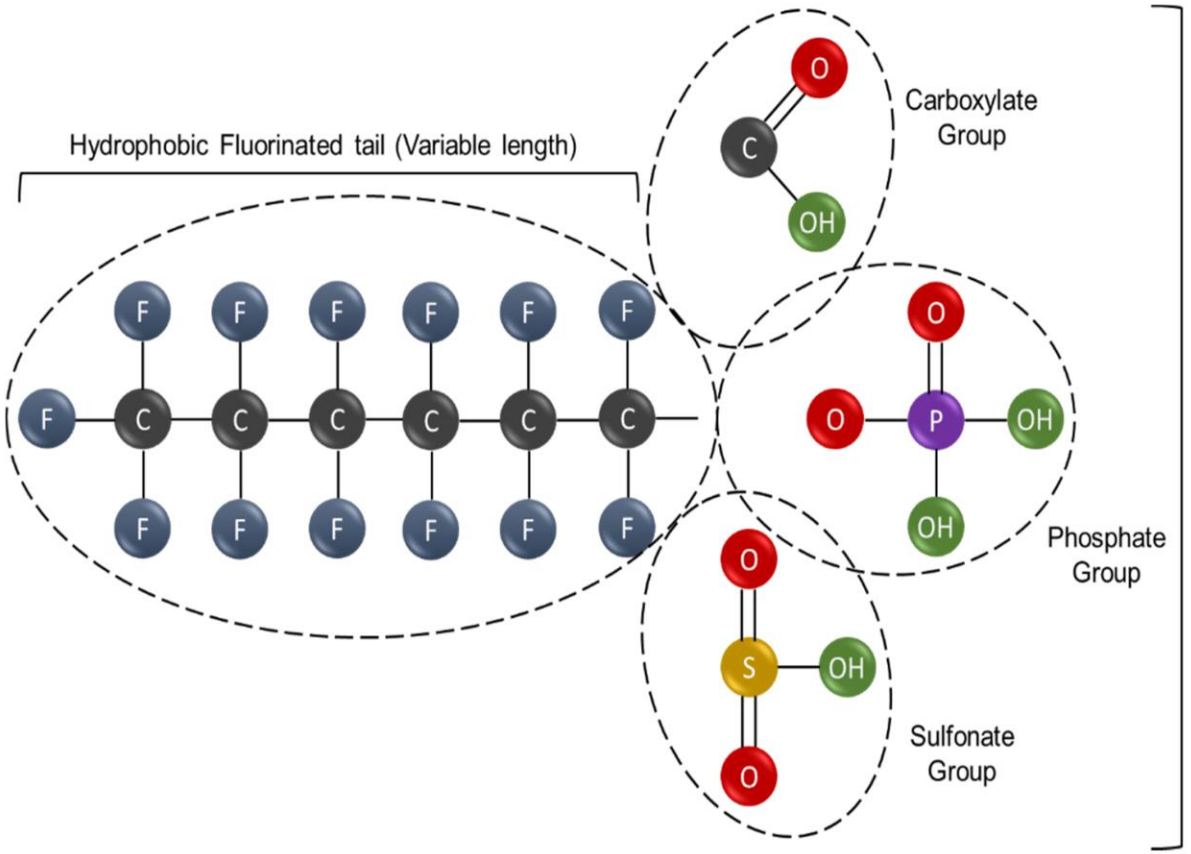
Per- & polyfluoroalkyl substances (PFAS)

- **PFAS** is the collective name for a large group (>12,000) of fluorinated compounds.
- Used in aerosol propellants; solvents; pesticides; antifoaming agents; surface treatments for textiles, leather, masonry, and paper and board; leveling agents in paints, coatings, and waxes; plastics; lubricants and greases; and fire-fighting foams.



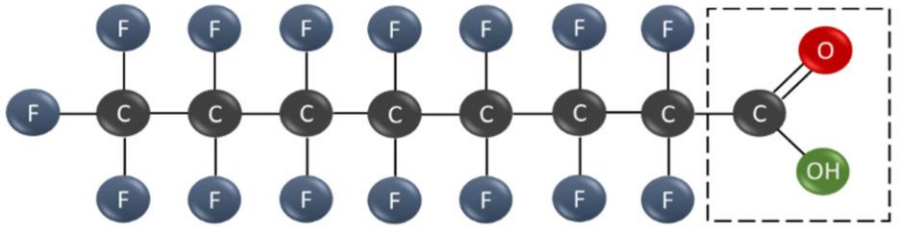
Forever Chemicals

- The bond between carbon and fluorine is incredibly strong, making PFAS a group highly stable, persistent substances.
- PFAS move relatively quickly through the environment, making their contamination hard to contain. PFAS has been detected worldwide in air, water, wastewater, and soil.
- 45% of the nation's tap water is estimated to have one or more types of PFAS (USGS)
- Numerous studies link some PFAS chemicals to cancers, high cholesterol, thyroid disease, liver damage, asthma, allergies, reduced vaccine response in children, decreased fertility, newborn deaths, low birth weight, birth defects, and delayed development (Harvard T.H. Chan School of Public Health).

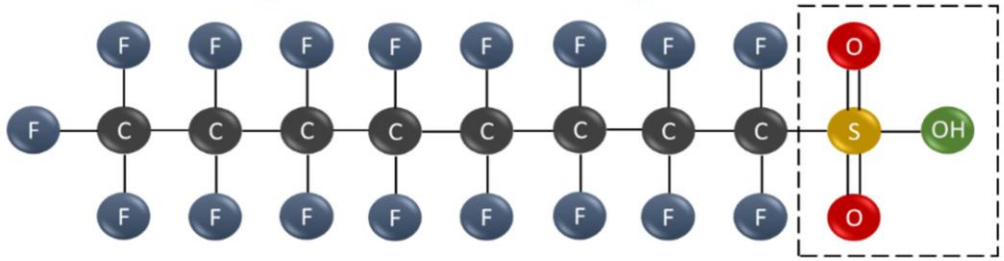


A)

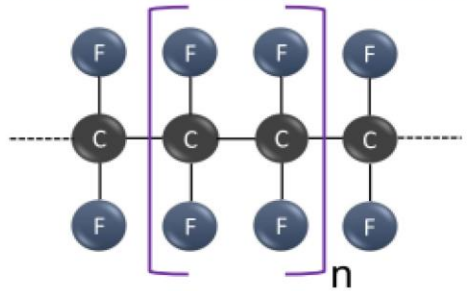
PFOA (Perfluorooctanoic acid C-8)



PFOS (Perfluorooctane sulfonic acid C-8)

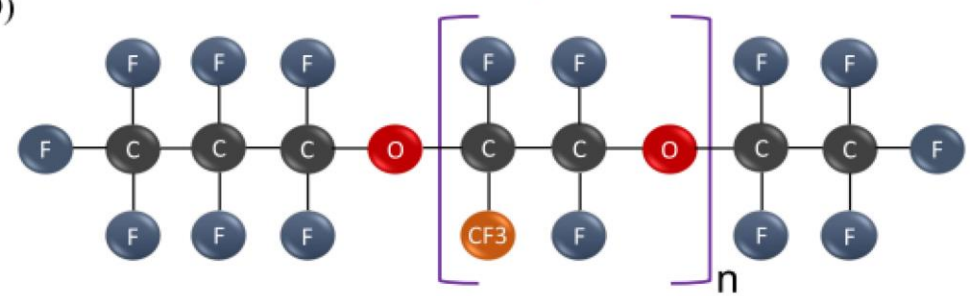


FLUOROPOLYMERS (e.g. Polytetrafluoroethylene, PTFE)

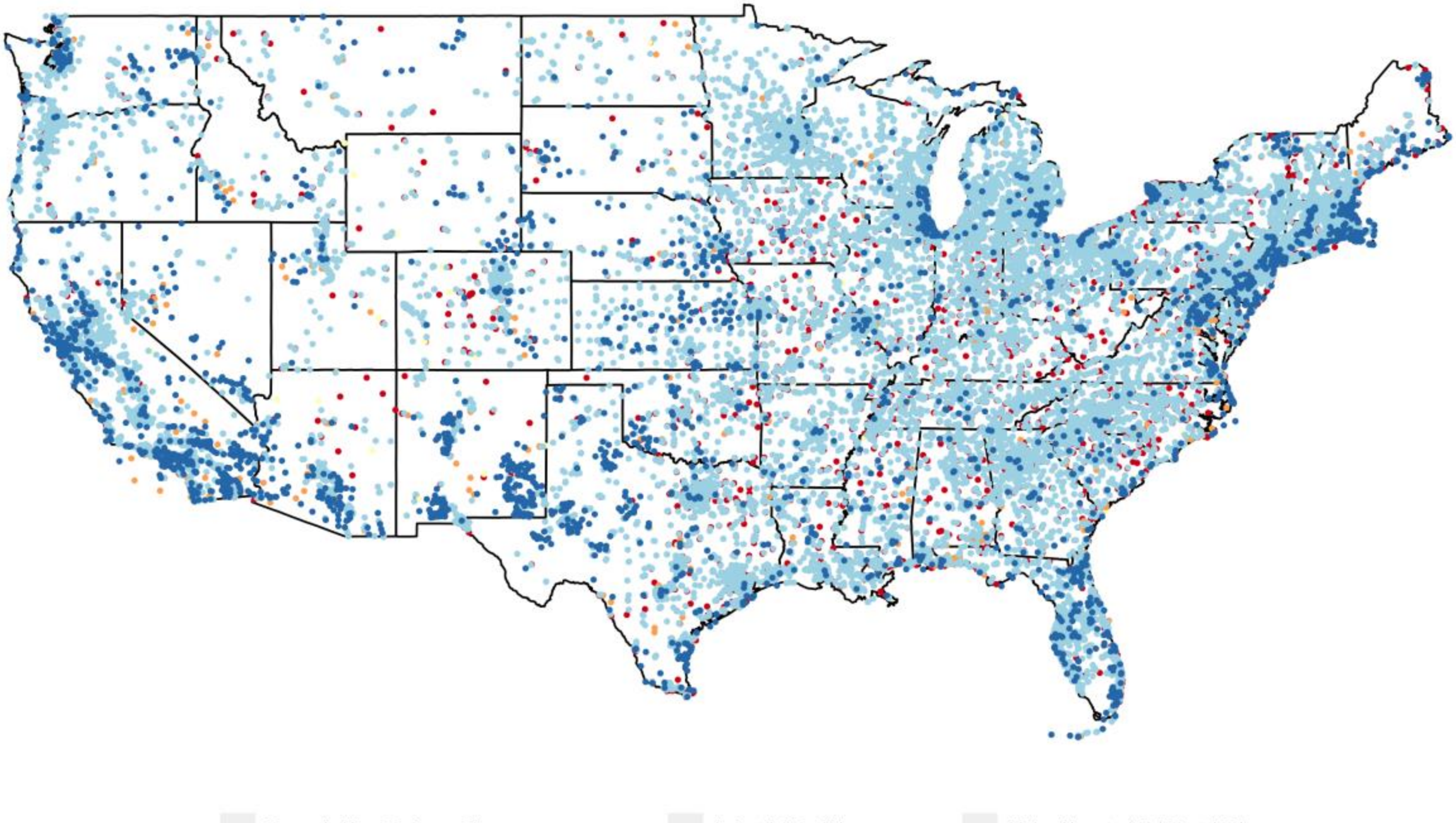


PERFLUOROPOLYETHERS (e.g. KRYTOX)

D)

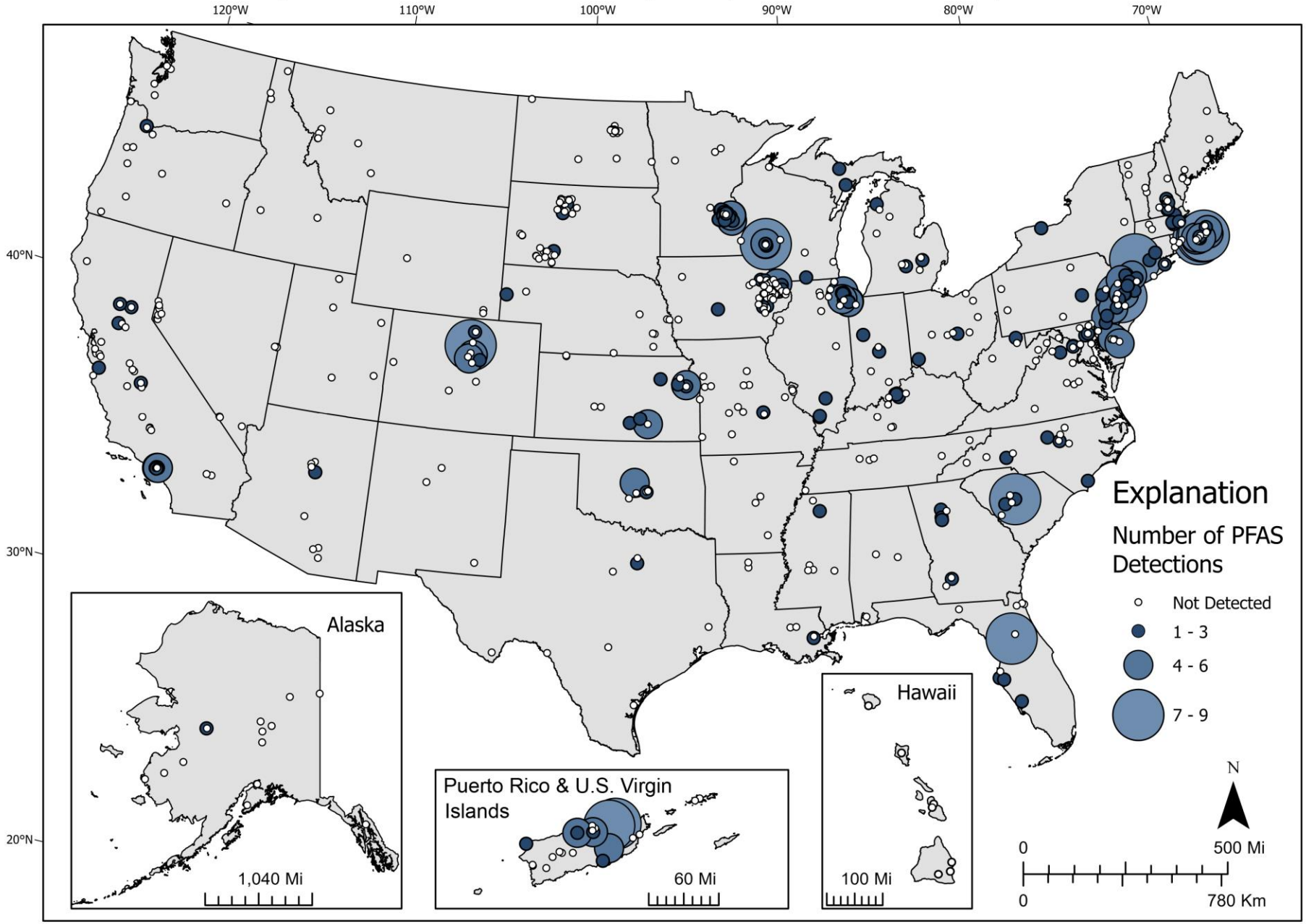


Panieri et al. 2022 in Toxics



Buckner, 2022

Per- and Polyfluoroalkyl Substances (PFAS) in Select U.S. Tapwater Locations



USGS
science for a changing world

Map represents all sampling locations not the only locations where PFAS was observed.

PFAS-TOX DATABASE

How to Use

Database | Chemicals | Health Outcomes | About

Search

The numbers in the heat map indicate the number of studies, not the number of significant effects. Click to select studies, click again to deselect.

Colors correspond to the study type: human in green, animal in blue, in vitro in orange.

PFAS	Total	Metabolic & Digestive System			Body Weight, Size & Growth			Endocrine System			Systemic/ Nonspecific/ Other			Reproductive System			Cell Toxicity/ Mortality			Circulatory System			Nervous System & Behavior			Immune System			Urinary System			Respiratory System			Musculoskeletal System			Genotoxicity			Sensory System			Cancers		
PFNA	631	119	63	32	161	57	1	129	49	35	22	29	40	133	20	8	1	26	47	62	9	12	43	15	4	46	14	4	41	9	3	23		1	8	9		5	3	6	15	4	1	14	1	
PFHxS	578	125	24	23	168	33	1	125	19	37	23	14	29	134	10	3	1	15	35	61	8	8	39	14	8	49	8	1	41	7		21	3	1	8	6	2	7		4	15	1		16		
PFDA	506	70	100	36	88	71		75	35	31	9	55	47	88	14	3		17	49	29	14	11	23	13	3	30	22	5	20	16	1	16	3	1	5	7		2	4	7	9	1		10	2	3
PFUnDA	297	54	22	19	67	28		59	15	25	10	7	18	60	9	1		8	22	26	6	7	13	7	2	17	8	2	11	4	1	13	1		2	4		1		1	9	1		9		1
PFAS mix	204	40	35	11	39	31		49	24	14	5	22	10	29	15	2	2	19	18	12	14	1	7	17	2	9	12	1	7	9		5	4		4	7		2	4		4	2		9	2	
PFDoDA	203	20	26	18	29	28		29	17	24	5	12	28	32	14	3		8	23	7	4	7	9	8	2	12	4		6	4	1	7	2	1	1	5				2	6	1		6		1
PFBS	150	10	18	19	12	21		14	13	28	5	18	19	16	15	2		21	25	3	9	7	4	18	4	5	5	2	5	5	1	6	2	2	1	3	1		4	3	2	6		3	1	
PFHpA	143	25	14	17	27	9		22	9	20	5	7	17	32	4	1		6	20	12	3	4	5	3	2	8	5	2	3	3	1	4	1		1	1				1	6	1	1	6		
PFHxA	120	12	14	26	13	12		10	5	27		11	25	7	8	2		14	29	3	6	7		9	2	2	4	1	5	5	1	4	4		1	5	1			5	1	4	1	2	1	
PFBA	99	9	13	22	9	17		6	5	29	2	14	18	7	4	1		13	25	1	6	5		4	2	3	4		5	4	1	1	2		1	3	1		1	2	1	2		1		
PFTrDA	90	11	13	7	16	18		14	13	8	2	5	7	13	6			3	5	3	3	2	1	5		3	3		3	3	1	1				4				2	1		2		
PFTeDA	67	9	7	12	6	13		5	7	11	2	3	11	4	3	1		2	11	1	1	1		3	1	2	2		3	2	1	3				2				1					1
MeFOSAA	66	15		1	20			15	1		1		1	19						5			10			1			8			1			3					4			3		
PFAS + other	59	1	23	7	2	15		4	16	10		16	4	4	10		1	9	10	2	5		2	10	2		4	1	1	2			1			3			3			1		1		
PFHpS	58	11	2	1	19	3		15	3	2	1	1	1	20	1				2	5	1		5	1	1	4	2		2	1		3				1				3			1		
PFPeA	57	6	5	12	8	5		6	1	11	1	3	18	6	3			4	11	1	1	2		2		1	1	1	3	1	1	2			1	1				1		1	1	1	1	
EtFOSAA	49	11		1	10	1		10			2		2	14						4			9			1			6			1			1					3			4		
6:2 Cl-PFESA	44	6	10	4	10	12		6	10	4	1	11	2	8	5			11	5	4	3	2	1	3		3	3		3	2							1								
GenX	29		10	9		10			8	9		9	7		6	2		10	11		5	2		4			2	1		4				1		2							1		
PFDS	24	5	5	1	6	4		2	2	2	1	1	2	1	1			1	1	1	1			1		1	2		3	1		1			1	1				1			1		
8:2 Cl-PFESA	13	3	1	1	5			3	1	2		1		3	1			2	2	2			1			1			1																
6:2 FTSA	11		3	3		5		1				2	1		1			4	1			1		1			1																		
HFPO-TA	6	1	1	2		1		1	1	2			1					1	2	1									1																
ADONA	5		1	1		1			1	2		2			1			2	2		1	1		2			1			1				2			1	1		1				
PFO4DA	5	1	2	1		2		1	2	1		2	1		1			1	1	1	1			1			1		1	1						1								
PFO5DoDA	5	1	3			2		1	3			3			1			1		1	2						2		1	2						1								
PFPeS	5	2	1		1			1			1	1		1				1						1												1									
Nafion BP2	2		2			1			1			1									1						1			1														
PFNS	1	1									1																																		

Filters

Refresh page to reset all filters

Study Type

Click for study type specific histograms, hover for study counts

human | animal | in vitro

☒ Early Life Effects

Show All Effects

☒ Financial Conflict of Interest

All

Selected Studies

Hover to see details, click for PubMed.

- Abe et al. 2017
- Abe et al. 2017
- Abercrombie et al. 2021 ☒
- Abraham et al. 2020 ☒
- Adinehzadeh and Reo 1998
- Adinehzadeh et al. 1999
- Ahmed et al. 2019
- Aimuzi et al. 2019 ☒
- Aimuzi et al. 2020
- Ait Bamai et al. 2020 ☒
- Akerblom et al. 2017
- Alderete et al. 2019 ☒
- Alkhalawi et al. 2016 ☒
- Allendorf et al. 2019
- Alves et al. 2016 ☒
- Ammitzboll et al. 2019
- Andersson et al. 2019 ☒
- Annunziato et al. 2019 ☒
- Annunziato et al. 2020 ☒

Download Study List

Health Effects

- Reproductive effects
- Developmental effects or delays in children
- Increased risk of some cancers, including prostate, kidney, and testicular cancers.
- Reduced ability of the body's immune system
- Interference with the body's natural hormones.
- Increased cholesterol levels and/or risk of obesity.

epa.gov

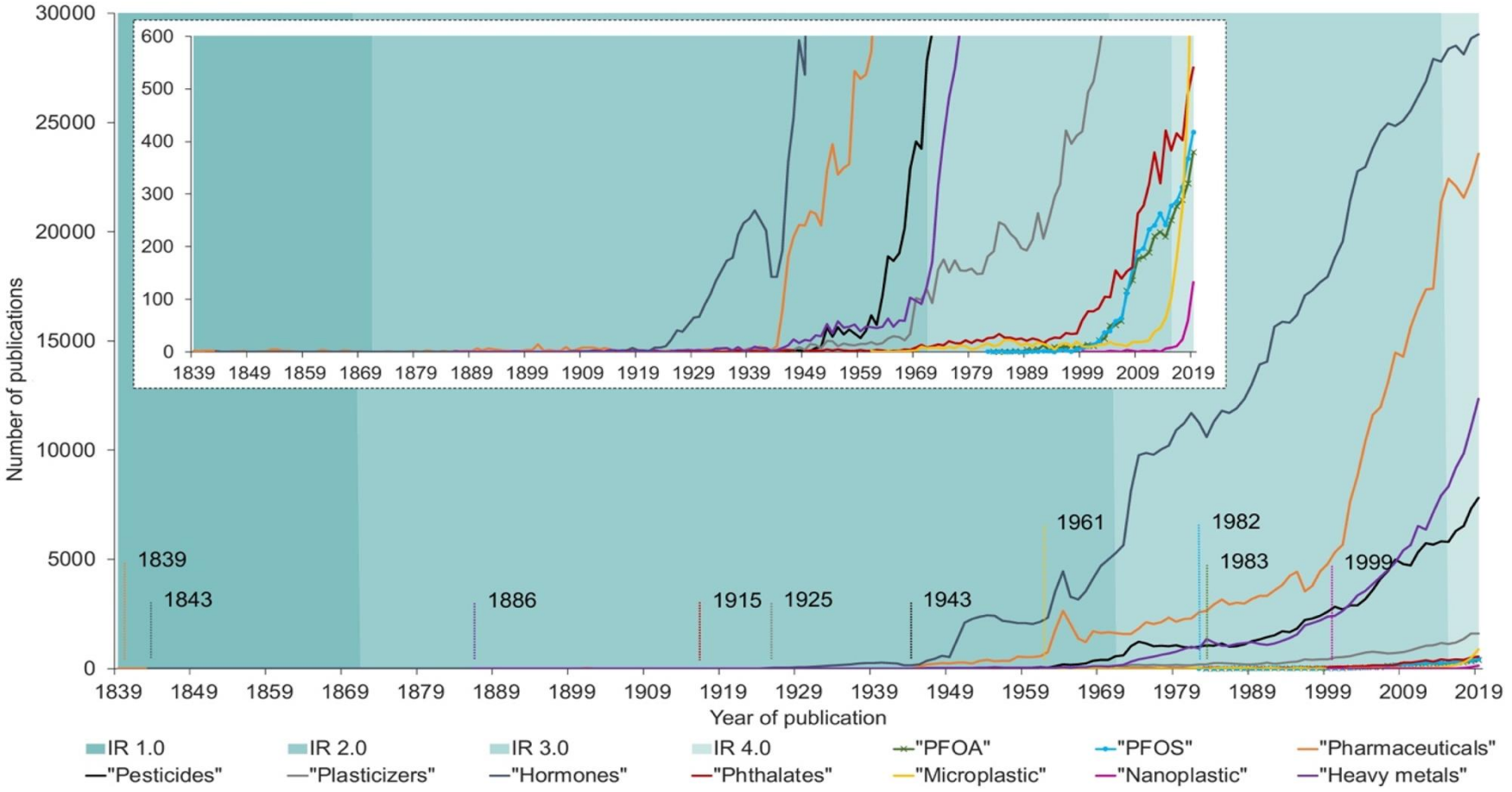
Health Effect Endpoint	PFBA (4)	PFBS (4)	PFPeA (5)	PFHxA (6)	PFHxS (6)	HFPO-DA (6)	ADONA (7)	PFHpA (7)	FOSA (8)	PFOA (8)	PFOS (8)	PFNA (9)	PFDA (10)	PFUnA (11)	PFDoDA (12)
Body weight	•	•		•	•	•	•		•	•	•	•	•	•	•
Respiratory	•	•		•	•	•				•	•	•	•		
Cardiovascular	•	•		•	•					•	•		•		•
Gastrointestinal	•	•		•	•					•	•	•	•		•
Hematological	•	•		•	•	•				•	•		•	•	•
Musculoskeletal	•	•		•	•					•	•				
Hepatic	•	•		•	•	•	•	•	•	•	•	•	•	•	•
Renal	•	•		•	•	•		•		•	•	•	•	•	•
Dermal	•					•		•		•	•				
Ocular	•	•		•		•				•	•				
Endocrine	•	•		•	•	•		•		•	•	•	•		•
Immunological	•	•		•	•	•	•	•		•	•	•	•		
Neurological	•	•		•	•	•			•	•	•		•		•
Reproductive	•	•		•	•	•	•	•		•	•	•	•		•
Developmental	•	•		•	•	•	•		•	•	•	•	•	•	•
Other noncancer						•				•		•			
Cancer						•				•	•				

(ATSDR). 2021.

Health Impacts

- Health costs linked to exposure to just a few PFAS are 52–84 billion Euros, and environmental remediation are 17 billion Euros (Goldenman et al. 2019).
- The bloodstream levels of PFOS and PFOA remain detectable among Americans (CDC, 2017).

Research Trends



Wee and Aris, 2023

Challenges

Widespread Presence of PFAS

Health and Environmental Risks

Persistence in the Environment

Regrettable substitution- substitution of well-studied toxic chemicals with less-studied ones.

Inconsistent Standards: The standards are diverse, and this class of chemicals has no consistent regulatory structure.

Partial Regulation: Most PFAS substances remain unregulated.

Innovative Policy Approaches

Zero Discharge Policies

- Implementing strict regulations on industrial discharge.
- Encouraging zero-waste initiatives.

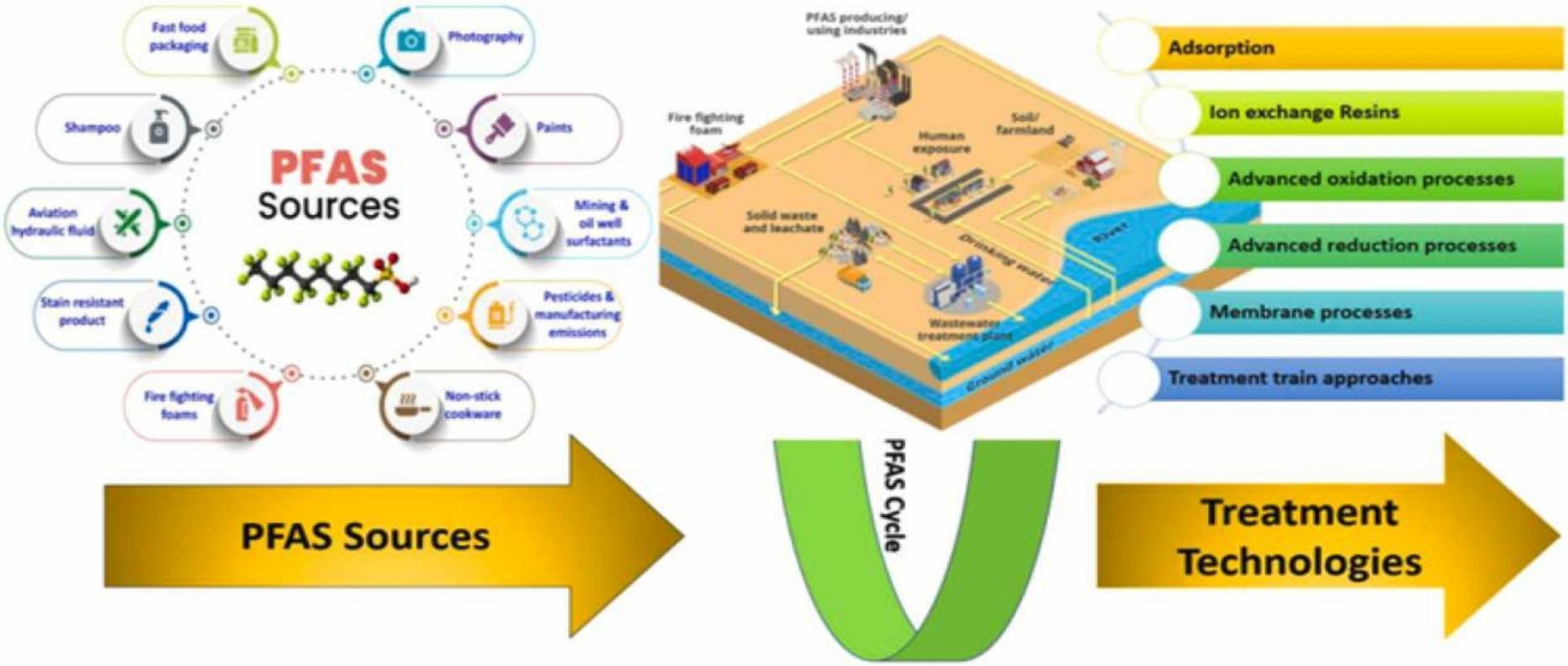
PFAS-Free Product Mandates

- Bans or restrictions on the use of PFAS in consumer products.
- Incentivizing the development of PFAS-free alternatives.

Advanced Water Treatment Technologies

- Investing in research for effective PFAS removal techniques.
- Implementing advanced filtration systems in water treatment plants.

Emerging Technologies



Yadav et al. 2022

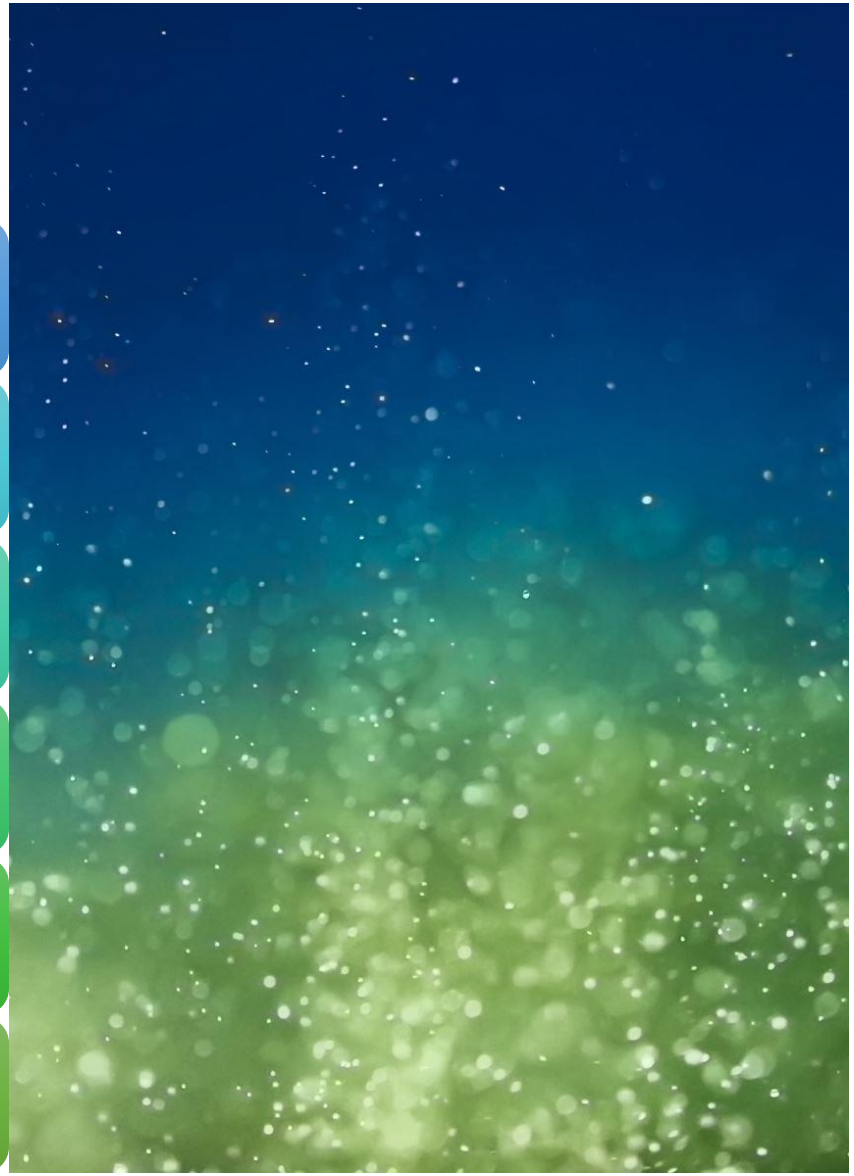
Regulatory

- Ban all PFAS in food contact materials (Maine and Washington)
- Ban from paper and paperboard food packaging (Denmark)
- Bans in firefighting foam (South Australia and Washington State)
- Regulate use in carpets and rugs (California)
- PFAS – Total limit (European Union)
- Essentiality Concept: limit the uses of hazardous chemicals to only those considered "essential" while fostering the development of safer alternatives.
- Regrettable substitution- substitution of well-studies toxic chemicals with less-studied ones; Managing PFAS as a class is needed to avoid chemicals.

(Kwiatkowski et al., 2020)

Markets

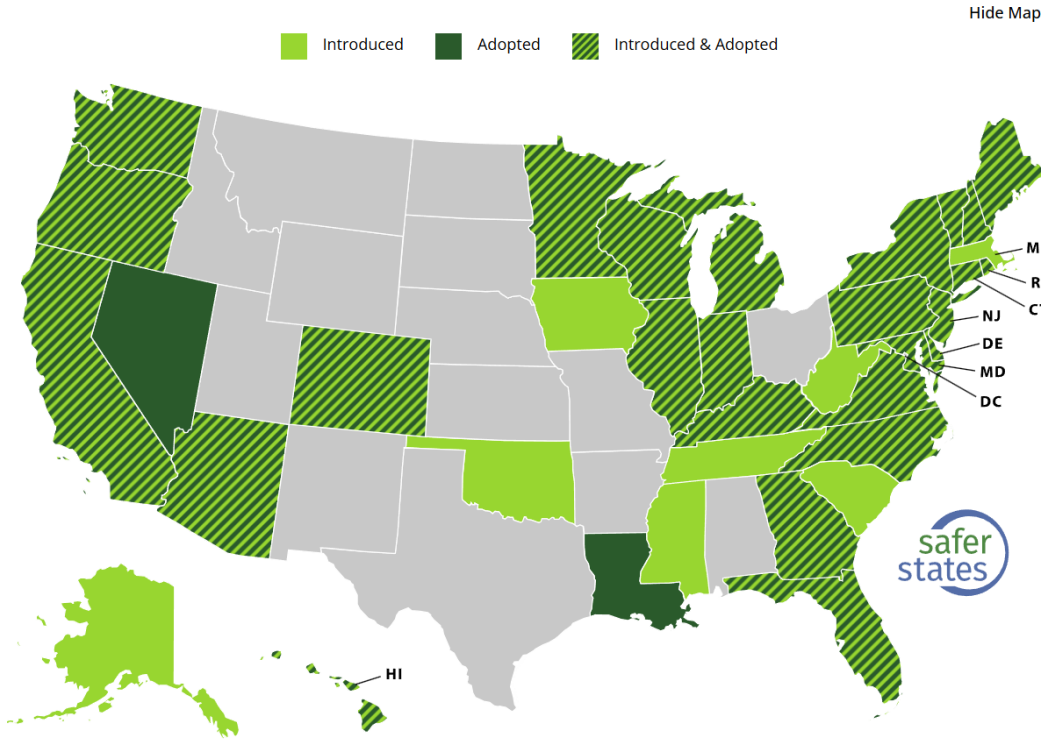
- Customer demand: Increasing demand for products with less harmful substances drives some companies to phase out PFAS.
- Corporate responsibility and value can play a role in changing supplies.
- Class: Prioritizing research and development funding for treatment and disposal/destruction methods for the entire class of PFAS
- Reporting: Retailers and product manufacturers need to know and publish where PFAS are present in their supply chains to foster greater transparency and confidence in the composition and safety of end products.
- Systematic Inventory of PFAS Industries at all scales.
- Advanced detection and monitoring



(Kwiatkowski et al., 2020; Ng et al. 2021)

Selected Policies

- Carpet collection, manufacturer notification of ingredients in child products, package reduction, restrict PCP with PFA
- Source reduction, disclosure to water consumers, and restricted sales.
- Technical and Financial assistance to drinking water systems
- Management plan, prohibit the sale of products
- Monitoring requirement



www.saferstates.org

Challenges and Considerations

1. **Cost and Feasibility**
    1. Balancing economic impacts with public health priorities.
    2. Identifying funding sources for mitigation efforts.
2. **Regulatory Harmonization**
    1. Aligning policies across different jurisdictions.
    2. Addressing challenges in enforcement and compliance.
3. **Scientific Uncertainties**
    1. Research gaps in understanding PFAS toxicity and exposure pathways.
    2. Incorporating evolving scientific knowledge into policy decisions.

Conclusions

- PFAS are widespread with impacts on health and the environment
- Persistence and multimedia properties make it complex to address
- Policies at source, transfer, and fate can help in addressing PFAS
- Emerging technologies at source, transfer, and fate show promise
- Challenges include cost feasibility in mitigation and scientific uncertainties
- There is a need for regulatory harmonization

Proposed PFAS National Primary Drinking Water Regulation (EPA)

Compound	Proposed MCLG	Proposed MCL (enforceable levels)
PFOA	Zero	4.0 parts per trillion (also expressed as ng/L)
PFOS	Zero	4.0 ppt
PFNA	1.0 (unitless) Hazard Index	1.0 (unitless) Hazard Index
PFHxS		
PFBS		
HFPO-DA (commonly referred to as GenX Chemicals)		

EPA Roadmap

RESEARCH

Invest in research, development, and innovation to increase understanding of PFAS exposures and toxicities, human health and ecological effects, and effective interventions that incorporate the best available science.

Objectives

- Build the evidence base on individual PFAS and define categories of PFAS to establish toxicity values and methods.
- Increase scientific understanding on the universe of PFAS, sources of environmental contamination, exposure pathways, and human health and ecological effects.
- Expand research on current and emerging PFAS treatment, remediation, destruction, disposal, and control technologies.
- Conduct research to understand how PFAS contribute to the cumulative burden of pollution in communities with environmental justice concerns.

RESTRICT

Pursue a comprehensive approach to proactively prevent PFAS from entering air, land, and water at levels that can adversely impact human health and the environment.

Objectives

- Use and harmonize actions under all available statutory authorities to control and prevent PFAS contamination and minimize exposure to PFAS during consumer and industrial uses.
- Place responsibility for limiting exposures and addressing hazards of PFAS on manufacturers, processors, distributors, importers, industrial and other significant users, dischargers, and treatment and disposal facilities.
- Establish voluntary programs to reduce PFAS use and release.
- Prevent or minimize PFAS discharges and emissions in all communities, regardless of income, race, or language barriers.

REMEDIATE

Broaden and accelerate the cleanup of PFAS contamination to protect human health and ecological systems.

Objectives

- Harmonize actions under all available statutory authorities to address PFAS contamination to protect people, communities, and the environment.
- Maximize responsible party performance and funding for investigations and cleanup of PFAS contamination.
- Help ensure that communities impacted by PFAS receive resources and assistance to address contamination, regardless of income, race, or language barriers.
- Accelerate the deployment of treatment, remediation, destruction, disposal, and mitigation technologies for PFAS, and ensure that disposal and destruction activities do not create new pollution problems in communities with environmental justice concerns.