PFAS AT THE LANDFILL

FOREVER WORKING WITH FOREVER CHEMICALS

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BIOSYSTEMS ENGINEERING

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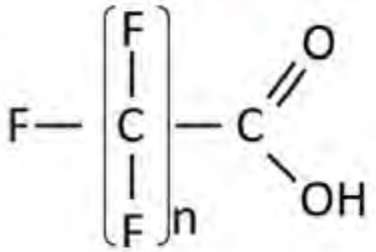
- WHAT ARE PFAS?
- HISTORY
- USES AND SOURCES
- LANDFILL PFAS
- TREATMENT AND REMEDIATION

WHAT ARE PFAS?

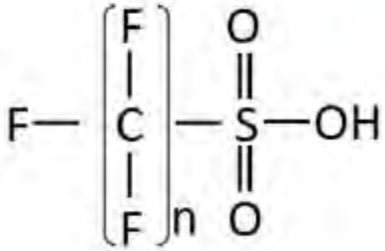
- CARBON BACKBONE WITH FLUORINE SATURATION (HYDROPHOBIC TAIL)
- “ACTIVE HEAD” OF ACID, SULFUR, OR OTHER GROUP (LIPOPHOBIC HEAD)
- 12,000 KNOWN, 4000 USED COMMERCIALLY, 200 TESTED FOR, BUT MOST STUDIES INCLUDE ONLY 10-20
- AMAZING QUALITIES: REPEL WATER, REPEL OIL, QUENCH FIRE, HEAT RESISTANT AND LAST FOREVER

Perfluoroalkyl carboxylic acids



n+1= 4, perfluorobutanoic acid (PFBA)
= 5, perfluoropentanoic acid (PFPeA)
= 6, perfluorohexanoic acid (PFHxA)
= 7, Perfluoroheptanoic acid (PFHpA)
= 8, perfluorooctanoic acid (PFOA)
= 9, perfluorononanoic acid (PFNA)
=10, Perfluorodecanoic acid (PFDA)

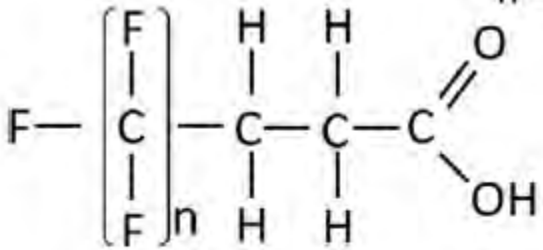
Perfluoroalkyl sulfonic acids



n= 4, perfluorobutanesulfonic acid (PFBS)
= 6, perfluorohexanesulfonic acid (PFHxS)
= 8, perfluorooctanesulfonic acid (PFOS)

Fluorotelomer acids

n = 5, 5:3 fluorotelomer carboxylic acid (5:3 FTCA)



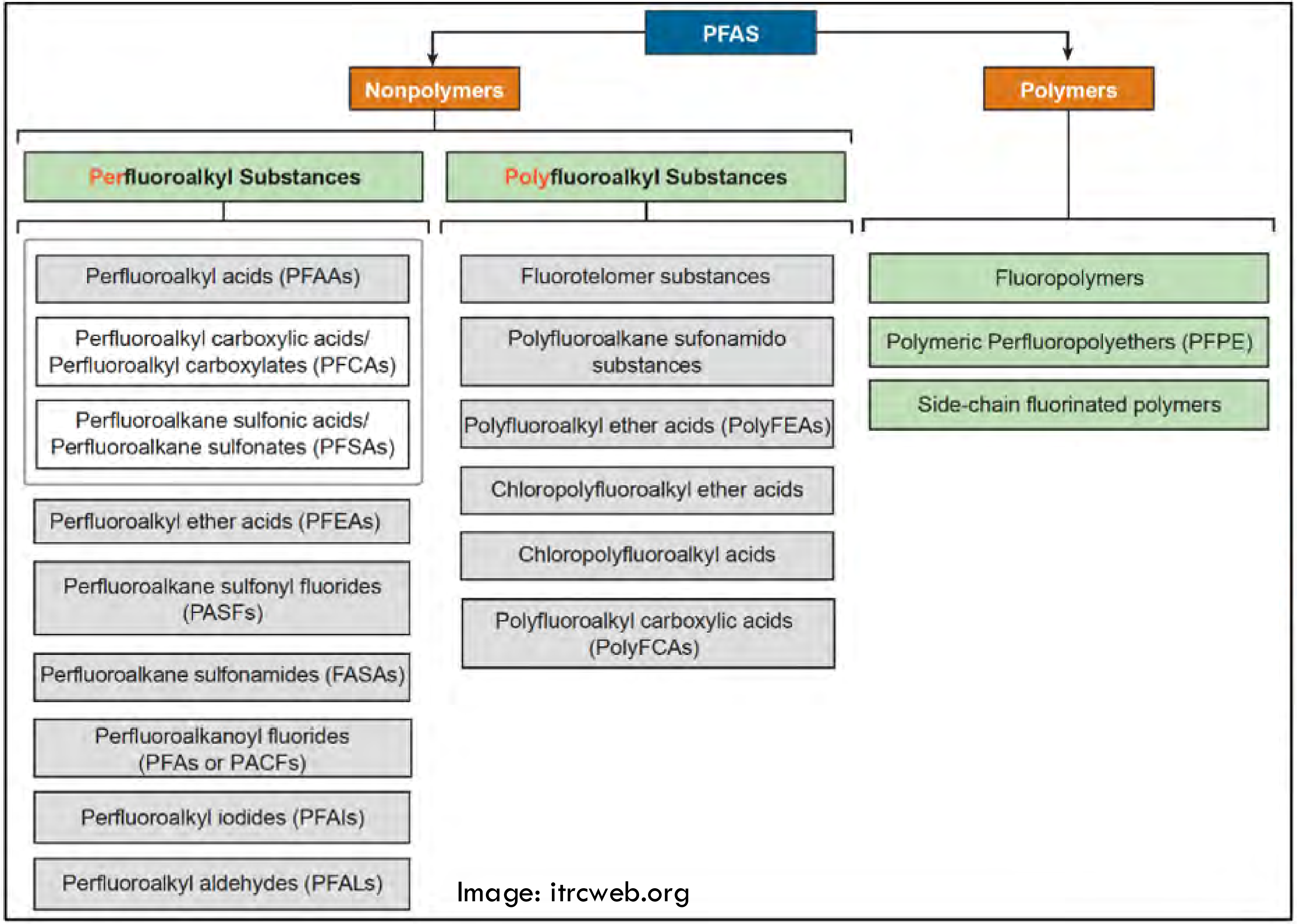


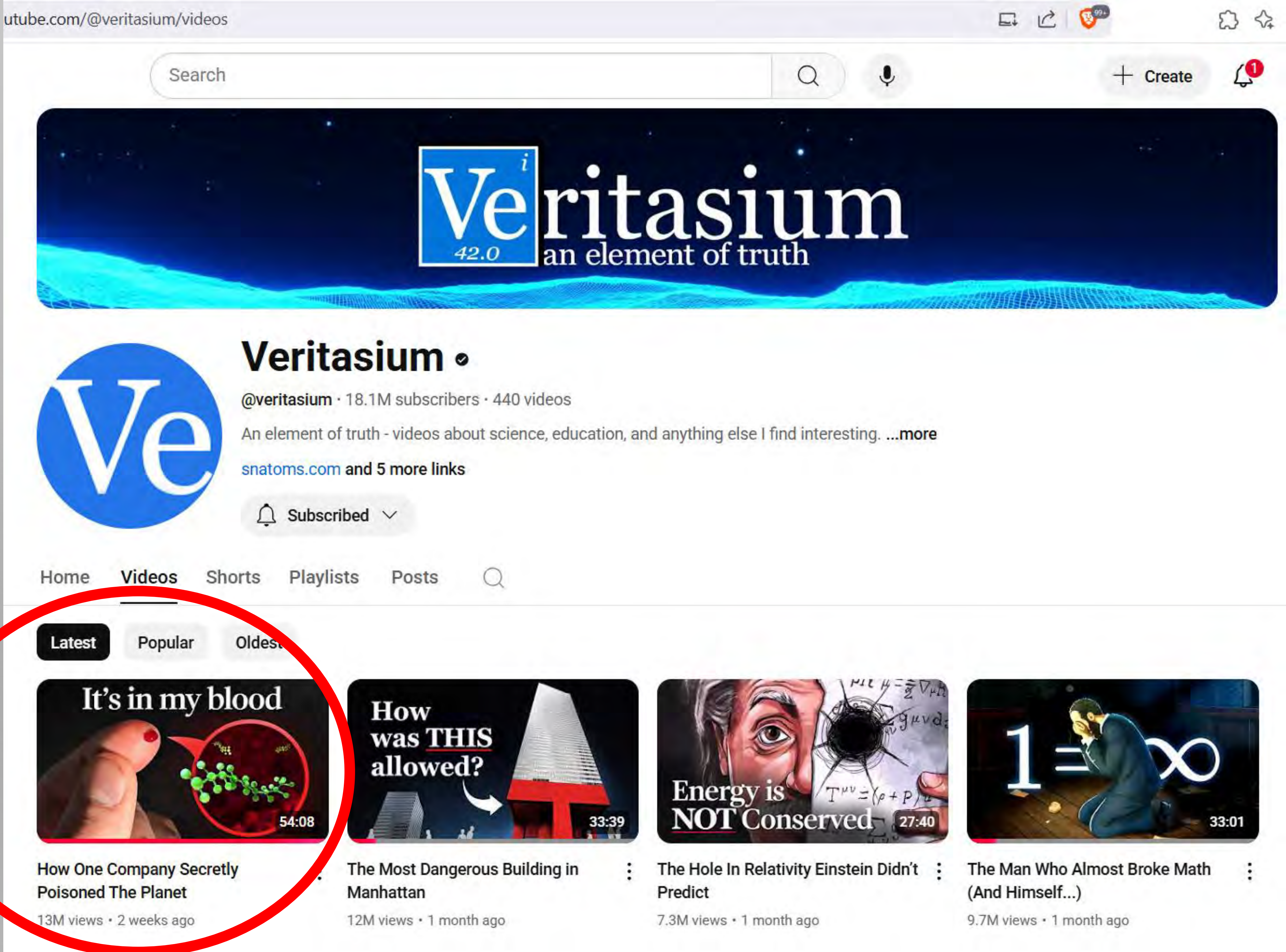
Image: itrcweb.org

Dark Waters

https://www.youtube.com/watch?v=RvAOuhyunhY

The Devil We Know

https://www.youtube.com/watch?v=7cCkADnhRqk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The Man Who Almost Broke Math (And Himself...)
9.7M views • 1 month ago

USES

- FOOD RELATED PACKAGING
- CARPETS, FABRIC FURNITURE, OUTDOOR CLOTHING
- GREASE, SEALANTS
- FFF

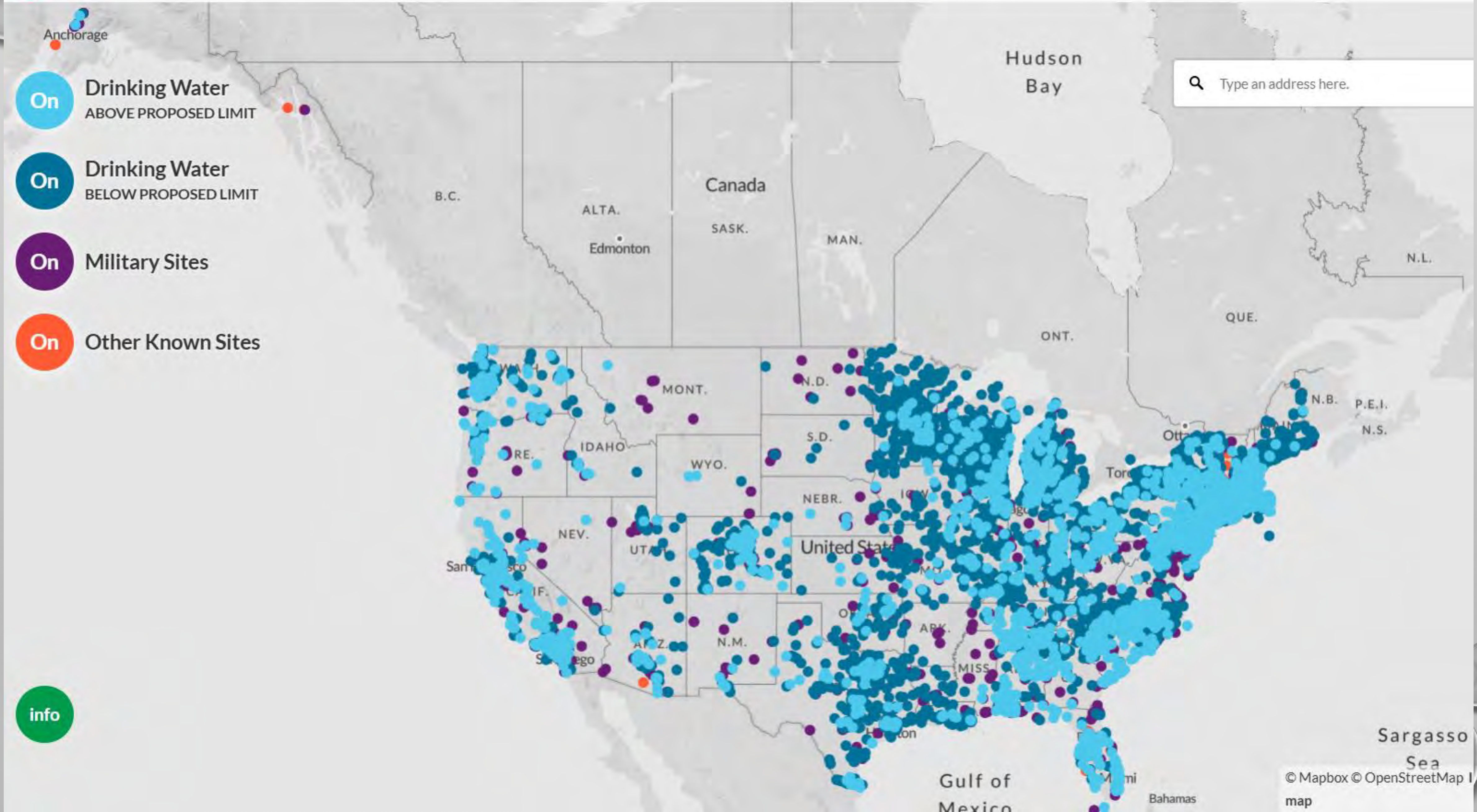

KIRKLAND Signature
MICROWAVE POPCORN
MOVIE THEATER BUTTER
Made with whole grain popcorn
Gluten-free
NET WT 3.3 OZ (93.5 g) Bag
/ ART. 888012
MICROWAVE POPCORN
PALOMITAS PARA MICROONDAS
THIS SIDE DOWN • CE CÔTÉ VERS LE BAS • ESTE LADO HACIA ABAJO


Image:switchbacktravel.com

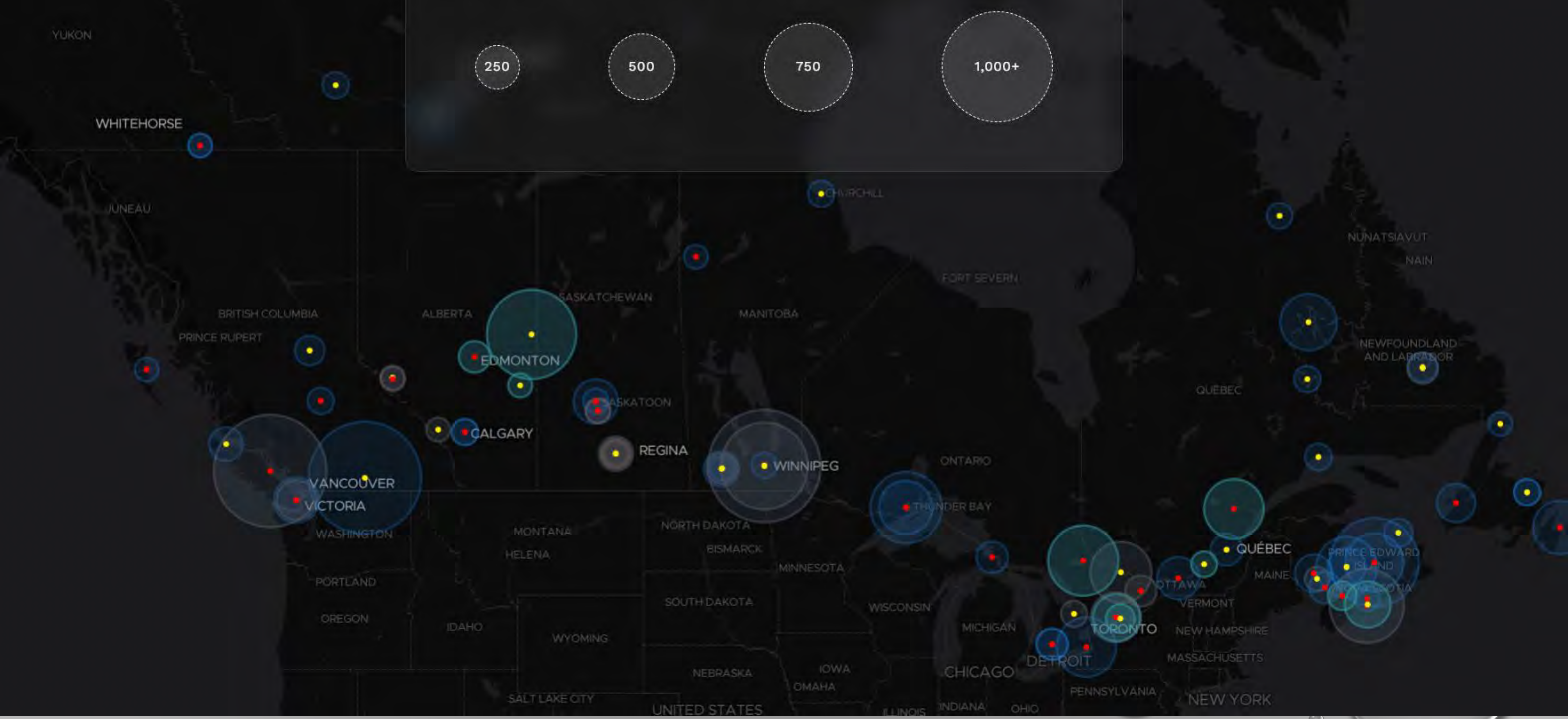

Image: myheavemsbest.com


Image: thefunctionalbody.com

PFAS contamination in the U.S. (March 24, 2025)



Forever chemicals are notoriously difficult to clean up once they spread beyond a contaminated site. Some hotspots are in cities, with more than 1,000 people living within one kilometre, while others are in far-flung locations with few — or no — neighbours.



CHALLENGES OF PFAS MONITORING

- DIFFICULT CHEMISTRY = EXPENSIVE
- WHAT ARE YOU SAMPLING? ACCESSING STANDARDS FOR INSTRUMENT CALIBRATION: 5,000 COMPOUNDS TO CHOOSE FROM. IONIC, NEUTRAL, VOLATILE, LONG CHAIN, SHORT CHAIN, ESTERS, SULFONATES, PHOSPHATES, TELOMERES, ETC.
- CHEMICAL TRANSFORMATION

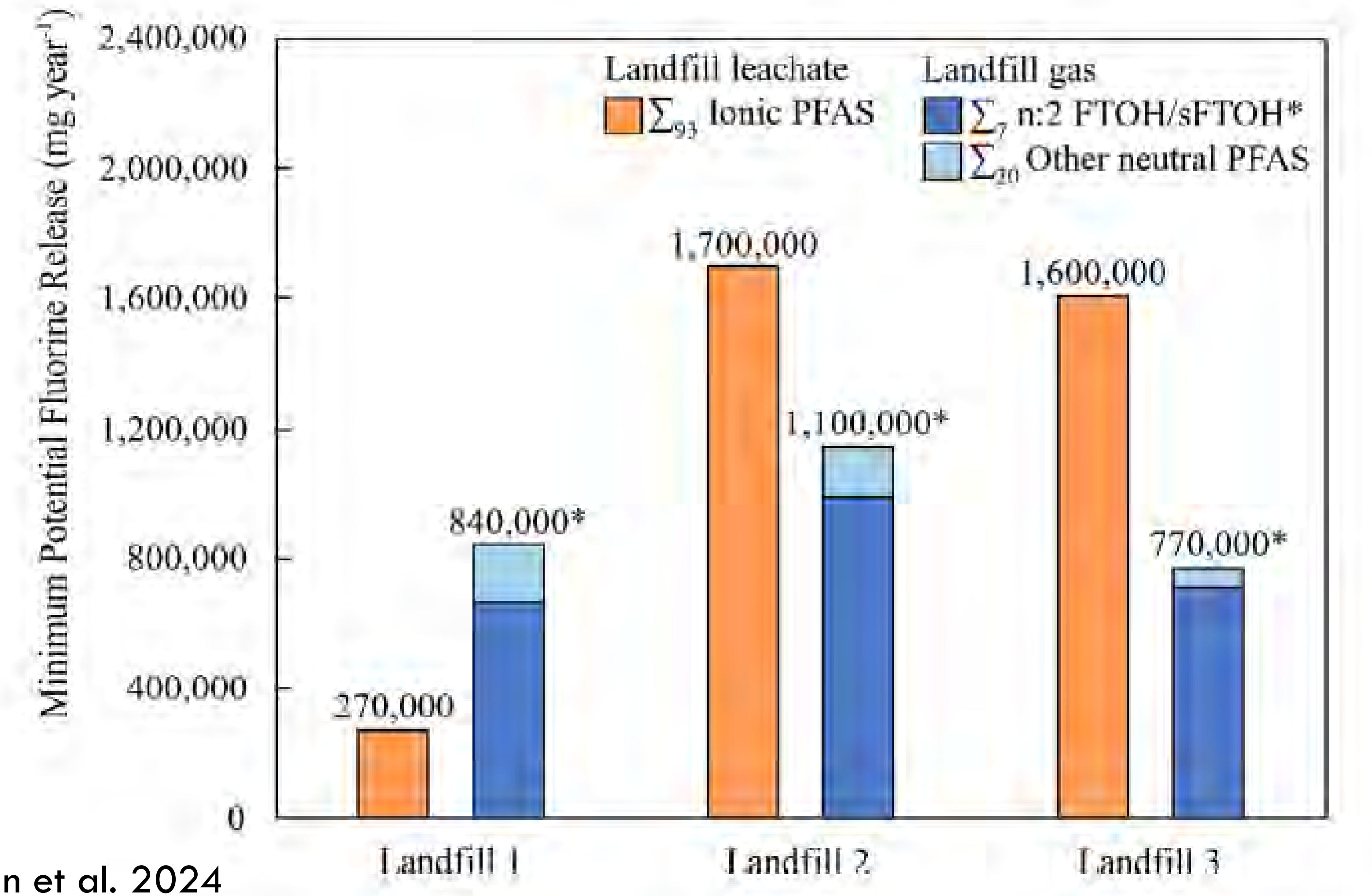
What is 4 ng/L ?

weight	volume	1000 gradations
Kg	L	1:1
g	mL	Part per thou
mg	µL	ppm
µg	nL	ppb
ng	pL	ppt

Olympic pool volume: 2,500,000 L
One drop: 0.05ml or 0.00005 L
2,500,000/0.00005 = 50,000,000,000

50 ppb/0.004 ppb = 12,500

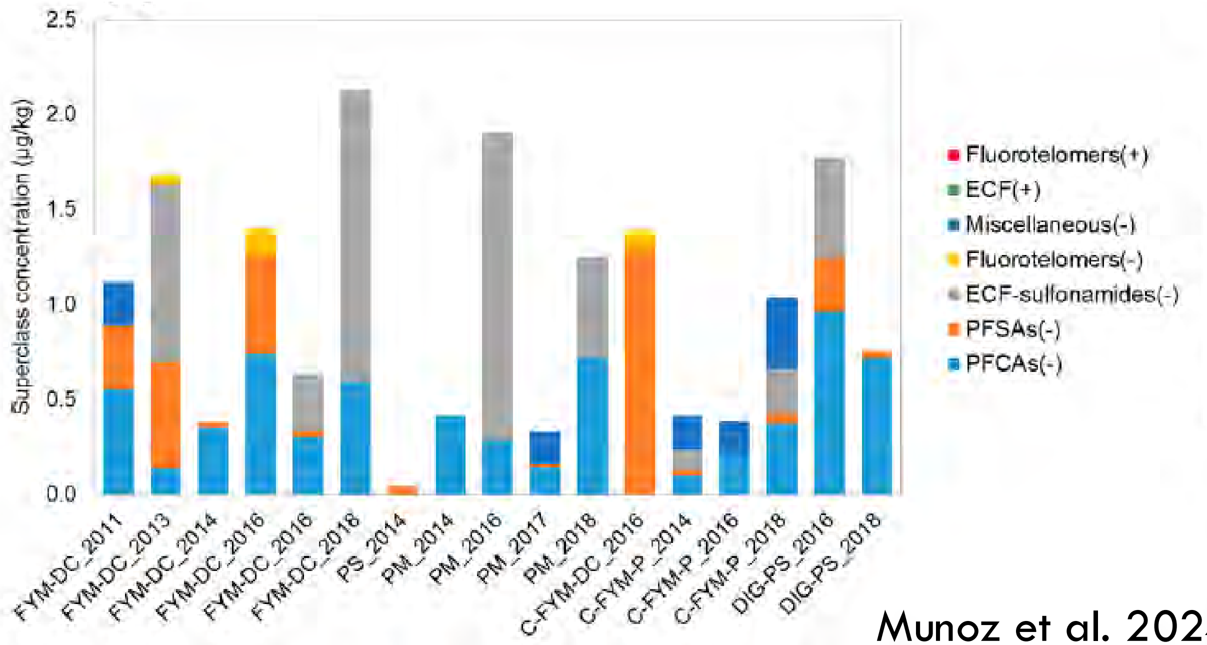
PFAS LEAVING THE LANDFILL: LEACHATE, GAS, COMPOST

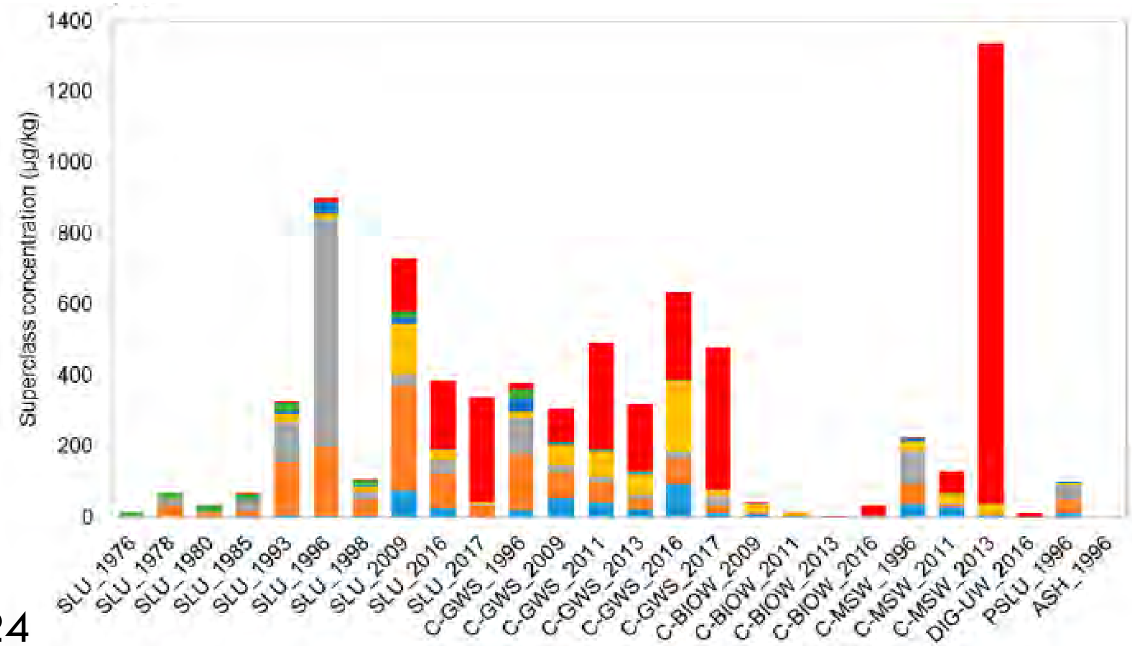


Lin et al. 2024

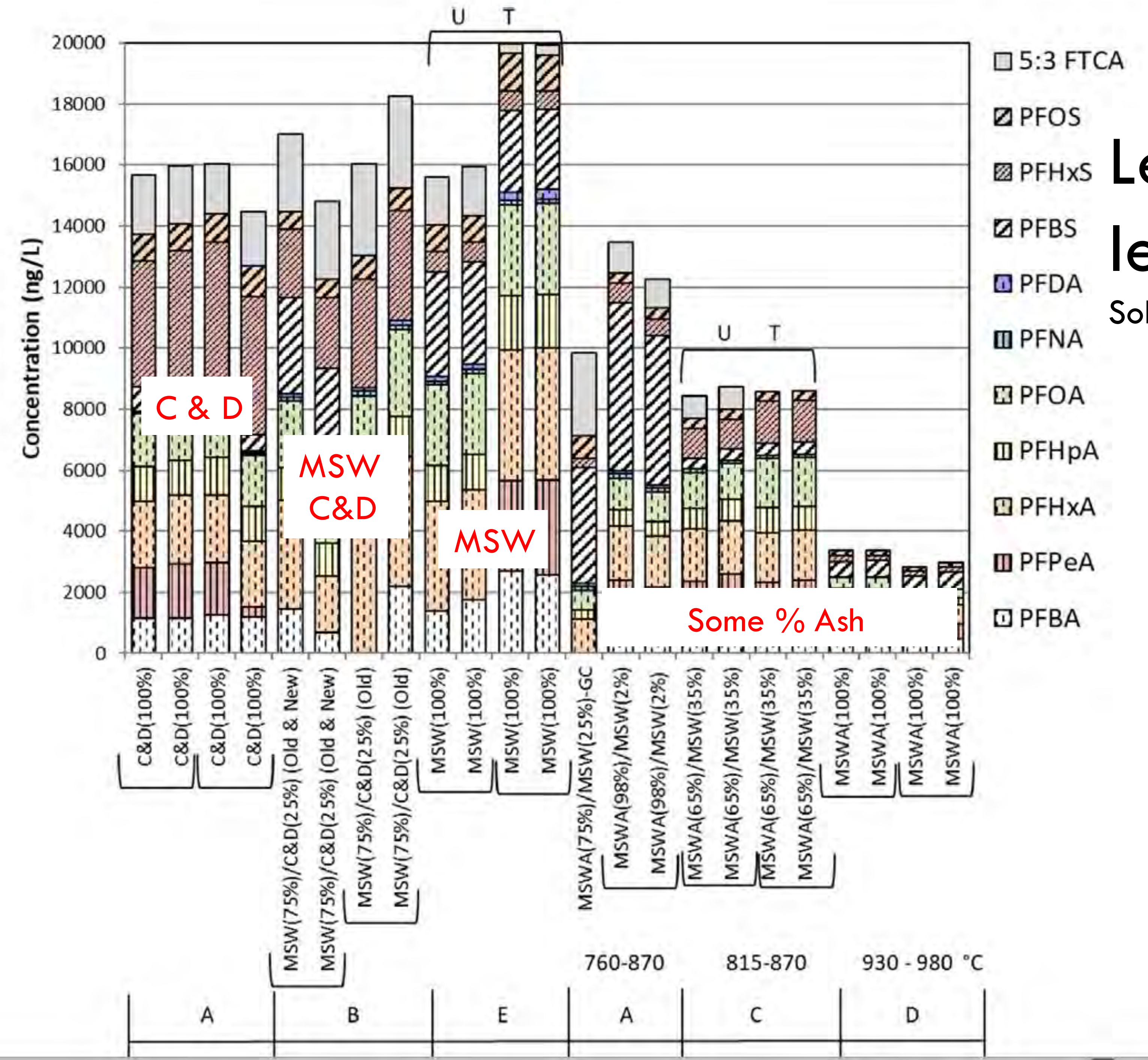
PFAS IN COMPOST

- SEWAGE SLUDGE: 539 ± 224 NG/G (DRY WEIGHT) [TOTAL OF 13 PFAS]
- MSW COMPOST (INC. FOOD PKG): 29 TO 76 NG/G (DW)
- MSW COMPOST (NO FOOD PKG): 2.4 TO 7.6 NG/G (DW) [TOTAL 17 PFAS]



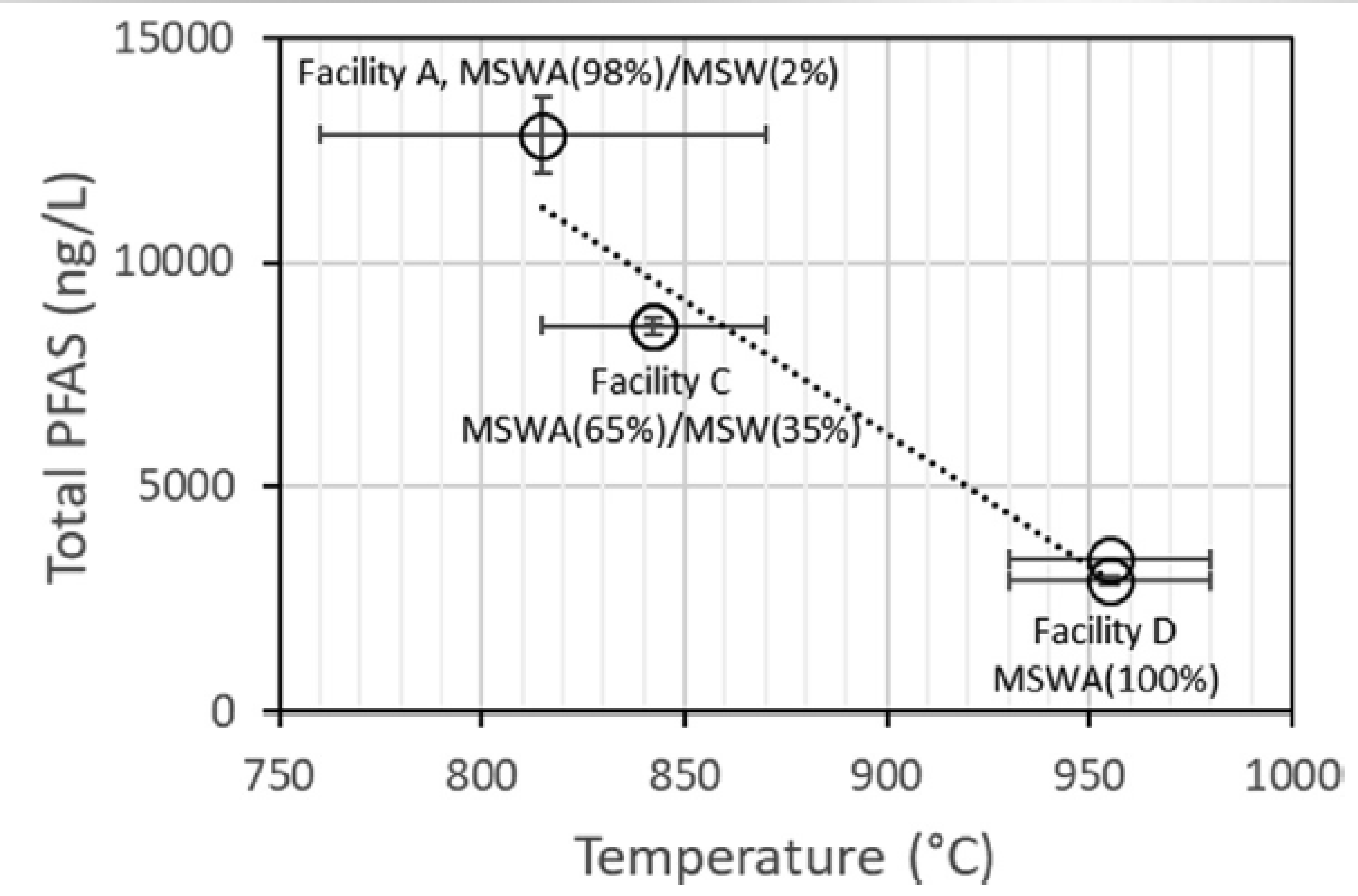


Munoz et al. 2024



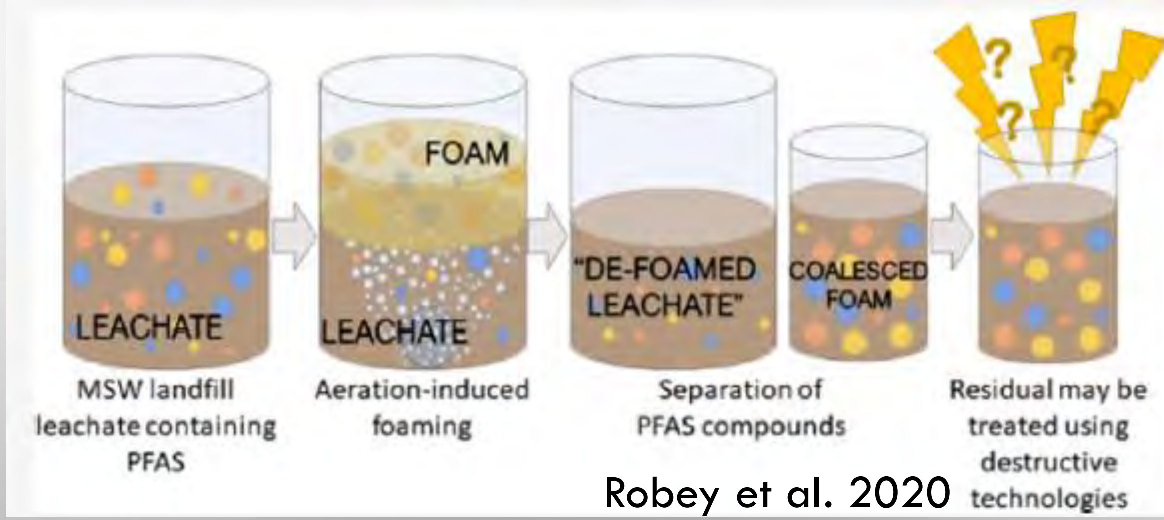
Leachate PFAS levels

Solo-Gabriele et al. 2020



Total PFAS (ng/L)
15000
10000
5000
0
Facility A, MSWA(98%)/MSW(2%)
Facility C
MSWA(65%)/MSW(35%)
Facility D
MSWA(100%)
750
800
850
900
950
1000
Temperature (°C)

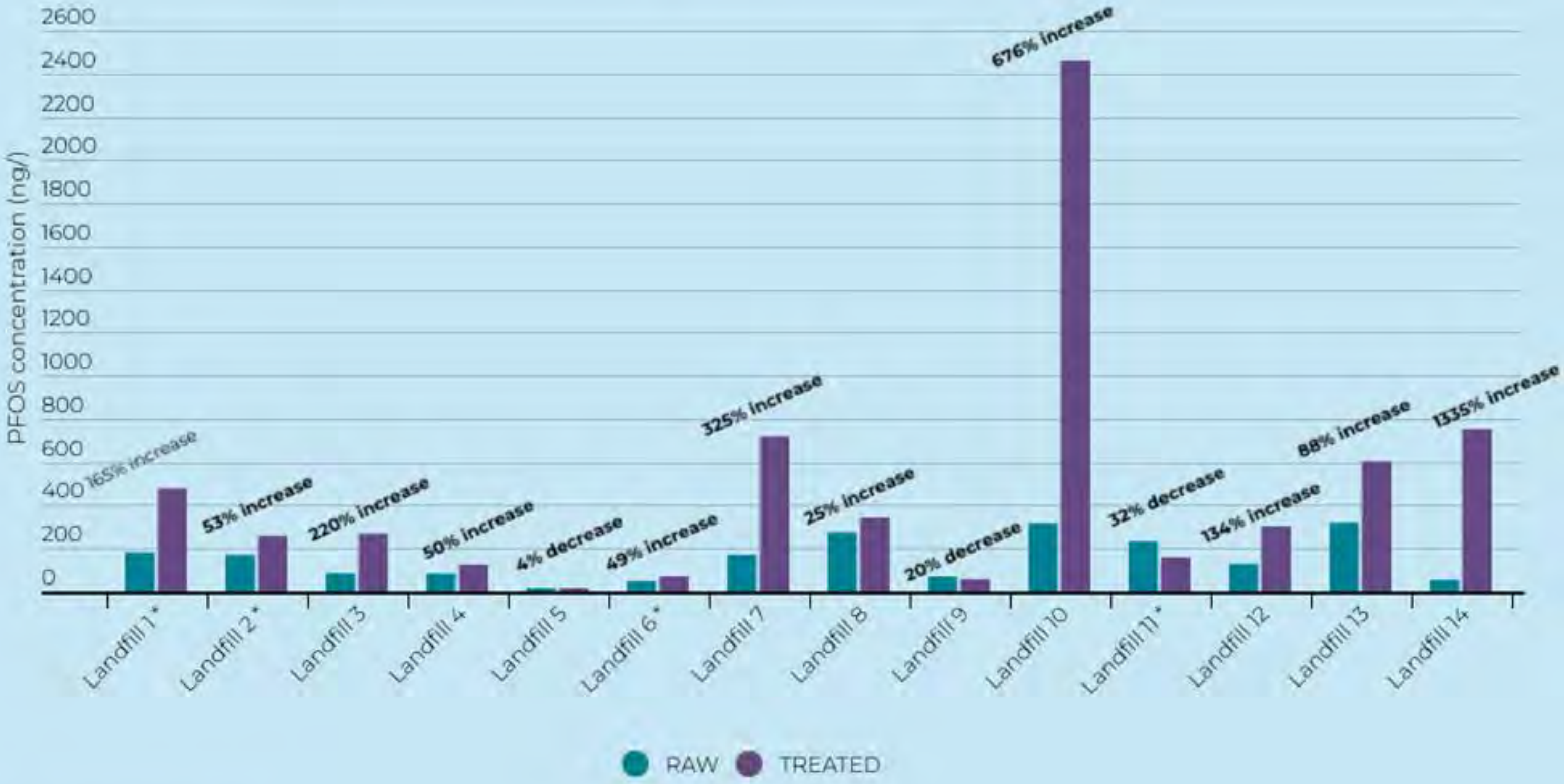
TREATMENT OPTIONS



Robey et al. 2020

- AERATION OF LEACHATE
- DAF-TYPE FOAM SKIMMING
- GAS CONDENSATE TO WWTP
- AC FILTER: 90% LONG CHAIN, 10% SHORT CHAIN REMOVED. FOULING WITH HIGH DOM. RINSE WITH MEOH AND INCINERATE A 900 C
- ION EXCHANGE RESINS: GOOD FOR SHORT CHAIN, FOULING TROUBLE
- RO CONCENTRATES PFAS IN WASTE WATER (25% OF TOTAL)
- MICROBIAL DECOMPOSITION: AEROBIC PROCESS DEVELOPED FOR SOIL CONTAMINATION

PFOS levels in raw vs treated landfill leachate



Source - Environment Agency

Neill & Megson 2024

MICROBIAL BIOTECHNOLOGY Open Access

Volume 17, Issue 4
April 2024
e14463
This article also appears in: Burning Questions in Microbial Biotechnology

OPINION | Open Access

Evolutionary obstacles and not C–F bond strength make PFAS persistent

Lawrence P. Wackett

First published: 09 April 2024 | https://doi.org/10.1111/1751-7915.14463

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Abstract

The fate of organic matter in the environment, including anthropogenic chemicals, is largely predicated on the enzymatic capabilities of microorganisms. Microbes readily degrade, and thus recycle, most of the ~100,000 commercial chemicals used in modern society. Per- and polyfluorinated compounds (PFAS) are different. Many research papers posit that the general resistance of PFAS to microbial degradation is based in chemistry and that argument relates to the strength of the C–F bond. Here, I advance the opinion that the low biodegradability of PFAS is best formulated as a biological optimization problem, hence evolution. The framing of the problem is important. If it is framed around C–F bond strength, the major effort should focus on finding and engineering new C–F cleaving enzymes. The alternative, and preferred approach suggested here, is to focus on the directed evolution of biological systems containing known C–F cleaving systems. There are now reports of bacteria degrading and/or growing on multiply fluorinated

BAM

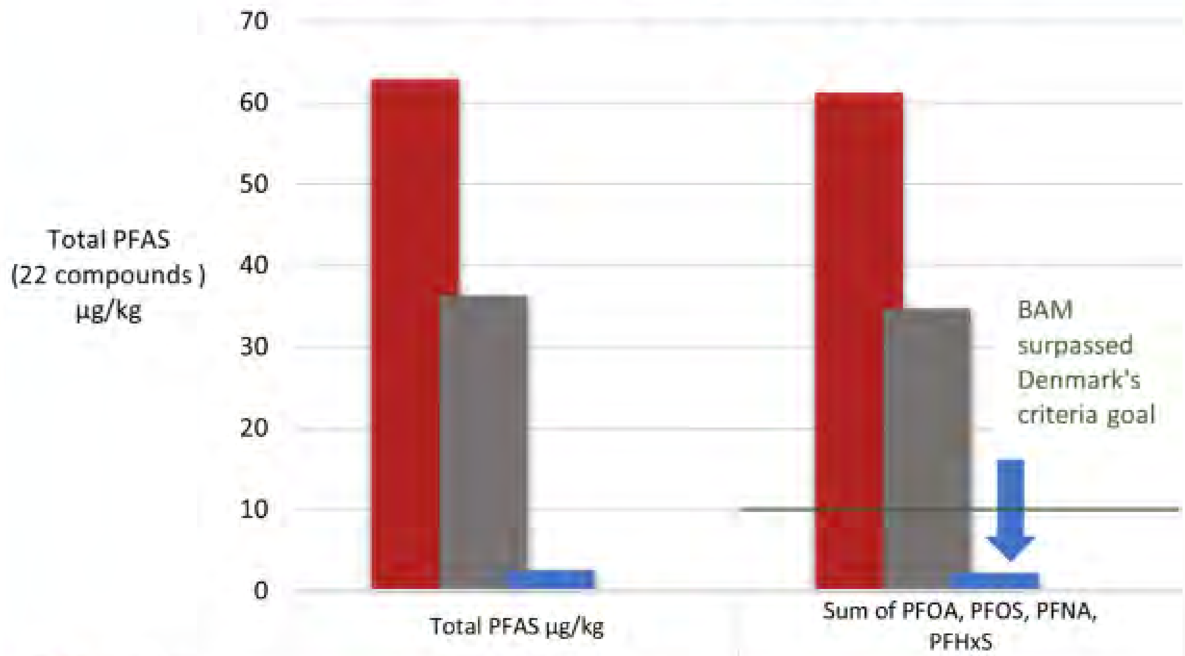
- Particle size ranges based on milling procedure
- Surface functional groups (carboxyl, hydroxyl, phenolic hydroxyl, and carbonyl groups)
- High cation exchange capacity
- Vapor Migration & Odor Control
- Immediate clean up of soil & groundwater through absorption and surface area remediation
- Effective on wide range of contaminants
  - Hydrocarbons
  - Chlorinated solvents
  - 1,4 – Dioxane
  - Some heavy metals
  - PCBs
  - PFAS

ORIN TECHNOLOGIES

Fire Fighting Training Facility—Denmark

- A third-party test was performed by a Danish government contractor comparing multiple stabilization technologies.
- BAM was tested.
- Denmark criteria is 10 ug/kg in soil.
- Achieved the Danish Environmental Protection Agency's remedial goal.

Treatment of PFAS Impacted Soil



	Total PFAS μg/kg	Sum of PFOA, PFOS, PFNA, PFHxS
Baseline Soil	63	61.3
Competitor Treated	36.3	34.7
BAM Treated	2.6	2.2
Reduction using BAM	95.9%	96.4%

ORIN TECHNOLOGIES

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