Per- and Polyfluoroalkyl Substances (PFAS): An Emerging Class of Toxic Environmental Contaminants

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What are PFAS?

Per- and polyfluoroalkyl substances

PFAS are man-made chemicals that have been used since the 1940's. They are considered chemicals of emerging concern because recently we became aware of their potential health risks:

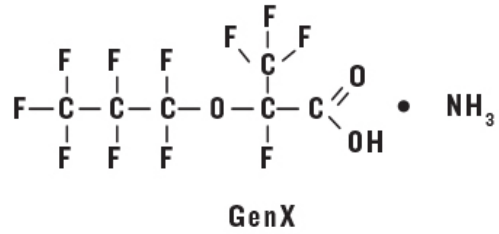
- Can cause hormonal imbalances
- Related to ≠ forms of **cancer**
- Linked to **organ toxicity**

Three of the most common PFAS are:

PFOS Perfluorooctanesulfonic acid

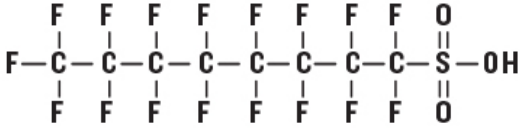
PFOA Perfluorooctanoic acid

GenX Perfluoro-2-propoxypropanoic acid



GenX

PFOA



PFOS

The strong C-F bond in the molecules make PFAS very stable and difficult to destroy

https://ensia.com/features/pfas/

However, the US Environmental Protection Agency estimates that there are more than 7500 PFAS and the list keeps growing

https://www.epa.gov/pfas/basic-information-pfas

What are PFAS used for?

- PFAS are a critical ingredient in **fire fighting foam** – a live saving technology

https://bit.ly/2z9uo2w

- PFAS are found in every day products, and are used to make them heat resistant, stain repellent, water repellent, and durable

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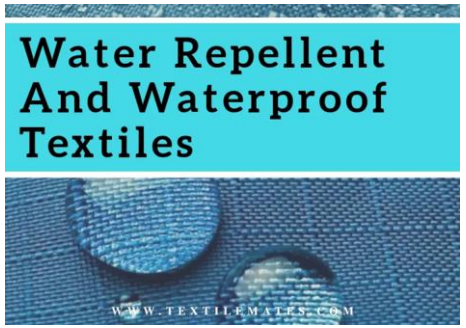
- Despite their toxicity, PFAS use cannot be eliminated until suitable replacements are found



Forever chemicals

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- The same properties that make PFAS useful make them problematic contaminants in the environment
- PFAS don't break down - they last a very long time in the environment and are thus known as ***forever chemicals***
- PFAS can dissolve in water and thus can move within the environment and are commonly detected in drinking water
- Some PFAS are extremely bioaccumulative – they can reach very high levels in animals, plants, and humans
- PFAS are a topic of worldwide concern, but there has been little official monitoring or regulation

https://www.epa.gov/pfas/basic-information-pfas

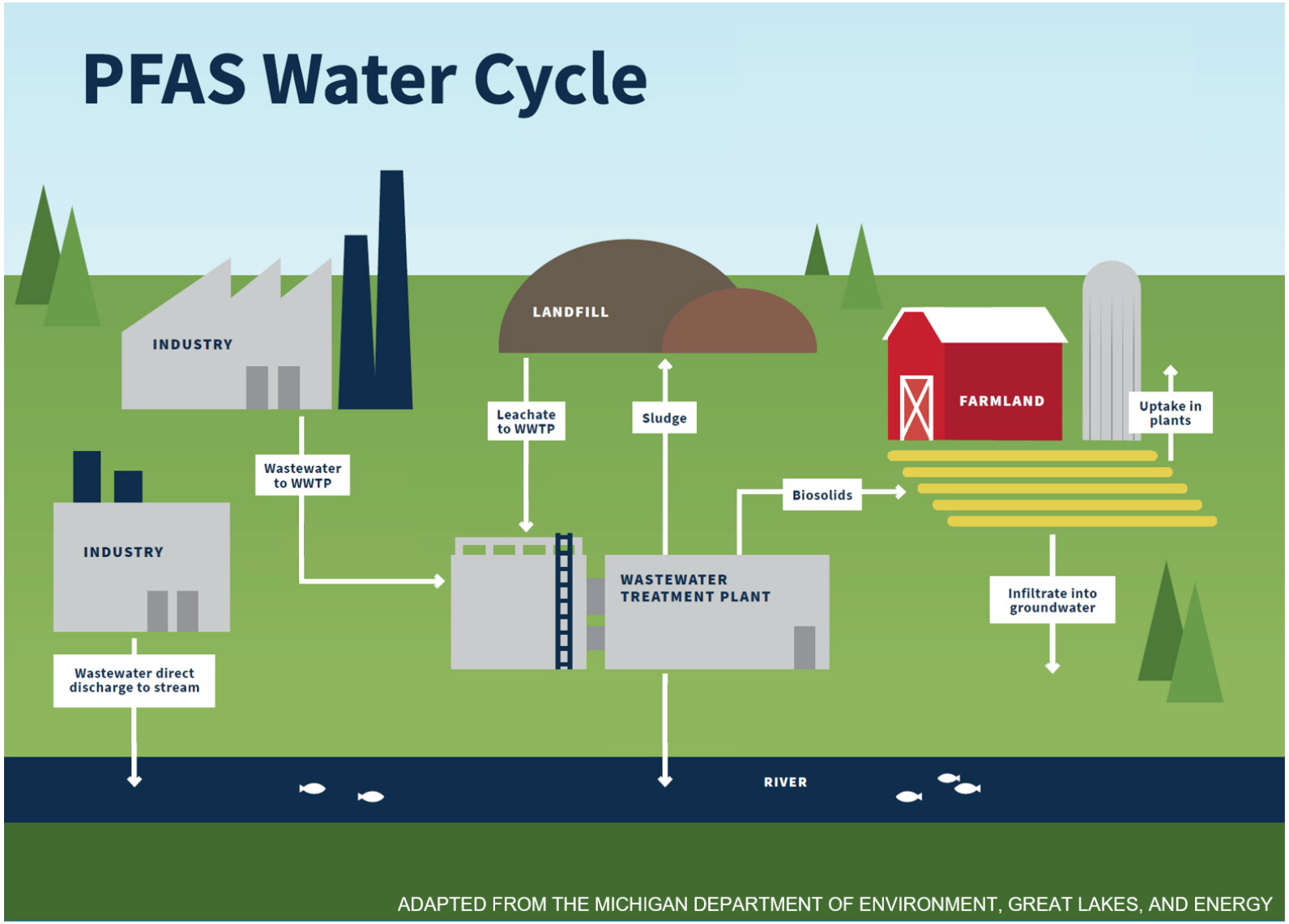

Figure provided by Anna Hagstrom, CT DEEP

- PFAS enter the environment via industrial and household waste
- PFAS are commonly detected at landfills and in water and biosolids from wastewater treatment plants
- PFAS move within the environment and can reach water, soil, and crop plants

In rare cases, PFAS contamination has devastated farms

Fred Stone, Farm Owner (news.bloomberglaw.com)

- Stoneridge Farm in Maine has been forced to shut down after high levels of PFAS were found in the milk. The farm participated in a municipal biosolids application program for many years, and also used sludge from a nearby paper mill.
  - PFAS were found in well water, animal feed grown onsite, the cows, milk, and blood of the farmer
  - News articles:
    - https://www.reuters.com/article/us-usa-dairy-chemicals/the-curious-case-of-tainted-milk-from-a-maine-dairy-farm-idUSKCN1R01AJ
    - https://news.bloomberglaw.com/environment-and-energy/denied-both-sales-and-aid-face-of-pfas-wonders-how-to-survive
    - https://bangordailynews.com/2019/08/16/news/maine-dairy-farmers-blood-tests-high-for-forever-chemicals-from-toxic-sludge/

PFAS in Food?

- Widespread PFAS contamination in food has **NOT** been demonstrated.
  - 16 individual PFAS have been included in the US FDA Total Diet Study since 2018.
  - Only very low levels of PFAS were found in 3 of 179 samples (https://www.fda.gov/food/chemicals/and-polyfluoroalkyl-substances-pfas)

PFAS in Connecticut: Task Force

- In summer 2019, there were two releases of PFAS at Bradley International Airport. In response, Governor Lamont formed an **Interagency PFAS Task Force** to develop a strategy to:
  - Minimize human health risk for Connecticut residents,
  - Minimize future releases of PFAS to the environment, and
  - Identify, assess, and clean up historic releases of PFAS to the environment

PFAS Interagency Task Force Meeting - August 28, 2019 (portal.ct.gov/DEEP)

PFAS in Connecticut: Action Plan

- The task force delivered an action plan to the governor on November 1, 2019. Key recommendations include:
  - Test for PFAS in drinking water and assess occupational and food-related PFAS exposures
  - Identify sites with likely PFAS contamination such as airports and landfills and test for PFAS in environmental media
  - Establish a take-back program for PFAS containing firefighting foams
  - Establish a public outreach team to communicate with members of PFAS-affected communities
  - More information and full report available:
    - https://portal.ct.gov/DEEP/Remediation--Site-Clean-Up/PFAS-Task-Force/PFAS-Task-Force

PFAS advisories in Connecticut

- Drinking Water Action Level: 0.070 ppb (parts per billion, µg/kg)
  - Water with higher PFAS concentrations should not be consumed
- Residential Direct Exposure Criterion: 1350 ppb
  - Soil PFAS concentrations above this level may be harmful in residential environments
- Groundwater Protection Criterion: 0.070 ppb
  - Groundwater with higher PFAS concentrations should not be used as drinking water
- GA Pollutant Mobility Criterion: 1.4 ppb
  - Soil PFAS concentrations above this level may cause groundwater contamination above the groundwater protection criterion

- All advisories refer to the sum of 5 PFAS concentrations: perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorononanoic acid (PFNA), perfluorohexane sulfonic acid (PFHxS), and perfluoroheptanoic acid (PFHpA)

Measuring PFAS at CAES

The Connecticut Agricultural Experiment Station
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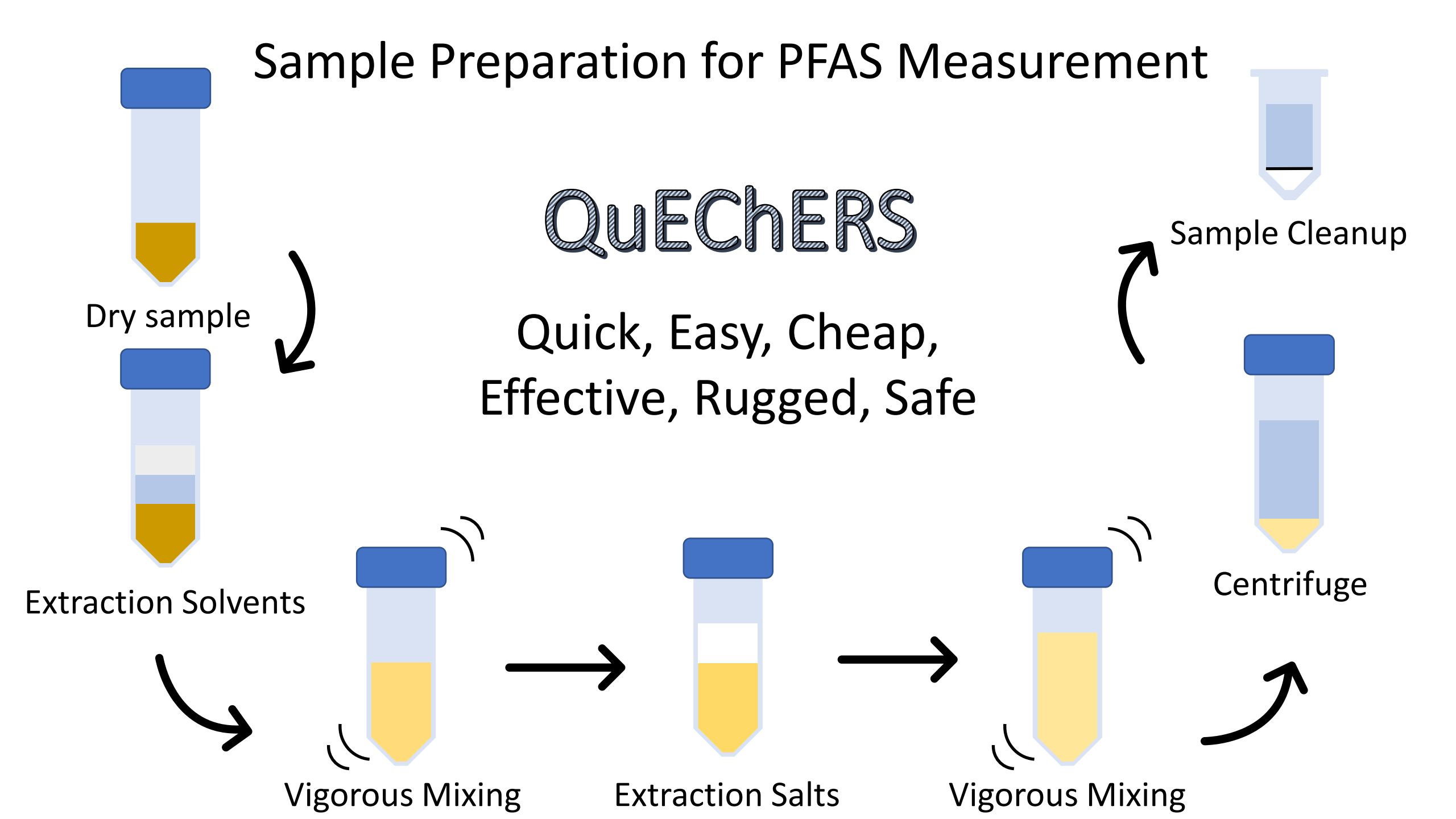
- We use liquid chromatography coupled with high resolution mass spectrometry to measure PFAS in:
  - Soil
  - Water
  - Plant tissues
  - Animal feed

Instrumentation for measuring PFAS (technologynetworks.com)

- We are collaborating with a team to develop PFAS specific detection software to use with our data

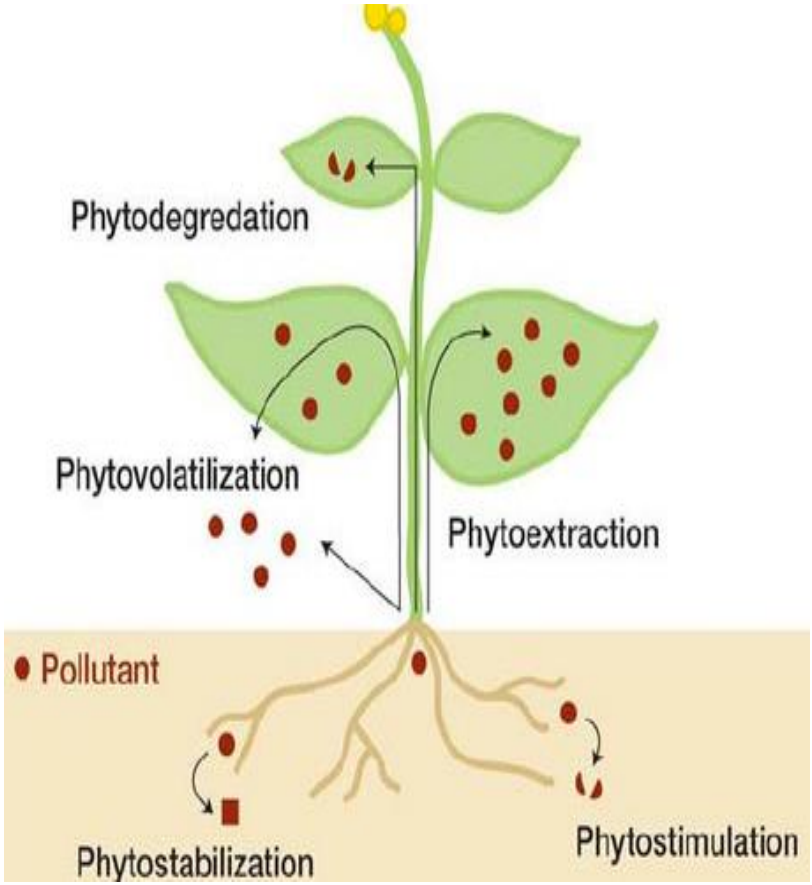
Sample Preparation for PFAS Measurement



PFAS Research at CAES: Phytoremediation

An option to remove PFAS from contaminated soil is **phytoremediation**: using plants to remove, transform, stabilize, and/or destroy pollutants

Chemicals can enter plants through the leaves or roots and be contained within the plant. Plants can be harvested and disposed of properly to remove contaminants from a site. Additionally, plants can transform many pollutants into less toxic chemicals.



https://blogs.umass.edu/natsci397a-eross/phytoremediation-the-future-of-environmental-remediation/

PFAS Research at CAES: Test site

We are working with the Micmac Nation, an indigenous group, and Upland Grassroots, a community organization to test phytoremediation of PFAS at the former Loring Airforce base, located in northern Maine

This photo shows the Burn House site where firefighting foam was frequently used for decades.

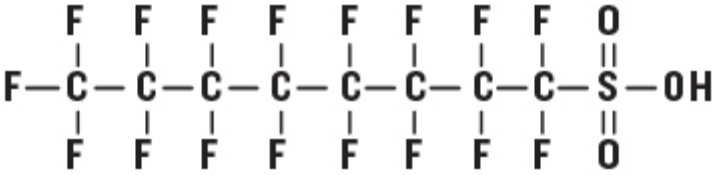
In 2019, we grew industrial hemp plants at the Burn House in a pilot project to assess PFAS phytoremediation potential

PFAS Research at CAES: Findings

- We found that PFOS was the primary contaminant at the Burn House site
  - We also measured an additional 19 PFAS, and identified 68 PFAS chemicals at the site (total)

- We found that 4 out of 19 measured PFAS significantly decreased in the soil where hemp was grown
  - An additional 5 compounds showed some evidence of decreasing

- Additional testing is taking place at the Loring site in summer 2020



PFOS

PFAS Research at CAES

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CAES continues to work on PFAS and other related emerging contaminants to safe guard CT agriculture

- Implementing PFAS measurement methods using liquid chromatography coupled with high resolution mass spectrometry
- Developing practical data analysis methods
- Exploring alternatives to enhance PFAS phytoremediation
- Collaborating with the community, government and academia

Contact Information

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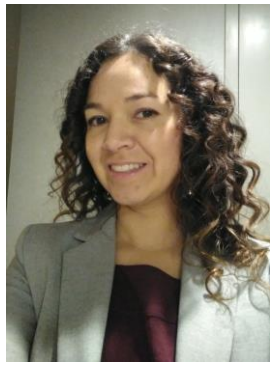

Please reach out to us with any question about PFAS in the environment!

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