Contaminated Site and Landfill Origins of Per- and Polyfluoroalkyl Substances (PFAS) and Determination of Leaching Characteristics

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Types and Sources of PFAS

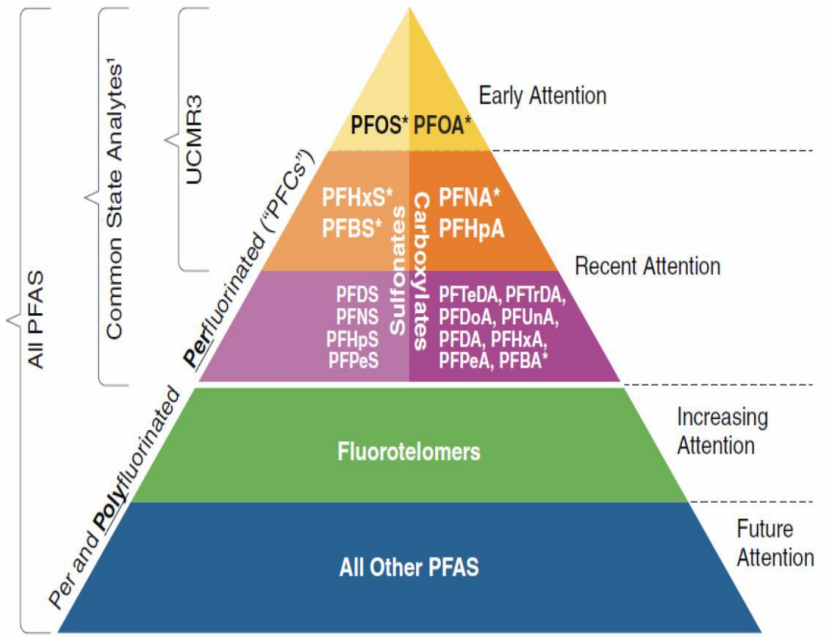


Image: ITRC Fact Sheet, 2017

Image: Pennsylvania PFAS Action Team Report, 2019.

Contaminated Soils

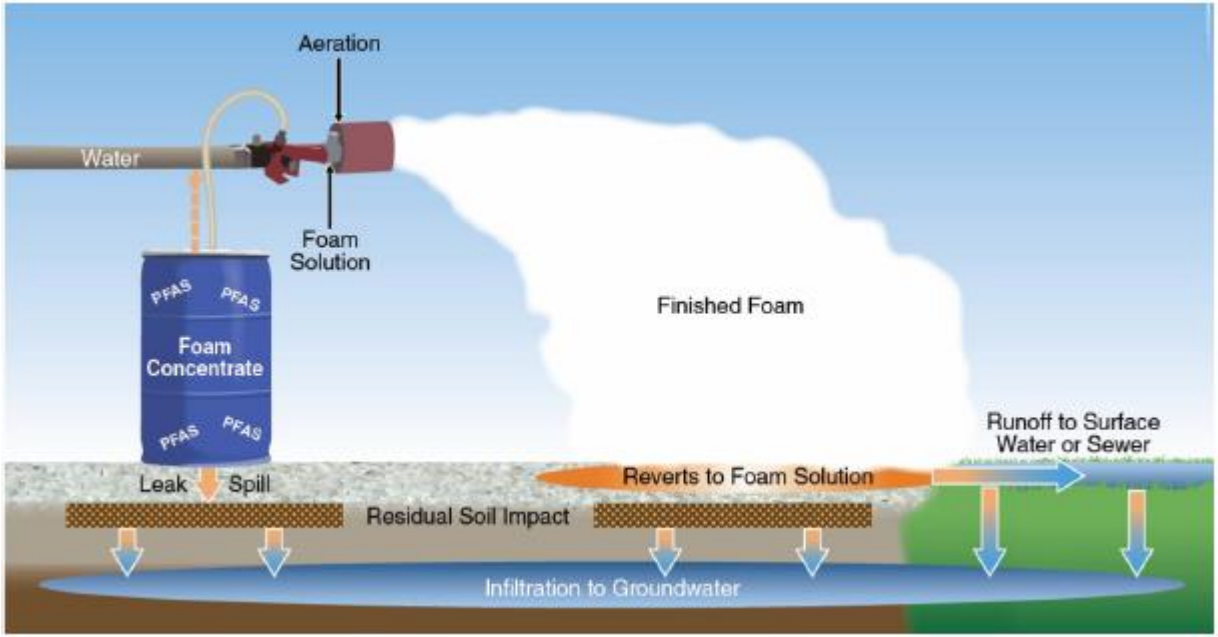


Image: ITRC Fact Sheet, 2017

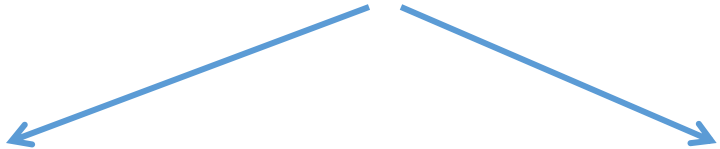
- Limited remediation options for contaminated soil
- Main concern: Sending to landfills

Current Situation

- Limited understanding for PFAS behaviour in soil.
- Different PFAS have different behaviour under different conditions:
  - This also applies to leaching characteristics with soil type being the most important variable.
- Limited data available on leachability
  - Lack of any soil acceptance/leachate criteria for PFAS disposal
- Ontario Regulation 347/558 Schedule 4 Leachate Criteria
  - Roughly 100x Ontario Drinking Waters Standards (O. Reg 169 Schedule 2) for some compounds

Problem Statement

- Limited PFAS remediation options for contaminated soils
- No regulatory criteria that regulates sending PFAS-contaminated soils to landfills
- Lack of understanding of leachability



Possible contamination of groundwater

Possible contamination of surface water

Objectives

- To identify leaching characteristics of PFAS in soil in relationship with:
  - Soil type
  - PFAS type
- To determine potential impact of contaminated soils to:
  - Landfill leachate
  - Groundwater
  - Drinking water
- A predictive tool to determine if contaminated soils can be sent to landfills

Experimental Design - Phase 1

AFFF without PFOS and PFOA

Spike soil at different amounts

Sandy loam

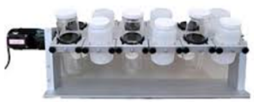
Homogenization

Subsample 5 g from each jar

Initial characterization of AFFF

100 g homogenized samples

TCLP



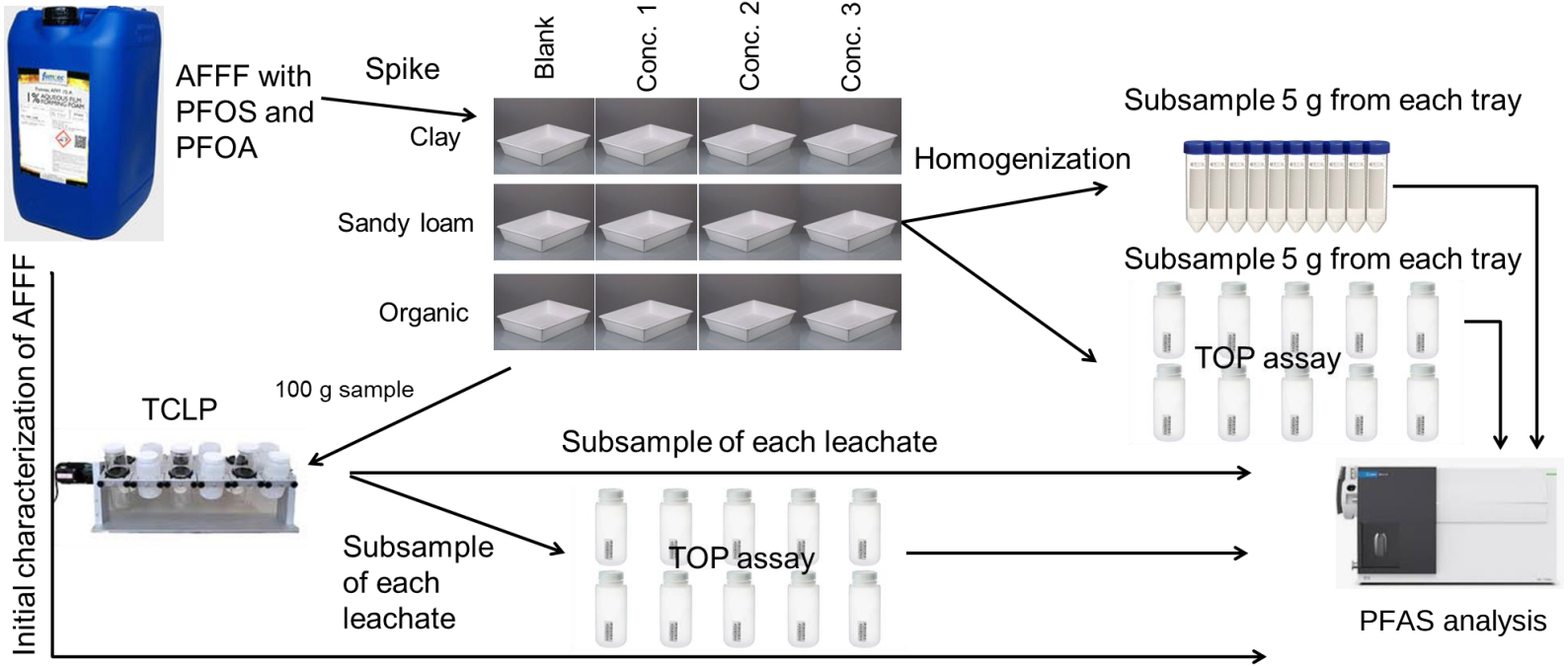
Subsample of leachate

Subsample of leachate

TOP assay

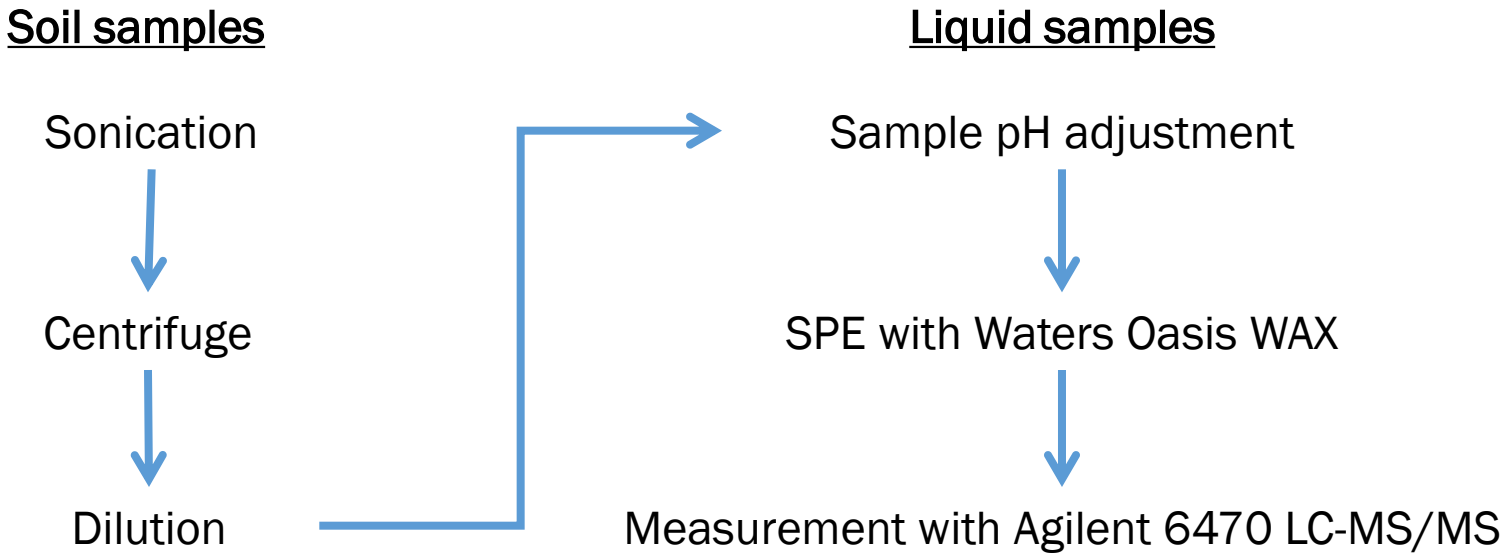
PFAS analysis

Experimental Design - Phase 2



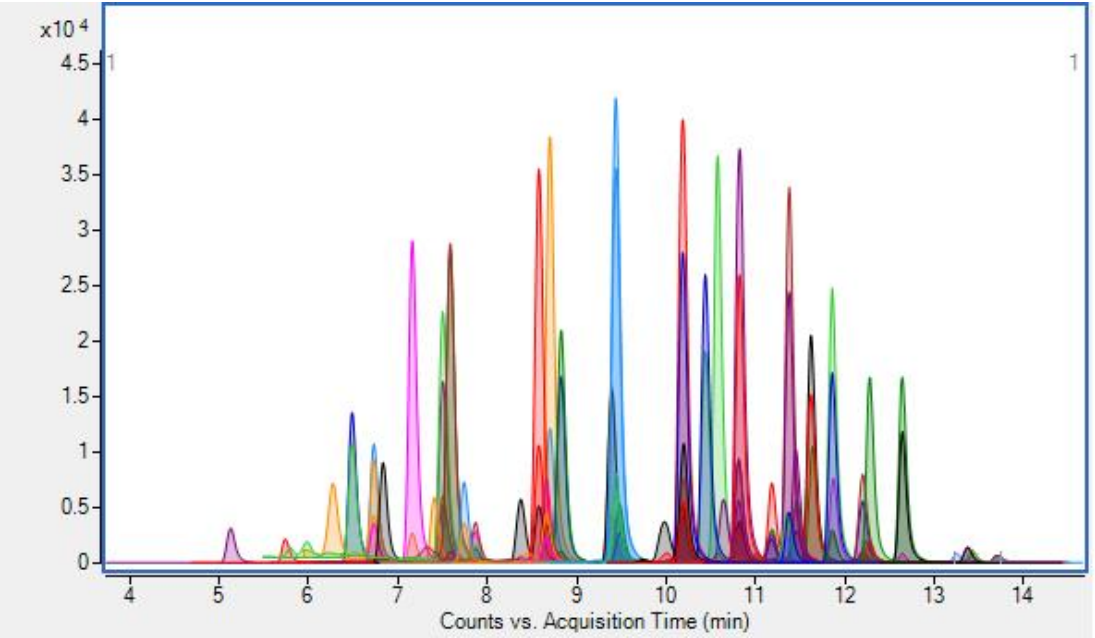
Analytical Method

- In-house developed method complying with EPA 533

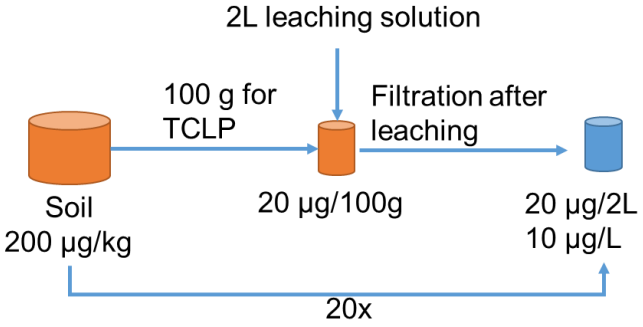


Analytical Method

- Quantification of 45 compounds (not only compounds in EPA 533)
- DL range for water samples: 1-5 ng/L
- DL range for soil samples: 1-2 µg/kg



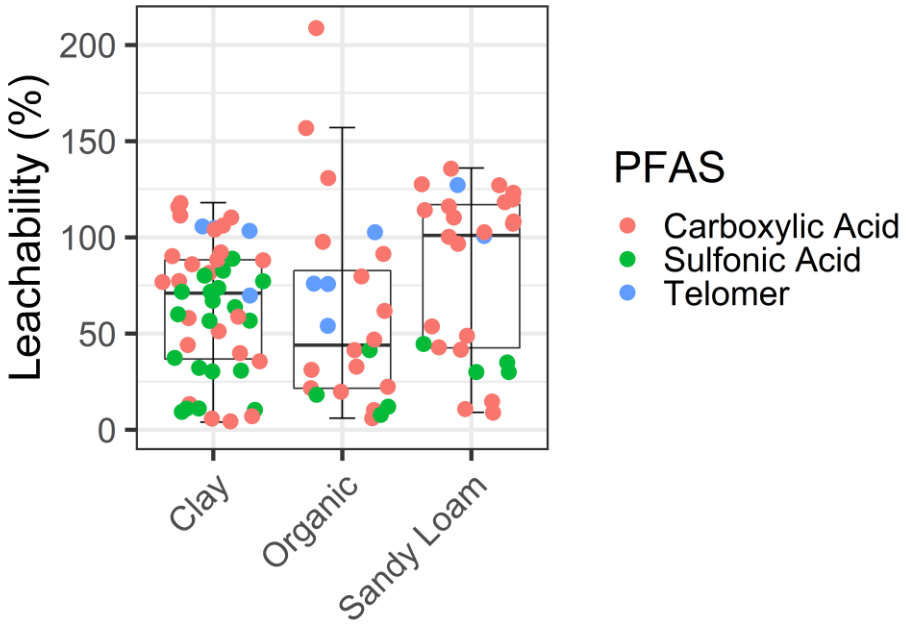
Leachability



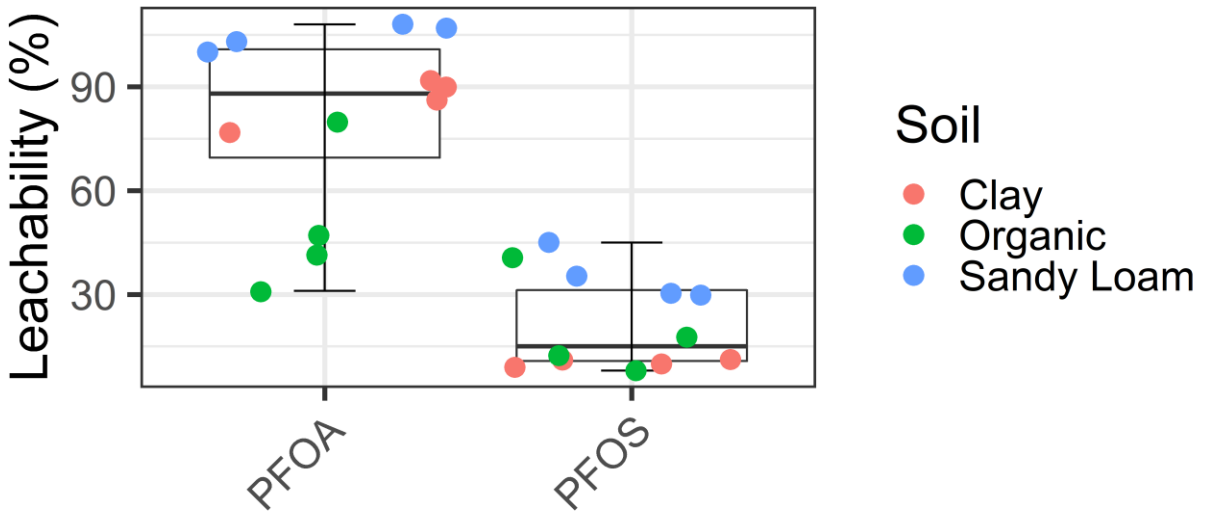
$$Maximum\ observable\ concentration\ in\ leachate\ \left(\frac{\mu g}{L}\right) = \frac{Measured\ \ in\ soil\ (ppb)}{20}$$

$$Leachability = \frac{Measured\ in\ leachate}{Maximum\ observable\ concentration\ in\ leachate}\ x\ 100$$

Behaviour of PFAS in Different Soil Types

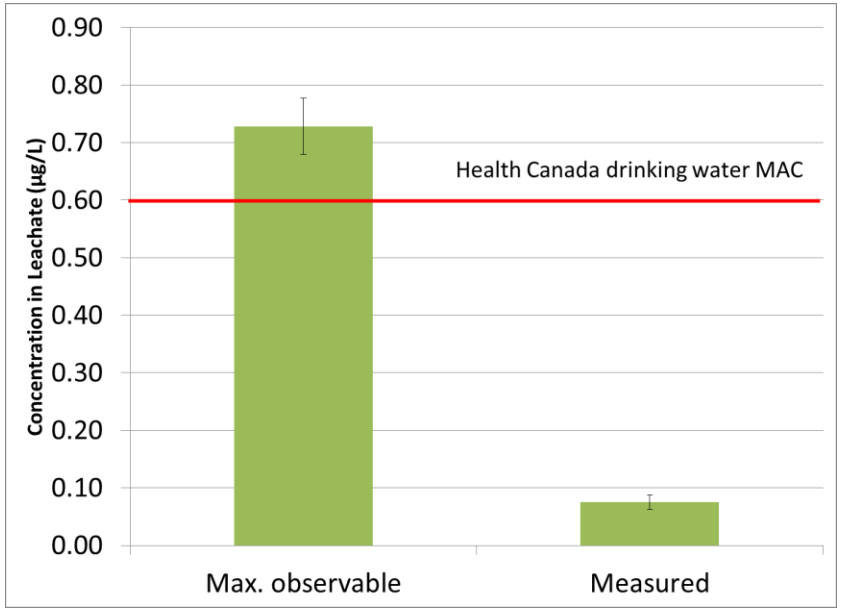


PFOS and PFOA: Leachability



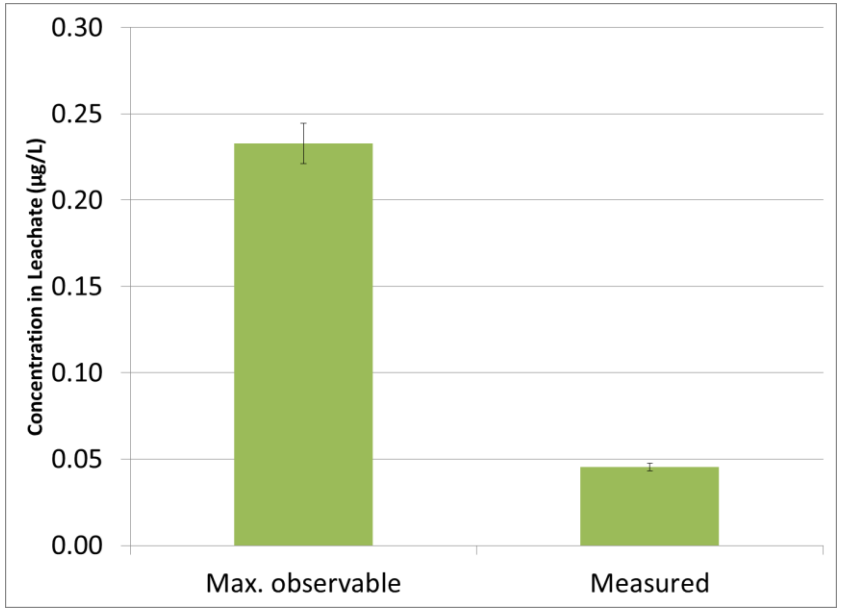
PFOS: Comparison with Regulations

- PFOS in clay
- Soil concentration
  - 14.6 ± 1 µg/kg
- Leachability 15%



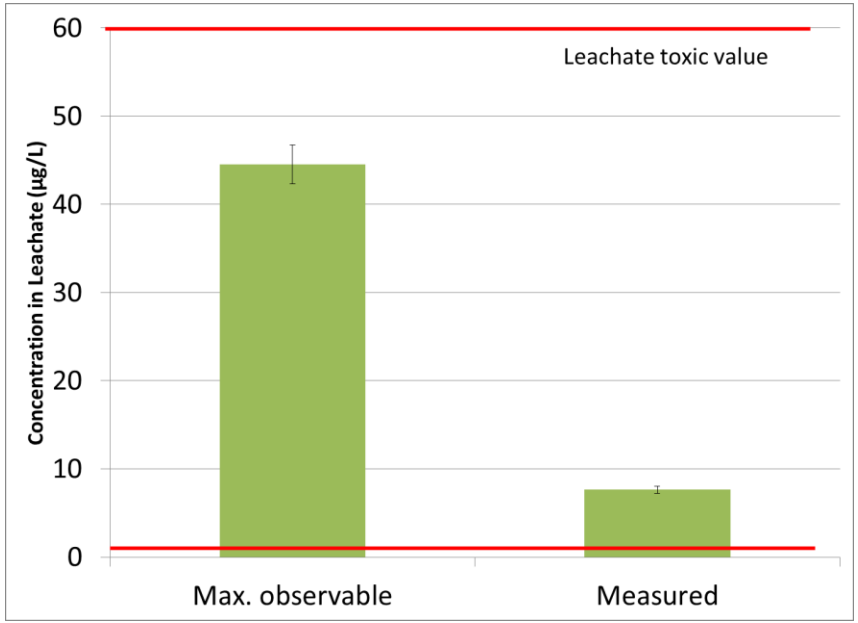
PFOS: Comparison with Regulations

- PFOS in sandy loam
- Soil concentration
  - 4.66 ± 0.5 µg/kg
- Leachability 20%



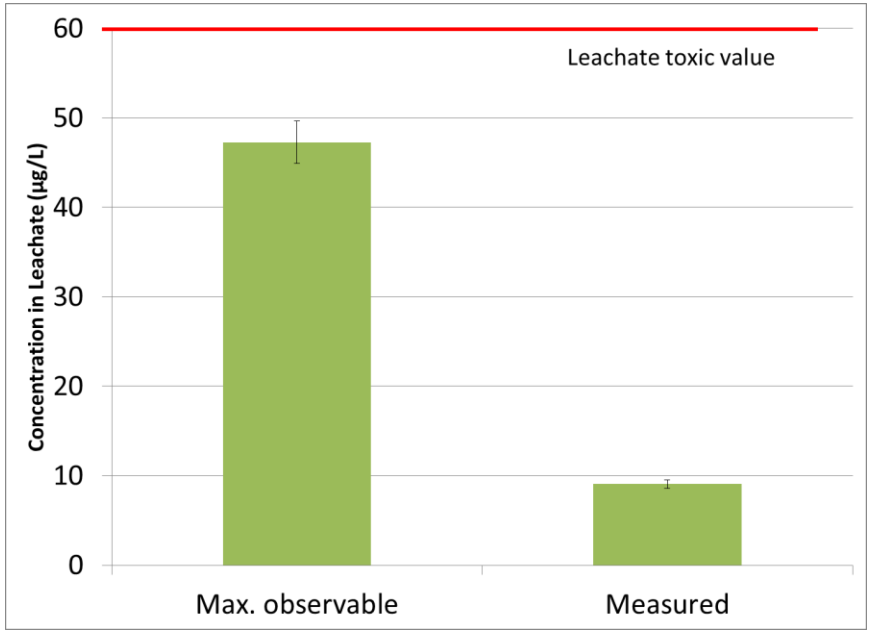
PFOS: Comparison with Regulations

- PFOS in clay
- Soil concentration
  - 890 ± 80 µg/kg (ppb)
- Leachability 18%
- 6000 µg/kg to reach assumed leachate toxic value (100x drinking water MAC)



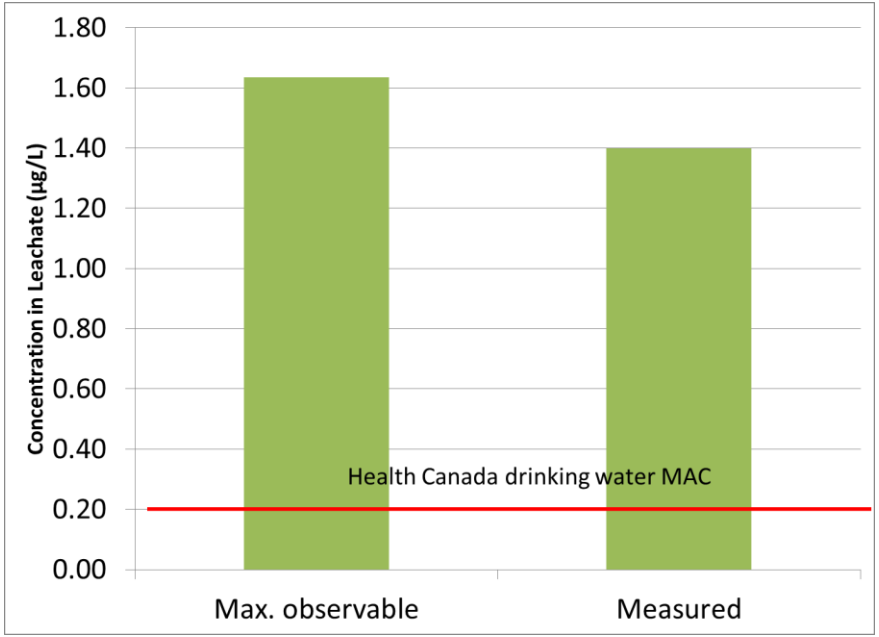
PFOS: Comparison with Regulations

- PFOS in sandy loam
- Soil concentration
  - 946 ± 65 µg/kg
- Leachability 20%
- Similar to clay



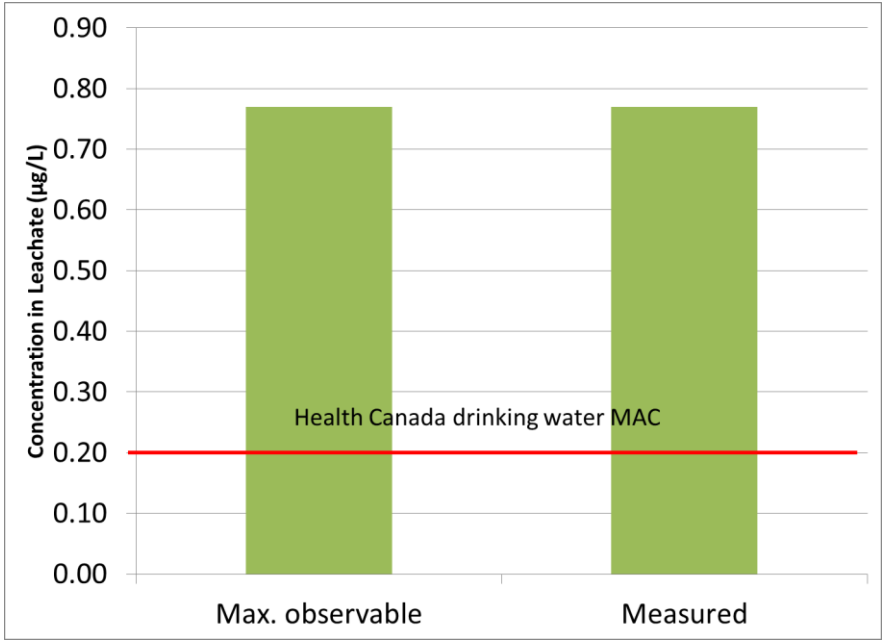
PFOA: Comparison with Regulations

- PFOA in clay
- Soil concentration
  - 32.7 ± 2 µg/kg
- Leachability 86%

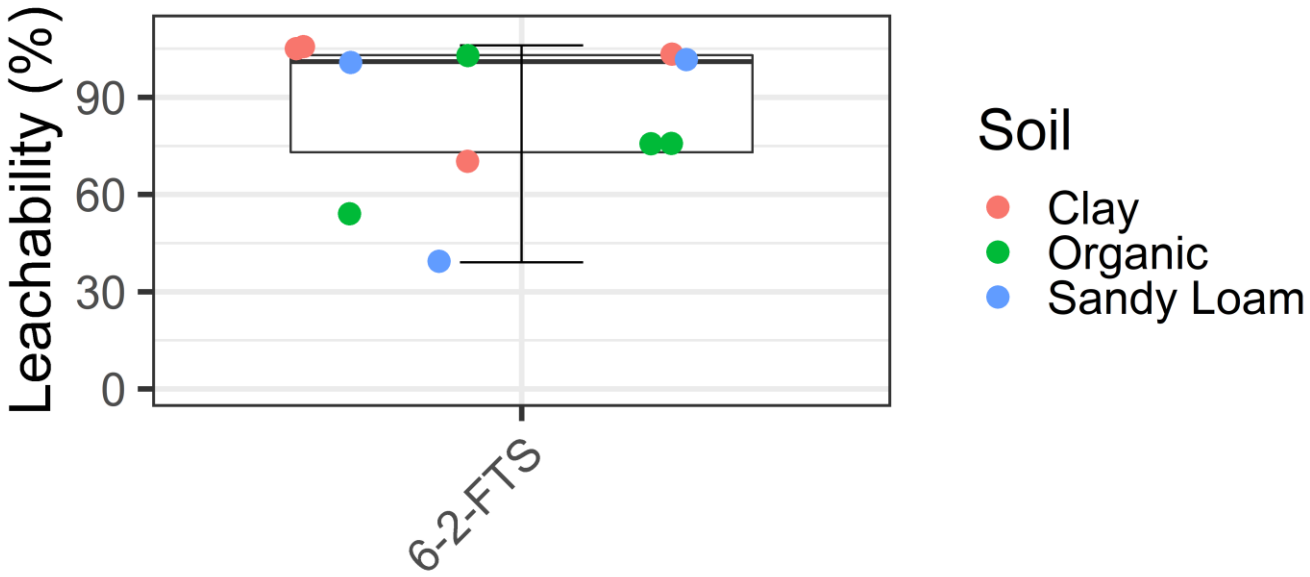


PFOA: Comparison with Regulations

- PFOA in sandy loam
- Soil concentration
  - 15.4 ± 1 µg/kg
- Leachability 100%



6:2 FTS: Leachability

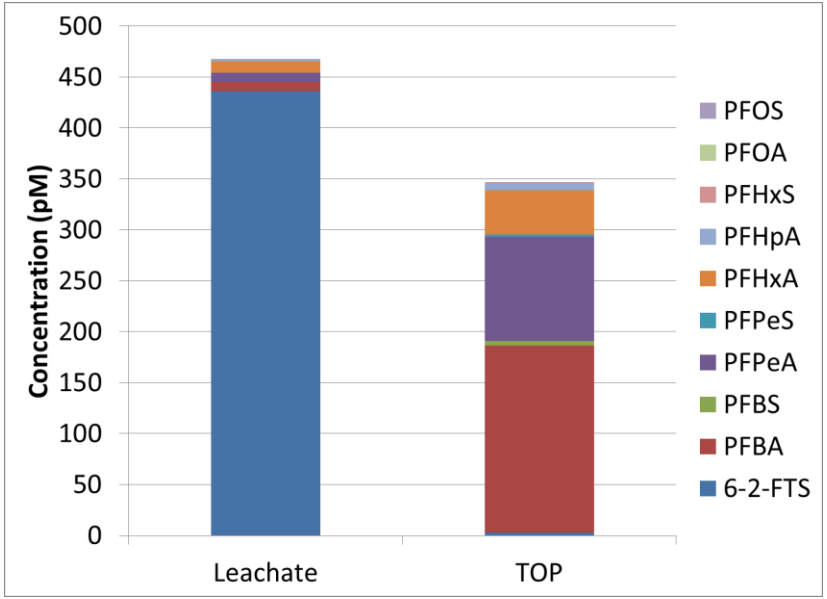


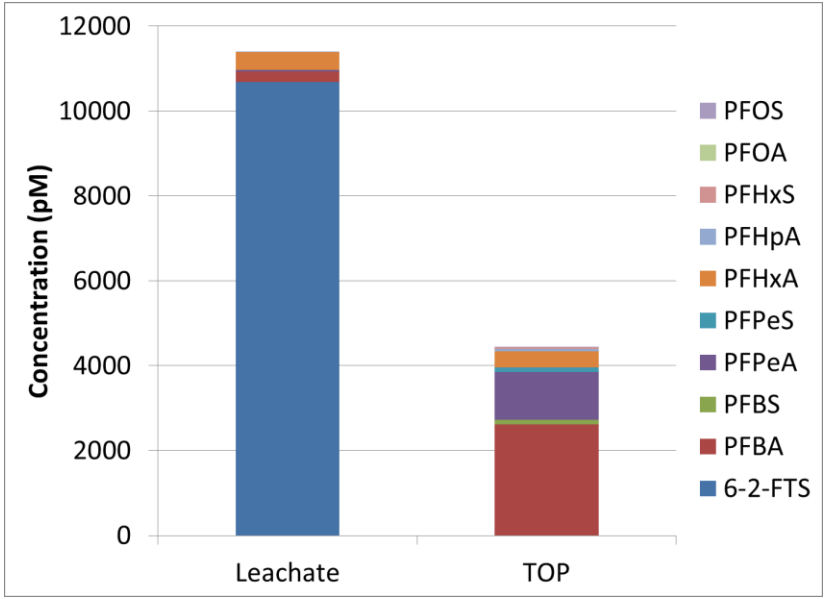
6:2 FTS: Concentration Dependence of Leaching

Soil (µg/kg)	Max. Observable in Leachate (µg/L)	Measured in Leachate (µg/L)	Leachability
3.70	0.19	0.19	101%
14.3	0.72	0.51	71%
172	8.59	3.35	39%

Soil type: Sandy loam
Health Canada drinking water screening value = 0.2 µg/L

TOP Assay in Phase 1

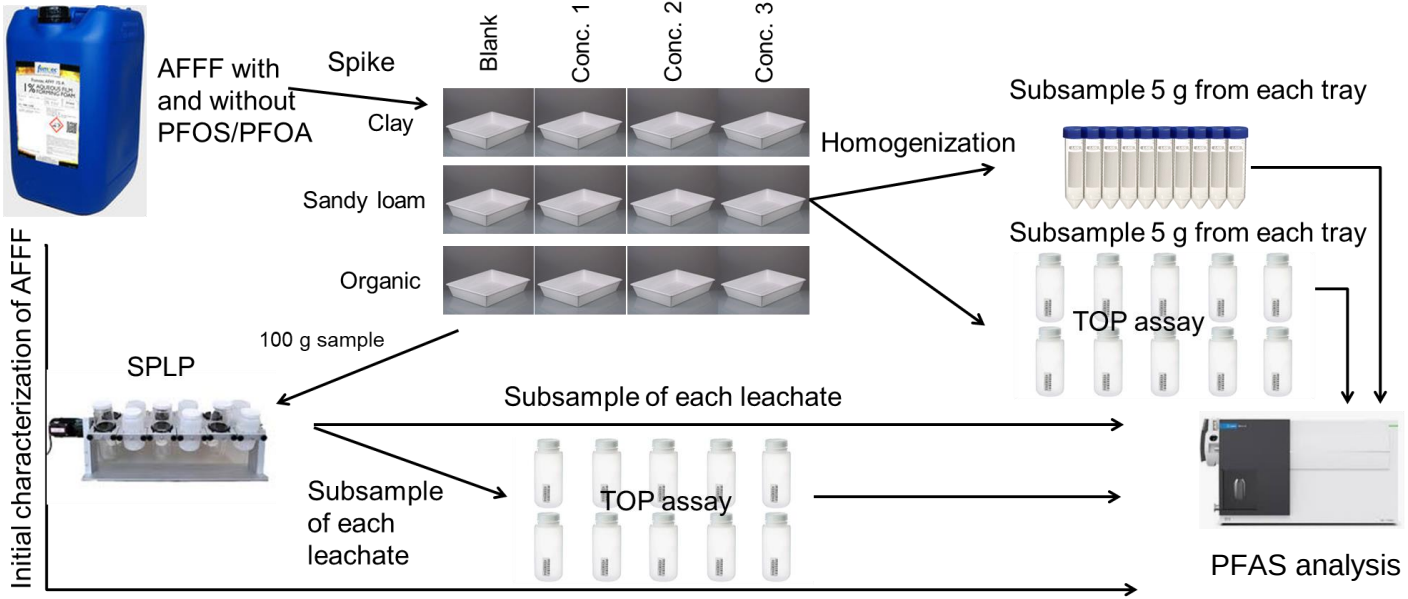




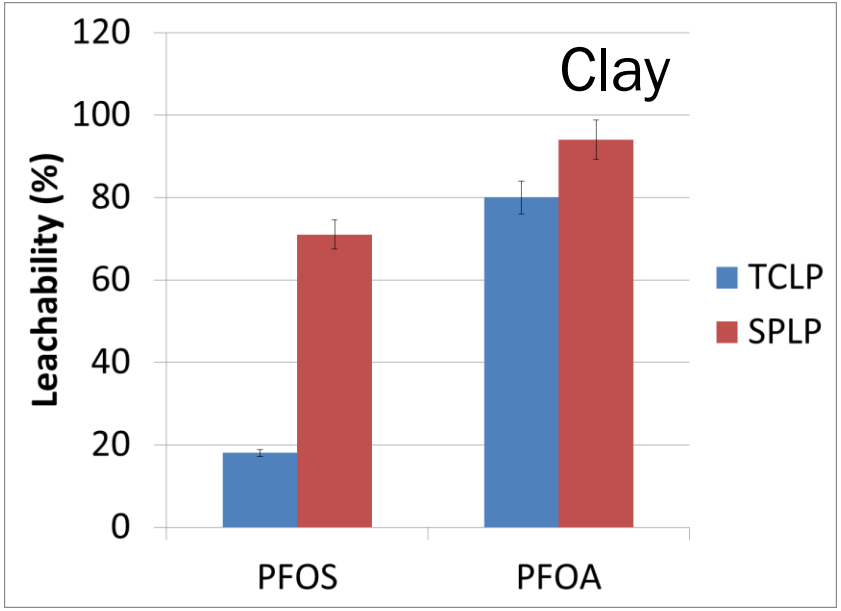
Conclusions

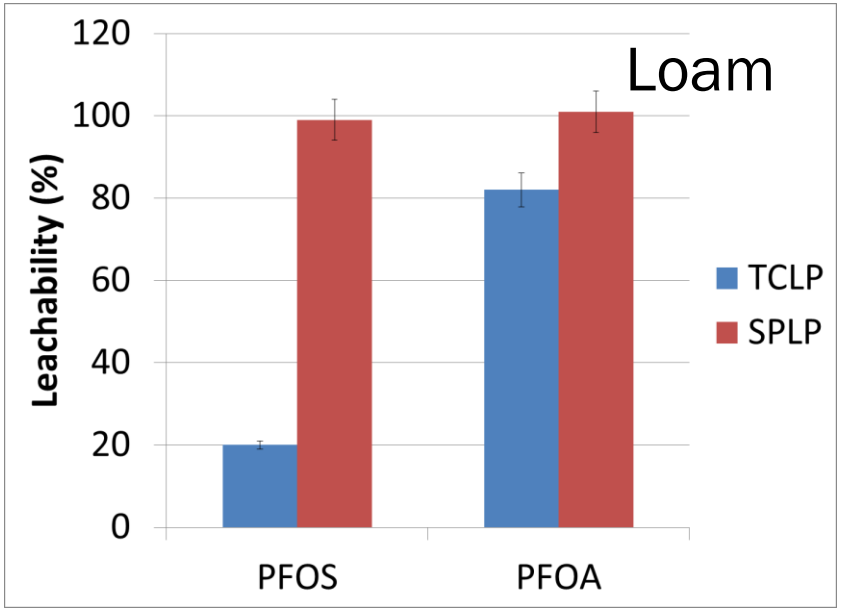
- Leachability of PFAS depends on:
  - Soil type
  - PFAS type
- Further research with actual landfill leachate and groundwater samples.
- A predictive tool can be developed using soil type and PFAS composition to account for contaminated sites' PFAS contribution to landfill leachate.
- PFAS in current AFFFs (i.e. 6:2 FTS) leach more than PFOS regardless of soil type. While assessing 6:2 FTS contamination, we need to consider short-chain carboxylic acids such as PFBA, PFPeA, and PFHxA.
- We need site-specific data to assess best management options for contaminated soils.

Ongoing/Planned Work



Preliminary Results of Ongoing Research





Acknowledgments

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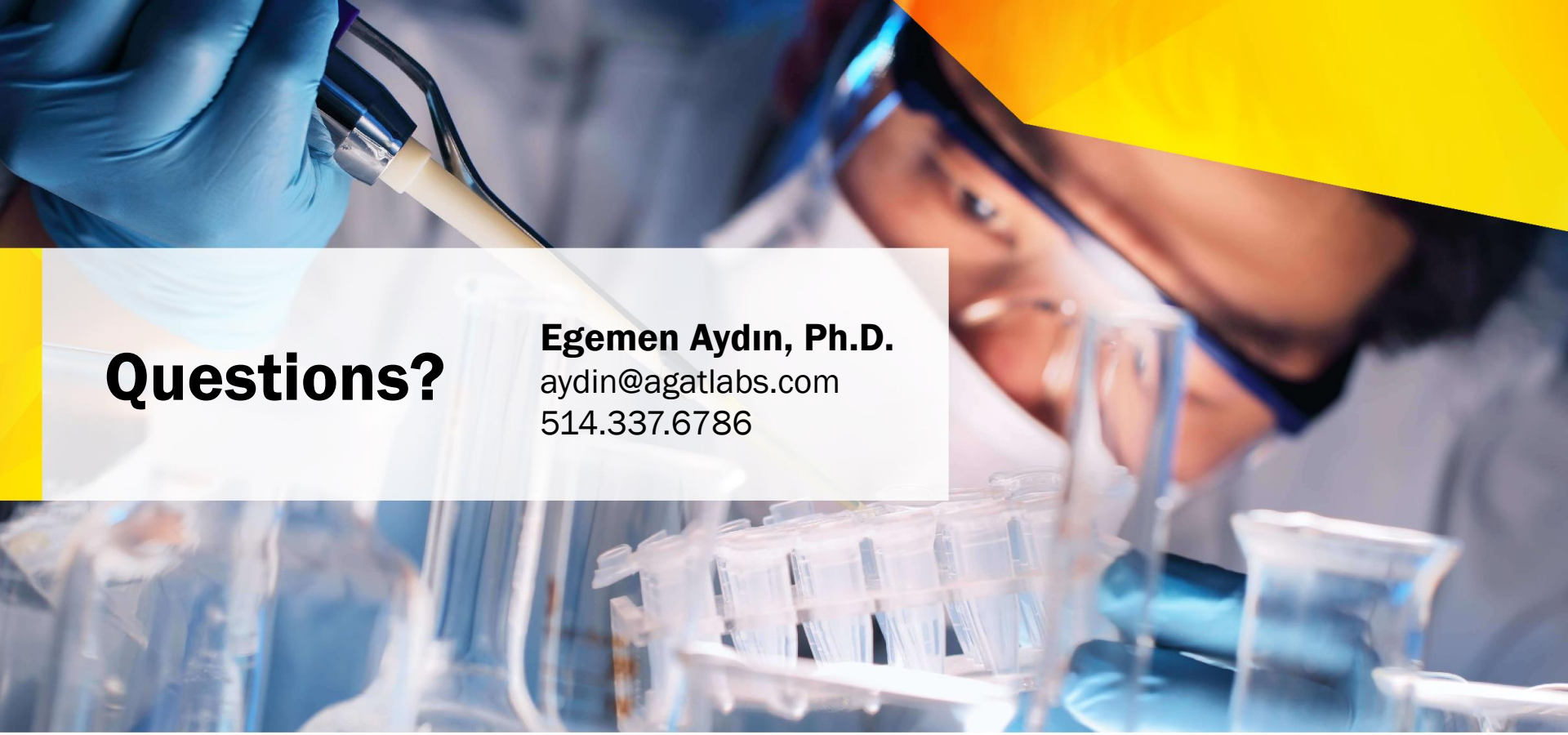
Bryan Chubb, C. Chem.



Questions?

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