PFAS in biosolids:
Partitioning during wastewater treatment and leaching from Florida biosolids

PFAS in e-waste:
Occurrence, types, and estimated quantities of PFAS in e-waste and appropriate management strategies for PFAS containing e-waste components

TAG Meeting 1 – March 20, 2023

Agenda

1. Introductions
2. Project overview
3. Planned tasks
4. Open discussion

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Hinkley Center
for Solid and Hazardous
Waste Management

PFAS in biosolids:

Partitioning during wastewater treatment and leaching from Florida biosolids

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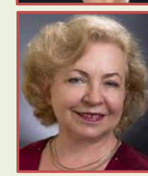
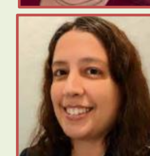


Natalia Soares Quinete, Assistant Professor
Florida International University, Environmental and Bioanalytical Chemistry



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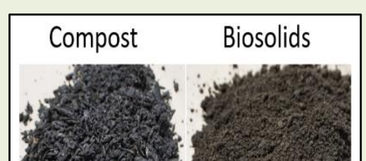
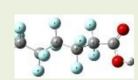




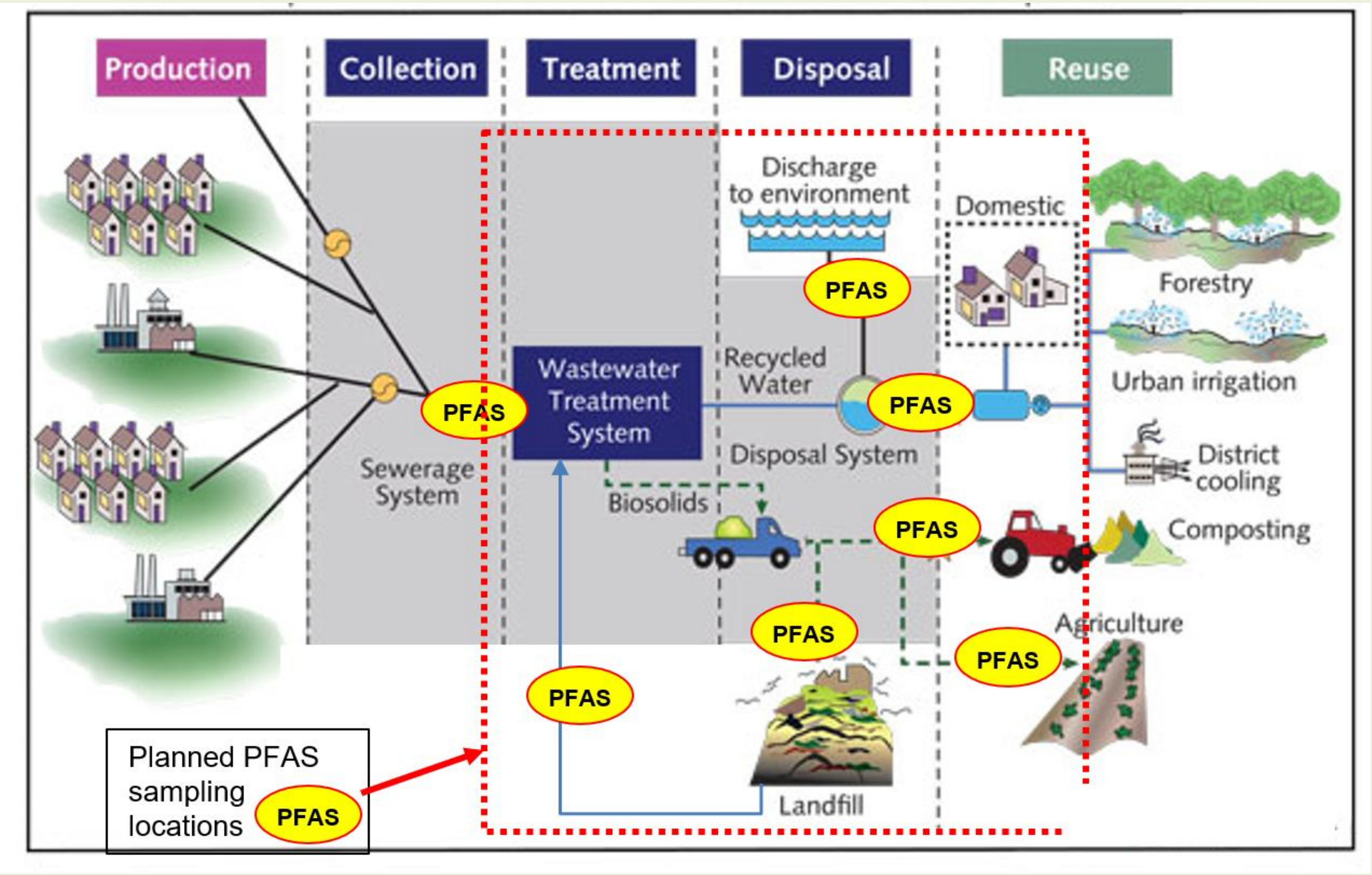
Where is PFAS in biosolids coming from ?

About 7.18 million tons per year (6.51 million kg/year) biosolid produced at wastewater treatment plants.

- 60% land-applied
- 20% landfilled
- 20% incinerated

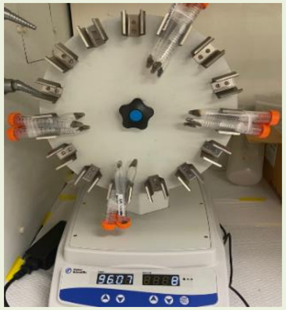
Landfilling biosolids contributes

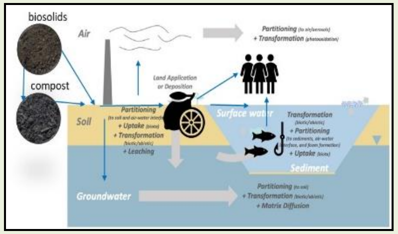
- 1,030 - 1,295 lbs of PFAS per year (470 to 590 kg/year) (Venkatesan and Halden, 2013; Dauchy et al., 2017)
- Land application of biosolids can result in uptake of perfluoroalkyl acids into edible crops (Blaine et al., 2013).



Objectives

1. Conduct **sampling of biosolids** after dewatering and drying processes at two Miami-Date wastewater treatment plants (South District and Central District Wastewater Treatment Plants).
2. Analyze biosolids samples for **PFAS content and component profile**; determine the prevalent PFAS compounds.
3. Conduct **leaching experiments** to evaluate the release of PFAS from biosolids under site-specific conditions.
4. Estimate **time dependent solubilization and the release** characteristics of the PFAS homologues from biosolids.
5. Further scientific understanding of **PFAS originating from biosolids as a source in the environment**, potential exposure pathways for human health and ecological effects.
6. Provide **recommendations** for appropriate testing and land application practices of biosolids in Florida.





Technical Approach

Tasks
Task 1. Biosolids sampling (Tansel)
Task 2. Chemical analyses of PFAS content in biosolids and leachates (Quinete)
Task 3. PFAS leaching experiments (Katsenovich)
Task 4. Estimation of PFAS release characteristics from biosolids (all)
Task 5. PFAS exposure from land application of biosolids and biosolids amended products (Tansel)
Task 6. Final report (guidance document) (all)
TAG Meetings

Technical Approach

Task 1. Biosolids sampling

1. Identify appropriate locations for biosolids sampling;
2. Sampling at two (2) wastewater treatment plants;
3. Samples will be collected for characterization and PFAS dissolution experiments:
   - before and after dewatering,
   - after drying, and
   - after composting processes

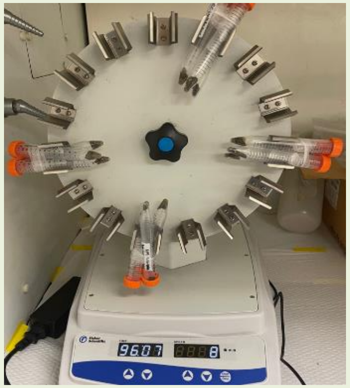
Technical Approach

Task 3. PFAS leaching experiments

Leaching experiments: laboratory batch experiments at biosolids/water ratio as 1:1 using a sacrificial approach. Homogenized and air dried biosolids

A control without biosolids but spiked with PFAS will be prepared to observe PFAS stability over the experimental period. Centrifuge tubes will be placed on an end-over-end tube revolver at 10 rpm.

To ensure a constant biosolids: water ratio, all samples will be sacrificed at certain times to evaluate for the release of PFAS after 1 day, 3 days, 7 days, 14 days, and 30 days.



FIU end-over-end tube revolver with PP tubes.

Technical Approach

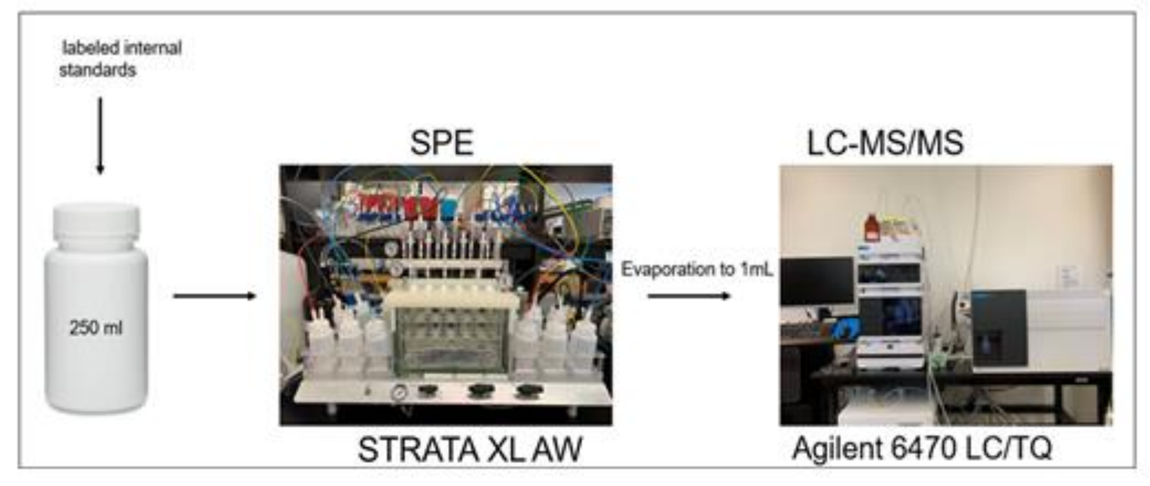
Task 2. Chemical analyses of PFAS content in biosolids and leachates

Identification of appropriate analytical techniques and methods for PFAS

- Establishment of appropriate PFAS sampling protocols and best practices.

Analyses

- Biosolids samples and reagent blanks will be analyzed by high-performance liquid chromatography.



FIU LC-MS/MS system for PFAS leachate analyses. Instrument detection limits 2-9 ng/L.

Technical Approach

Task 2. Chemical analyses of PFAS content in biosolids and leachates (cond.)

PFAS analytical capabilities, including the list of analytes and their detection limits, recoveries, repeatability and reproducibility.

Compounds	IDL (ng/L)	MDL (ng/L)	Recovery	Intraday variation	Interday Variation	Compounds	IDL (ng/L)	MDL (ng/L)	Recovery	Intraday Variation	Interday Variation
PFBA	0.26	0.05	102	4.10	5.36	PFOS	1.35	0.04	103	4.23	13
FBSA	2.04	0.05	113	2.28	5.93	6-2 FTS	44.6	0.35	128	3.47	7.04
PFBS	0.99	0.01	101	0.80	1.27	PFONS	1.98	0.022	92.5	2.9	4.68
PFPeA	9.00	0.13	103	6.10	10.10	PFNA	4.66	0.034	91.6	4.1	5.79
PFPeS	0.51	0.02	102	1.38	1.38	N-MeFOSAA	97.30	0.29	90.3	7.55	8.29
PFHxA	1.93	0.01	98.9	3.59	3.73	N-EtFOSAA	54.24	0.45	94.5	9.61	4.45
FHxSA	3.47	0.03	91.0	3.77	6.23	PFNS	2.77	0.011	64.7	9.68	12.1
PFHxS	2.31	0.04	102	4.67	3.55	PFDA	3.58	0.02	98.9	2.76	5.08
4-2 FTS	5.93	0.03	103	2.68	1.96	PFDS	18.32	0.33	98.6	9.74	14.5
Adona	0.98	0.02	100	4.67	4.66	8-2 FTS	47.76	0.02	94	3.25	7.15
GenX	5.90	0.02	100	1.43	2.99	PFUdA	7.98	0.2	105	3.69	5.22
PFHpA	1.76	0.05	121	3.62	10.00	PFDoA	32.7	0.22	113	3.42	6.83
PFHpS	8.55	0.04	102	3.95	4.04	PFTrDA	107.75	1.37	99.8	4.82	7.25
PFOA	2.04	0.04	98.9	6.18	9.29	PFTeDA	205.34	1.99	128	6.55	20.2
FOSA	5.16	0.04	106	4.34	2.99	PFONDS	66.01	0.36	103.8	9.71	13.3

IDL: instrument detection limits and MDL: method detection limit

Technical Approach

Task 4. Estimation of PFAS release characteristics from biosolids

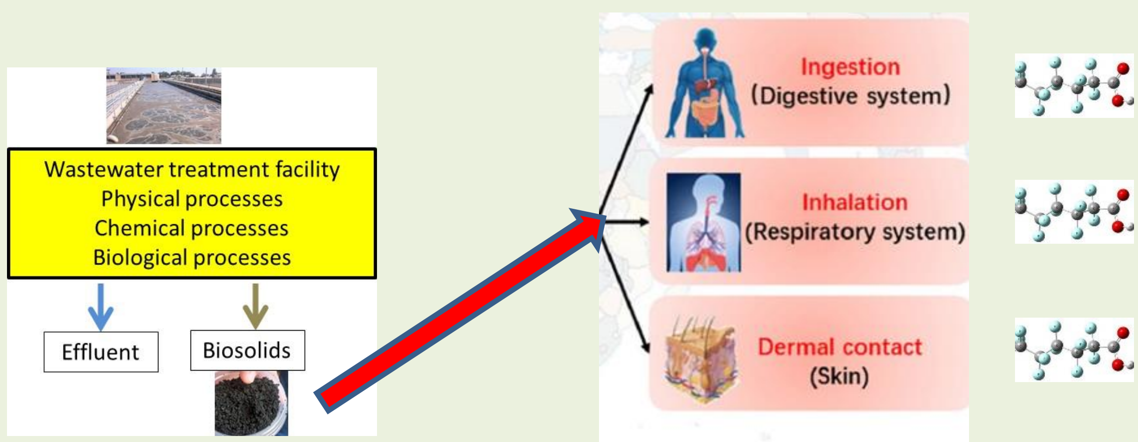
- PFAS release characteristics will be correlated with divalent metals and anions content released from biosolids during dissolution experiments.
- It has been reported in literature that the presence of divalent ions (e.g., Ca^{2+} or Mg^{2+}) at solid-liquid interface can affect sorption and desorption characteristics of PFAS on bio- and mineral materials (Du et al., 2014).
- PFAS release profile will be analyzed and interactive effects of cations on PFAS release will be quantified.

- If funded for a second year, a more detailed dissolution testing will be included in the research plans.

Technical Approach

Task 5. PFAS exposure from land application of biosolids and biosolids amended products

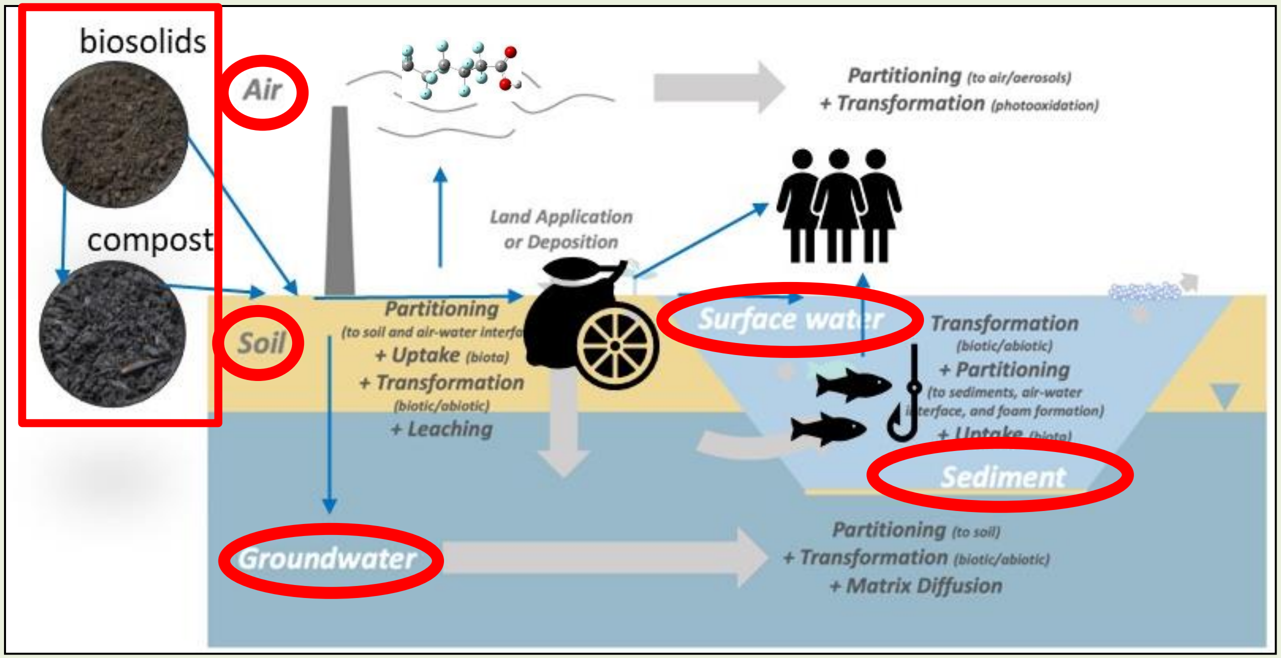
- Evaluate the potential PFAS exposure routes via land application of biosolids; potential exposure and threats to human health and the environment.
- Health risk assessment process based on selected PFAS characteristics (water solubility, organic carbon partition coefficient, and volatility).



Technical Approach

Task 5. PFAS exposure from land application of biosolids and biosolids amended products

- ingestion (water solubility and organic carbon partition coefficient),
- inhalation (volatility in air),
- dermal (lipid solubility), or ocular (water solubility).



Technical Approach

Task 6. Final report (guidance document)

The final report will include:

1. PFAS type and levels in biosolids,
2. PFAS release mechanisms from biosolids,
3. Experimental data results from leaching tests,
4. Release rates,
5. PFAS fate model, and
6. Relevant data and analyses.

Anticipated Benefits

Benefits for end users:

- What types of PFAS entering wastewater treatment plants partition to biosolids?
- Should we be concerned about PFAS in biosolids for land application?
- Do PFAS leach from biosolids over time?
- Is there any difference in PFAS content and composition in samples collected before and after dewatering, after drying, composted biosolids and leachate?
- Is there any effect on the PFAS dissolution behavior from biosolids in the presence of divalent metals like Ca^{2+} or Mg^{2+} that is potentially important to include in a fate and transport site evaluation?
- What is the current status of PFAS regulations in the US?
- Which PFAS should be included in a database for biosolids that would affect biosolids management.

What is e-waste

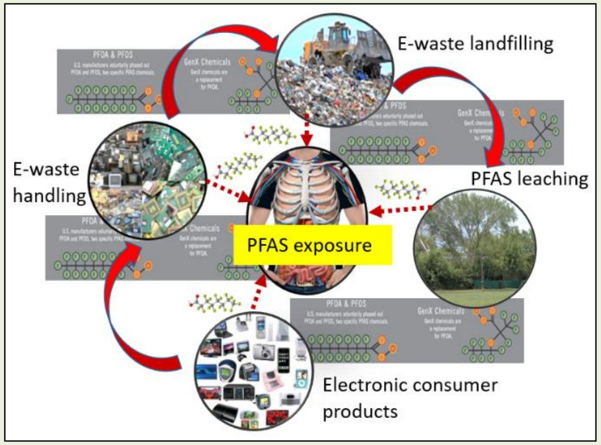
Old, end-of-life or discarded appliances using electricity. computers,

- consumer electronics (i.e., computers,
- LCD/CRT screens, mobile phones),
- large appliances (e.g., refrigerators, washer/dryers) and similar consumer products

E-product or service	Expected use time by consumers (yrs)
Flat panel television	7.4
Digital camera	6.5
DVD player or recorder	6.0
Desk top computer	5.9
Notebook, laptop computer	5.5
Tablet computer	5.1
Cell phone (not smart phone)	4.7
Smart phone	4.6

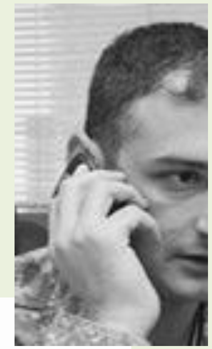
PFAS in e-waste:

Occurrence, types, and estimated quantities of PFAS in e-waste and appropriate management strategies for PFAS containing e-waste components



Telephone

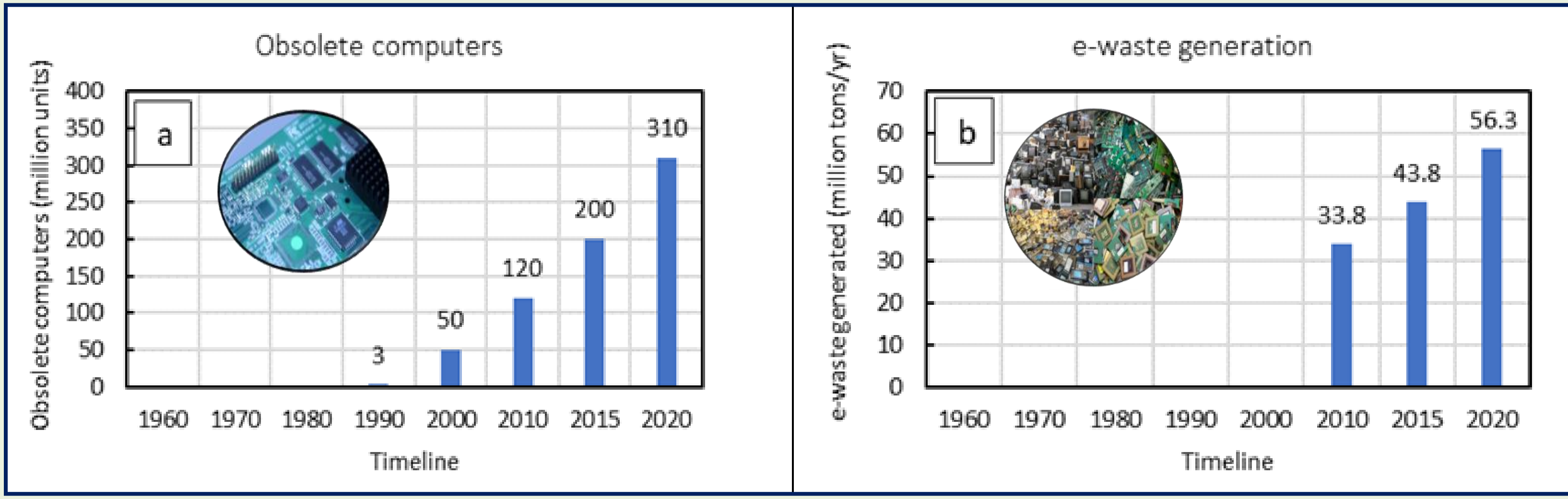
60 years



20 years

in progress for a good solution

Quantities of e-waste



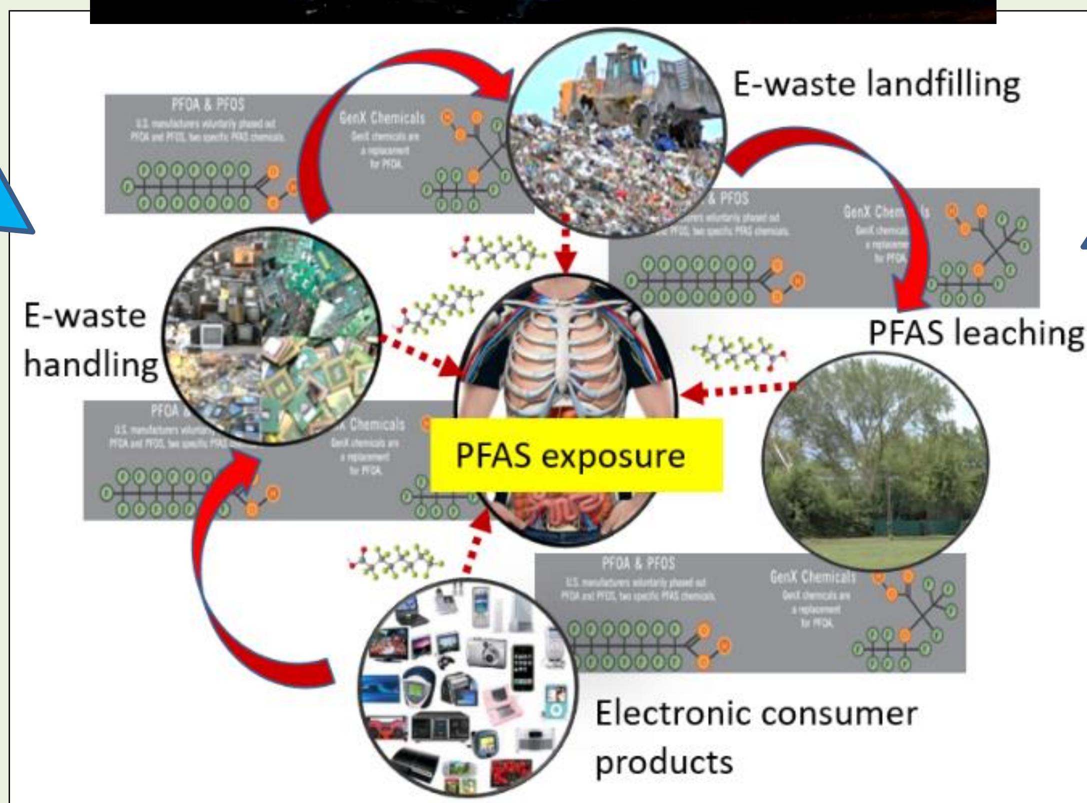
PFAS in e-waste

Product	Use in electronic system components and manufacturing processes	
Mobile devices	• Anti-smudge on touch panel	• Smoothness
Printed circuit boards	• Dielectric properties • Heat resistance	• Solder resistance • Low water absorption
Electric wire and cables	• Electric insulation • Dielectric properties	• Molding and processing
Foldable smartphones	• Transparency • Low dielectric constant	• Flexibility • Improving folding function
Electronic industry	• Testing electronic devices & equipment • Heat transfer fluids • Solvent systems and cleaning	• Carrier fluid/lubricant deposition • Etching piezoelectric ceramic filters
Semiconductor industry	• Photoresistance • Photosensitivity • Controlling diffusion of acid to unexposed regions • Reducing reflection on surface • Wetting agent • Non-stick coating on carrier wafers • Bonding agent	• Increasing stress tolerance • Separation of high voltage components (dielectric fluid) • Electrical signal for mechanical & thermal signals • Providing liquid crystal with dipole moment • Reducing static electricity build-up and dust attraction • Cleaning integrated circuit modules • Antireflective coating
Glass surface treatment & finishing	• Making glass hydrophobic and oleophobic • Preventing misting • Repelling dirt • Etching and polishing	• Improving fire or weather resistance • Increasing speed of etching, improving wetting • Solvent displacement drying
Metallic & ceramic surfaces	• Making surfaces hydrophobic and oleophobic	• Ease of cleaning
Wires and cables	• Increasing temperature endurance • Providing fire resistance	• Providing high stress crack resistance

What happens to e-waste

Exposure during handling

Leaching



Technical Approach

Tasks
Task 1. Visits to e-waste recycling centers and sampling of e-waste components
Task 2. Chemical analyses of PFAS content and type in e-waste
Task 3. Leaching experiments
Task 4. Modeling PFAS release and mobilization from discarded e-waste components
Task 5. PFAS exposure during e-waste handling
Task 6. Final report
TAG Meetings

Technical Approach

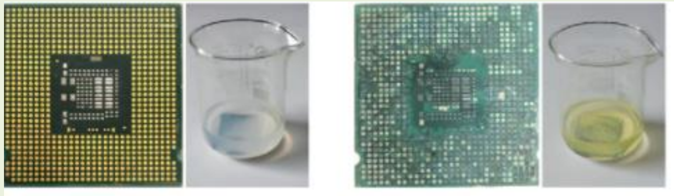
Task 3. Leaching experiments

Dissolution and leaching experiments under different environmental conditions (i.e., pH, temperature)

Release and leaching profiles of PFAS from selected e-waste components.

Specific samples tested will include:

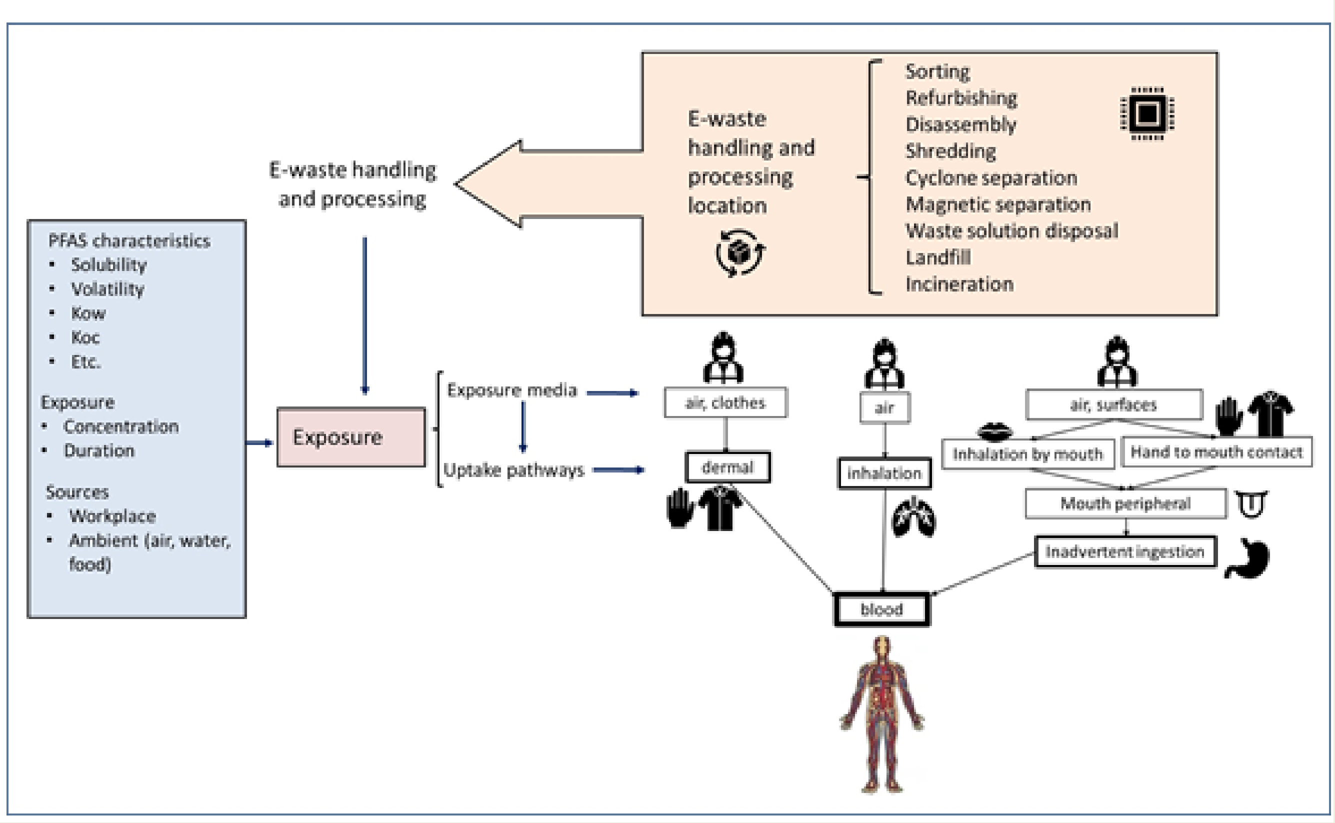
- Mobile devices
- Printed circuit brads
- Wires and cables
- Glass surfaces
- Flat panel displays or liquid crystal displays
- Metallic and ceramic surfaces



Technical Approach

Task 5. PFAS: in leachate + exposure via e-waste handling

- ingestion (water solubility and organic carbon partition coefficient),
- inhalation (volatility in air),
- dermal (lipid solubility), or ocular (water solubility).



Thank you.

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