Unregulated Organic Chemicals (UOCs) in Biosolids: Prioritization, Fate and Risk Evaluation for Land Applications

(EPA Grant 84042501)

March 26, 2024
Midwest Biosolids Association
First Conference Meeting, Beck Center

THE Water Research FOUNDATION

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Water Environment Federation the water quality people

Unregulated Organic Chemicals (UOCs) in Biosolids: Prioritization, Fate and Risk Evaluation for Land Applications

TASK 1

Prioritization of UOCs

- Database of UOCs in Biosolids
- List of high priority UOCs

TASK 2

Two rapid assays for UOCs in biosolids:
1) Mobile fraction
2) Bioavailable fraction

TASK 3

Field Evaluations:

- 6 sites
- Class A in food or feed crop fields
- Class B for non-ag site
- Leaching/runoff
- Plant uptake
- Worm accumulation

TASK 4

Exposure Assessment & Risk Modeling:

a) Literature data

b) Field study results

c) Model formulations & recommendations

TASK 5

Stakeholder Collaboration & Engagement

(EPA Grant 84042501)

Synopsis of Project Activities

Objective 1

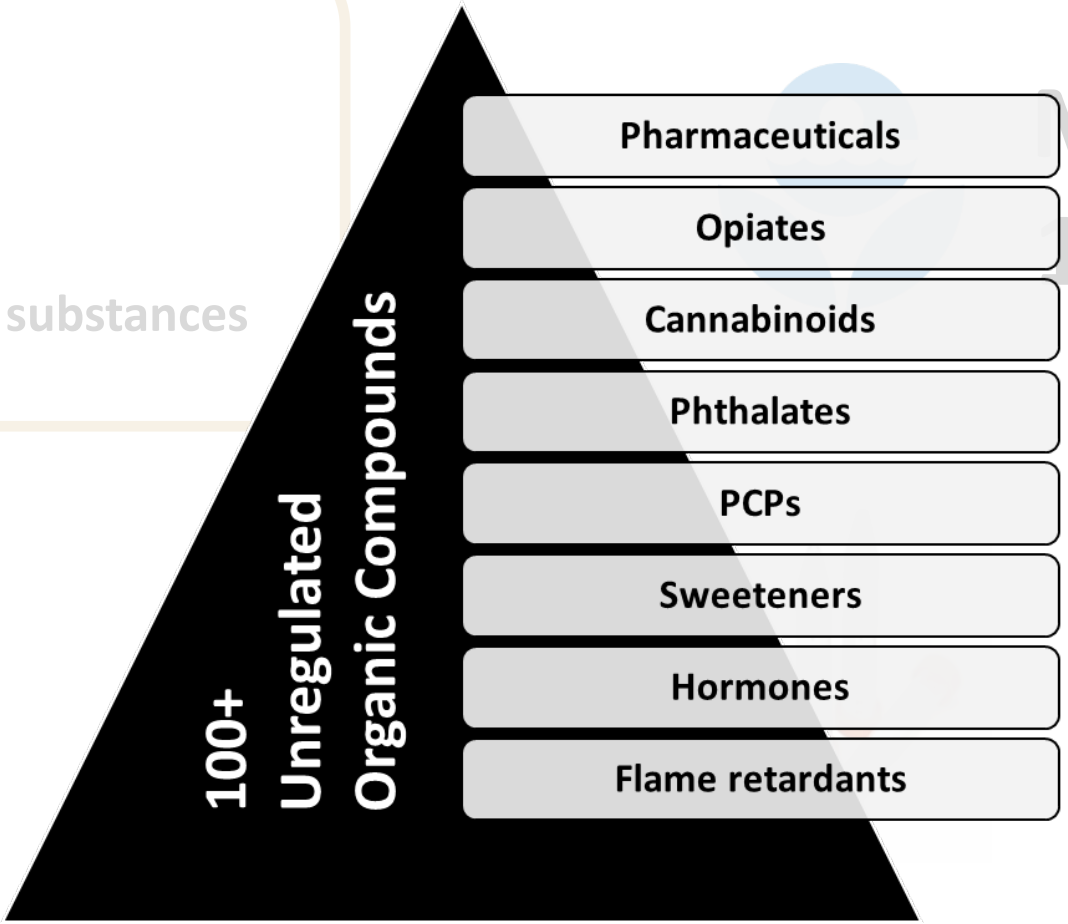
- Assessment and prioritization
- Comparison of other prioritization lists
- Comparison with measured biosolids data
- Where we are - 45 High Priority UOCs Identified for risk assessment

UOC Method development (We had PFAS covered)

Biosolids

- Salts
- Lipids
- Humic substances

Soil

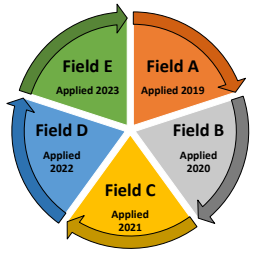


Modified EPA 1694 method

EMR-Lipid

Study sites

Site 1

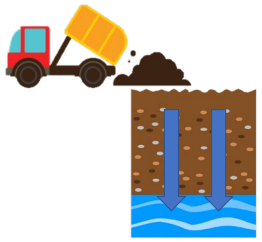


5- year cycle snapshot

Crop uptake

Persistence after biosolids applicati

Site 2

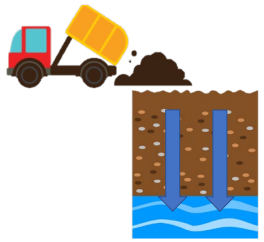


Accumulation and mobility at ~40-y DLD field site

Persistence and mobility at a newly applied site

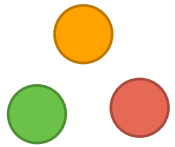
UOC/PFAS in soil profile from irrigated water

Site 3



Historically applied as a fertilizer for crops with different soil properties than Site 1 or 2

Site 4



Persistence and mobility for three soil types

Crop uptake for three soil types

Sampling plan for USA Site 1

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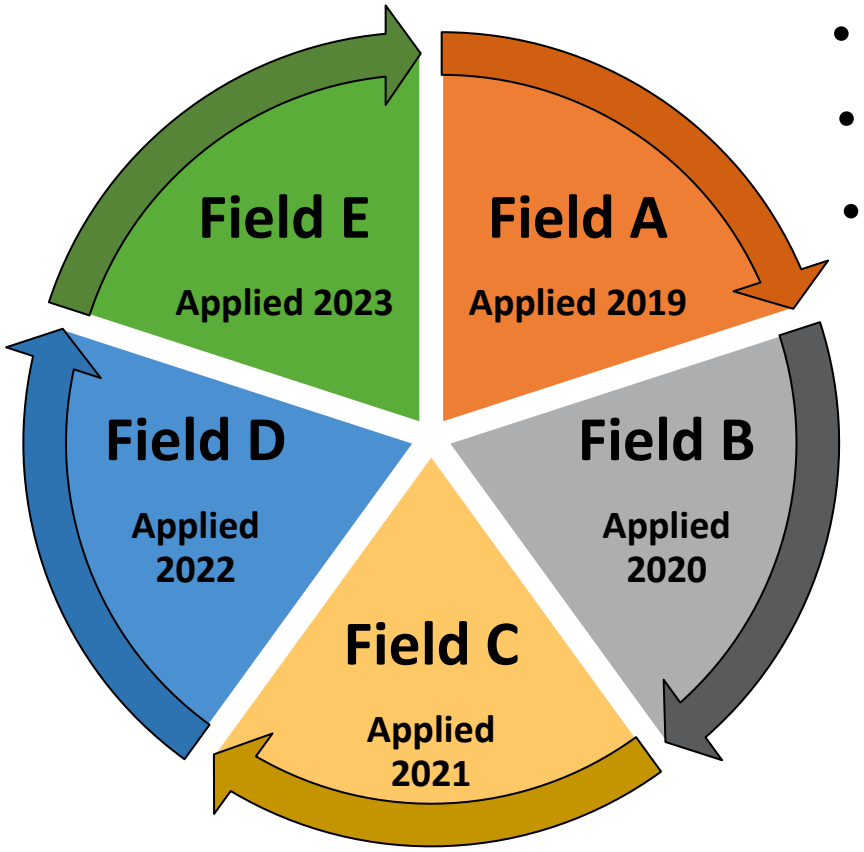
5-year biosolids application cycle



Site characteristics

- 1 field applied per year in a 5 –y cycle
- Biosolids stored outside until applied
- Low depth to water table and no wells

Snapshot of PFAS and UOCs fate and persistence in the 5-year rotation

Tracking persistence on a freshly applied area

Crop uptake of PFAS and UOCs present in the biosolids applied to the fields

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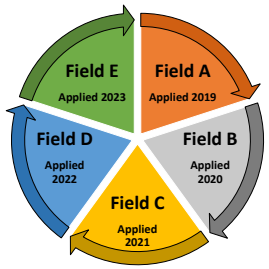
Site 1 UOCs



2022 Biosolids

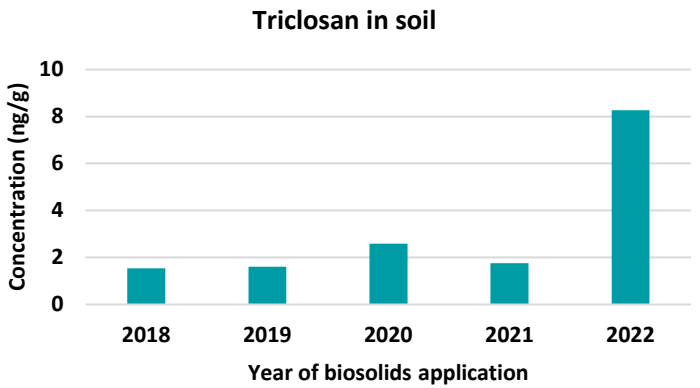
Concentration detected in Biosolids (d.w.) with SPE

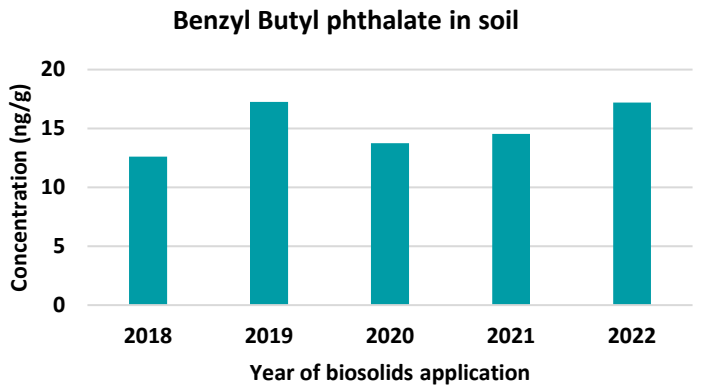
	Compound	Concentration (ng/g)	CV%
Opiates	Naloxone	1100	59.8
PCPs	DEET ←	22	10.8
	Oxybenzone	140	25.4
	Bisphenol A	590	38.2
	Nonylphenol	4300	26.9
Pharmaceuticals	Harmane	48	18.3
	Miconazole ←	700	4.6
	Ciprofloxacin	300	23.6
	Diphenhydramine ←	230	9.1
	Maprotiline	98	9.2
	Ofloxacin	270	15.9
	Amiodarone	120	5.8
	Amitriptyline	48	25.2
	Hydroxychloroquine	670	9.3
	Tonalide	2000	13.7
	Ibuprofen	410	19.7
	Salicylic acid ←	9300	24.3
	Sebacic acid	2700	33.6
	Triclosan ←	160	8.8
	Azelaic acid ←	43000	17.1
Phthalates	Di(2-ethylhexyl) phthalate	2800	2.0
	Diisodecyl phthalate	1300	1.4

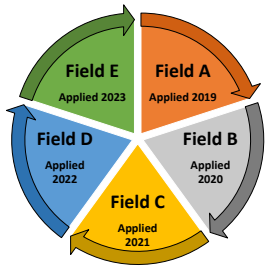
5-year snapshot in soil

Concentration detected in soil by year of application (d.w.) (ng/g)

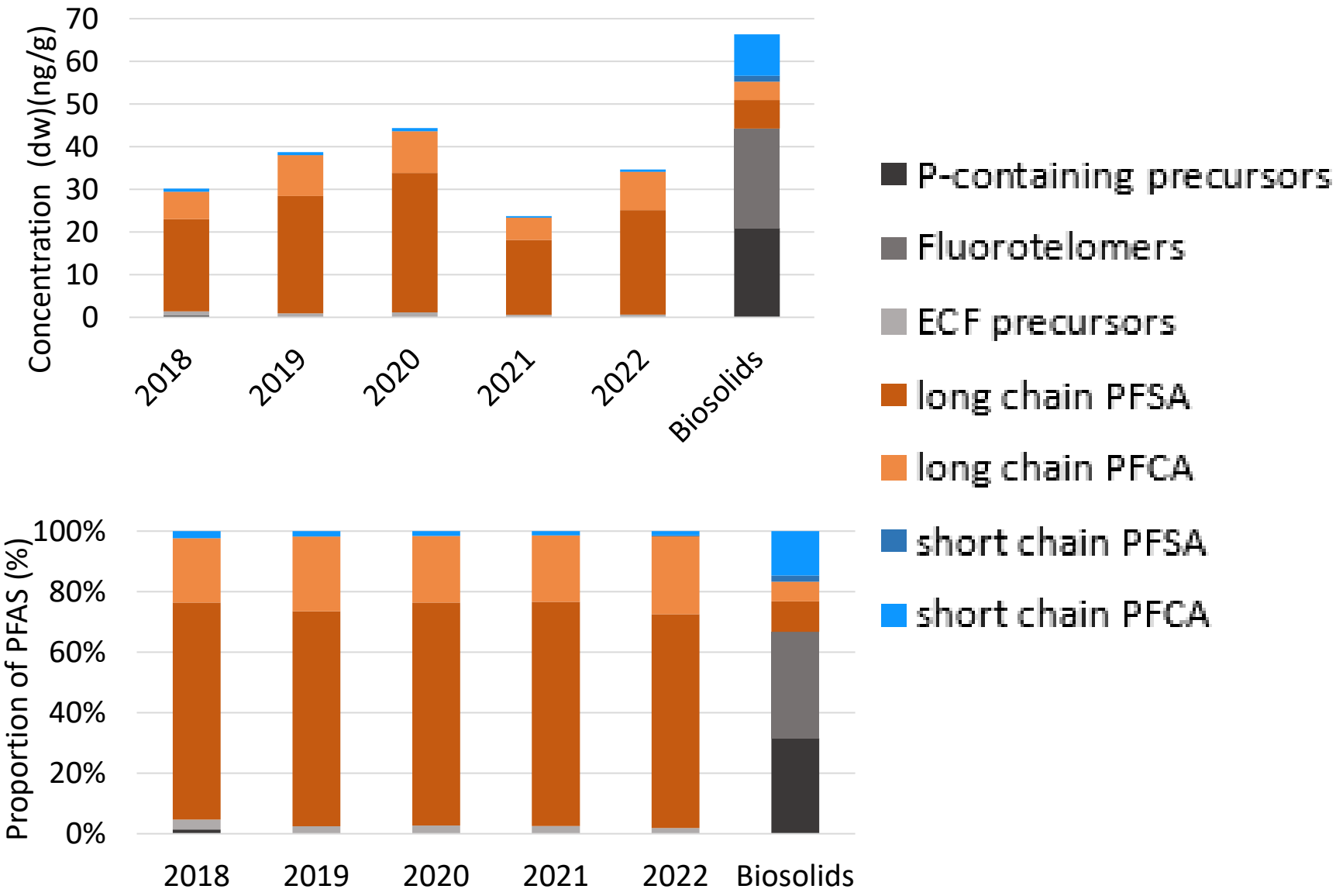
	Compound	2018	2019	2020	2021	2022
PCPs	DEET ←	n.d.	24.16	17.87	19.97	17.72
Pharmaceuticals	Miconazole ←	*1.8*	*0.47*	*2.61*	*1.39*	*1.06*
	Diphenhydramine ←	n.d.	12.18	n.d.	n.d.	n.d.
	Fluoxetine	n.d.	2.34	4.59	n.d.	n.d.
	Carbamazepine	n.d.	1.84	3.22	n.d.	n.d.
	Triclosan ←	1.54	1.61	2.59	1.76	8.27
Phthalate	Benzyl Butyl phthalate ←	12.6	17.25	13.74	14.53	17.21
	Di(2-ethylhexyl) phthalate ←	19.21	26.75	29.94	*7.19*	*10.81*
	Dibutyl phthalates	8.87	5.23	10.17	2.4	9.64
	Diisodecyl phthalate	1.14	0.48	n.d.	n.d.	1.16
	Diethyl phthalate	5.79	2.29	1.48	n.d.	*1.28*





Site 1  PFAS

5-year snapshot
2023 Sampling
PFAS concentrations and %
Distribution of PFAS groups



Site 2 (DLD) and Neighboring Fields

Site 2 Sampling areas

Dedicated Land Disposal (LDL) Area:

Site - annual subsurface injection of biosolids have occurred for ~40 years at NON-agronomic rates.

Dry farmed area:

Biosolids and effluent water were never applied

Dry farmed crops

Application of biosolids will begin this year

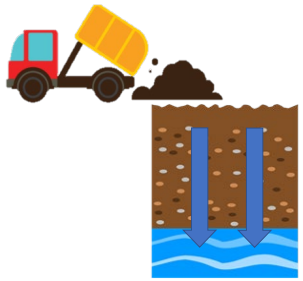
Spray irrigated área:

Effluent treated water is sprayed during the dry months

Irrigated crops

Objectives

- PFAS/UOCs distribution and mobility after decades of dedicated land disposal as a waste management strategy (DLD)
- Impact of first applications of biosolids in a field
- PFAS/UOCs leaching profiles under effluent irrigation
- Crop uptake of UOCs/PFAS present in the biosolids and eluent treatment water (APN33 and APN13+14)



Site 2
DLD

2022 Biosolids

Concentration detected in Biosolids (d.w.) with SPE

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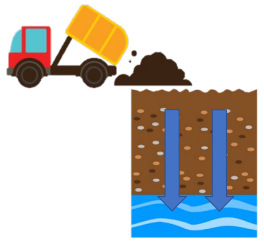
Opiates	Naloxone	1100	59.8
PCPs	DEET	22	10.8
	Oxybenzone	140	25.4
	Bisphenol A	590	38.2
	Nonylphenol	4300	26.9
Pharmaceuticals	Harmane	48	18.3
	Miconazole	700	4.6
	Ciprofloxacin	300	23.6
	Diphenhydramine	230	9.1
	Maprotiline	98	9.2
	Ofloxacin	270	15.9
	Amiodarone	120	5.8
	Amitriptyline	48	25.2
	Hydroxychloroquine	670	9.3
	Tonalide	2000	13.7
	Ibuprofen	410	19.7
	Salicylic acid	9300	24.3
	Sebacic acid	2700	33.6
	Triclosan	160	8.8
	Azelaic acid	43000	17.1
Phthalates	Di(2-ethylhexyl) phthalate	2800	2.0
	Diisodecyl phthalate	1300	1.4

Surface soil

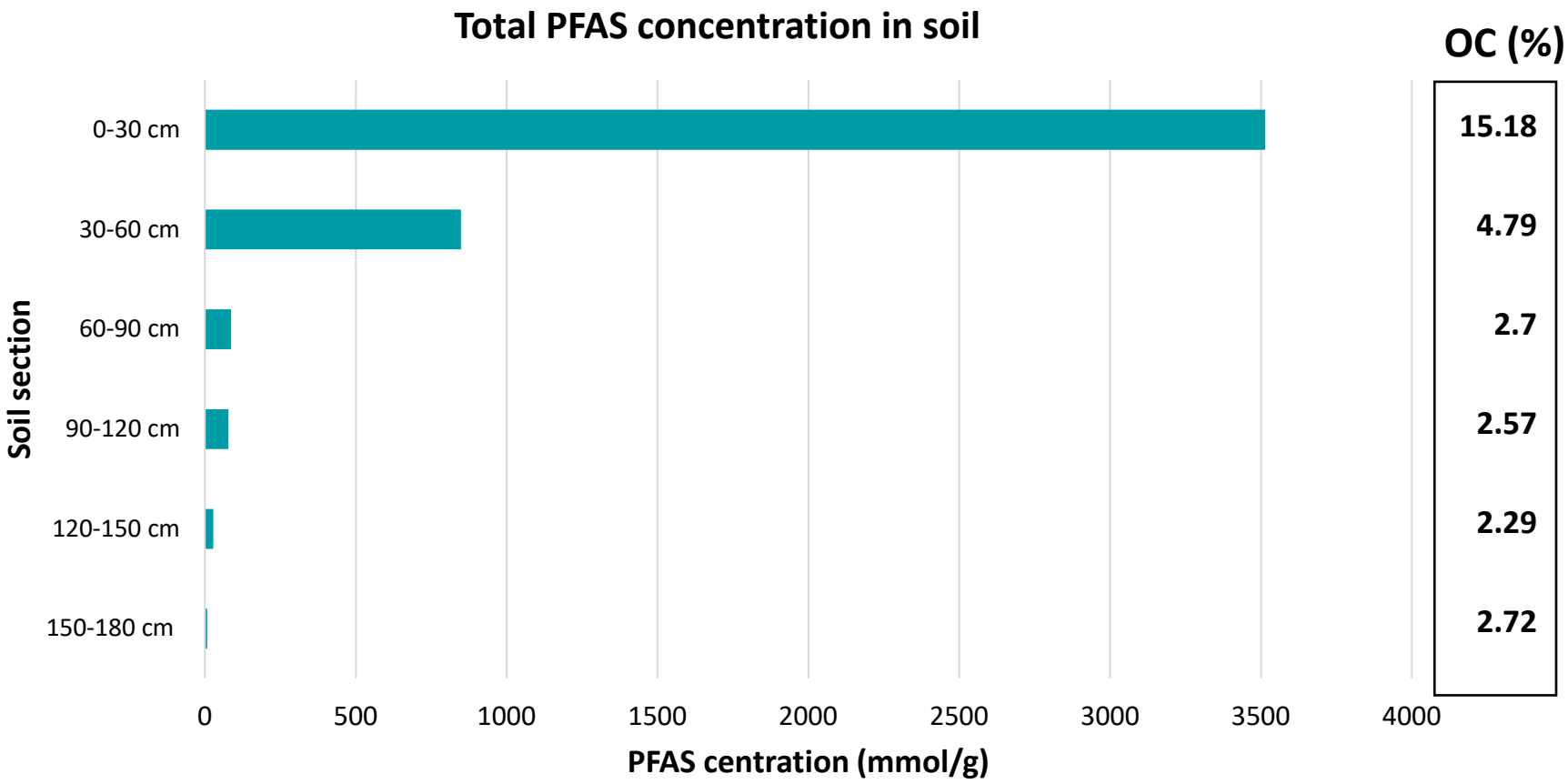
Concentration detected in Soil (d.w.) with SPE

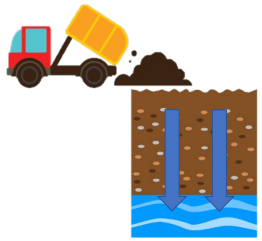
	Compound	Concentration (ng/g)	CV%
Flame retardants	Tris(2-butoxyethyl) phosphate	86	10.8
Opiates	Fentanyl	<LOQ	-
	Methadone	59	5.6
	Naloxone	250	67.7
PCPs	Bisphenol A	38	31.6
	Nonylphenol	3600	10.9
Pharmaceuticals	Miconazole	580	2.8
	Diphenhydramine	600	5.0
	Doxepin	17	12.2
	Fluoxetine	470	4.3
	Haloperidol	13	10.5
	Maprotiline	57	8.2
	Venlafaxine	44	10.9
	Amiodarone	<LOQ	-
	Amitriptyline	53	3.8
	Carbamazepine	7	19.4
	Tonalide	1100	14.1
	Ibuprofen	60	16.1
	Sebacic acid	35	24.3
	Triclosan	180	8.5
Phthalates	Benzyl Butyl phthalate	27	14.7
	Di(2-ethylhexyl) phthalate	460	17.1
	Dibutyl phthalates	13	10.6
	Diisodecyl phthalate	300	22.9

Site 2



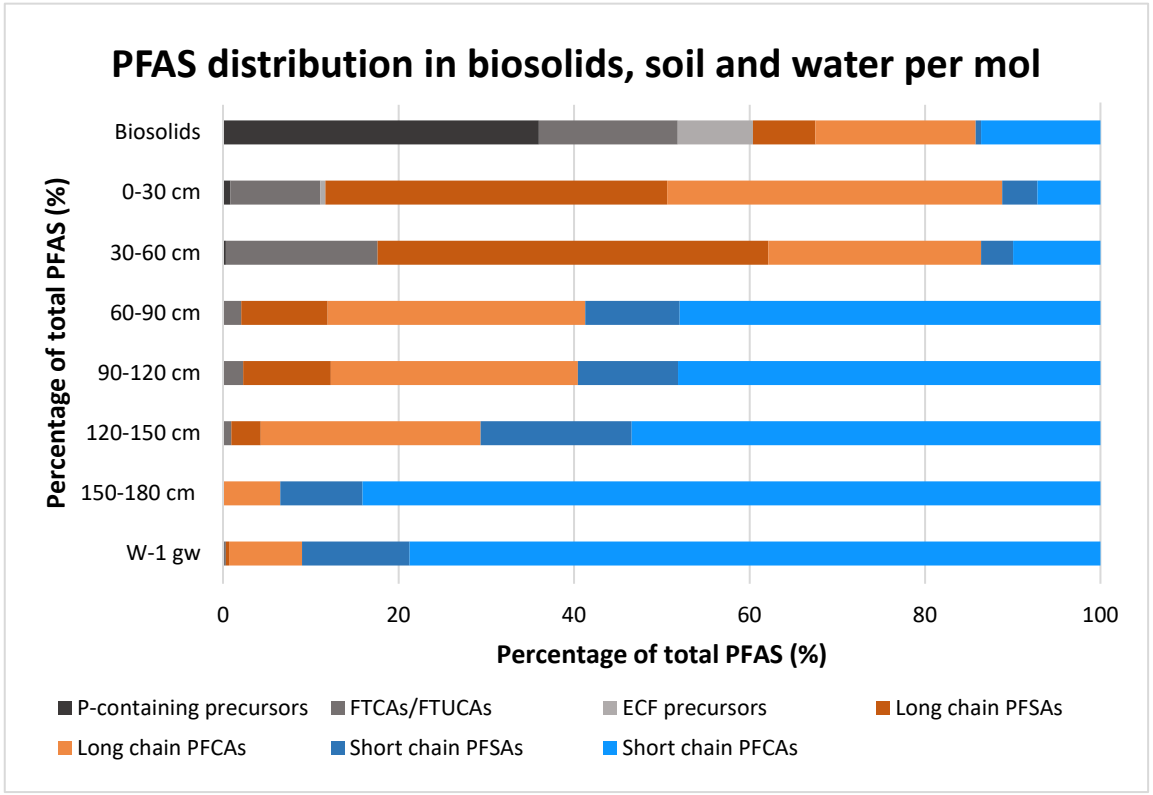
PFAS mobility in the DLD area

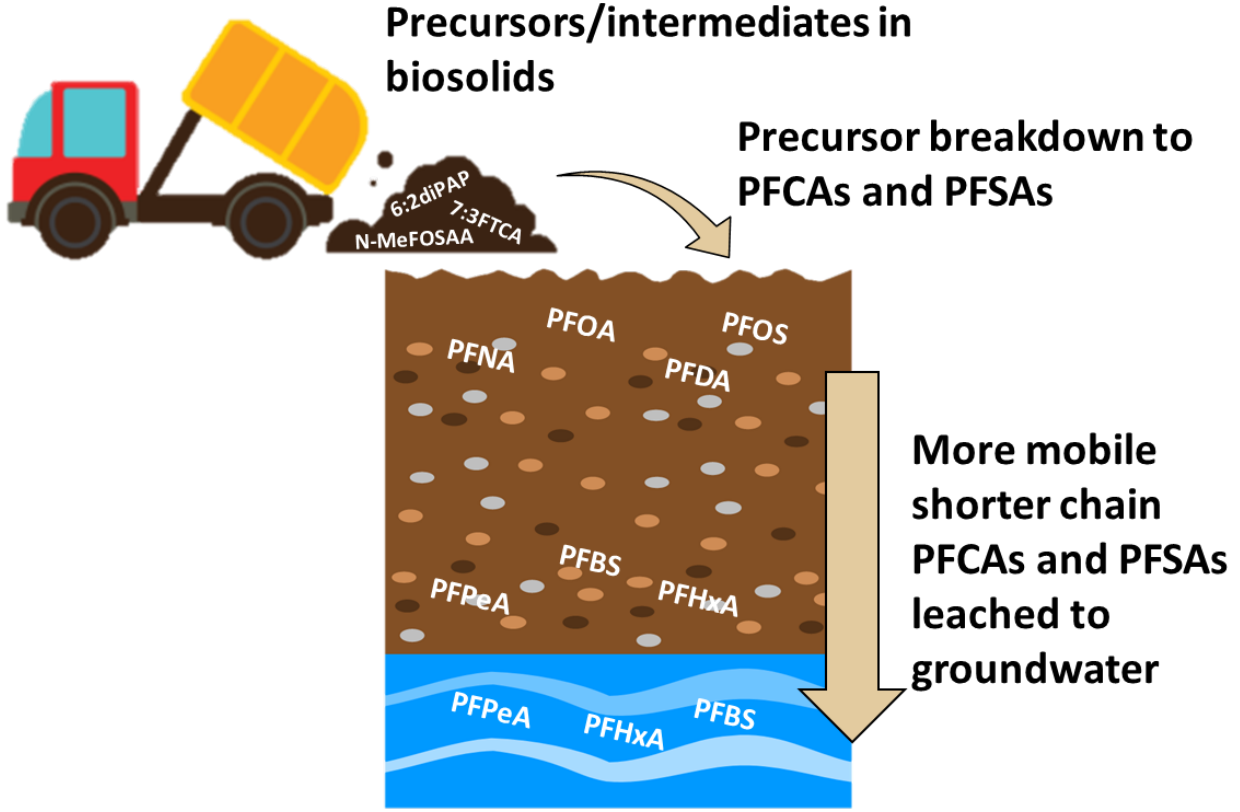




Site 2

PFAS mobility in the DLD area





Site 3

Concentration detected in Biosolids (d.w.) with SPE

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PCPs	DEET	22	10.8
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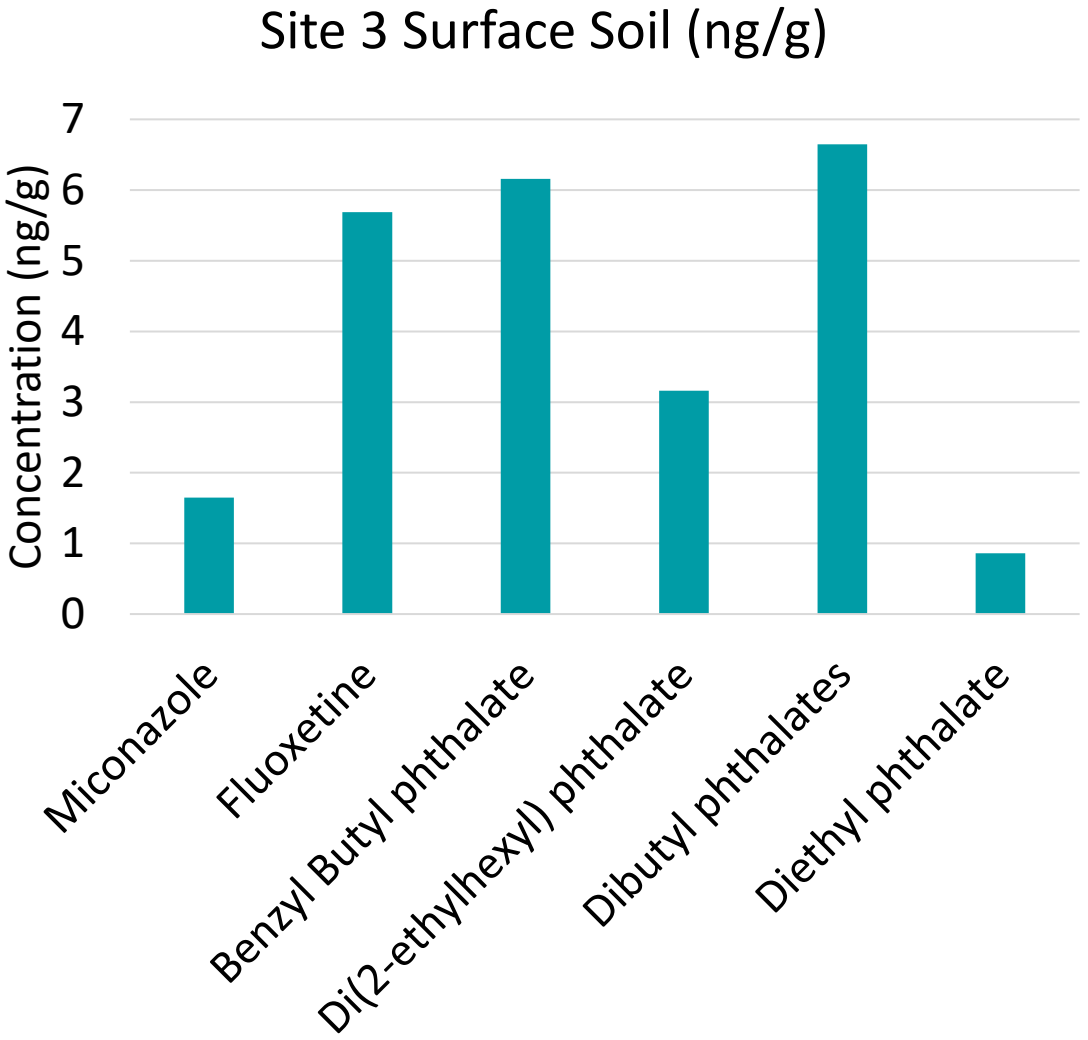
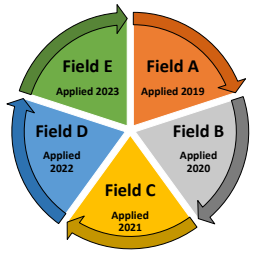


Future work

Extraction and analysis | In the queue | On going | Next season

Site 1

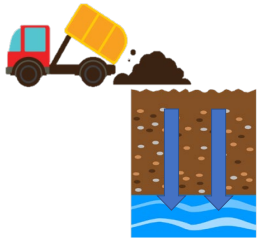


5- year cycle snapshot

Crop uptake +1

Persistence after biosolids applicati

Site 2

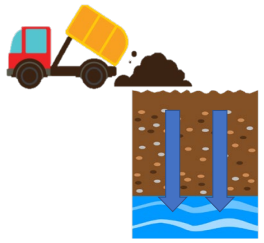


Accumulation and mobility at historically applied field +1

Persistence and mobility at a newly applied site +1

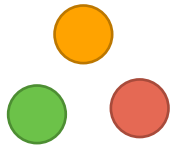
Mobility of PFAS from irrigated water

Site 3



Historically applied with different soil properties

Site 4



Persistence and mobility at three soil types

Crop uptake at the three soil types

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UCR: Ongoing Work for Task 3

Task 3: Conduct field studies under different application scenarios at various sites to support a national approach

Cool Season Vegetable Study

- 9/30/2022-12/29/2022
- Study completed: 8/23/2023

Warm Season Vegetable

- 6/27/2023-9/11/2023
- Samples stored and ready for extraction and analysis

UCR: Ongoing Work for Task 3

Task 3: Conduct field studies under different application scenarios at various sites to support a national approach

Fruit Study

- Young trees planted in 2022
- Field study planned for 2024-2025

Thank you!

Lee Lab Research Group

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