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PFAS and Biosolids: The EPA Roadmap, What States and Utilities Are Doing, and a Research Approach to PFAS in Biosolids Land Application

Thursday, December 9, 2021

1:00 PM – 2:30 PM ET

Water Environment Federation®
the water quality people®

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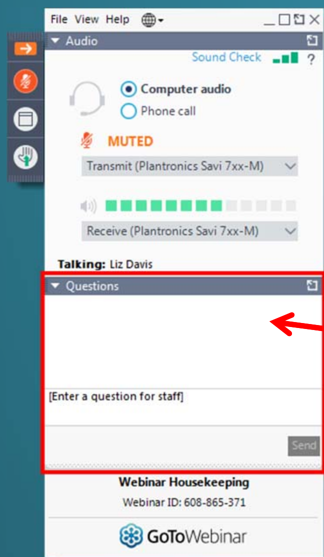
How to Participate Today



- **Audio Modes**
  - Listen using Mic & Speakers
  - Or, select "Use Telephone" and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this webcast.**

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Today's Presenters

Introduction: Alexie Kindrick, Tetra Tech
Moderator: Maile Lono-Batura, WEF Director, Sustainable Biosolids Programs

Speakers:

Deborah Nagle, Director
US Environmental Protection Agency, Washington, DC
Office of Water, Office of Science & Technology

Anne Tavalire, Regional IPP PFAS Specialist
Michigan Department of Environment, Great Lakes, and Energy (EGLE).

Dr. Jeff Prevatt, Deputy Director
Pima County Regional Wastewater Reclamation Department (RWRD)

Dr. Ian Pepper, Environmental Microbiologist
University of Arizona (WEST Center)

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PFAS Strategic Roadmap:
EPA's Commitments to Action 2021-2024

epa.gov/pfas

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Overview of Today's Briefing

- **EPA Council on PFAS**: Roadmap and Early Actions
- **EPA's Approach to Tackling PFAS**: Principles and Goals
- **Actions**: Commitments and Timelines
- **Next Steps**: Engagement and Implementation

PFAS Strategic Roadmap: EPA's Commitments to Action 2021–2024

EPA 6

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EPA Council on PFAS: Roadmap and Early Actions

- EPA Administrator Michael Regan established the EPA Council on PFAS in April 2021 and charged it to develop a bold, strategic, whole-of-EPA strategy to protect public health and the environment from the impacts of PFAS.
- The Council is comprised of senior technical and policy leaders from across EPA program offices and Regions and is chaired by Assistant Administrator for Water Radhika Fox and Acting Region 1 Administrator Deb Szaro.
- The PFAS Council developed a strategic roadmap to lay out EPA's whole-of-agency approach to tackling PFAS and set timelines by which the Agency plans to take concrete actions during the first term of the Biden-Harris Administration. The Roadmap fills a critical gap in federal leadership, provides a basic floor of federal protection, and supports states' ongoing efforts to address PFAS.
- Complementing the strategic roadmap, EPA has already taken bold actions on PFAS since January 2021, including on drinking water, hazardous substance designation, effluent guidelines, and chemical safety.

EPA's Approach to Tackling PFAS: Principles

PFAS contamination poses unique challenges, and EPA must use every tool in its tool box. EPA's approach is centered around the following principles:

- Consider the Lifecycle of PFAS.
- Get Upstream of the Problem.
- Hold Polluters Accountable.
- Ensure Science-Based Decision-Making.
- Prioritize Protection of Disadvantaged Communities.

EPA's Approach to Tackling PFAS: Goals

RESEARCH

Invest in research, development, and innovation to increase understanding of PFAS exposures and toxicities, human health and ecological effects, and effective interventions that incorporate the best available science.

RESTRICT

Pursue a comprehensive approach to proactively prevent PFAS from entering air, land, and water at levels that can adversely impact human health and the environment.

REMEDIATE

Broaden and accelerate the cleanup of PFAS contamination to protect human health and ecological systems.

EPA Actions

- Office of Chemical Safety and Pollution Prevention
- Office of Water
- Office of Land and Emergency Management
- Office of Air and Radiation
- Office of Research and Development

Actions: Office of Water

- **Publish final toxicity assessment for GenX and five additional PFAS (PFBA, PFHxA, PFHxS, PFNA, PFDA).** GenX published October 2021; others ongoing.
- **Publish health advisories for GenX and PFBS.** Expected Spring 2022.
- **Restrict PFAS discharges from industrial sources through a multi-faceted Effluent Limitations Guidelines program.** Expected 2022 and ongoing.
- **Leverage National Pollutant Discharge Elimination System permitting to reduce PFAS discharges to waterways.** Expected Winter 2022.
- **Publish improved analytical methods.** Expected Fall 2022 and Fall 2024.
- **Publish final recommended ambient water quality criteria for PFAS.** Expected Winter 2022 and Fall 2024.
- **Enhance data availability on PFAS in fish tissue.** Expected Summer 2022 and Spring 2023.
- **Finalize risk assessment for PFOA and PFOS in biosolids.** Expected Winter 2024.
- **Undertake nationwide monitoring for PFAS in drinking water.** Final rule expected Fall 2021.
- **Establish a national primary drinking water regulation for PFOA and PFOS.** Proposed rule expected Fall 2022, final rule expected Fall 2023.

GenX -Scope of Toxicity Assessment

- **GenX Chemicals:** HFPO Dimer Acid and its Ammonium Salt
- **Sources of Exposure:** industrial facilities that use GenX technology for polymer production, facilities that produce fluoromonomers, contaminated water, air, soil, biosolids, and possibly others
- **Exposure Routes:** Oral
- **Health Outcomes:** Liver, Hematological, Reproductive/Developmental, Kidney, Immune, Cancer
- **Potentially susceptible groups:** Adults, Children, Pregnant Women and their developing embryo/fetus, and Lactating Women in general population

GenX - Final Reference Doses (RfDs)

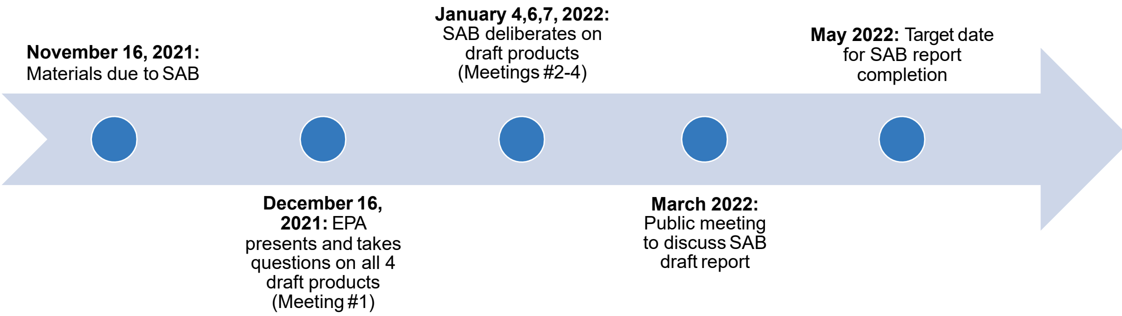
	2018 Public Comment Draft	2021 Final
Critical Study	Oral reproductive and developmental toxicity study (Dupont 18405-1037, 2010)	Oral reproductive and developmental toxicity study (Dupont 18405-1037, 2010)
Critical Effect	Single cell necrosis in parental males	Constellation of liver lesions (defined by the NTP PWG to include cytoplasmic alteration, hepatocellular single cell and focal necrosis, and hepatocellular apoptosis) in parental females
Dosing Duration	84 - 85 days	53 – 64 days (depending on timing of conception)
POD_{HED}	0.023 mg/kg/day	0.01 mg/kg/day
UF_L	1	1
UF_S	3 (1 for subchronic RfD)	10 (1 for subchronic RfD)
UF_A	3	3
UF_H	10	10
UF_D	3	10
UF_{TOTAL}	300 (100 for subchronic RfD)	3000 (300 for subchronic RfD)
RfD	Subchronic = 2×10^{-4} mg/kg/day Chronic = 8×10^{-5} mg/kg/day	Subchronic = 3×10^{-5} mg/kg/day Chronic = 3×10^{-6} mg/kg/day

PFAS National Primary Drinking Water Regulation

EPA is seeking advice from the EPA's SAB on four draft scientific products to be used to inform the PFAS NPDWR –

- Proposed Approaches to the Derivation of a Draft MCLG for PFOA
- Proposed Approaches to the Derivation of a Draft MCLG for PFOS
- Framework for Estimating Noncancer Health Risks Associated with Mixtures of PFAS
- Analysis of Cardiovascular Disease Risk Reduction as a Result of Reduced PFOA and PFOS Exposure

PFAS NPDWR - SAB Peer Panel Public Meetings



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PFAS NPDWR - Systematic Review of PFOA and PFOS Health Effects Literature since 2016 Health Advisories

New literature since 2016 HAs	PFOA	PFOS
# of new animal tox studies	25 relevant studies	29 relevant studies
# of new human epidemiological (epi) studies	350 relevant studies	338 relevant studies
# of new cancer studies – epi; tox	13 (8 medium or high quality); 1	11 (8 medium or high quality); 0
Health effects observed	Strongest evidence for: immune, developmental, cardiovascular, hepatic effects and cancer Suggestive evidence for: reproductive, nervous, endocrine, and metabolic effects	Strongest evidence for: immune, developmental, cardiovascular, and hepatic effects Suggestive evidence for: reproductive, nervous, endocrine, metabolic effects, and cancer
# of new PK or PBPK studies	44 relevant studies	37 relevant studies

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PFAS NPDWR - 2021 Draft RfDs for PFOA & PFOS

- PFOA and PFOS will be first NPDWRs for any PFAS
- PFOA and PFOS RfDs anticipated to be much lower and PFOA CSF anticipated to be higher than those in the 2016 Health Advisory based on
  - New studies (2016 to present) with health effects identified at lower doses than prior developmental/reproductive studies
  - Quantitative use of epidemiology data
  - Updated toxicokinetic models

	PFOA	PFOS
2021 Preliminary Noncancer critical effects and candidate draft RfDs (mg/kg/day)	**Developmental immune (antibody response; epidemiological [epi] study): 1.5 X 10^{-9}**	**Developmental immune (antibody response; epi): 8 X 10^{-9}**
	Developmental (birth wt; epi): ~10^{-7} to 10^{-8}	Developmental (birth wt; epi): ~10^{-7} to 10^{-8}
	Cardiovascular (increased total cholesterol; epi): ~10^{-7} to 10^{-8}	Cardiovascular (increased total cholesterol; epi): ~10^{-7} to 10^{-8}
2016 Noncancer final RfD (mg/kg/day)	2X10^{-5}	2X10^{-5}
Cancer descriptor	Likely (Suggestive in 2016)	Suggestive
CSF value increase or decrease since 2016	Increased since 2016	NA
2021: Driver of MCLG	Cancer	Noncancer

Actions: Cross-Program

- **Engage directly with affected communities in every EPA Region.** Expected Fall 2021 and ongoing.
- **Use enforcement tools to better identify and address PFAS releases at facilities.** Ongoing actions.
- **Accelerate public health protections by identifying PFAS categories.** Expected Winter 2021 and ongoing.
- **Establish a PFAS voluntary stewardship program.** Expected Spring 2022.
- **Educate the public about the risks of PFAS.** Expected Fall 2021 and ongoing.
- **Issue an annual public report on progress towards PFAS commitments.** Winter 2022 and ongoing.

Next Steps

- **EPA is committed to transparent, equitable, and inclusive engagement with all stakeholders to inform the Agency's work.**
- **EPA is engaged in a national engagement effort as it seeks to partner for progress on PFAS.**
  - **National webinars** to share the strategic roadmap and its actions (held Oct-Nov 2021)
  - **Stakeholder listening sessions** with non-governmental organizations; Congressional stakeholders; federal partners; Tribal, state, and local governments; environmental justice organizations; and industry groups
  - **A focus on impacted communities**, engaging directly with communities in every EPA Region.
- **Through the roadmap, EPA seeks to harness the collective resources and authority across federal, Tribal, state, and local governments to empower meaningful action now.**

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PFAS Strategic Roadmap

EPA's Commitments to Action 2021-2024

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MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

Michigan’s IPP PFAS Initiative

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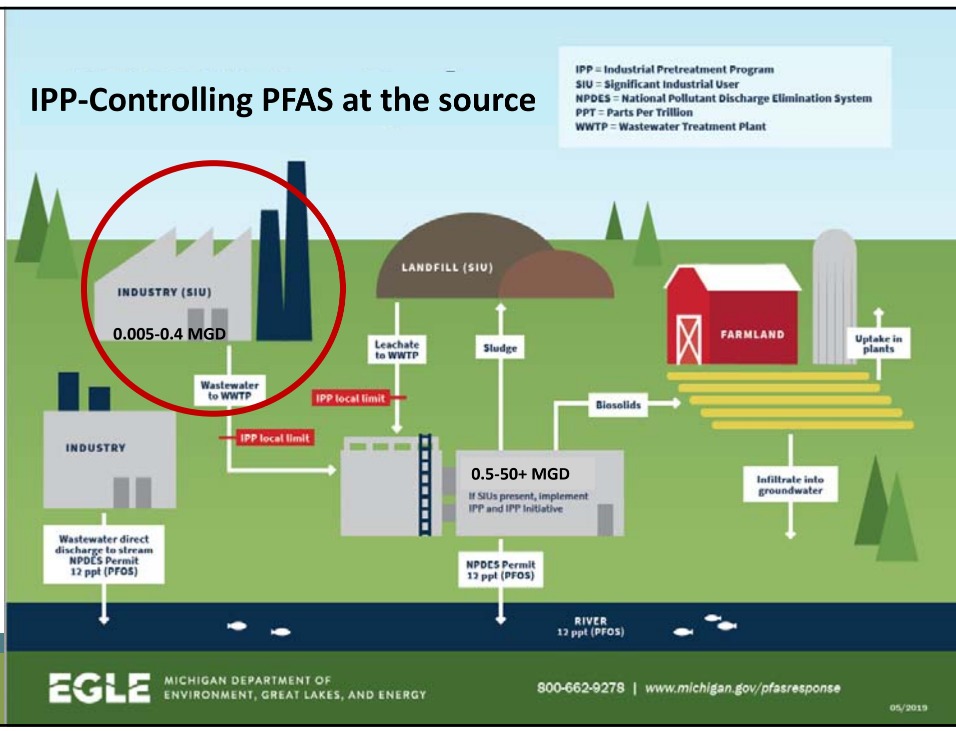

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PFAS Criteria in MI – Surface Water

Natural Resources & Environmental Protection Act (NREPA) - Part 31

PFAS	Concentration (PPT)	Value
PFOA (Drinking Water Source)	420	WQV
PFOA	12,000	WQV
PFOS (Drinking Water Source)	11	WQV
PFOS	12	WQV

*WQV = Water Quality Values

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IPP PFAS Initiative

- February 2018 – 95 WWTPs required to screen Industrial Users
  - Evaluate Industrial Users with potential sources of PFAS
  - Follow-up sampling of probable sources if found
  - Sample WWTP effluent if sources > screening criteria (12 ppt PFOS)
  - Sample WWTP Biosolids if WWTP effluent ≥ 50 ppt PFOS
  - Reports submitted 2018-2019

*As of December 2021, we now have 98 IPP WWTPs

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IPP PFAS Initiative: Ongoing Requirements

- Ongoing WWTP Effluent PFAS Sampling
  - Monthly, Quarterly, Semi-Annually
- Status Reports to EGLE
  - Quarterly or Semi-Annually
- Work with Sources to Reduce/Eliminate PFOS
  - Ongoing Source Monitoring
  - Recommend PFOS Local Limit
  - Recommend PFOS Reduction plans in local ordinances and industrial user permits

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Sources of PFOS, Number by Type

Industry/Category/Type	Total Number Evaluated[1]	Number (%) Sources of PFOS by Type[2]	Range Effluent PFOS exceeding screening level of 12 ppt
Landfills that accepted industrial wastes containing PFOS	56	49 (88%)	13-5,000
Metal Finishing w/history of fume suppressant use	327	48 (15%)	13-240,000
Contaminated Sites associated with industries or activities w/PFOS use	40	20 (50%)	14-34,000
Centralized Waste Treaters (CWTs) accepting PFOS-related wastes	16	12 (75%)	13-8,400
Paper Manufacturing, Packaging	14	9 (64%)	16-410
Commercial Industrial Laundries	14	7 (50%)	24-98
Chemical Manufacturers	17	4 (24%)	18-4,600,000
AFFF-contaminated Sewers	5	5 (100%)	12-45,000

1Estimated based on 2018 WWTP IPP Annual Report data for total metal finishers; others estimated based on industries surveyed and/or sampled during the IPP PFAS Initiative. Number of types per subcategory may be low since sewer users that did not meet local screening criteria may not have been sampled. The information presented in this document has been compiled from many sources including, but not limited to, compliance submittals, laboratory reports, voluntary surveys, emails, internet searches and personal communications. These sources contained variable levels of detail. This document represents our best effort to compile, organize, and summarize this information at this point in time.

[2]*Sources* are those exceeding the screening level of 12 ppt PFOS at least once.

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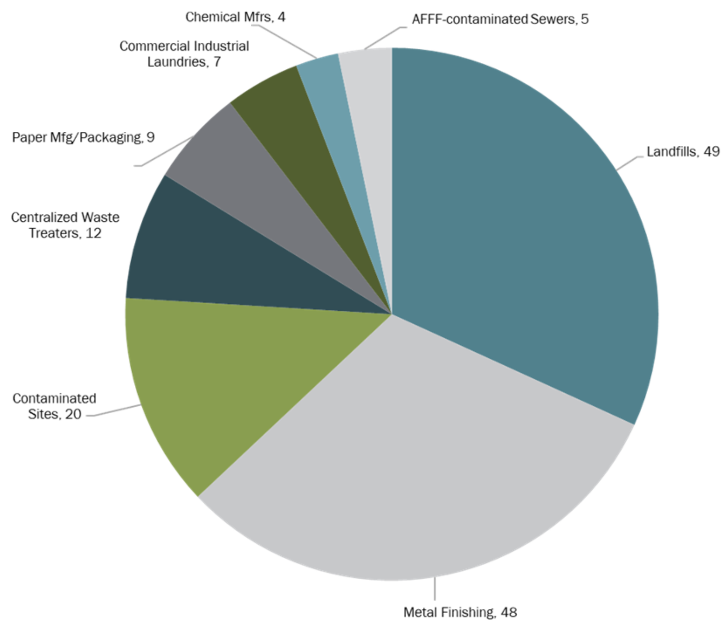
Sources of PFOS

- Metal Finishing:
  - Chrome Plating
  - Chromate Conversion Coatings
  - Other/Unknown
- Contaminated Sites:
  - Metal Finishers
  - Paper Mfg
  - Paint Mfg
  - Leather Tannery
  - AFFF Infiltration
  - Former Landfills
  - Misc Sources
- Includes both active & closed sanitary landfills; and 1 haz waste landfill



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Substantial Reductions in PFOS Discharges from WWTPs

Municipal WWTP	PFOS, Effluent (ppt, most recent**)	PFOS Reduction in Effluent (highest to most recent)	Actions Taken to Reduce PFOS
WWTP #57	11	99%	Treatment (GAC) at source (1)
WWTP #92	11	99%	Treatment (GAC) at sources (2)
WWTP #74	21	99%	Elimination of PFOS source (1)
WWTP #49	12	96%	Treatment (GAC/resin) at source (1)
WWTP #14	7	99%	Treatment (GAC) at source (1)
WWTP #50	<6	98%	Treatment (GAC) at source (1)
WWTP #40	24	93%	Treatment (GAC) installed at sources (4) plus 2 construction sites
WWTP #53	5	92%	Treatment (GAC) at sources (2), change water supply
WWTP #54	10	90%	Eliminate leak AFFF, some cleaning
WWTP #38	10	68%	Treatment (GAC/resin) at sources (16)

**Data (rounded) received by November 24, 2021

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Successful PFAS Treatment

Granular Activated Carbon (GAC)	Treatment for other pollutants (e.g. metals) then GAC: Metal finisher process wastewater
Granular Activated Carbon & Resin	GAC (high grade) with Resin Polishing: Metal finisher w/contaminated storm water runoff
Resin	Resin only: Successful for AFFF-contaminated groundwater cleanup

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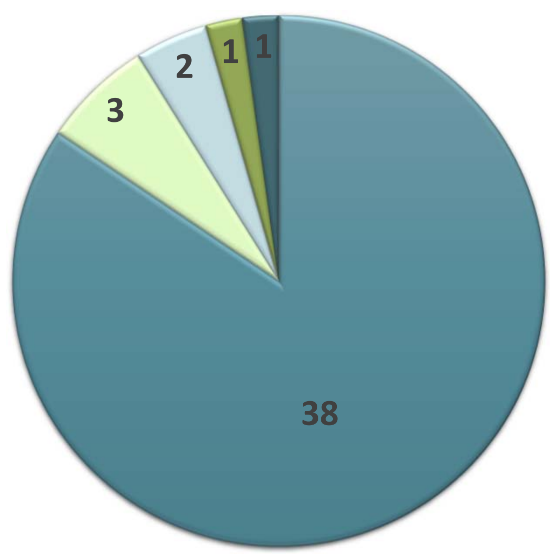
PFAS Pretreatment Type, by Number of Facilities* Using

- GAC Only
- GAC & Ionic Exchange Resin
- PAC Added to Trmt Tank Prior to Precipitation & Filter press
- DAF & small pore filter bag
- Unknown



*Indirect dischargers only

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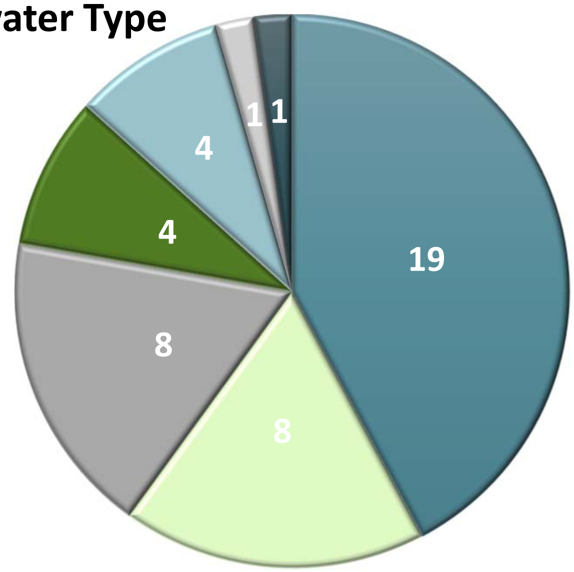
PFAS Pretreatment* by Wastewater Type

- Metal Finishing
- Centralized Waste Treatment
- Groundwater Cleanup
- Construction Dewatering
- Landfill Leachate
- Other/Unknown
- Recycling



*Indirect dischargers only

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Cleaning/Replacement of Tanks/Equipment

- Some success with cleaning, replacement in contained, small areas (single tank, sumps, lift station, and related pipes)
- Less successful with larger, complex facilities, but may reduce PFAS loading to pretreatment systems

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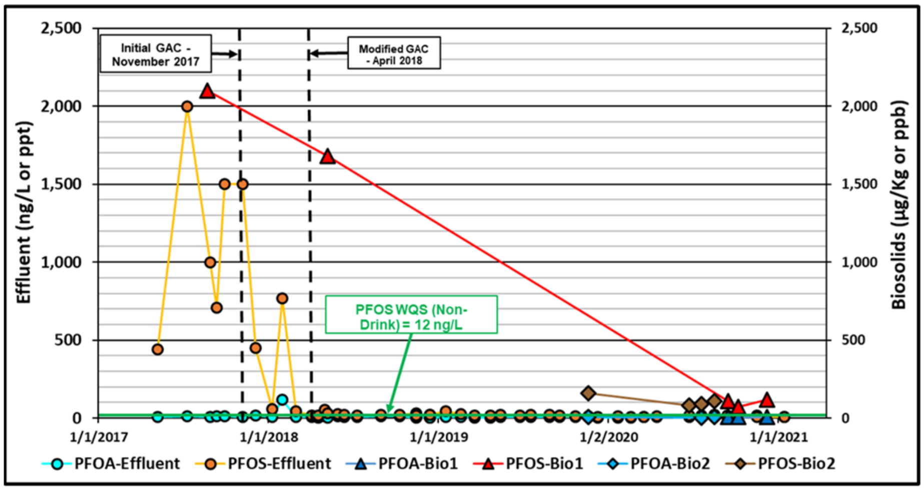
Reduce PFOS at the source = Reduce PFOS at WWTP #57



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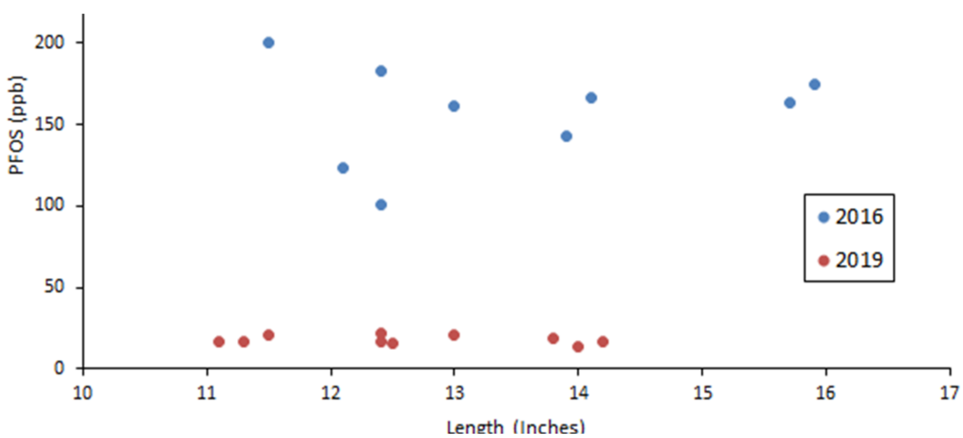
PFOS, Largemouth and Smallmouth Bass, Holloway Reservoir, Flint River



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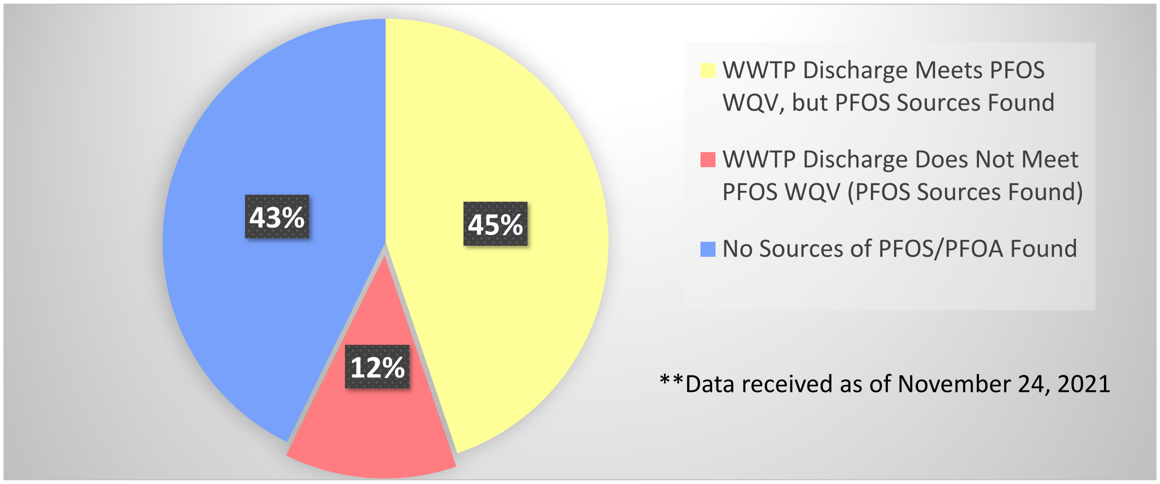
Current Effluent Compliance Status of 96 IPP WWTPs with PFOS WQV



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Additional Information

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- **IPP PFAS Initiative:** IPP PFAS Initiative Webpage
- **Source Doc**: Industrial Sources of PFOS to Municipal Wastewater Treatment Plants as identified through the Michigan Department of Environment, Great Lakes, and Energy Industrial Pretreatment program Per-and Polyfluoroalkyl Substances Initiative
- **Summary Report**: Initiatives to Evaluate the Presence of PFAS in Municipal Wastewater and Associated Residuals (Sludge/Biosolids) in Michigan
- **Detailed Report**: Evaluation of PFAS in Influent, Effluent, and Residuals of Wastewater Treatment Plants (WWTPs) in Michigan
- **Fume Suppressant Study:** PFAS in Fume Suppressant Products at Chrome Plating Facilities
- **Permit Strategy:** Municipal NPDES Permitting Strategy for PFOS and PFOA
- **Field Summary and Technical Reports**: EGLE Biosolids PFAS Webpage
- **MPART:** https://www.michigan.gov/pfasresponse/

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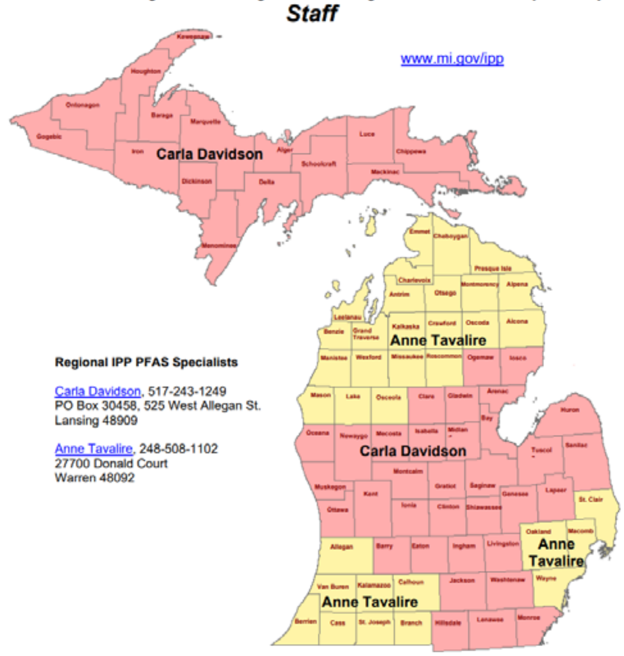
Industrial Pretreatment Program (IPP)
Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS)
Staff



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PFAS in Biosolids

A utility perspective

PIMA COUNTY
WASTEWATER RECLAMATION

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Landfill Disposal

Challenges

PIMA COUNTY
WASTEWATER RECLAMATION

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Leachability

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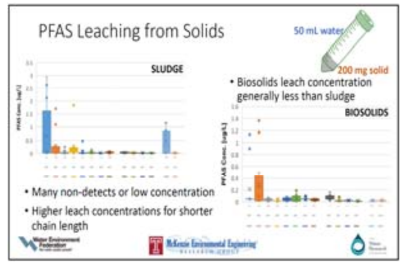
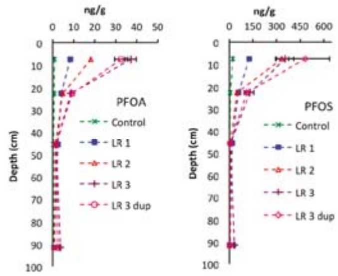


Transport in Soils


Environmental Science & Technology

Occurrence and Fate of Perfluorochemicals in Soil Following the Land Application of Municipal Biosolids

Jennifer G. Sepulvado, Andrea C. Blaine, Lakhwinder S. Hundal, and Christopher P. Higgins

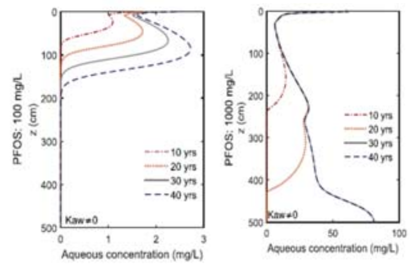


Transport & Retention

A Mathematical Model for the Release, Transport, and Retention of Per- and Polyfluoroalkyl Substances (PFAS) in the Vadose Zone

Bo Guo[1], Jicai Zeng[1], and Mark L. Brusseau[1,2]

[1]Department of Hydrology and Atmospheric Sciences, University of Arizona, Tucson, AZ, USA, [2]Department of Environmental Science, University of Arizona, Tucson, AZ, USA



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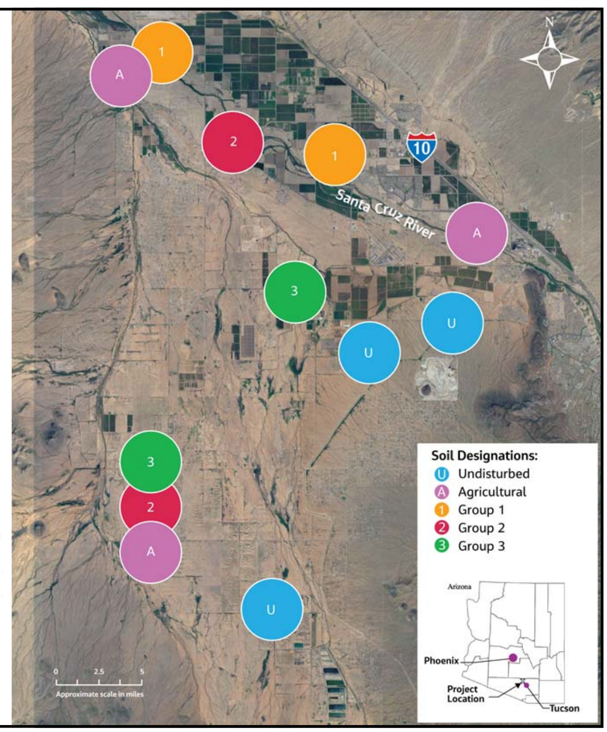
Sample Locations

- **73** Soil samples from 1' 3' and 6' depth intervals
- **10** Wastewater samples from 5 treatment facilities
- **9** Irrigation wells associated with agricultural sites
- **4** Biosolids samples from Tres Rios WRF
- **6** Field blanks
- **3** Equipment blanks
- **3** Chemicals used in treatment processes
- **1** Bighorn Fire ash

Soil Designation	Agricultural	Irrigated	Biosolids Applied	Application Years
Undisturbed	-	-	-	-
Agricultural	✓	✓	-	-
Group 1	✓	✓	≤ 20 tons/acre	4 - 9
Group 2	✓	✓	21-30 tons/acre	12 – 20
Group 3	✓	✓	> 30 tons/acre	6 - 9



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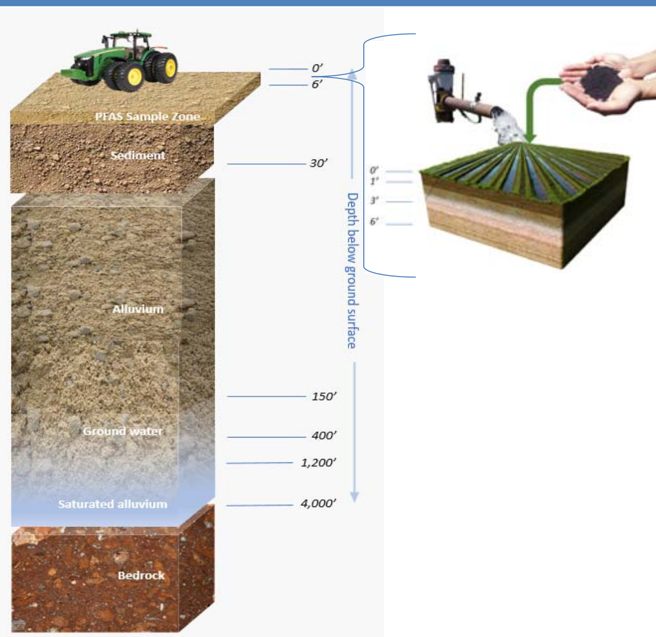
Soil Sampling

- Soil sampling utilized a hand augers
- Sample depths of 1’, 3’, and 6’ below the surface
- Strict protocol followed to prevent PFAS contamination



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Analysis Results

Ground Water and Soils

PIMA COUNTY
WASTEWATER RECLAMATION

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Contaminant	AGRICULTURAL SITES ng/L (ppt)			GROUP 1 ng/L (ppt)		GROUP 2 ng/L (ppt)		GROUP 3 ng/L (ppt)	
DONA	ND	ND	ND	ND	ND	ND	ND	ND	ND
F-53B (Major)	ND	ND	ND	ND	ND	ND	ND	ND	ND
F-53B (Minor)	ND	ND	ND	ND	ND	ND	ND	ND	ND
GenX	ND	ND	ND	ND	ND	ND	ND	ND	ND
NEtFOSAA	ND	ND	ND	ND	ND	ND	ND	ND	ND
NMeFOSAA	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFBS	10	ND	3.8	ND	1.4	ND	0.68	0.68	3.6
PFDA	1.9	ND	ND	ND	ND	ND	ND	ND	0.57
PFDoA	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFHpA	5.3	ND	3.2	0.28	0.98	ND	0.26	ND	1.9
PFHxS	34	0.30	20	0.24	7.7	0.3	0.76	0.52	7.0
PFHxA	14	ND	8.6	ND	1.9	ND	ND	2.2	6.9
PFNA	3.4	ND	0.57	ND	0.28	ND	ND	ND	0.63
PFOS	80	ND	26	ND	11	0.53	ND	ND	15
PFOA	20	ND	9.1	ND	3.1	ND	0.81	ND	5.0
PFTeA	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFTriA	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFUnA	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes: ND indicates not-detected. ng/L = ppt
Black indicates values above the method detection limit (MDL)
Blue values indicate values above the method reporting limit (MRL)

Groundwater Monitoring

- PFAS detected in nearly all irrigation sources
- PFAS concentrations higher in irrigation sources never receiving biosolids
- Highest PFAS concentration in irrigation source farthest removed from the Santa Cruz River

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No Biosolids

Contaminant	Depth 1' (µg/kg (ppb))	3'	6'	PFAS present in Irrigation Wells
DONA	ND	ND	ND	
F-53B (Major)	ND	ND	ND	
F-53B (Minor)	ND	ND	ND	
GenX	ND	ND	ND	
NEtFOSAA	ND	ND	ND	
NMeFOSAA	ND	ND	ND	
PFBS	0.03	ND	ND	✓
PFDA	0.05	ND	ND	✓
PFDoA	ND	ND	ND	
PFHpA	0.05	0.03	0.04	✓
PFHxS	0.07	0.06	0.09	✓
PFHxA	0.09	0.06	0.05	✓
PFNA	0.08	ND	ND	✓
PFOS	1.85 ± 1.2	0.59 ± 0.37	0.25 ± 0.17	✓
PFOA	0.26 ± 0.14	0.18 ± 0.12	0.22 ± 0.09	✓
PFTeA	ND	ND	ND	
PFTriA	ND	ND	ND	
PFUnA	ND	ND	ND	
Moisture	10.9%	12.1%	12.3%	
PFOS Attenuation	N/A	63%	84%	

≤20 Tons of Biosolids
4-9 year application

Contaminant	Depth 1' (µg/kg (ppb))	3'	6'	PFAS present in Biosolids	PFAS present in Irrigation Wells
DONA	ND	ND	ND		
F-53B (Major)	ND	ND	ND		
F-53B (Minor)	ND	ND	ND		
GenX	ND	ND	ND		
NEtFOSAA	ND	ND	ND		
NMeFOSAA	ND	ND	ND		
PFBS	ND	0.08	0.04	✓	✓
PFDA	0.10	ND	ND	✓	
PFDoA	ND	ND	ND	✓	
PFHpA	0.08	0.06	ND	✓	✓
PFHxS	0.10	0.17	0.04	✓	✓
PFHxA	0.14	0.11	ND	✓	✓
PFNA	0.06	ND	ND	✓	✓
PFOS	1.58 ± 1.76	0.29 ± 0.20	ND	✓	✓
PFOA	0.32 ± 0.33	0.26 ± 0.26	ND	✓	✓
PFTeA	ND	ND	ND	✓	
PFTriA	ND	ND	ND		
PFUnA	ND	ND	ND	✓	
Moisture	7.8%	9.5%	9.9%		
PFOS Attenuation	N/A	82%	100%		

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21-30 Tons of Biosolids
12-20 year application

Depth	1'	3'	6'	PFAS present in	
Contaminant	µg/kg (ppb)			Biosolids	Irrigation Wells
DONA	ND	ND	ND		
F-53B (Major)	ND	ND	ND		
F-53B (Minor)	ND	ND	ND		
GenX	ND	ND	ND		
NEtFOSAA	ND	ND	ND		
NMeFOSAA	ND	ND	ND		
PFBS	0.17	0.10	0.12	✓	✓
PFDA	0.56	0.06	0.05	✓	
PFDoA	0.04	ND	ND	✓	
PFHpA	0.09	0.09	0.06	✓	✓
PFHxS	0.03	0.04	0.05	✓	✓
PFHxA	0.13	0.09	0.09	✓	
PFNA	0.43	0.12	ND	✓	
PFOS	3.11 ± 2.06	0.64 ± 0.31	0.22 ± 0.09	✓	✓
PFOA	0.47 ± 0.29	0.49 ± 0.18	1.65 ± 2.38	✓	✓
PFTeA	ND	ND	ND	✓	
PFTriA	ND	ND	ND		
PFUnA	ND	ND	ND	✓	
Moisture	5.3%	10.5%	10.2 %		
PFOS Attenuation	N/A	**79%**	**93%**		

>30 Tons of Biosolids
6-9 year application

Depth	1'	3'	6'	PFAS present in	
Contaminant	µg/kg (ppb)			Biosolids	Irrigation Wells
DONA	ND	ND	ND		
F-53B (Major)	ND	ND	ND		
F-53B (Minor)	ND	ND	ND		
GenX	ND	ND	ND		
NEtFOSAA	ND	ND	ND		
NMeFOSAA	ND	ND	ND		
PFBS	0.37	0.20	0.14	✓	✓
PFDA	0.98	0.11	0.15	✓	✓
PFDoA	0.24	ND	0.08	✓	
PFHpA	0.19	0.16	0.24	✓	✓
PFHxS	0.12	0.15	0.16	✓	✓
PFHxA	0.51	0.22	0.13	✓	✓
PFNA	0.43	0.15	0.05	✓	✓
PFOS	4.13 ± 1.86	1.22 ± 1.36	0.46 ± 0.46	✓	✓
PFOA	0.84 ± 0.48	1.32 ± 1.43	0.51 ± 0.61	✓	✓
PFTeA	0.09	ND	ND	✓	
PFTriA	ND	ND	ND		
PFUnA	0.10	ND	ND	✓	
Moisture	9.5%	8.9%	10%		
PFOS Attenuation	**N/A**	**84%**	**90%**		

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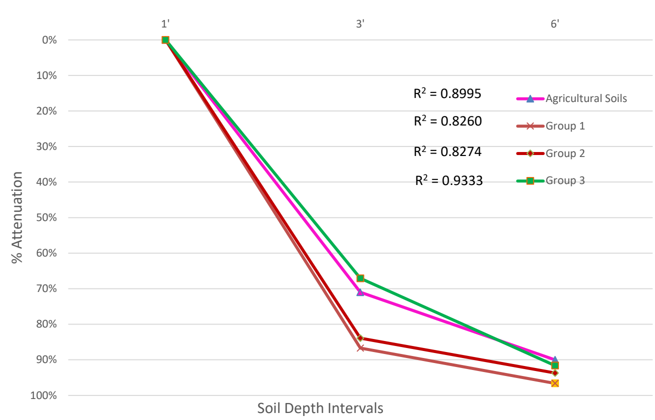
% Attenuation	No Biosolids Agriculture Only			≤20 tons/acre Group 1 Soils				21-30 tons/acre Group 2 Soils			>30 tons/acre Group 3 Soils				
	3 locations			4 locations				3 locations			5 locations				
3'	67%	85%	75%	89%	84%	93%	91%	60%	81%	92%	55%	67%	84%	87%	93%
6'	85%	-	95%	95%	97%	-	-	85%	93%	-	86%	94%	92%	-	97%



PFAS Attenuation

- Strong correlation for adsorption of PFAS
- Retained in the first few feet
- Minimal migration below 6' depth
- 90% - 97% attenuation for all soil groups

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Conclusions

- PFOS and PFOA were detected at very low concentrations
- Concentrations were comparable to agricultural sites never receiving biosolids
- PFAS presence in irrigation sources likely contributes to detection in soils
- Biosolids soils only slightly higher than agricultural soils without biosolids
- All concentrations decreased with depth
- 85% - 97% attenuation by 6'
- Minimal migration in soils

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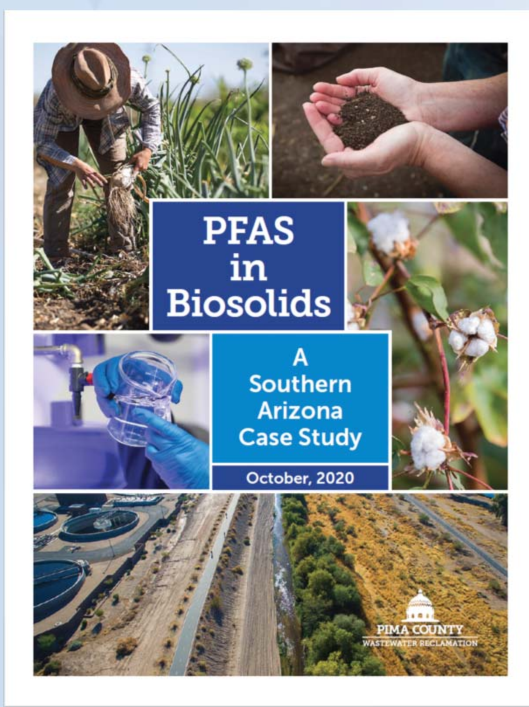


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Incidence of Pfas in soil following long-term application of class B biosolids

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HIGHLIGHTS

- Long-term land application of biosolids resulted in low incidence of soil PFAS analytes.
- PFAS soil concentrations in irrigated agricultural plots with or without land application of biosolids were similar.
- Biosolids and irrigation water were sources of PFAS.
- >70% attenuation of total PFAS occurred within the surface 180 cm of soil.

GRAPHICAL ABSTRACT

PFAS Accumulation and Leaching in Agricultural Soils

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ABSTRACT

This field study investigated the impact of long-term land application of biosolids on PFAS presence in soils that received annual repetitive land application of Class B biosolids from 1984 to 2019. Soil samples were collected from three depths of 30.5, 91 and 183 cm below land surface. Biosolid and groundwater samples used for irrigation were also collected. Concentrations measured for 18 PFAS compounds were evaluated to assess incidence rates and potential impact on groundwater. No PFAS analytes were detected at the three sampling depths for soil samples collected from undisturbed sites with no history of agriculture, irrigation, or biosolids application (background control sites). Relatively low mean concentrations of PFAS ranging from non-detect to 1.9 μg/kg were measured in soil samples collected from sites that were used for agriculture and that received irrigation with groundwater, but never received biosolids. PFAS concentrations in soils amended with biosolids were similarly low, ranging from non-detect to a mean concentration of 4.1 μg/kg. PFOS was observed at the highest concentrations, followed by PFOA for all locations. PFAS detected in the irrigation water were also present in the soil. These results indicate that biosolids and irrigation water are both important sources of PFAS present in the soils for all of the study sites. Not all PFAS detected in the biosolids were detected in the soil. Very long chain PFAS present in the biosolids were not detected or were detected at very low levels for soil, suggesting potential preferential retention within the biosolids. The precursor NMeFOSAA was present at the second highest concentrations in the biosolids but not detected in soil, indicating possible occurrence of transformation reactions. The total PFAS soil concentrations exhibited significant attenuation with depth, with a mean attenuation of 73% at the 183 cm depth. Monotonically decreasing concentrations with depth were observed for the longer-chain PFAS.

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PFAS THREAT TO LAND APPLICATION

Ian Pepper
The University of Arizona

EVALUATION OF FATE AND TRANSPORT OF PFAS FOLLOWING LONG-TERM LAND APPLICATION OF BIOSOLIDS: A COLLABORATIVE NATIONAL STUDY

National Collaborative Project Overall Objective

To evaluate whether or not land application of biosolids is a significant public health route of exposure to per- and polyfluoroalkyl substances (PFAS)

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THE ISSUE

- PFAS identified as causing adverse human health effects
- PFAS known to be present in wastewater and ultimately in biosolids

THE QUESTION

- Does land application of biosolids result in significantly increased human exposure to PFAS?
- Will it lead to a national ban on land application?

ROUTE OF EXPOSURE

- Exposure to PFAS in groundwater (leaching through soil)
- Exposure to PFAS in crops (plant uptake)

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LOCAL PROBLEM SOLVED BY LOCAL STUDY

- January 2020 – Pima County Board of Supervisors impose moratorium on land application in Pima County (Tucson, AZ)
- March – October 2020 – University of Arizona Water and Environmental Technology Center (WET) in collaboration with Pima County Wastewater evaluate incidence and transport of PFAS following long-term land application
- Data showed low incidence of soil PFAS and limited mobility of PFAS through soil and vadose zone
- Data presented to Pima County Administrator and Board of Supervisors
- December 2020, moratorium rescinded
- Peer review publication: 793 (2021) 148449

FOR A NATIONAL PROBLEM WE NEED A NATIONAL STUDY

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SPECIFIC OBJECTIVES

Evaluate

- Conduct a literature review of land application/PFAS studies, past and present to ensure collaborations with, and extensions of, ongoing work and negation of duplicative research
- Incidence of PFAS analytes in soil following long-term land application of biosolids
- Mobility (leaching) of PFAS analytes through soil and vadose zone under natural conditions including the influence of rainfall and/or irrigation
- Crop uptake of PFAS analytes
- Utilize paired data sets of soil PFAS concentrations versus plant uptake

These specific objectives should be evaluated over a variety of different soils, depth to groundwater, and climates, by studying land application plots nationally, across the entire United States, including irrigated and non-irrigated soils.

Depth and breadth of dataset should be sufficient to allow future predictions of possible groundwater contamination events and crop uptake of PFAS.

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HOW THE PROPOSED STUDY IS UNIQUE AND DIFFERENT FROM EPA-FUNDED RESEARCH ON PFAS

- National scope over all of the US
- Research at each study site will be identical allowing for direct comparison of results
- Study will allow for unique model development
- Proactive stance will pre-empt any attempt to ban land application nationally

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SCOPE OF WORK IN YEAR 1

GOAL: Evaluate the incidence and mobility of PFAS in soil following long-term land application of Class B and/or Class A biosolids

Soil Sample Collection at Select Sites

- Soil samples taken at 1, 3 and 6 feet depths from the surface
- 4 replicates
- Samples collected from across the U.S.
  - Farmers with long-term land application plots, with records of biosolid loading rates
  - Academic researchers with established long-term land application plots with known biosolids applications at different loading rates
  - We anticipate at least 30 sample sites across broad geographic regions

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POTENTIAL SITES TO BE SAMPLED (to date)

- We already have potential sites identified in 10 states nationally and anticipate many more.
- Necessary criteria to be eligible for the project
  - Long-term (>10 years) land application
  - Known loading rate of biosolids
  - If possible, multiple loading rates (2 or 3 different rates) plus control (no biosolids)
  - Any soil PFAS data from prior years
  - Rainfall or irrigation data, if possible
  - Soil characterization data, if possible
  - Depth to groundwater
  - PFAS analytical data from biosolids, if available

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SUITE OF PFAS ANALYTES TO BE CONDUCTED (this is not the final list – needs discussion)

DONA
F-53B Major
F-53B Minor
HFPO-DA (GenX)
N-ethylperfluorooctanesulfonamidoacetic acid (NEtF)
N-methylperfluorooctanesulfonamidoacetic acid (Nme)

Perfluorobutanesulfonic acid (PFBS)
Perfluorodecanoic acid (PFDA)
Perfluorododecanoic acid (PFDoA)

Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)

Perfluorohexanoic acid (PFHxA)
Perfluorononanoic acid (PFNA)
Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorotetradecanoic acid (PFTeA)
Perfluorotridecanoic acid (PFTriA)
Perfluoroundecanoic acid (PFUnA)

GROUNDWATER ANALYSIS

Groundwater from sites with existing monitoring wells will be analyzed for PFAS analytes
- Number of samples TBD

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DATA ANALYSIS

- All data will be recorded at the University of Arizona
- Data for individual sites will be sent to the PI responsible for the site for statistical analysis
- Any available soil PFAS data from previous years should also be identified
- These data will ultimately be used to quantify the incidence of PFAS following land application under a broad range of influencing factors. They will also be used for the development and testing of models to predict PFAS leaching potential. Such models can be employed to help assess risks of groundwater contamination, and to determine soil screening levels that are anticipated to be protective of groundwater quality

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PFAS TRANSPORT WITHOUT BIOSOLIDS

- Dr. Brusseau (University of Arizona) will evaluate PFAS transport through pristine soils via a $1.2m Department of Defense grant
- Data will allow for an evaluation of the effects of biosolids on mobility, relative to non-biosolid PFAS transport and will aid in model development

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SCOPE OF WORK FOR CROP UPTAKE STUDIES (Year 2)

Goal: Evaluate the potential for crop uptake of PFAS following land application

In the interest of time, only general concepts are presented here. Actual details or proposed studies will be developed by the W4170 National Research Group on land application over several months.

- Uptake studies likely to begin Fall 2022 or Spring 2023
- Uptake from existing long-term land application plots utilized in Year 1 for incidence and mobility study with and without fresh application of biosolids
- Depending on funding availability new land application sites may be developed
- Biosolids will be analyzed for PFAS prior to application for inclusion in study
- Crops to be grown: these will include two crops that can potentially be grown all over the United States e.g. wheat + ??
- All sites will be "real world" in size and subject to standard agricultural and biosolids application practices
- All studies will be replicated (4 reps ?)
- PFAS analysis of plant material will be conducted following harvest of each crop
- PFAS analytes to be investigated will be determined based on analytical capability

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DATA ANALYSIS

- Data will be statistically analyzed by PI responsible for the site
- Data will be interpreted with respect to uptake from different soils, climate zones, crop type and biosolid loading rates
- Data will also be analyzed with respect to potential health hazards from PFAS ingested via intake of crop residues through risk assessment

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FUNDING REQUIRED (YEAR 1)

Estimate

Cost Per Site:

3 soil depths x 4 replicates x 3 loading rates (hypothetical) = 36 samples

1) Soil Sampling Personnel = Cost covered by partners	
2) Shipping	TBD
3) Soil Processing	$800
4) PFAS Suite Analysis ($400/soil sample @ 36 samples)	$14,400
5) Groundwater collection & PFAS analysis ($300/sample)	<u>TBD</u>
	$15,200 + shipping + groundwater analysis

Soil sampling and analysis for 30 sites = $456,000 + shipping
Groundwater monitoring cost = $300/sample, total for all sites TBD

Total project cost estimate (year 1) ≈ $0.5 million

FUNDING REQUIRED (YEAR 2)

- Funding requirements for crop uptake of PFAS is difficult to estimate without knowing details of specific experiments
- We anticipate that we need to raise at least $500,000 to conduct these studies in a meaningful manner
- The specific number of uptake studies will be tailored to the available amount of funding

TOTAL PROJECT COST≃ $1m PLUS

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SUGGESTED CONTRIBUTIONS

Design flow greater than 50 MGD	$25,000
Design flow between 25 and 50 MGD	$20,000
Design flow between 5 and 25 MGD	$15,000
Design flow between 1 and 5 MGD	$5,000
All others	$1,000
Non-profit associations	$3,000
Consulting firms	$5,000
Biosolids private sector management firms	$10,000

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LIKELY PARTNERS

1. Utilities: Any wastewater treatment plant that recycles its biosolids via land application may be interested in funding the project (16,000 WWTPs nationally)
2. Non-Profit Associations: Groups such as CASA, NACWA, NEBRA, MABA, NW Biosolids, Arizona Business Council will be contacted. These groups in turn are well connected with utilities.
3. Private Sector: Companies that manage biosolids for public agencies will be contacted. These include companies like Synagro, Denali Water, Material Matters and others.

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PROGRESS TO DATE

- Advisory Committee formed
- Scope of Work created (Draft)
  - reviewed by Advisory Committee
  - would like input from W4170
- Draft Scope of Work will be sent to potential partners and contributors to aid in fundraising
- $85,000 pledged to date

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PROJECT COORDINATION

- It is recommended that all funding contributions be sent to the University of Arizona, Water and Environmental Technology Center (WET)
- Need a central collection agency (WET) which will document all contributions within an Advisory Committee oversight
- All funding of projects will also be documented with Advisory Committee oversight i.e. $$ going from project funds at UA → collaborating research groups
- All funding transactions will be transparent and well documented
- University of Arizona will apply low overhead (indirect cost) rate of only 10%
- WET Center has 20 years of experience of collecting membership funds (input) and establishing subaccounts for chosen research projects (output)
- A project advisory subcommittee will provide input on project as it proceeds and recommend improvements as appropriate
- USEPA will be communicated with in every step to ensure the project provides them what is needed in order to perform credible risk assessment

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PROJECT OUTCOMES

- Documentation of whether or not land application of biosolids is a significant public health route of exposure to PFAS via contamination of groundwater and/or crop uptake
- Development of models to predict whether or not significant leaching of PFAS through soil and vadose zone is likely to occur
- Risk assessment of ingestion of crops grown on land applied plots
- Specific recommendations for the need of:
  - groundwater analysis for PFAS
  - impact, if any, to crops at land application sites
  - continued land application due to low potential risk of PFAS exposure
- Presentations at national and international meetings
- Final report and recommendation to EPA
- Other ??

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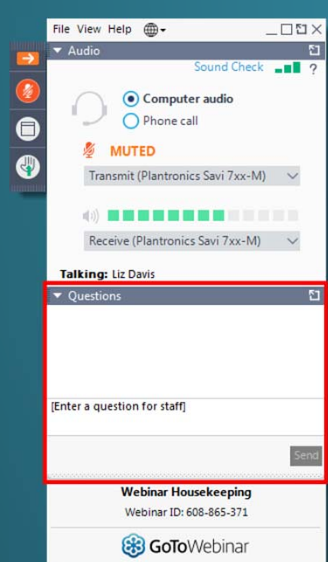

Questions?

Deborah Nagle, US EPA, Office of Water, Office of Science & Technology

Anne Tavalire, Michigan Department of Environment, Great Lakes, and Energy (EGLE).

Dr. Jeff Prevatt, Pima County Regional Wastewater Reclamation Department (RWRD)

Dr. Ian Pepper, University of Arizona (WEST Center)

Water Environment Federation
the water quality people

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