PFAS THREATS TO LAND APPLICATION?

A nationwide research project

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POLY- AND PERFLUORINATED COMPOUNDS (PFAS)

- Formerly called “perfluorinated compounds” (“PFCs”)
- Family of anthropogenic chemicals used for decades to make products resistant to heat, oil stains, grease and water
- Perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) most prevalent PFCs in the U.S.
- Regarded by EPA as “emerging contaminants”

CHARACTERISTICS OF PFOS AND PFOA (PFAS)

- Persistent in the environment, resistant to microbial degradation processes
- Found worldwide in soil, sediments, and water
- Soluble and can migrate through soils
- Almost all people in the U.S. have PFAS in their blood in parts per billion (ppb)

HEALTH ADVISORIES FOR PFOS AND PFOA

- EPA Health Advisory Levels for Drinking Water
  - January 2009
    - PFOS = 200 ng/L (ppt)
    - PFOA = 400 ng/L (ppt
  - May 2016 Health Advisory Level for Drinking Water
    - Combined PFOS + PFOA not to exceed 70 ng/L (ppt)

PFAS AND BIOSOLIDS

PFAS Potential Exposure from Biosolids

- Direct exposure (minimal risk)
- Indirect exposure
  - drinking water
  - plant/animal uptake
- Bioaccumulation

FOCUS ON PFAS IN BIOSOLIDS

Industrially Contaminated Biosolids Used for Land Application (Lindstrom, 2011)

- Land application in Decatur, Alabama, 1995-2008
- Biosolids contaminated by effluent from industries producing PFAS, e.g., manufacturer
- 34,000 dry metric tons applied to ≃ 2000 ha of agricultural fields (17 metric ton/ha)
- Surface and ground waters contaminated with PFOA at levels above EPA Health Advisory Levels

This led to scrutiny of PFAS in biosolids.

FOCUS ON PFAS IN BIOSOLIDS

Bioaccumulation of PFCs by Earthworms (Rich et al., 2015)

- Lab study
- Soil contaminated with PFAS
  - Nalgene 1 L bottles
- 5 worms added to each bottle
  - Industrially contaminated biosolids
  - PFOS in soil = 243 ng/g (ppb) – high level found only where industrial contamination has happened
- Incubated for 28 days

RESULT

- Bioaccumulation of PFAS

QUESTION: Is this realistic?

FOCUS ON PFAS IN BIOSOLIDS

Uptake of PFAS into Edible Crops (Blaine et al., 2013)

Greenhouse studies

- Soil contaminated with PFAS
  - Industrially contaminated biosolids
  - Biosolids applied at 10x agronomic rate
- Pot study!!
  - Lettuce grown and shown to take up PFCs
  - PFOS levels in soil ≃ 100 ng/g (ppb)
- Spiked (unrealistic) studies show uptake of PFAS

Field Studies

- Municipal and industrial biosolids applied up to 10x agronomic rate
  - maximum PFOS soil level ≃ 14 ng/g (ppb)
  - PFOS in corn grain below the level of detection

Author quote:
"… crops grown on soils amended with municipal biosolids (not impacted by PFAA industries) are unlikely to be a primary source of PFC exposure."

CLASSIC RESEARCH MISTAKES

Research Mistake #1:

Pot studies instead of field studies

Research Mistake #2:

10x agronomic rate is not the same as 10 years at 1x rate

Research Mistake #3:

Spiked chemicals not the same as chemicals within biosolids

NEW STATE REGULATIONS FOR DRINKING WATER

Massachusetts & Maine 20 ppt for sum of 6 PFAS

California 5.1 and 6.5 ppt Notification Levels respectively for PFOA and PFOS

- PFAS are the only common drinking water contaminant regulated in the parts per trillion.... and in the low parts per trillion in some states.
- 1 ppt = 1 second in 31,700 years
- **CONCERN OVER PFAS LED TO PIMA COUNTY ARIZONA BOARD OF SUPERVISORS (IN TUCSON) IMPOSING A MORATORIUM ON LAND APPLICATION OF BIOSOLIDS IN PIMA COUNTY IN JANUARY 2020**
- Biosolids subsequently landfilled, resulting in cost increase of $1.3m to $3.3m annually

IS LAND APPLICATION A MAJOR SOURCE OF PFAS?

COLLABORATIVE STUDY BETWEEN UNIVERSITY OF ARIZONA AND PIMA COUNTY WASTEWATER

Field study implemented in Pima County in 2020

- Surface and depth soil samples collected from agricultural plots that had received known loadings of biosolids since 1984
- Analyzed for PFAS
- Biosolids and groundwater samples also assayed
- Appropriate controls also utilized

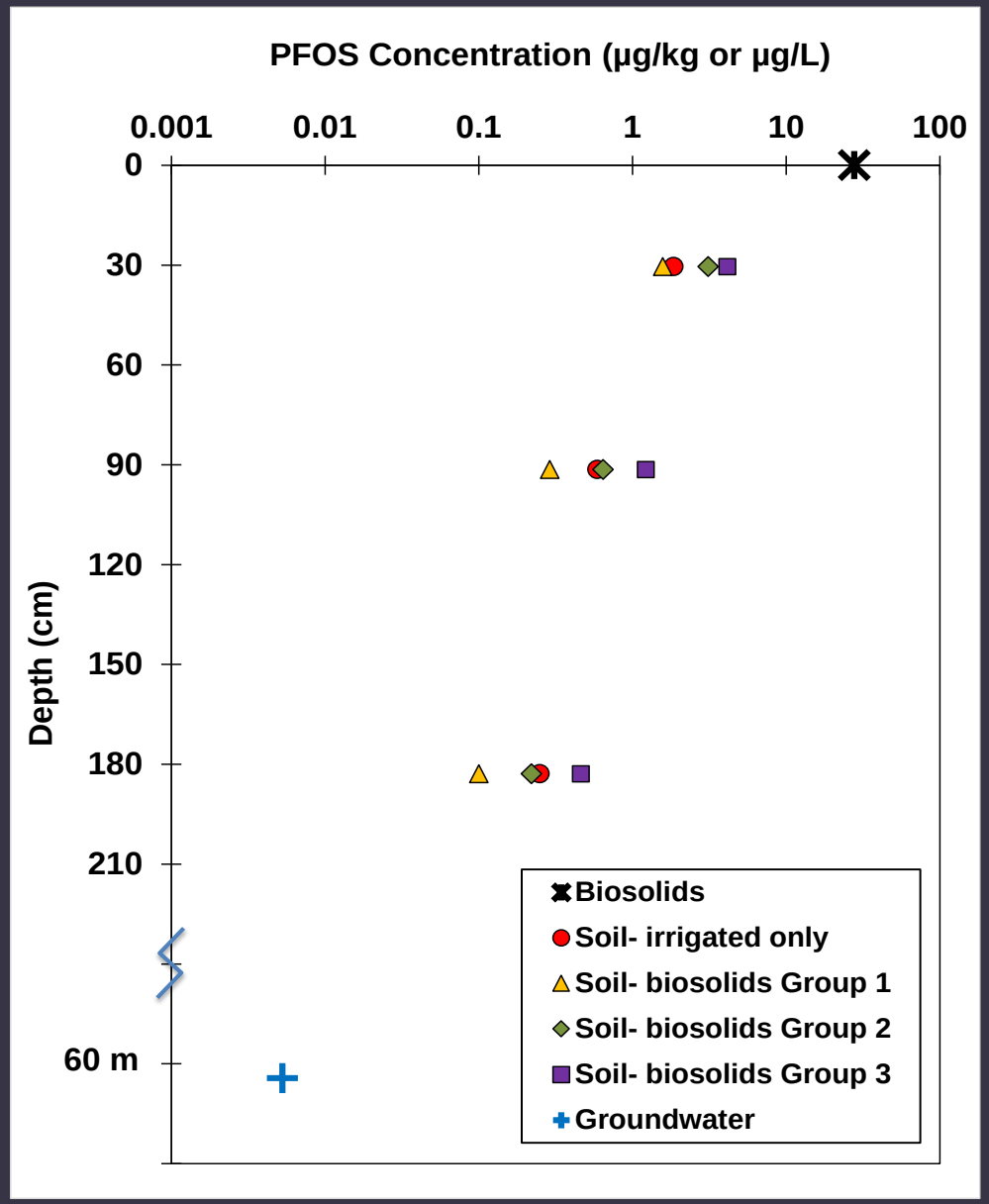
PROJECT SAMPLE PLAN CRITERIA

Field Type	Agriculture	Irrigated with groundwater	Cumulative biosolids applied	Duration of application (years)
Undisturbed	No	No	None	--
Agricultural	Yes	Yes	None	--
Group 1	Yes	Yes	≤20 (tons/acre)	4-9
Group 2	Yes	Yes	21-30 (tons/acre)	12-20
Group 3	Yes	Yes	>30 (tons/acre)	6-9

PFAS CONCENTRATIONS IN BIOSOLIDS SOIL AND WATER

- Low In biosolids: low ppb (typical of non-industrially impacted biosolids)
- In irrigation water: up to 80 ppt
- In undisturbed desert: non detect in soil
- Similar levels in irrigated agricultural plots with or without biosolids land application <10 ppb in soil

TRANSPORT OF PFOS



Mean concentrations of PFOS in biosolids, soil, and groundwater (log scale). Note that the geometric mean concentration for all field types is used for groundwater.

HIGHLIGHTS

- Low incidence of PFAS analytes in soils with long-term land application of biosolids
- PFAS soil concentrations in irrigated agricultural plots were fairly similar with or without land application of biosolids
- Biosolids and irrigation water were both sources of PFAS
- 72% attenuation of PFAS occurred within the surface 6 feet of soil

MORATORIUM ON LAND APPLICATION RESCINDED IN NOVEMBER 2020

PFAS THREAT TO LAND APPLICATION

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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)

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 national or state bans or severe restrictions?**

ROUTES OF EXPOSURE:

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

PIMA COUNTY RESEARCH: LOCAL PROBLEM SOLVED BY LOCAL STUDY

- Study focused on incidence, mobility, and crop uptake (where PFAS shows up after land application of biosolids)
- *Science of the Total Environment*: 793 (2021) 148449

FOR A NATIONAL PROBLEM WE NEED A NATIONAL STUDY

SPECIFIC OBJECTIVES

- Conduct a **literature review** of land application/PFAS studies to avoid duplicative research
- At land application sites nationwide, measure:
  - Incidence of PFAS in soil following long-term land application of biosolids and at various soil depths
  - **Assess Mobility** (leaching) of PFAS analytes through soil and vadose zone including the influence of rainfall and/or irrigation, using paired data sets of soil PFAS concentrations and groundwater PFAS levels
  - **Crop uptake** of PFAS analytes, utilizing paired data sets of soil PFAS concentrations versus plant uptake
  - Include a variety of different soils, depths to groundwater, and climates, by studying land application plots across the entire United States, including irrigated and non-irrigated soils.

Depth and breadth of dataset should be sufficient to:

- **Prove hypothesis that typical, background levels of municipal biosolids applied long-term do not increase soil levels of PFAS to levels that threaten groundwater or crop safety.**
- **Provide robust field data to calibrate modeling that predicts PFAS in groundwater & crops.**

UNIQUE ASPECTS OF THE NATIONAL COLLABORATIVE PROJECT:
How is it different from EPA-funded research on PFAS?

- Nationwide scope of project which will complement EPA funded research
- Research methodology at each site will be identical, allowing for direct comparison of data and a national set of real-world field data
- Study will provide for robust, calibrated model development
- Quantitative data will allow for risk assessments on specific sites

OTHER UNIQUE ASPECTS

- Brute strength approach – compile a massive amount of data at the national level
- Will clearly differentiate typical municipal biosolids vs. industrially contaminated biosolids; for example, MI uses non-risk-based cut off of ≤ 150 ppb PFOS.

STANDARDIZATION OF RESEARCH

- All PFAS analyses conducted by the same lab
- Strict sampling & analysis protocol followed at all sites.
- Soil, groundwater, and plant samples collected from long-term land application sites with known biosolids loadings
- Soil samples all collected at the same depths: surface 1 foot, 3 feet, and 6 feet (or as determined by review of literature)
- All soil samples sent to University of Arizona for sieving prior to being sent to University of Arizona Laboratory for Emerging Contaminants for PFAS analysis

SCOPE OF WORK

- Careful planning will be vital to ensure project is complementary to past and present ongoing research
- We will seek input from: Advisory Committee; utilities, State Biosolid Coordinators; U. S. EPA, private sector; other stakeholders
- Detailed scope of work currently being prepared with input from W4170

OUTLINE OF WORK FOR YEAR 1

Soil Sample Collection at Select Sites

- Soil samples taken at 1, 3 and 6 feet depths from the surface

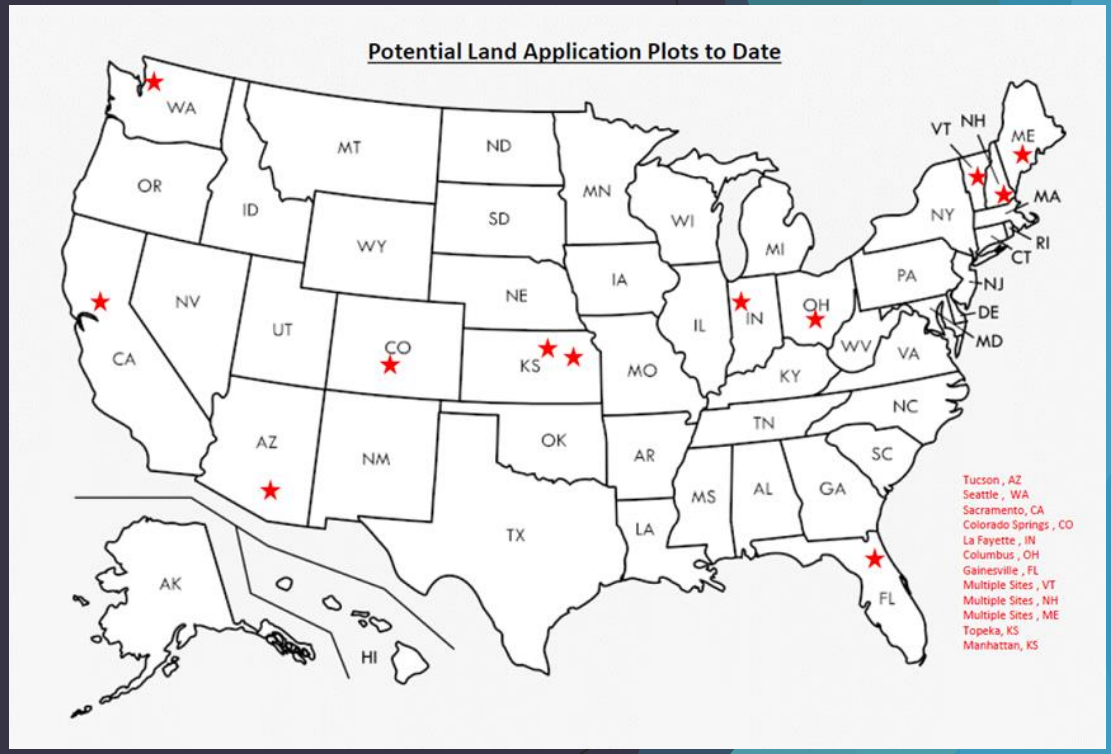
- Groundwater samples taken allowing for data pairing soil PFAS levels with groundwater PFAS levels

- 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

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



PROPOSED SUITE OF PFAS ANALYTES

These will be chosen based on:

- Latest research
- Input from stakeholders
- Health concerns from various analytes

All relevant analytes will be considered.

ADDITIONAL RESOURCES

- 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

- Other U. S. EPA research will be monitored

SCOPE OF WORK IN YEAR 2
FOLLOW-UP SAMPLING & CROP UPTAKE STUDIES

- Compilation, screening, & analysis of all data. Identification & filling of data gaps.
- Additional evaluation of crop uptake, if needed:
  - 2 or 3 common crops will be grown on land application sites (likely including grass hay, because of ME concerns, corn, and possibly soybean. All sites will grow same crops.
- At harvest, various edible portions of plants will be analyzed for PFAS.

FUNDING REQUIRED

A minimum of $1M is required for the 2-year project.

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

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.

PROJECT OUTCOMES

- Documentation of whether or not land application of biosolids across the U. S. is a significant public health route of exposure to PFAS via contamination of groundwater and/or crop uptake
- Development of a large, robust data set that can inform & calibrate models to predict whether or not the following are likely to occur:
  - significant leaching of PFAS impacting groundwater
  - significant plant uptake affecting crop quality & safety
- Final report with specific recommendations for modeling, regulation, & monitoring
  - e.g. - sensible approach for sampling & monitoring of biosolids, soils, etc.
- Support for continued land application due to low potential risk of PFAS exposure in many situations, but possible monitoring or restrictions needed in some situations, especially when industrially-impacted biosolids were/are involved.
- Presentations at national and international meetings

PROGRESS TO DATE

- Advisory Committee formed
- Detailed Scope of Work being created
  - Will be reviewed by Advisory Committee with input from W4170
- $300,000 pledged to date
- Enough funding for 30 sites

PROPOSED SCHEDULE

- Fundraising: Ongoing

- Planning: May - July 2022
- W4170 Meeting: June 5-7 2022
- Project Initiation: Aug/Sept 2022

QUESTIONS?

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