EPA Research Grant Annual Report

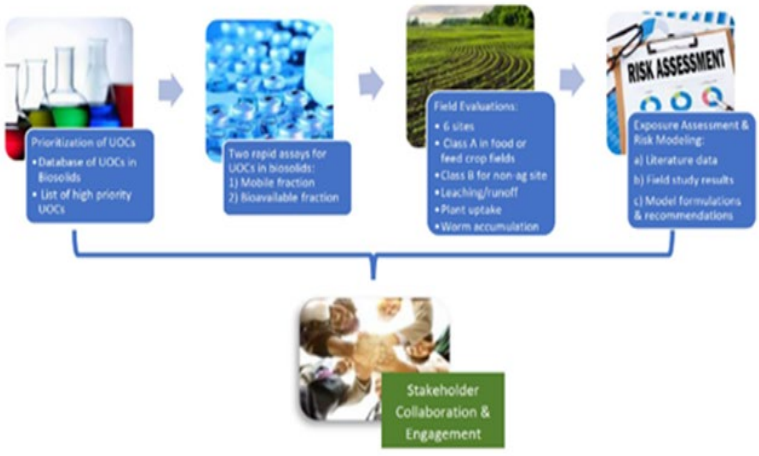
EPA Grant Number: 840240501
Project Title: Unregulated Organic Chemicals in Biosolids: Prioritization, Fate and Risk Evaluation for Land Application
Period Covered by the Report: Year 1 (October 1, 2021 – October 1, 2022)
Date of Report: November 2022
Investigators: Lola Olabode, Jay Gan, Linda Lee, Drew McAvoy, Patrick Dube
Institutions: The Water Research Foundation (WRF), University of California, Riverside, Purdue University, University of Cincinnati, Water Environment Federation.

1. Status, Progress, Preliminary Data, Results, and Evaluations

The goal of this research is to address key data gaps in our understanding of the occurrence and fate of unregulated organic chemicals (UOCs) in biosolids when land applied and identify which UOCs in biosolids-amended soils may pose a high risk to human and ecosystem health.
There are five main objectives of this research, each supported by a series of tasks with task leads and research team members:

- Objective 1: Conduct data mining and modeling to prioritize UOCs by identifying chemicals with a higher propensity to be mobile and bioavailable following biosolids land applications.
- Objective 2: Develop rapid standard methods for measuring mobile and bioavailable fractions of UOCs in biosolids.
- Objective 3: Conduct field studies under different application scenarios to determine plant uptake, earthworm accumulation, leaching and runoff of the high-priority UOCs at sites in California, Virginia, Illinois, and Indiana to support a national approach.
- Objective 4: Evaluate risk assessment fate and transport models for their prediction accuracy using literature, laboratory, and field derived data; and
- Objective 5: Work closely with industry partners and community stakeholders to solicit input and develop risk-based optimal management practices to ensure safe land applications of biosolids nationwide.

The research goal is a combination of field, laboratory and modeling activities as outlined below



Progress Summary:
Good progress has been made in the first year of the project. The project kick-off meeting was held on February 14, 2022, with the participation from the research team(s), project advisory committee, and utility advisory stakeholders. Several meetings have been conducted and hosted by the Water Research Foundation with the other awarded grantees, and EPA cooperators. Below are the first-year accomplishments and significant findings of this research:

Objective 1: Conduct data mining and modeling to prioritize UOCs by identifying chemicals with a higher propensity to be mobile and bioavailable following biosolids land applications.
Approach (involves assessing biosolids-borne UOCs by their occurrence, persistence, bioaccumulation, mobility, and human toxicity following amendment to soil)

- Compounds of highest concern were identified by conducting a persistent ($T_{1/2}$), bioaccumulation (BCF), soil mobility (K_{oc}), and potential for human toxicity (rat LD_{50}) assessment.
- Four different scenarios were conducted: (1) persistence and mobility, (2) mobility and bioaccumulation, (3) persistence, bioaccumulation, and human toxicity, and (4) persistence, mobility, bioaccumulation, and human toxicity.
- A scoring scheme was developed to help rank order the compounds of greatest concern (Table 1 in Appendix A).
- Persistent scores (biodegradation half-lives) and bioaccumulation scores (BCFs) were developed using USEPA and ECHA PBT criteria. The mobility scores (K_{oc}) were based on the FAO soil mobility classification criteria.
- The scores for each endpoint range from 1 to 6 with 1 being of highest concern and 6 the lowest of concern.

Preliminary Results

- Four different scenarios were conducted in this assessment: (1) persistence and mobility, (2) mobility and bioaccumulation, (3) persistence, bioaccumulation, and human toxicity, and (4) persistence, mobility, bioaccumulation, and human toxicity.
- Scores for the different scenarios were summed and the UOCs were ranked from the lowest score (highest priority) to the highest score (lower priority).
- The assessment screened out UOCs with measured biosolids concentrations < 1 mg/kg. Invoking this screen reduced the total number of UOCs to 73.
- If an organic compound appeared in all four scenarios, then it was classified as a chemical of highest concern. If a chemical appeared in 3 out of the four scenarios, then it was assigned a classification as a chemical with lower concern. The overall results from this assessment are provided in Table 2 of Appendix A.
- This assessment resulted in 31 high priority UOCs and 12 UOCs with lower concern.

In support of Objective 1,

- The UCR research team ordered analytical standards and optimized instrument parameters for analysis of 44 test chemicals, 23 internal standards, and 2 surrogates needed for planned studies.
- Purdue's research team assessed UOCs commonly found in biosolids, acquired new standards, optimized instrument(s), and performed extraction methodologies.

Objective 2: Develop rapid standard methods for measuring mobile and bioavailable fractions of UOCs in biosolids.

- Progress has been made in bioavailability assay method optimization, site preparation for the first field study in southern CA, bioavailability assay method validation and application, start of the vegetable plot study in southern CA, and site survey for the feed crop study in Central Valley, CA.
- With an optimized and modified LC-MS/MS method that includes different mobile phases and gradients, and different MS tune parameters from the EPA Method 1694 for PPCPs, the team is able to analyze priority UOCs, surrogate internal standards (SISs), and two quantitative internal standards (QISs) from a mixture of these chemicals in both methanol and LC-MS grade water via targeted LC-MS/MS analysis.
- Film extraction methods have been optimized for LC-MS/MS analysis and preliminary results show that CIPS films indeed absorb the majority of the priority UOCs even where PE films did not.
- Optimized GC-MS methods are almost complete for the analysis of select BDEs.

Objective 3: Conduct field studies under different application scenarios to determine plant uptake, earthworm accumulation, leaching and runoff of the high-priority UOCs at sites in California, Virginia, Illinois, and Indiana to support a national approach.

- Field soil samples were collected from the prepared vegetable beds and stored for future analysis of background levels of UOCs.
- Class A biosolids were collected for initial analysis and for use in future bioassays.
- Materials were purchased and site preparation was completed for the first field study. Biosolids were delivered, and the 4 different treatments were prepared for planting of different winter vegetables. The vegetable plots were seeded with 3 different vegetable types and each row was fertilized with one of four randomized treatments.
- Planning is underway to conduct the site survey for the feed crop study.
- Extraction methods for porewater, soil, biosolids, and plant and earthworm tissue have been sourced and once optimized they will provide the data necessary for further determination of partition coefficients and estimation of UOC bioavailability in biosolids and biosolids-amended soils.
- Acquisition of additional standards and surrogates, instrument optimization, testing and optimizing of extraction and clean-up methods for a wide range of UOCs and field preliminary data and study design.
- Re-assessment of the optimization of the instrumental methodology for UOCs analysis
- Biosolids extraction methods for UOCs.
- PFAS analysis of initial samples from two sites.
- Two site visits (Initiated sampling plan strategies for 3 sites)

Objective 4: Evaluate risk assessment fate and transport models for their prediction accuracy using literature, laboratory, and field derived data.

In accordance with the project timeline, this task has not started.

Objective 5: Work closely with industry partners and community stakeholders to solicit input

and develop risk-based optimal management practices to ensure safe land applications of biosolids nationwide

- Dr. Nicole Dennis (UCR) provided an update on the progress of contaminant list during the Water Environment Federation National Biosolids Leadership Call. This meeting included representatives from regional biosolids associations and leaders.
- Organized several team call meetings with other grantees and EPA cooperators on grant progress and participated in two notable grantee meetings.
- Conducted a stakeholder meeting at WEFTEC 2022 with Utility stakeholders, project advisors and EPA cooperators.

2. Changes in Key Personnel

No changes in key personnel have been made through October 1, 2022

3. Expenditures to Date

The expenditures to date are in line with progress by WRF and individual team members. WRF continues to keep close track of financial records. As of 09/30/2022, $187,859 or approximately 12.50% of the project budget has been spent.

4. Quality Assurance

The Quality Assurance Project Plan (QAPP) was approved by Benjamin Packard and Michelle Henderson on 01/26/2022.

5. Outputs/Outcomes and Findings of Significance

A preliminary list of prioritized UOCs has been produced. Four different scenarios were conducted (1) persistence and mobility, (2) mobility and bioaccumulation, (3) persistence, bioaccumulation, and human toxicity, and (4) persistence, mobility, bioaccumulation, and human toxicity. The scores for the different scenarios were summed and the UOCs were rank ordered from the lowest score (highest priority) to the highest score (lower priority). The overall results from this assessment were presented to stakeholders and will be continually assessed throughout the project period. Supporting teams simultaneously optimized instrument parameters for analysis, acquired new standards, assessed UOCs commonly found in biosolids, and performed extraction methodologies. The teams completed bioavailability assay method optimization, site preparation for the first field study in southern CA, completed bioavailability assay method validation and application, started the vegetable plot study in southern CA, and completed a site survey for the feed crop study in Central Valley, CA. With an optimized and modified LC-MS/MS method that includes different mobile phases and gradients, and different MS tune parameters from the EPA Method 1694 for PPCPs, the team is able to analyze priority UOCs, surrogate internal standards (SISs), and two quantitative internal standards (QISs) from a mixture of these chemicals in both methanol and LC-MS grade water via targeted LC-MS/MS analysis. Film extraction methods were optimized for LC-MS/MS analysis and preliminary results show that CIPS films indeed absorb the majority of the priority UOCs even where PE films did not. Field studies of the high-priority UOCs at sites in California, Virginia, Illinois, and Indiana are underway. Progress has been made in the acquisition of additional standards and surrogates, instrument optimization, testing and optimizing of extraction and clean-up methods for a wide range of UOCs and field preliminary data and study design.

The team is continuously working with other grantees, industry partners, and biosolids community stakeholders to solicit input and develop risk-based optimal management practices to ensure safe land applications of biosolids nationwide.

6. Subaward Monitoring Activities

WRF requires that sub-awardees submit progress reports and invoices on a quarterly basis. This annual report is a culmination of the progress reports submitted to date. WRF continues to closely track the financial aspects of this project.

Review of Financial and Programmatic Reports

Form SF-425 was prepared and submitted on 11/16/2022.

Site Visits and/or Desk Reviews

WRF reviewed each of the 3 Universities' most recent Single Audit Reports and performed Desk Reviews on all 4 subrecipients.

Audit Findings and Related Pass-Through Entity Management Decisions

None

7. Research Misconduct Status

There is no indication, nor suspicion, of research misconduct.

8. Planned Activity for the Subsequent Reporting Period (September 2022 – August 2023)

Objective 1: Conduct data mining and modeling to prioritize UOCs by identifying chemicals with a higher propensity to be mobile and bioavailable following biosolids land applications.

- Additional data searches and assessments for determining the highest priority UOCs will continue for the next six months.

Objective 2: Develop rapid standard methods for measuring mobile and bioavailable fractions of UOCs in biosolids.

- Complete soil slurry kinetics experiment and optimize extraction methods for porewater, soil, and biosolids.
- Complete bioavailability method applications, such as the derivation of chemical partition coefficients (K_{film}) and estimation of chemical bioavailability (C_{free}) from both water and soil slurry kinetics experimentation.

Objective 3: Conduct field studies under different application scenarios to determine plant uptake, earthworm accumulation, leaching and runoff of the high-priority UOCs at sites in California, Virginia, Illinois, and Indiana to support a national approach.

- Replace passive samplers in the vegetable plots at the laboratory equilibrium time point prior to the anticipated harvest.
- Complete the field-plot study in southern CA, the validation of the extraction and analysis procedures for non-PFAS UOCs in biosolids, and the UOC analysis for 3 sites on biosolids.
- Complete sampling plans for two sites on PFAS data from the initial exploration samples.
- Conduct field surveys, sample collection, analysis, and a VA site visit.
- Initiate sample collection (soil cores, groundwater, and surface soil) from three sites, and sample processing for PFAS and non-PFAS UOCs as samples arrive from the CA and VA sites.

- Add a new field site

Objective 4: Evaluate risk assessment fate and transport models for their prediction accuracy using literature, laboratory, and field derived data; and

- Begin activities on *Task 4 – Evaluation of Fate and Transport Risk Model Formulations*. Key findings will be provided in the next annual report.

9. Publications

- Abstract accepted: Nicole M. Dennis, Qingyang Shi, Aspen Smith, and Jay Gan. Annual Society of Toxicology and Chemistry (SETAC) North America meeting in Pittsburgh in November 2022. "Unregulated Organic Chemicals in Biosolids: Prioritization, Fate and Risk Evaluation for Land Applications"
- Costello M., Choy Y. and Lee L.S. Unregulated organic chemicals in sewage sludge before and after two anaerobic treatment processes, ACS (American Chemical Society) Fall 2022, Sustainability in a changing world. Chicago IL & Hybrid August 21-25, 2022. https://acs.digitellinc.com/acs/sessions/517856/view

Presentations and Invited Talks:

- Lee, L.S. PFAS Characteristics & Trends in Waste Management. Shipshewana, IN, Feb. 9, 2022.
- Lee, L.S. PFAS Occurrence, Fate & Mitigation in the Context of Biosolids, IWEA, Kokomo, IN, March 9, 2022.
- Drew C. McAvoy – *Prioritization of Biosolids-Borne UOCs*, Unregulated Organic Chemicals (UOCs) in Biosolids: Prioritization, Fate and Risk Evaluation for Land Applications, EPA Biosolids Grantees Meeting with EPA Cooperators and Project Manager, EPA Grant 84042501. August 2022

EPA Research Grant Annual Report Summary

Period Covered by the Report: October 1, 2021 – October 1, 2022
Date of Report: November 2022
EPA Agreement Number: 840240501
Title: Unregulated Organic Chemicals in Biosolids: Prioritization, Fate and Risk Evaluation for Land Application
Research Category: Water Treatment, Water Quality, Water
Project Period: Year 1 (October 1, 2021 – October 1, 2022)
Investigators: Lola Olabode, Jay Gan, Linda Lee, Drew McAvoy, Patrick Dube
Institutions: The Water Research Foundation (WRF), University of California, Riverside, Purdue University, University of Cincinnati, Water Environment Federation.

Objective of Research:
This research is addressing Research Area #2 of the EPA National Priorities Solicitation - "Better understanding of the occurrence, fate, and transport of chemical pollutants in land-applied biosolids, particularly those that may persist and/or accumulate in soils and biota"
There are five main objectives, each supported by a series of tasks with task leads and research team members:

- Objective 1: Conduct data mining and modeling to prioritize UOCs by identifying chemicals with a higher propensity to be mobile and bioavailable following biosolids land applications.
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Progress Summary/Accomplishments (Outputs/Outcomes):
A preliminary list of prioritized UOCs has been produced. Four different scenarios were conducted (1) persistence and mobility, (2) mobility and bioaccumulation, (3) persistence, bioaccumulation, and human toxicity, and (4) persistence, mobility, bioaccumulation, and human toxicity. The scores for the different scenarios were summed and the UOCs were rank ordered from the lowest score (highest priority) to the highest score (lower priority). The overall results from this assessment were presented to stakeholders and will be continually assessed throughout the project period. In support of this exercise, other teams are simultaneously optimizing instrument parameters for analysis, acquiring new standards, assessing UOCs commonly found in biosolids, and performing extraction methodologies.

The teams successfully completed bioavailability assay method optimization, site preparation for the first field study in southern CA, bioavailability assay method validation and application, start of the vegetable plot study in southern CA, and site survey for the feed crop study in Central Valley, CA. With an optimized and modified LC-MS/MS method that includes different mobile phases and gradients, and different MS tune parameters from the EPA Method 1694 for PPCPs, the team is able to analyze priority UOCs, surrogate internal standards (SISs), and two quantitative internal standards (QISs) from a mixture of these chemicals in both methanol and LC-MS grade water via targeted LC-MS/MS analysis. Film extraction methods have been optimized for LC-MS/MS analysis and preliminary results show that CIPS films indeed absorb the

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The team is continuously working with other grantees, industry partners, and biosolids community stakeholders to solicit input and develop risk-based optimal management practices to ensure safe land applications of biosolids nationwide.

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Future Activities:

- Additional data searches and assessments for determining the highest priority UOCs will continue for the next six months.
- Complete bioavailability method applications, soil slurry kinetics experiment and optimize extraction methods for porewater, soil, and biosolids.
- Complete the field-plot study in southern CA, the validation of the extraction and analysis procedures for non-PFAS UOCs in biosolids, and the UOC analysis for 3 sites on biosolids.
- Complete sampling plans for two sites on PFAS data from the initial exploration samples.
- Conduct field surveys, sample collection, analysis and a VA site visit.
- Initiate sample collection (soil cores, groundwater, and surface soil) from three sites, and sample processing for PFAS and non-PFAS UOCs as samples arrive from the CA and VA sites.
- Add a new field site
- Begin activities on *Task 4 – Evaluation of Fate and Transport Risk Model Formulations*.

Supplemental Keywords:

sludge; emerging contaminants; contaminant transport; risk assessment; organic chemicals

Relevant Website:

https://www.waterrf.org/unregulated-organic-chemicals-biosolids-prioritization-fate-and-risk-evaluation-land-applications

Water Research Foundation 5125 - Unregulated Organic Chemicals in Biosolids: Prioritization, Fate and Risk Evaluation for Land Application https://www.waterrf.org/research/projects/unregulated-organic-chemicals-biosolids-prioritization-fate-and-risk-evaluation-3

Appendix A: Preliminary Prioritization of Biosolids-Borne UOCs (Objective 1)

Table 1. Scoring scheme for the endpoints in this assessment.

Parameter	Limits	Units	Score
Persistence ($T_{1/2}$)	> 180	days	1
	60 - 180	days	2
	30 - 60	days	3
	7 - 30	days	4
	1 - 7	days	5
	< 1	days	6
Bioaccumulation (BCF)	000	L/kg	1
	4000 - 5000	L/kg	2
	3000 - 4000	L/kg	3
	2000 - 3000	L/kg	4
	1000 - 2000	L/kg	5
	< 1000	L/kg	6
Mobility (K_{oc})	< 10	L/kg	1
	10 - 100	L/kg	2
	100 - 1,000	L/kg	3
	1,000 - 10,000	L/kg	4
	10,000 - 100,000	L/kg	5
	> 100,000	L/kg	6
Human Toxicity (LD_{50})	< 5	mg/kg	1
	5 - 50	mg/kg	2
	50 - 500	mg/kg	3
	500 – 2,000	mg/kg	4
	2,000 – 5,000	mg/kg	5
	> 5,000	mg/kg	6

Table 2. Preliminary results using the top 50 organic compounds from the four assessment scenarios.

Chemicals of highest concern (all 4 scenarios)	Chemicals of lower concern (3 of 4 scenarios)
1,2,5,6,9,10-Hexabromocyclododecane	2,2',4,4',5-Pentabromodiphenyl-ether (BDE 99)
2,2',3,3',4,4',5,5',6,6'-decabromodiphenyl-ether (BDE 209)	2,2',4,4',6-pentabromodiphenyl ether (BDE 100)
(3alpha,5beta)-Cholestan-3-ol	2,2',4,4'-Tetrabromodiphenyl-ether
4-Chloroaniline	beta-Sitosterol
Acetaminophen	Ibuprofen
Aroclor 1254	Melamine
Bis(1,3-dichloropropan-2-yl)-hydrogen-phosphate	Naproxen
Bisphenol-A	Ofloxacin
Butylated-hydroxytoluene	Stigmasterol
Caffeine	Sulfanilamide
Campesterol	Terephthalic-acid
Carbamazepine	Tributyl-phosphate
Chlortetracycline	
Cholesterol	
Coprosterol	
Desmosterol	
Dibutyltin (DBT)	
Diphenhydramine	
Diphenyl-phosphate-(DPHP)	
Doxycycline	
Epitetracycline	
Ergosterol	
Gemfibrozil	
Isochlortetracycline	
Metformin	
Minocycline	
N-Nitrosodimethylamine	
Polyethylene-terephthalate	
Tetracycline	
Trichloroethylene	
Tris(methylphenyl)-phosphate	

Appendix B: Project Kick-Off Call, and Prioritization of Biosolids-Borne UOC Slides

THE Water Research FOUNDATION

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

Kick-Off Project Team and PAC Meeting

February 14, 2022

3-4:45 ET

ABOUT

MISSION

Advancing the science of water to improve the quality of life

VISION

To create the definitive research organization to advance the science of all things water to better meet the evolving needs of subscribers and the water sector

VALUES

Integrity • Leadership • Respect
Innovation • Collaboration

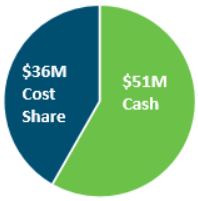
THE WATER RESEARCH FOUNDATION – AT A GLANCE

Funded Research

$82M

Contractually Funded

Managed by 54 Staff



Research Portfolio

1 Federal Contracts

3 Federal/State Grants

72 Co-funded Projects

15 Co-funders

264 Active Projects

Subscribers

1030 UTILITIES

79 CONSULTANTS

57 MANUFACTURERS

Research Programs

- Research Priority
- Tailored Collaboration
- Emerging Opportunities
- Unsolicited Research
- Grants/Awards
- Facilitated Research
- Paul L. Busch Award

230 Average Contracts/Year

19 Ave. Contracts in Process/Month

100 Payments/Month

15* Reimbursements Per Month

*not typical

Outline/Agenda

- **Introductions**
- **Responsibilities**
  - WRF
  - PAC
  - PI and Co-PI responsibilities
- **Timeliness Policy**
- **Deliverable Options/Opportunities**
- **Scope of Work and Progress to-date – Research Team**
- **Schedule**
- **Next Steps**

Project Management Structure

US EPA
Benjamin Packard
Project Officer

Objective 5: Collaboration and Engagement
Lead: WEF, WRF

Stakeholder & Utility Engagement Committee
Lola Olabode, WRF (PI)
Claudio Ternieden – WEF (Co-Chair)
John Albert – WRF (Co-Chair)

Project Management Team
Lola Olabode (PI)
Linda Lee, Purdue (Co-PI)
Jay Gan, UC Riverside (Co-PI)
Drew McAvoy , U Cinn (Co-PI)
Patrick Dube – WEF (Co-PI)
Jeff Moeller (Monitoring Manager)
Ashwin Dhanasekar, WRF (Research Manager)

Project Advisory Committee
Mohammed Abu-Orf
Nick Basta – Ohio State University
John Uzupis & Mary Firestone - MABA
Xia Kang – Virginia Tech
Greg Kester - CASA
Erica McKenzie – Temple University
Jeff Prevatt – Pima County, Arizona
Maria Lucia Silveira- W4170

Objective 1
Prioritization of Biosolids – Borne UOCs
Lead: U of Cinn

Objective 2
Rapid Assays for Lability and Bioavailability
Lead: UC Riverside, Purdue U

Objective 3
Field Evaluation of Fate and Risks of Biosolids-Borne UOCs
Leads: UC Riverside, Purdue U

Objective 4
Evaluation of Fate and Transport Risk Assessment Model Formulations
Lead: U of Cinn

PAC Members

1. Mohammed Abu-Orf
2. Nick Basta – Ohio State University
3. John Uzupis & Mary Firestone - MABA
4. Xia Kang – Virginia Tech
5. Greg Kester - CASA
6. Erica McKenzie – Temple University
7. Jeff Prevatt – Pima County, Arizona
8. Maria Lucia Silveira- W4170

EPA Cooperators

- Carolyn Acheson - ORD
- Ronn Hermann -ORD
- Liz Resek -HQ

Research Team

1. University of California, Riverside
2. University of Cincinnati, Cincinnati OH
3. Purdue University, Indiana
4. Hampton Roads Sanitation Districts (HRSD)
5. Los Angeles Sanitation Districts (LASAN)
6. Water Environment Federation
7. Las Gallinas Valley Sanitary District (LGVSD), San Rafael, CA
8. Metropolitan Water Reclamation District of Greater Chicago (MWRDGC)

Utility Advisory Committee

9. City of Kansas
10. City of Charlotte
11. San Francisco Public Utilities Commission (SFPUC)
12. Orange County Sanitation District
13. DC Water
14. NYC DEP
15. Mid Atlantic Biosolids Association (MABA)
16. California Association of Sewer Agencies (CASA)
17. New England Biosolids Residuals Association (NEBRA)
18. National Association of Clean Water Agencies (NACWA)
19. NorthWest Biosolids

Additional Organizational Support

20. HDR
21. US Water Alliance
22. The Nature Conservancy
23. Rural Community Assistance Partnership (RCAP)
24. Tree People
25. Iowa Soybean Association
26. Merrill Brothers
27. W4170

7

Current Working Timeliness Policy for WRF

- Co-PIs must adhere to project schedule in Project contract (*Exhibit B*)
- 60 days late: PI ineligible to submit new WRF proposals until 60 days after resolution
- 6 months late: PI organizational unit ineligible to submit new WRF proposals until 60 days after resolution
- Request no-cost extension ≥ 30 days before submitting new proposals

 1

No-Cost Extension Policy

- No Cost Extension Policy
- Extension of contract schedule, but no funding change
- Researcher responsibility to inform WRF of circumstances needing an NCE
- Written request required. Specify length of extension and reason
- If approved contract amendment required
- Project schedule will not be extended beyond nine (9) months without WRF Senior Management Team approval.

Project Contractual Deliverables

- Project Report Guidelines
- Scope of Work
- Interim Reports
- Web Updates
- Technical Summary
- Format Style Guide for Draft and Final Report
- Participating Utility Letters of confirmation
- Assignment of copyright (Exhibit E)

Project Start Date: October 1, 2021
Project End Date: June 30, 2024

	Year 1				Year 2				Year 3			
Objective/Tasks (Responsible Lead)	1	2	3	4	1	2	3	4	1	2	3	4
QAPP Preparation and Contracting	■											
Obj. 1.Prioritizationof Biosolid-borne UOCs (McAvoy, U. of Cinn.)	■	■	■	■	■	■						
Obj. 2. Rapid Assay Methods (Purdue, UC-Riverside)												
2.1 Porewater Assay (Lee, Purdue)		■	■	■	■	■						
2.3 Bioavailability Assay (Gan, UC-Riverside)		■	■	■	■	■	■	■				
Obj. 3. Field Studies (UC-Riverside, Purdue)												
3.1 Food Crops (vegetables, fruit trees) in CA (Gan, UC-Riverside)			■	■	■	■	■	■	■	■	■	■
3.2 Feed Crop Field Studies												
Site #1: MWRDGC site in Chicgao, IL (Lee, Purdue)		■	■	■	■	■	■	■				
Site #2.:Progress Farm, Virgina Beach, VA (Lee, Purdue)		■	■	■	■	■	■	■				
Site #3: Tile-drained fields in Indiana (Lee, Purdue)				■	■	■	■	■				
Site #4: Central Valley, CA (Gan, UC-Riverside)					■	■	■	■	■	■	■	■
3.3 Land Reclamation Site in Las Gallinas, CA, (Lee, Purdue)		■	■	■	■	■	■	■				
Obj. 4. Risk Assessment (McAvoy, U. of Cinn.)					■	■	■	■	■	■	■	■
Obj. 5. National Collaboration and Engagment (Olabode, WRF, Dube WEF)												
5.1 WEF-WEF Partner Coordination, Education, Outreach	■	■	■	■	■	■	■	■	■	■	■	■
5.2 Stakeholder Engagement Activities	■	■	■	■	■	■	■	■	■	■	■	■
Manuscript Preparation & Submission				■	■	■	■	■	■	■	■	■
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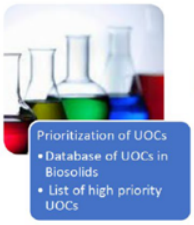
Unregulated Organic Chemicals in Biosolids: Prioritization, Fate and Risk Evaluation for Land Applications

(EPA Grant 84042501)

Synopsis of Project Activities

Prioritization of Biosolids-Borne UOCs

(Objective 1)



1) Develop a database that contains all measured UOCs and their frequency of detection.
2) Exclude UOCs from the list if:
   a) Risk assessments and/or regulatory standards have already been developed;
   b) UOC is a pesticide or a well-studied chemical class (e.g., PAHs);
   c) naturally produced, such as phytosterols;
   d) detected at low frequency (<10%), and
   e) low concentrations in biosolids.
3) Identify UOCs of high concern by conducting a persistent and bioaccumulative (PB) analysis using the U.S. EPA's TSCA criteria.
4) Refine identified list of priority UOCs for further study.

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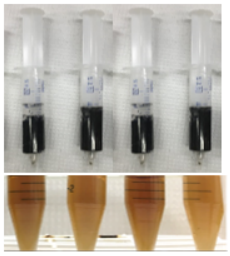
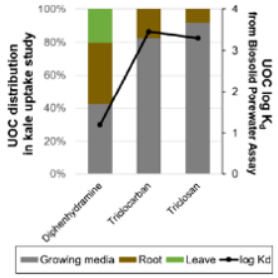
Rapid Assays for Lability and Bioavailability

Objective 2

Develop or optimize and validate with field data simple, rigorous methods to predict the lability, bioavailability and bioaccumulation potential of the priority UOCs in biosolids and soils.

Pore-water Assays





Biomimetic Assays for Bioavailability-Bioaccumulation Assessments

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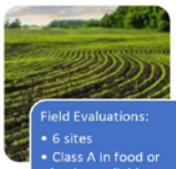

Field Evaluations:
- 6 sites
- Class A in food or feed crop fields
- Class B for non-ag site
- Leaching/runoff
- Plant uptake
- Worm accumulation

Field Studies

Objective 3

Site/Characteristics	Planting	Biosolids	Samples
SCREC, Irvine, CA: Sandy loam; deep groundwater table	Common vegetables; fruit trees	Class A; composted biosolids; agronomic rates	Edible tissues; soil cores; edge-of-field runoff; earthworms
MWRDGC, Chicago, IL: Sandy loams; groundwater 5-14'	Corn (feedstock)	Class A; agronomic rates; Stable Class B; one-time varied non-agronomic rates	Archived stover; soil cores; lysimeters; earthworms
Progress Farm, VA: Silt loam, sandy loam; loam; groundwater ≤3'	Corn, soybeans (feedstock)	Cambi THP Class A; agronomic rates	Corn stover/grain; soybeans/leaves; deep/shallow groundwater; surface water; edge-of-field runoff; soil cores;
Howard & Cass Counties, IN:	Corn, soybeans (feedstock)	Class A; agronomic rates	Soil cores; tile drains
Central Valley, CA: Sandy loam; deep groundwater table	Alfalfa, wheat, corn (feedstock)	Class A; agronomic rates	All crops; soil cores; earthworms
Las Gallinas Valley, CA: Loam to clay loams; groundwater 3-11'	None	Class B; varied; non-agronomic rates	Soil cores; groundwater; edge-of-field runoff;

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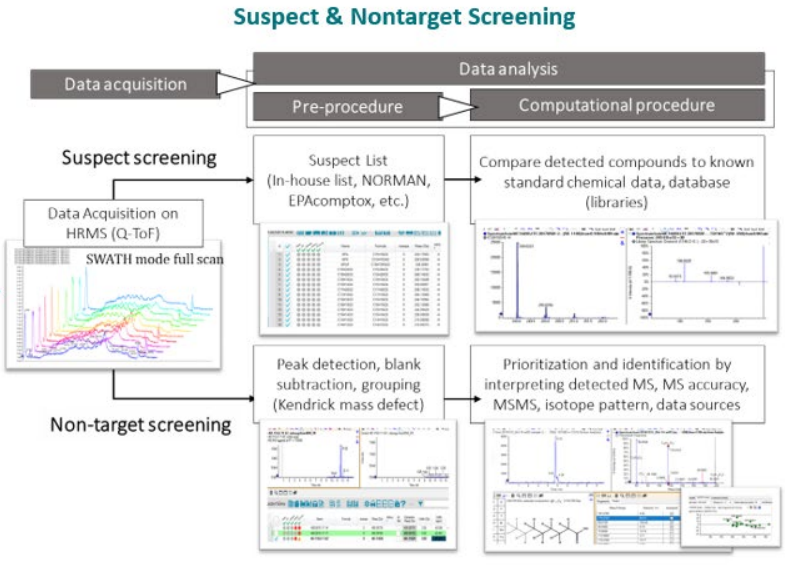
Analytical Flow

Extraction with Surrogate Subset & other QAQCs

Sample clean-up

Suspect Nontarget Screening for UOC Selection

Quantification



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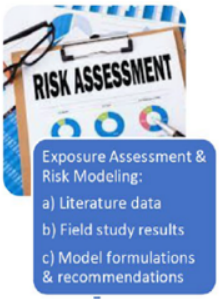

Evaluation of Fate and Transport Risk Assessment Model Formulations

(Objective 4)

- Gather model formulations for invertebrate bioaccumulation, plant uptake, bioaccumulation, leaching to groundwater, and runoff to surface waters.
- Conduct literature searches for the UOC model input parameters.
- Conduct sensitivity analysis on the model input parameters.
- Evaluate model formulations for accuracy and robustness.
- Develop a user-friendly risk calculator for assessing ecological and human health.
  -This tool will be developed in Excel with VBA as the programming language.

Collaboration and Engagement

Objective 5

- Facilitate communications, education, outreach, and dissemination between the research team, project and utility advisory committees, non-traditional stakeholders, and community.
- WEF/WRF will bring together key partners to support and provide valuable guidance, engagement, and distribution/circulation of the results and impacts of this project.
- Joint network includes WEF's 30,000+ members, 45 Member Associations, utilities, trade associations, community groups, and WRF's 1200+ subscribers and online research library.
- WEF/WRF will host three professionally facilitated stakeholder engagement meetings and workshops (one virtual and two in-person), two webinars and facilitate sharing of the results at conferences (including WEF's specialty conferences and WEFTEC).
- Dedicated Virtual Space for stakeholder engagement, collaboration and communications!

https://www.waterrf.org/unregulated-organic-chemicals-biosolids-prioritization-fate-and-risk-evaluation-land-applications

QAPP

Contents Page

Schedule

Project Start Date: October 1, 2021
Project End Date: June 30, 2024

	Year 1				Year 2				Year 3			
Objective/Tasks (Responsible Lead)	1	2	3	4	1	2	3	4	1	2	3	4
QAPP Preparation and Contracting	■											
Obj. 1.Prioritizationof Biosolid-borne UOCs (McAvoy, U. of Cinn.)	■	■	■	■	■	■						
Obj. 2. Rapid Assay Methods (Purdue, UC-Riverside)												
2.1 Porewater Assay (Lee, Purdue)		■	■	■	■	■						
2.3 Bioavailability Assay (Gan, UC-Riverside)		■	■	■	■	■	■	■				
Obj. 3. Field Studies (UC-Riverside, Purdue)												
3.1 Food Crops (vegetables, fruit trees) in CA (Gan, UC-Riverside)			■	■	■	■	■	■	■	■	■	■
3.2 Feed Crop Field Studies												
Site #1: MWRDGC site in Chicgao, IL (Lee, Purdue)		■	■	■	■	■	■	■				
Site #2.:Progress Farm, Virgina Beach, VA (Lee, Purdue)		■	■	■	■	■	■	■				
Site #3: Tile-drained fields in Indiana (Lee, Purdue)				■	■	■	■	■				
Site #4: Central Valley, CA (Gan, UC-Riverside)					■	■	■	■	■	■	■	■
3.3 Land Reclamation Site in Las Gallinas, CA, (Lee, Purdue)		■	■	■	■	■	■	■				
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Manuscript Preparation & Submission				■	■	■	■	■	■	■	■	■
Reporting				■	■			■	■			■

What's next?

Quality Assurance Project Plan – V1.0 Approved

WRF Contractual Key Deliverables

- Periodic Report 1 (includes Obj. 2.2; acquisition of chemical standards, instrument optimization, and preliminary study on bioavailability assay for UOCs) January 1, 2022
- Periodic Report 2 (includes Obj. 2.2, Obj. 3.1; bioavailability assay method development and experimental design for the first field study in southern CA) April 1, 2022

Important Grant Deliverables

- EPA Annual reports: Due 90 days from grant anniversary (10/01/2022, 10/1/2023)
- DRAFT Final Report: April 1, 2024
- EPA final report: June 30, 2024

Thank You

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

(EPA Grant 84042501)

Prioritization of BiosolidsBorne UOCs

Drew C. McAvoy, Ph.D., P.E.

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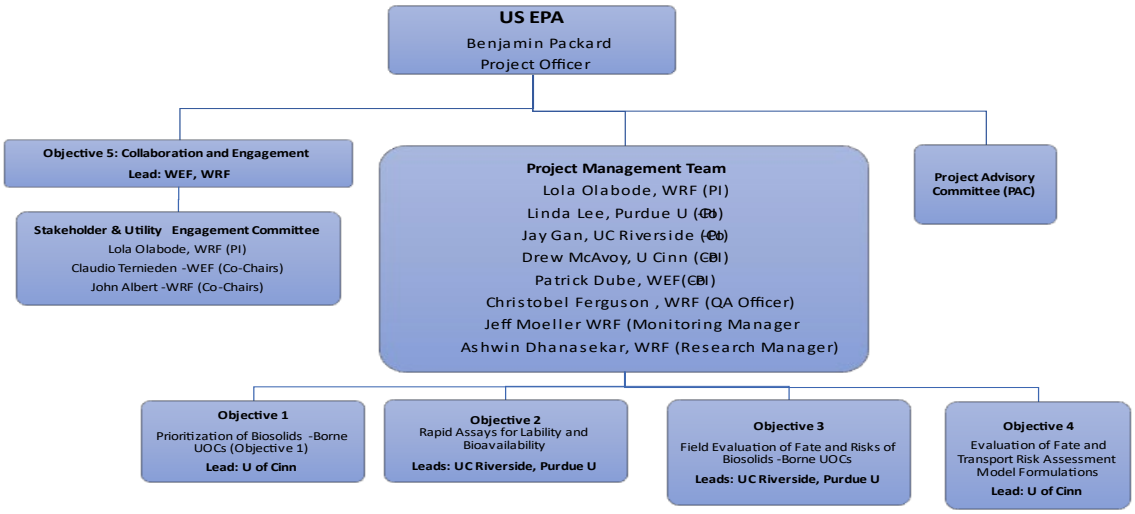
Project Management Structure



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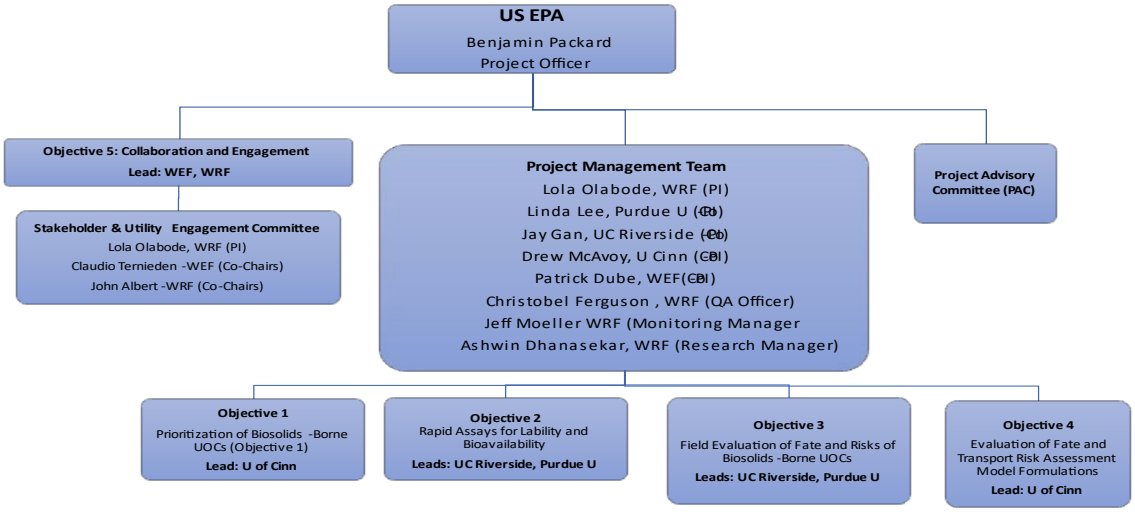

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Prioritization of Biosolids-Borne UOCs

(Objective 1 - Approach)

1) Develop a database that contains all UOCs measured in biosolids and their physical (e.g., Kow, pKa,Sw) and biological (e.g.,biodeg, sorption, uptake) properties
2) Exclude UOCs from the list if:
    a) risk assessments and/or regulatory standards have already been developed;
    b) is an agricultural pesticide or a well -studied chemical class (e.g., PAHs);
    c) is a metal or inorganic compound;
    d) is naturally produced, such as phytosterols; and
    e) has low concentration in biosolids
3) Identify UOCs of high concern by conducting mobility (M), persistent (P), bioaccumulative (B), and toxicity (T) assessments
4) Identify final list of priority UOCs for further study

Data and Model Sources

Data Sources

EPA Biennial Review (20182019)
EPA Biennial Review (BR) Search (2022)
EPA CompTox Biosolids Dashboard (2022)
EPA ECOTOX (2022)
EPA National Sewage Sludge Survey (2009)
Literature Searches

Model Sources

EPA ECOSAR (2017)
EPA EPISuite (2017)
EPA TEST (2022)
NIH OPERA (2018)

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Chemical Categories

Included (total = 383)	Excluded (total = 542)
Antibiotics	Agrochemicals
Antimicrobials	CFCs
Cleaning Products	Dioxins/Furans
Colorants	Food Additives
Flame Retardants/PBDEs	Natural Hormones
Fragrances	Industrial Solvents
Organic Solvents	Inorganics/Metals
Other Organics	Organotins
Personal Care Products	PCBs/PBBs
Pharmaceuticals	PFAS
Phthalates	Recreational Drugs
Plasticizers	Research Chemicals
Quaternary Ammonium Compounds	Volatile Organics

Database Parameters

General Parameters	Assessment Parameters	Other Parameters
Chemical Name	Biosolids Concentration	Solubility
CAS Number	Koc (soil)	Kow
Smiles Notation	Biodegradation (aquatic)	pKa
Molecular Formula	Bioconcentration Factor (BCF)	Henry's Law constant
Molecular Weight	LC50 (fish, daphnid)	LD50 (rat)
Category	EC50 (algae)	Chv (fish, daphnid, algae)
		LC50 (earthworm)

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Scoring Scheme

Persistence

Parameter	Limits	Units	Score
Aquatic Half-Life (Biodegradation)	> 180	days	1 (slow biodeg)
	60 - 180	days	2
	30 - 60	days	3
	7 - 30	days	4
	1 - 7	days	5
	< 1	days	6 (rapid biodeg)

Bio-uptake

Parameter	Limits	Units	Score
Bioconcentration Factor (BCF)	> 5000	L/kg	1 (high uptake)
	4000 - 5000	L/kg	2
	3000 - 4000	L/kg	3
	2000 - 3000	L/kg	4
	1000 - 2000	L/kg	5
	< 1000	L/kg	6 (low uptake)

Mobility

Parameter	Limits	Units	Score
Soil Adsorption (Koc)	< 10	L/kg	1 (high mobility)
	10 - 100	L/kg	2
	100 - 1,000	L/kg	3
	1,000 - 10,000	L/kg	4
	10,000 - 100,000	L/kg	5
	> 100,000	L/kg	6 (low mobility)

Toxicity

Parameter	Limits	Units	Score
Aquatic Toxicity (Acute)	< 0.1	mg/L	1 (highly toxicity)
	0.1 - 1.0	mg/L	2
	1.0 - 10.0	mg/L	3
	10.0 - 50.0	mg/L	4
	50.0 - 100.0	mg/L	5
	> 100.0	mg/L	6 (low toxicity)

Preliminary Assessment Results

Assessment Approach	Value Used	Number of Compounds
Category Elimination	NA	383
Biosolids Concentration	> 1 mg/kg	69
PBT	Sum ≤ 10	18
MPT	Sum ≤ 10	35
MPBT	Sum ≤ 15	29

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What's next?

Verify database values and finalize the prioritization scheme for the UOCs in biosolids

Important Grant Deliverables

EPA Annual reports: Due 90 days from grant anniversary (10/01/2022)

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Questions?

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