EPA Research Grant Annual Report

EPA Grant Number: 84024501
Project Title: Unregulated Organic Chemicals in Biosolids: Prioritization, Fate, and Risk Evaluation for Land Application
Period Covered by the Report: Year 2 (October 1, 2022 – October 1, 2023)
Date of Report: December 2023
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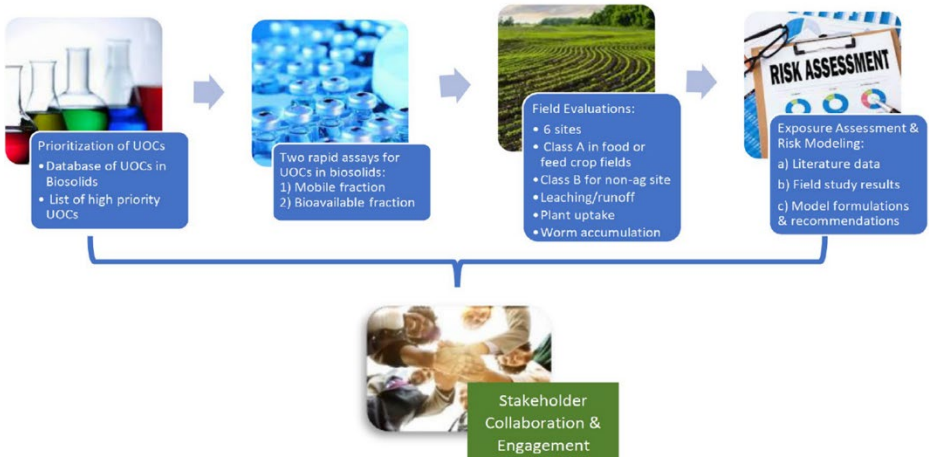
1. Status, Progress, Preliminary Data, Results, and Evaluations

The goals of this research which have not changed from the original application 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 considerable 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:
Great progress has been made in the second year of the project. The goals from the original application have not changed. Several meetings have been held throughout the year with partner organizations, utilities, community stakeholders, and organizations. Meetings have also been jointly held with the other awarded grantees, and EPA cooperators. Additional time is required for the fieldwork to be completed and as a result the team will be requesting a two-year no cost extension. Below are the second-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. Goals for the period covering April 1- September 30, 2023, were to complete Objective 1 on conducting a prioritization assessment for biosolids-borne UOCs. The prioritization assessment utilized information on the occurrence, persistence, bioaccumulation, mobility, and potential toxicity of biosolids-borne UOCs following amendment to soil. The UOCs were screened based on chemical type and concentration.

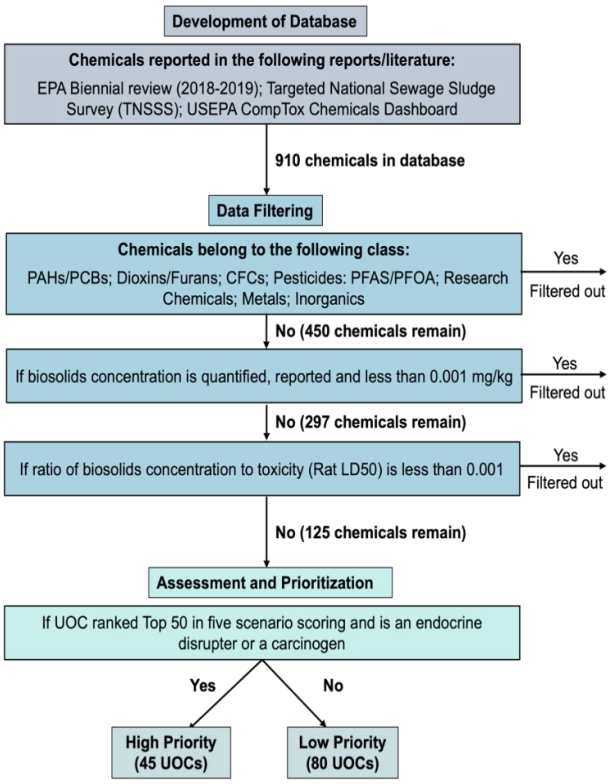
Approach (involves assessing biosolids-borne UOCs by their occurrence, persistence, bioaccumulation, mobility, and human toxicity following amendment to soil)

- 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.
- 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 one being of highest concern and six the lowest of concern.

Preliminary Results

- A total of 910 chemicals were included in the consolidated database. The list includes chemicals from the USEPA CompTox Chemicals Dashboard, USEPA biennial report (2018-2019), USEPA TNSSS biosolids study (2006), and UOCs found in the literature. After agrichemicals, CFCs, industrial solvents, inorganic compounds, metals, PAHs, and PCBs were screened from the list a total of 450 UOCs remained. Secondary screening was performed to filter UOCs with concentration < 0.001 mg/kg followed by the ratio of biosolids concentration to toxicity < 0.001. This resulted in 125 UOCs. Figure SS-1 summarizes the approach, assessment, and evaluation of UOCs.

Figure SS-1. Schematic representation of selection and prioritization of UOCs.



- The 125 UOCs were scored based on a scoring scheme for mobility (K_{OC}), persistence ($t_{1/2}$), bioaccumulation (BAF), and toxicity (Rat LD_{50}) with a lower score indicating higher priority. Individual scores for each parameter were added to evaluate the priority UOCs using five scenarios – (1) mobility and bioaccumulation, (2) mobility and persistence, (3) mobility, persistence, and toxicity, (4) persistence, bioaccumulation, and toxicity, and (5) mobility, persistence, bioaccumulation, and toxicity. The UOCs were then ranked based on the individual scenario scores. A total of 11 UOCs ranked in the Top 50 for all five scenarios. There were also 13 compounds identified as carcinogens and 23 compounds identified as endocrine disruptors from the list of 125 UOCs.
- The carcinogens, endocrine disruptors, and Top 50 compounds that appeared in all five scenarios were categorized as high priority. This represented 45 compounds in total (Table SS-1). The remaining 80 UOCs were categorized as low priority.
- The 125 priority UOCs from this evaluation were also compared to other biosolids priority lists: (1) State of the Science review of occurrence and physical, chemical, and biological processes affecting biosolids-borne trace organic chemicals in soil prepared by Higgins et al. (2010) for the Water Environment Research Foundation, (2) assessment of organic contaminants in material spread on land prepared by *wca* Environment Ltd. for the Scottish EPA (SEPA, 2019), and (3) chemicals of interest in biosolids a summary of key information and hazard ranking prepared by ToxStrategies Inc. for the Texas Commission for Environment Quality (TCEQ, 2021). Eight UOCs from this study were present in two of the three priority lists. These compounds included BDE-47, BDE-207, BDE-99, Tonalide, Sulfanilamide, Ofloxacin, Triclocarban, and Triclosan.

Chemical	CASRN	Chemical Class
N-Nitrosodimethylamine	62-75-9	Other Organics
1,2-Dichlorobenzene	95-50-1	Cleaning Products
1,2-Dichloropropane	78-87-5	Industrial solvent
1,2,4-Trichlorobenzene	120-82-1	Industrial solvent
1,4-Dioxane	123-91-1	Fragrance
2,6 Dinitrotoluene	606-20-2	Industrial solvent
4-(1,1,3,3-Tetramethylbutyl) phenol	140-66-9	Other Organics
4-Chloroaniline	106-47-8	Other Organics
4-Methyl 2-pentanone	108-10-1	Industrial solvent
4-Nonylphenol	104-40-5	Other Organics
4-Nonylphenol-diethoxylate	20427-84-3	Other Organics
4-Octylphenol	1806-26-4	Other Organics
Aroclor 1254	11097-69-1	Industrial solvent
BDE 209	1163-19-5	PBDEs
BDE 47	5436-43-1	PBDEs
BDE 99	60348-60-9	PBDEs
Bis(1,3-dichloropropan-2-yl)-hydrogen-phosphate	72236-72-7	Flame Retardant
Bisphenol-A	80-05-7	Pharmaceutical
Campesterol	474-62-4	Other Organics
Carbamazepine	298-46-4	Pharmaceutical
Cashmeran (DPMI)	33704-61-9	Fragrance
Di(2-ethylhexyl)-phthalate	117-81-7	Other Organics
Digoxin	20830-75-5	Pharmaceutical
Diisodecyl phthalate	26761-40-0	Phthalates
Diisononyl phthalate	28553-12-0	Phthalates
Dimethyl sulfone	67-71-0	Industrial Solvent
Chemical	**CASRN**	**Chemical Class**
Diphenhydramine	58-73-1	Pharmaceutical
Ergosterol	57-87-4	Pharmaceutical
Estrone	53-16-7	Hormones
Fluoxetine	54910-89-3	Pharmaceutical
Galaxolide	1222-05-5	Fragrance
Monobutyltin (MBT)	78763-54-9	Organotins
N-Nitrosobutylamine	924-16-3	Other Organics
N-Nitrosodiethylamine	55-18-5	Other Organics
N-Nitrosopiperidine	100-75-4	Other Organics
N-Nitrosopyrrolidine	930-55-2	Other Organics
Phenol	108-95-2	Pharmaceutical
Sertraline	79617-96-2	Pharmaceutical
Toluene	108-88-3	Volatile Organics
Tonalid	21145-77-7	Fragrance
Tonalide (AHTN)	1506-02-1	Fragrance
Tributyltin (TBT)	688-73-3	Organotins
Trichloroethylene	79-01-6	Industrial Solvent
Triclosan	3380-34-5	Pharmaceutical
Triphenyltin (TPhT)	892-20-6	Organotins

Table SS-1. List of high priority UOCs.

In support of Objective 1,

- The UCR research team finalized extraction methods for water/porewater and soil. Acceptable recoveries were observed for all 44 priority UOCs, and the finalized biosolids extraction method provided acceptable recoveries for 42 of the 44 targeted UOCs. The two UOCs having unacceptable recoveries were 3,3',5,5'-Tetrabromobisphenol A (TBBPA) and Triclocarban. Methods are detailed in a draft manuscript. This manuscript will also outline the UOC residue values from recycled irrigation water, field soil, and Class A biosolids used in field plot studies.
- Purdue's research team assessed UOCs commonly found in biosolids, acquired new standards, optimized instrument(s), and performed extraction methodologies.
- The database and analysis of the highest priority UOCs has been completed. The results have been compiled into a final report.

No difficulties were encountered during the reporting period. Teams will be meeting in the next quarter to further discuss Objective 1 findings.

Objective 2: Develop rapid standard methods for measuring mobile and bioavailable fractions of UOCs in biosolids. The goals for the period between October 1, 2022 - April 1, 2023, were bioavailability method applications, completion of vegetable field-plot study in southern CA, data analysis and write up for bioavailability-assay methods, site preparation for the second field study in southern CA, and sample collection and analysis in Central Valley, CA.

- Pilot water and soil kinetics tests were completed for range finding purposes, fine-tuning of the planned kinetics experiments, and an initial reference point for field deployment time for each of the chosen passive sampling films.
- The finalized extraction methods for water/porewater and soil had acceptable recoveries for 44 priority UOCs, and the finalized biosolids extraction method provided acceptable recoveries for 42 of the 44 targeted UOCs. The two UOCs having unacceptable recoveries were 3,3',5,5'-Tetrabromobisphenol A (TBBPA) and Triclocarban. Methods are being detailed in a draft manuscript which should be ready for publication by the next reporting period along with the UOC residue values from recycled irrigation water, field soil, and Class A biosolids used in field plot studies.
- A slight adjustment was made to the final analyte list, totaling 46 UOCs (**Table 1**) for several reasons: analytes producing unstable transition ions were removed, backordered chemicals were removed, chemicals with low extraction recoveries despite using the best available extraction techniques were removed, 2 PFAS were added for more overlap with Purdue, and 6PPD-Q, a degradation product of 6PPD that is a common additive to tires, was added due to recent data on its widespread occurrence and a strong research interest.
- LC-MS/MS methods of chemical analysis have been finalized (**Table 2**) for 44 UOCs in the mixture requiring LC-MS/MS analysis and instrumental limits of detection and quantification (LOD/Qs) are in the process of being updated.
- Methods of extraction have been finalized and LOD/Qs are currently being calculated for the UOC mixture in water/porewater, thin films, and soil. A preliminary GC-MS method of analysis has been established for the 2 UOCs in the mixture requiring GC-MS analysis (**Table 3**). Method optimization is underway, and LOD/Qs are being calculated. Extraction methods for these 2 UOCs are also currently being validated.

- Water and soil kinetics and traditional soil partitioning experiments have been completed. From them, chemical partition coefficients for the thin films and water/porewater (K_{film}), and soil and porewater (K_d) will be calculated. This data is also still being processed.
- A dosing area was established, and physical boundaries were installed around the avocado and mandarin trees, and then fertilized for the upcoming growing season with the same treatments (percentage of traditional fertilizer replacement) in replicates of three as were used for the vegetable study.
- The Purdue team discovered that the Modified EPA 1694 method provided significantly better results than the Enhanced Matrix Removal-Lipid method (EMR). Therefore, it will be the one selected for biosolids and soil extractions. Several compounds including hormones showed to have poor recoveries and will be removed from the UOCs target list.

Table 1. The UCR final list of 46 LC-MS/MS or GC-MS optimized priority UOCs, SISs, and QISs.

Analyte	Analyte	SIS	QIS
1,2,5,6,9,10-Hexabromocyclododecane (HBCD)	3,3',5,5'-Tetrabromobisphenol A (TBBPA)	$^{13}C_6$-PFHxA	$^{13}C_2$-PFHxA (MPFHxA)
Perfluorohexanoic acid (PFHxA)	Perfluorohexane sulfonic acid (PFHxS)	d_{15}-TPhP	d_3-Meprobamate
Perfluorobutane sulfonic acid (PFBS)	Tributyl phosphate (TBP)	$^{13}C_6$-methyl paraben	$^{13}C_{12}$-BDE 47
Triphenyl phosphate (TPhP)	Tris-(2-butoxyethyl) phosphate (TBEP)	d_5-6PPD-q	
Tris(2-chloroethyl) phosphate (TCEP)	2,2',4,4',5-Pentabromodiphenyl ether (BDE 99)	d_4-DINP	
2,2',4,4'-Tetrabromodiphenyl ether (BDE 47)	Methylparaben (MePB)	d_4-4-NP	
Caffeine	4-Chloroaniline	d_{16}-BPA	
Bisphenol A (BP-A)	4-nonylphenol (4-NP)	d_{10}-Lidocaine	
4-Octylphenol (4-OP)	2-anilino-5-[(4-methylpentan-2-yl)amino]-cyclohexa-2,5-diene-1,4-dione (6PPD-q)	d_5-BP3	
Triphenyltin (TPhT)	Lidocaine	$^{13}C_6$-sulfathiazole	
Miconazole	Triclocarban	d_5-alprazolam	
Triclosan	Galaxolide (HHCB)	d_3-naproxen	
Tonalide (AHTN)	Oxybenzone (BP3)	d_2-β-estradiol	
Acetaminophen	Naproxen	d_5-methamphetamine	
Diazepam	Chlortetracycline	d_3-CBD	
Sulfathiazole	Carbamazepine	d_9-Caffeine	
Fluoxetine	Metformin	d_3-triclosan	
Atenolol	Indomethacin	d_3-ibuprofen	
Ibuprofen	Norethindrone	d_7-atenolol	
17β-estradiol	Estrone	d_{10}-Carbamazepine	
Diisodecyl phthalate (DIDP)	Diisononyl phthalate (DINP)	d_6-Fluoxetine	
Methamphetamine	Cannabidiol (CBD)		
Cannabinol (CBN)	Δ9-tetrahydrocannabinol (Δ9-THC)		

Soil and water partition coefficients (K_d) were derived at three concentrations using batch equilibration method. A partial list of K_d values are listed in Table 2.

Table 2. Calculated K_d values for field soil and porewater

Chemical	Kd±SE
4-Chloraniline	3.76±3.28
Methamphetamine	0.04±0.02
Acetaminophen	0.30±0.06
Naproxen	20.18±16.35
Lidocaine	0.55±0.04
Carbamazepine	0.17±0.01
Sulfathiazole	1.78±1.19
TBP	0.03±0.02
Atenolol	0.40±0.11
Galaxolide	0.01±6.0E3
TCEP	0.61±0.13
Diazepam	0.01±2.0E3
Norethindrone	0.21±0.02
Indomethacine	0.36±0.17
TPhT	3.22±3.92
TBEP	0.05±5.0E4
DINP	0.23±0.0
Chlortetracycline	0.30±0.16

The goals of bioavailability method applications and completion of the first vegetable field-plot study in southern CA have been met with progress made on the fruit tree field study. Data analysis and write up for the instrument and extraction method development and their application for biomimetic chemical assays to assess bioavailability will be completed in the next reporting period.

Problems encountered:

- General LC-MS/MS maintenance and operating issues randomly occurred causing several temporary instrument-use backlogs.
- Increased waiting time for some laboratory supplies and/or increased necessity to adjust experimental designs due to supply issues, causing temporary delays.
- Consumables, instrument service and repairs have become substantially more expensive.

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.

- Significant progress was made by the **UCR** team towards the fruit tree study in southern CA. The second vegetable field study in southern CA has been completed. Fertilization treatments for all fruit trees have been completed and peaches have been harvested.
- Extraction method optimization is finalized for extraction of 44 UOCs of study interest from water/porewater, soil, thin films, biosolids and vegetable tissues. All samples from the first vegetable study have been extracted and analyzed for UOC residues.

- Field soil and irrigation water collected from the South Coast Research and Education Center (SCREC) have been extracted and stored (-20 C) and are awaiting analysis for background levels of the priority UOC mixture.
- The Class A biosolids and treatments used for the first vegetable study have been freeze-dried and stored at room temperature. Upon finalization of the biosolids extraction/clean-up methods (that lean heavily on Purdue's simplified method currently reported), stored samples will be extracted and analyzed for UOC concentrations.
- One of two planned vegetable studies has been completed and all edible vegetable tissue samples have been processed, freeze-dried, and stored at room temperature. Films were retrieved at harvest and stored (0 C), soil samples were taken at several time points from each vegetable row and stored (0 C), and earthworms were opportunistically sampled and stored (0 C). Stored samples will be processed, extracted, and analyzed for UOC concentrations according to finalized protocols as they continue to become available for this complex mixture.
- The Irvine Water District delivered additional Class A biosolids to the field site at SCREC. The four different fertilizer treatments were prepared for the start of the fruit tree study and samples were collected for UOC residue analysis.
- The fruit tree field study began earlier than planned (January 2023 vs July 2023) because the avocado and mandarin trees need the entire growing season's fertilizer applied the winter prior to flowering, fruiting, and harvesting. Initial soil samples were taken from each tree prior to initial fertilizer application and stored (-20 C) for future residue analysis.
- Both vegetable studies have been completed. All the plant tissue samples from the first vegetable study have been extracted and analyzed. All edible vegetable tissue samples from the second field study have been processed and stored (-80 °C) for analysis. Thin-film passive samplers were retrieved at harvest and stored (0 °C), soil samples were taken at several time points from each vegetable row and stored (0 °C), and corn earworms were opportunistically sampled and stored (0 °C). Stored samples will be processed, extracted, and analyzed for UOC concentrations according to the finalized protocols for this complex mixture, and will be available for reporting in the next reporting period.
- The peach portion of the tree fruit field study has been completed and the edible portion has been processed and stored (-80 °C). Thin-film passive samplers were retrieved at harvest and stored (0 °C), soil samples were taken at several time points from each peach tree and stored (0 °C). Stored samples will be processed, extracted, and analyzed for UOC concentrations in the peaches and apples according to finalized protocols for this complex mixture, and will be available for reporting in the next reporting period.
- Passive samplers were deployed for apple trees. Harvest will be in the next two weeks and the fruit, soil samples, and films will be processed and stored for extraction and analysis.
- Chemical partition coefficients were determined using the batch equilibration method and the partition coefficients (K_d) will be derived for use in lab and field studies.
- Preliminary validation of biosolids and soil extraction methods for UOCs were conducted by the **Purdue** team.
- A second visit was made to LGV and VWD, CA sites for sampling.
- Completed general sampling (surface soil) of the VWD, Ca site.
- Analysis of VWD project one samples for PFAS near to completion and initiated for UOCs.
- Finished general sampling (soil cores and ground water) for LGV site.

- Started assessment of PFAS mobility in DLD site.
- Finalized pre-biosolids application collection of groundwater and storm water at the HRSD site and initiated sampling after biosolids application.
- Initiated sample processing for PFAS and non-PFAS UOCs for the HRSD site samples. The site visit for HRSD will be completed during the next reporting period.
- Initial site identified for evaluating tile-drain tile drain discharge as well as crop uptake did not end up having much PFAS contamination. As a result, the team has identified a second site that receives biosolids (subsurface injection) from a WWTP and where soybeans and corn are grown. The team is currently collaborating with the farmer to better understand the site and its potential. If the site meets our criteria including a good understanding of what fields drain to which tiles, we will set up stations this fall.
- More personnel were hired for the project to work on the PFAS side of this project.

In the next period, the Purdue team will:

- Complete the data processing for the validation of the extraction and analysis procedures for non-PFAS UOCs in biosolids and soil.
- Complete the data processing for a 'Rapid' method for PFAS that uses the QuEChERS method coupled to clean up with an ENVI-Carb cartridge and comparison with other methods.
- Complete the UOCs analysis for the HRSD, LGV and VWD biosolids.
- Assess Santa Rosa City as a sampling site, and potentially create a sampling plan.
- Installation of ISCO run-off samplers at LGV and VWD sites.
- Start the continuous sampling of the areas applied with biosolids in 2023 at the LGV, VWD sites and continue with the sampling at HRSD site.
- Continue with the extraction and analysis for PFAS and non-PFAS UOCs as samples arrived from CA and VA sites.
- Complete de PFAS fate assessment of the DLD area and potentially complete it for non-PFAS UOCs.
- Complete project one of the VWD site for UOCs/PFAS.
- Evaluate the second tile-drained site identified since the first one did not work out due to low PFAS presence in the solids being applied to the site.
- Continue discussions on a new MWRD field site, which may now be a site in Illinois.
- Confirm up the SRC site in CA that is going to be added to the project where biosolids have been applied historically.

Problems Encountered - 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.

UCR Team:

- General LC-MS/MS maintenance and operating issues randomly occurred causing several temporary instrument-use backlogs.
- Increased waiting time for some laboratory supplies and/or increased necessity to adjust experimental designs due to supply issues, causing temporary delays.
- Consumables including chemical standards, solvents, specialty gases, and instrument service and repairs have become substantially more expensive.
- Costs for attending meetings have risen significantly.

UCR Team Rationale for Proposed Changes/revised goal

The planned feed crop study in Central Valley, CA will not be completed due to lack of response from the managers of the proposed study location. In lieu of the feed crop survey study, the UCR team proposes to carry out studies under laboratory-controlled conditions to 1) understand the environmental fate of 6-PPDQ, a newly emerged UOC from tire wear particles, in soil, and 2) to mechanistically elucidate mechanisms and factors influencing translocation of PFAS compounds from vegetative organs to fruits, using tomato as a model plant. Additional time will be required to complete this proposed change/modification to the initial goal of a feed crop study in Central Valley, California

Purdue Team:

- The technical problems with the instrumentation encountered in the previous reporting period still impact the sample injection and therefore in the validation of methods.
- The delay in the method validation has also delayed the rapid assay methods.
- Procedural mistakes by the company doing the samples at CA yielded to a complete resampling of the LGV area, and therefore delayed the sampling processing.
- The considerable number and variety of compounds targeted poses a challenge for the non-PFAS UOC method validation, hence the data analysis required more time than anticipated.
- The inclusion of more sampling areas such as VWD and SRC increases the load of work and therefore slows the average progress.
- It would be ideal to be able to study the areas applied with biosolids for at least 2 years, that will increase the time needed to complete the project.
- Initial site identified for tile-drain work has low PFAS presence in the solids that are land-applied. A second site was identified.

Purdue Team Rationale for Proposed Changes

- Addition of the SRC site but at a small effort scale. The Chicago MWRD site was discarded due to legal problems and limitations. An additional site (VWD) in CA (and now the SRC site) was added. Another Midwest site has been identified in IL.

As a result of the problems encountered, additional time will be required to rectify and complete Objective 3.

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

The review and evaluation of existing risk model formulations will continue during the upcoming period. Work on a Python code for predicting the fate and transport of UOCs following biosolids amendment to soil will also be initiated. This timing is in accordance with the schedule for Objective 4 – Evaluation of Fate and Transport Risk Model Formulations. Key findings from this objective will be provided in the upcoming reporting period. All research team members will be meeting in the first quarter of 2024 (March 2024) to solicit additional technical input from the field researchers, cooperators, project advisors, and utility stakeholders before completion of Objective 4. Delays in Objective 3 may also impact prediction accuracy of the laboratory and field derived data.

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 team participated at the W4170 annual meeting in Chicago, IL June 26-28, 2023, hosted by a WRF subscribing municipality and research field site - Metropolitan Water Reclamation District of Greater Chicago. Drs Linda Lee -Purdue University and Dr Drew McAvoy provided progress updates to members of W4170 (utility stakeholders, project advisors, community partners, and academics) on *Prioritization of Biosolids-Borne UOCs*. This meeting was jointly held with WRF PFAS Management workshop for Wastewater Treatment Utilities on June 26-28, 2023. The meeting was an opportunity to further strengthen relationships with industry partners and community stakeholders, to solicit input to ensure optimal management practices of land applications of biosolids nationwide (**meeting engagement and participation aligns with objective 5**).
- The WRF team organized and participated in quarterly team meetings with other grantees and EPA cooperators on grant progress. The team participated in two notable grantee meetings.
- The Water Environment Federation hosted a Circular Water Economy (CWE) Summit in Nashville, TN on July 18-20, 2023. The Summit was designed to bridge the gap between industrial and municipal water leaders – and the communities they both serve – as they pursue sustainable solutions to water challenges.
- Maile Lono-Batura facilitated two (2) stakeholder engagement opportunities during the Summit that encouraged dialogue around contaminants in recovered resources, opportunities to reduce contamination, and how we can bolster the quality of renewable resources.

1. Pre-Summit (i.e., Circular Water Economy) Deep Dive Discussions
    - This stakeholder consultation session offered participants a project overview, progress updates, and reported resources available. Participants broke out into two groups to dig deeper into the following questions:
        - Define barriers (current and future) in creating quality recovered resources.
        - Identify exemplary programs and strategies that address these barriers.
2. World Cáfes
    - Small group discussions were also integrated into the CWE Summit programming to gather additional insight from the larger audience.
    - Sharing success stories across the represented industries (automotive; manufacturing; food and beverage processing; pulp, paper, and packaging; oil, gas, and energy). <u>Contaminants:</u> How are industries addressing contaminants in water systems? What is promising and where do we need to continue to improve?
    - Small groups exchanged real world examples and concepts that focused on product quality through avoidance of nonrenewable materials in production and downstream contamination of valuable recovered resources. Recovered resources have a clear role in ensuring that options exist for regenerative agriculture, water resilient infrastructure, and climate change mitigation and adaptation.
    - Given the success of the small group discussions at the CWE Summit, they will become a fixture showpiece of the event into the future. WEF looks forward to continuing to offer this stakeholder consultation feature as part of the program to encourage

networking, engaging thought leaders, and building a body of knowledge that will propel WEF's goal to lead the transformation to the Circular Water Economy.

2. **Changes in Key Personnel**

Maile Lono-Batura - Water Environment Federation replaced Patrick Dube as of October 1, 2022. Her CV is included in this report (Appendix B). Maile hosted the inaugural WEF Circular Economy Summit in Nashville Tennessee July 2023.

3. **Expenditures to Date**

The project tasks are being closely monitored. Expenditures for subrecipient activities and associated in-kind contributions lag behind programmatic activities due to automated billing systems on the institutions' side. Invoices are generated on a cumulative basis for several months of activities at a time. Year-end subrecipient invoices and reports on in-kind contributions are currently being posted to WRF accounts and will be included in the first Financial Status Report of 2024. As of 09/30/2023, $339,206 or approximately 22.64% of the project budget has been spent. WRF will continue to review, monitor, and evaluate all financial expenditures and records as the project progresses. Current expenditures will be included in WRF's Financial Status Report due to be filed on December 20, 2023.

4. **Quality Assurance**

The Quality Assurance Project Plan (QAPP) was approved by Benjamin Packard and Michelle Henderson on 01/26/2022. Method development and optimization for extracting and analyzing UOCs is being evaluated by the QAQC criteria to determine adequacy of the methods.
PFAS analysis of field samples and trip blanks included replication and met all established QAQC criteria.

5. **Outputs/Outcomes and Findings of Significance**

The preliminary list of prioritized UOCs was further refined. A database of 910 biosolids-borne chemicals was developed after compiling EPA lists of biosolids. Through a screening approach, the number of priorities UOCs were reduced to 125. Five scoring scenarios were then evaluated, i.e., mobility and bioaccumulation; mobility and persistence; mobility, persistence, and toxicity; persistence, bioaccumulation, and toxicity; and mobility, persistence, bioaccumulation, and toxicity. The 125 priority UOCs were categorized into high and low priority. A total of 45 UOCs were classified as high priority and the remaining 80 UOCs were classified as low priority. Although the database and analysis of the highest priority UOCs has been completed, the overall results will be continually assessed throughout the project period. The UCR team prioritized 44 UOCs. The finalized extraction methods for water/porewater and soil had acceptable recoveries, and the finalized biosolids extraction method provided acceptable recoveries for 42 of the 44 targeted UOCs. The two UOCs having unacceptable recoveries were 3,3',5,5'-Tetrabromobisphenol A (TBBPA) and Triclocarban. Details of the methods will be presented in the next reporting period for publication along with the UOC residue values from recycled irrigation water, field soil, and Class A biosolids used in field plot studies in selected California sites by the UCR team. Development of a passive sampling assay using simple materials to estimate bioavailable and labile chemical concentrations represents a novel scientific undertaking for biosolids-borne contaminants. The combined laboratory and field studies will demonstrate how to calibrate passive samplers for use

in terrestrial environments, validate applicability of passive samplers for detecting UOCs in soil and apply them to assessing bioavailability of UOCs to surrounding biota. The method may be readily transferred to other users in understanding contaminant fate and transport following biosolids applications, contributing to better management and expansion of biosolids use in agriculture. Preliminary validation of biosolids and soil extraction methods for UOCs were completed during this period in California, Indiana, Illinois, and Virginia. Field studies of the high-priority UOCs at these sites are ongoing. A few technical problems were encountered with the instrumentation from the previous reporting period. This still impacts the sample injection, and therefore in the validation of methods. The delay in the method validation also delayed the rapid assay methods. Procedural sampling mistakes resulted in re-sampling of a site rea, and thus delayed the sampling processing. The number and variety of compounds targeted poses a challenge for the non-PFAS UOC method validation, hence the data analysis requires more time than anticipated. Added sampling areas have increased workload. Studying the areas applied with biosolids for at least 2 years will increase the time needed to complete the project. The team is continuously working with other grantees, industry partners, and biosolids community stakeholders and has expanded its outreach by bridging the gap between industrial and municipal water leaders via active engagement in the WEF inaugural circular economy water summit. This research will continue 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 12/20/2023.

Site Visits and/or Desk Reviews

WRF reviewed each of the 3 Universities' most recent Single Audit Reports and performed Desk Reviews on all four 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 2023 – August 2024)

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.

- A publication will be prepared on the prioritization of biosolids-borne UOCs in amended soils during the upcoming period.

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

- In the upcoming reporting period, all analysis and extraction methods will be finalized and further used to: examine the potential for these biosolids-borne UOCs to enter the

food chain, validate the biomimetic passive samplers as viable chemical surrogates for biological tissue testing, and estimate the bioavailability (Cfree) of a low-dose complex UOC mixture of environmental concern under agronomically realistic field conditions to inform human and ecological risk assessments. Chemical partition coefficients (Kfilm and Kd) and estimation of chemical bioavailability (Cfree) from water and soil slurry kinetics experimentation will be reported.

- Complete the data processing for the validation of the extraction and analysis procedures for non-PFAS UOCs in biosolids and soil.
- Complete the data processing for a 'Rapid' method for PFAS that uses the QuEChERS method coupled to clean up with an ENVI-Carb cartridge and comparison with other methods.
- Complete the UOCs analysis for the HRSD, LGV and VWD 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.

- In the upcoming reporting period, the second vegetable field study, and the fruit tree study in southern CA will be completed. The data analysis will be ongoing and partly available for the next period report.
- 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.
- Assess Santa Rosa City as a sampling site, and potentially create a sampling plan.
- Installation of ISCO run-off samplers at LGV and VWD sites.
- Start the continuous sampling of the areas applied with biosolids in 2023 at the LGV, VWD sites and continue with the sampling at HRSD site.
- Continue with the extraction and analysis for PFAS and non-PFAS UOCs as samples arrived from CA and VA sites.
- Complete PFAS fate assessment of the DLD area and potentially complete it for non-PFAS UOCs.
- Complete project one of the VWD site for UOCs/PFAS.
- Evaluate the second tile-drained site identified since the first one did not work out due to low PFAS presence in the solids being applied to the site.
- Continue discussions on a new MWRD field site, which may now be a site in Illinois.
- Confirm up the SRC site in CA that is going to be added to the project where biosolids have been applied historically.

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

- The review and evaluation of existing risk model formulations will continue during the upcoming period. Work on a Python code for predicting the fate and transport of UOCs following biosolids amendment to soil will also be initiated. This timing is in accordance with the schedule for Objective 4 – Evaluation of Fate and Transport Risk Model Formulations. Key findings from this objective will be provided in the upcoming reporting period.

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.

- Plan and host a collaborative project, partner, cooperator, utility/industry, and stakeholder meeting at Purdue University in Lafayette Indiana March 25-27, 2024.

9. Publications

- Abstract Submitted: Nicole M. Dennis, Audrey Braun, and Jay Gan. LC-MS/MS and Extraction Methods for Targeted Analysis of a Complex Mixture of Environmental Concern in US Biosolids. The Society of Toxicology and Chemistry (SETAC) North America 44th Annual Meeting, November 13, 2023, Louisville, Kentucky.
- Audrey Braun, Nicole M. Dennis, and Jay Gan. Sorption of Biosolids-borne Unregulated Organic Chemicals (UOCs) in Soil. The Society of Toxicology and Chemistry (SETAC) North America 44th Annual Meeting, November 13, 2023, Louisville, Kentucky.

Presentations and Invited Talks:

- Warke, M., and McAvoy, D. Prioritization of Biosolids-Borne UOCs, Oral Presentation, USDA W4170 Annual Meeting, June 27, 2023, Chicago, IL.
- Warke, M. and McAvoy, D. Prioritization of Biosolids-Borne Unregulated Organic Compounds, Poster Presentation, Postdoc Appreciation Week organized by Postdoctoral Association at Cincinnati Children's Hospital Medical Center, September 19, 2023, Cincinnati, OH.
- Warke, M., and McAvoy, D. Prioritization of Biosolids-Borne UOCs, Oral Presentation, EPA Biosolids Grantee Meeting 5, September 22, 2023, Virtual Meeting.

EPA Research Grant Annual Report Summary

Period Covered by the Report: October 1, 2022 – October 1, 2023
Date of Report: December 2023
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, 2022 – October 1, 2023)
Investigators: Lola Olabode, Jay Gan, Linda Lee, Drew McAvoy, Maile Lono-Batura
Institutions: The Water Research Foundation (WRF), University of California, Riverside, Purdue University, University of Cincinnati, Water Environment Federation.
Objective of Research:
This research addresses "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:

- 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.

Progress Summary/Accomplishments (Outputs/Outcomes):
During this research period, the previous list of prioritized UOCs was refined. A database of 910 biosolids-borne chemicals was developed after compiling EPA lists of biosolids-borne chemicals. A screening approach reduced the number of priority UOCs to 125. Five scoring scenarios were evaluated, i.e., mobility and bioaccumulation; mobility and persistence; mobility, persistence, and toxicity; persistence, bioaccumulation, and toxicity; and mobility, persistence, bioaccumulation, and toxicity. The 125 priority UOCs were categorized into high and low priority. A total of 45 UOCs were classified as high priority and the remaining 80 UOCs were classified as low priority. While the database and analysis of the highest priority UOCs has been completed, the overall results will be continually assessed throughout the project period. The UCR team prioritized 44 UOCs. The finalized extraction methods for water/porewater and soil had acceptable recoveries, and the finalized biosolids extraction method provided acceptable recoveries for 42 of 44 targeted UOCs. The two UOCs having unacceptable recoveries were 3,3',5,5'-Tetrabromobisphenol A (TBBPA) and Triclocarban. Details of the methods will be presented for publication along with the UOC residue values from recycled irrigation water, field soil, and Class A biosolids used in field plot studies in selected California sites. Development of a passive sampling assay using simple materials to estimate bioavailable and labile chemical concentrations represents a novel scientific undertaking

for biosolids-borne contaminants which may contribute to better management and expansion of biosolids-use in agriculture. Preliminary validation of biosolids and soil extraction methods for UOCs were completed during this period in targeted sites in California, Indiana, Illinois, and Virginia. Field studies of the high-priority UOCs at these sites are ongoing. A few technical problems were encountered with the instrumentation from the previous reporting period. This still impacts the sample injection, and therefore in the validation of methods. The delay in the method validation also delayed the rapid assay methods. Procedural sampling mistakes resulted in re-sampling of a site rea, and thus delayed the sampling processing. The number and variety of compounds targeted poses a challenge for the non-PFAS UOC method validation, hence the data analysis requires more time than anticipated. Added sampling areas have increased workload. The team continues to work with other grantees, industry, and biosolids community stakeholders, and expanded outreach by participating at WEF's Circular Economy Water Summit in 2023.

Publications/Presentations:

- Warke, M., and McAvoy, D. Prioritization of Biosolids-Borne UOCs, Oral Presentation, USDA W4170 Annual Meeting, June 27, 2023, Chicago, IL.
- Warke, M. and McAvoy, D. Prioritization of Biosolids-Borne Unregulated Organic Compounds, Poster Presentation, Postdoctoral Association at Cincinnati Children's Hospital Medical Center, September 19, 2023, Cincinnati, OH.
- Alvarez-Ruiz R., Lee L.S. Assessment of the PFAS accumulation and leaching to groundwater from biosolids land-applied as a waste management strategy, American Chemical Society (ACS) Spring 2023, Crossroads of Chemistry, Indianapolis IN & Hybrid March 26-30
- Nicole M. Dennis, Audrey Braun, Jay Gan. LC-MS/MS and Extraction Methods for Targeted Analysis of a Complex Mixture of Environmental Concern in US Biosolids. The Society of Toxicology and Chemistry (SETAC) 44th Annual Meeting, November 13, 2023, Louisville, KY.
- Audrey Braun, Nicole M. Dennis, Jay Gan. Sorption of Biosolids-borne Unregulated Organic Chemicals (UOCs) in Soil. The Society of Toxicology and Chemistry (SETAC) 44th Annual Meeting, November 13, 2023, Louisville, KY.

Future Activities:

- Prepare publication on the prioritization of biosolids-borne UOCs in amended soils.
- Finalize all analysis and extraction methods and procedures for non-PFAS UOCs in biosolids, and the UOC analysis for three sites on biosolids.
- Complete the data processing for the validation of the extraction and analysis procedures for non-PFAS UOCs in biosolids and soil.
- Conduct field surveys, sample collection, analysis, and a Virginia site visit.
- Conduct stakeholder meeting(s) at Purdue University in Lafayette, Indiana March 2024.

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

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

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

(EPA Grant 84024501)

Prioritization of Biosolids-Borne UOCs

Manas Warke, Ph.D. and Drew C. McAvoy, Ph.D., P.E.
University of Cincinnati

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

(EPA Grant 84042501)

Prioritization of Biosolids-Borne UOCs

Manas Warke, Ph.D. and Drew C. McAvoy, Ph.D., P.E.
University of Cincinnati

Synopsis of Project Activities

Objective 1

Talk Overview

- Motivation
- Data acquisition and filtering
- Scoring scheme
- Assessment and Prioritization
- Comparison with other biosolids priority lists
  - Higgins et al. (2011)
  - SEPA (2019)
  - TCEQ (2021)
- Conclusion

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Motivation of Prioritization Scheme

- Big challenge for regulatory authorities is to determine the highest priority chemicals for conducting risk assessments
- Need to derive a short list of UOCs of greatest concern for human health and the environment
- Prioritization of UOCs in biosolids based on their occurrence, mobility, persistence, bioaccumulation, and potential toxicity

Data Acquisition

910 chemicals identified

- USEPA CompTox Chemicals Dashboard
- USEPA Biennial report (2020-2021)
- USEPA TNSSS Biosolids study (2006)
- USEPA Biosolids list (2022)
- Literature

Data Filtering

- Metals and inorganic compounds
- Well studied classes of chemicals
- Restrictions have been developed or considered
- Agrichemicals

Primary data filtering
Metals, Inorganics
CFCs
Dioxins/Furans
PAHs, PCBs
PFAS
Agrichemicals/Pesticide

450 chemicals remained

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Data Filtering

- Duplicates
- Available biosolids concentration data

297 chemicals remained

- Biosolids concentration/LD50 < 0.001

125 chemicals remained

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Parameters for Evaluation

Parameter	Source
Persistence ($t_{1/2}$)	OPERA, EPI Suite (half-lives estimates)
Bioaccumulation (log BCF)	OPERA, EPI Suite
Toxicity (Rat LD_{50})	OPERA
Mobility (K_{oc})	OPERA, EPI Suite

Scenario Scoring

Mobility (Koc) (L/kg)	
Parameter	Score
< 10	1
10 - 100	2
100 - 1000	3
1000 - 10000	4
10000 - 100000	5
> 100000	6
Meli et al., 2002	

Persistence ($t_{1/2}$) (days)	
Parameter	Score
> 180	1
60 – 180	2
30 – 60	3
7 – 30	4
1 – 7	5
< 1	6
USEPA (1999)	

Bioaccumulation (log(BCF))	
Parameter	Score
> 3.699	1
3.602 – 3.699	2
3.477 – 3.602	3
3.301 – 3.477	4
3 – 3.301	5
< 3	6
USEPA (1999)	

Toxicity (Rat LD50) (mg/kg)	
Parameter	Score
< 5	1
5 – 50	2
50 – 500	3
500 – 2000	4
2000 – 5000	5
> 5000	6
United Nations (2013)	

Lower scores → Higher priority

- **Mobility + Persistence**
- **Mobility + Bioaccumulation**
- **Mobility + Persistence + Toxicity**
- **Persistence + Bioaccumulation + Toxicity**
- **Mobility + Persistence + Bioaccumulation + Toxicity**

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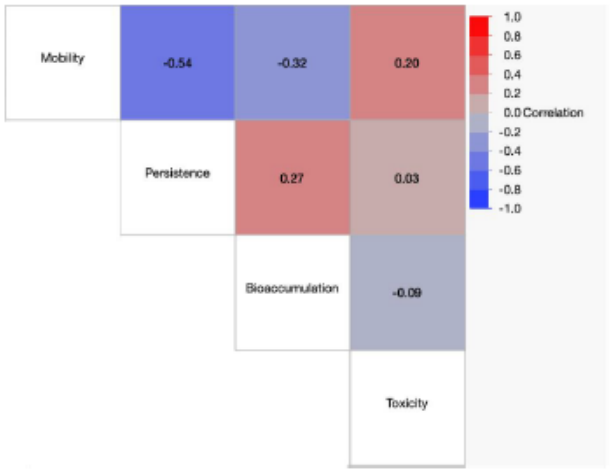
Correlation Between Parameters



p-value < 0.0001

Toxicity vs Mobility (0.0251)

Toxicity vs Bioaccumulation (0.7487)

Toxicity vs Persistence (0.3037)

Carcinogens and Endocrine Disruptors

- Carcinogens (IARC database)
- Endocrine Disruptors (USEPA list 1 and list 2, WHO list of endocrine disruptors)

1 Class 1 Carcinogen
12 Class 2 Carcinogens

23 Endocrine Disruptors

List of Carcinogens

Chemical	CASRN
Digoxin	20830-75-5
N-Nitrosodimethylamine	62-75-9
4-Chloroaniline	106-47-8
N-Nitrosodiethylamine	55-18-5
N-Nitrosopiperidine	100-75-4
1,4-Dioxane	123-91-1
N-Nitrosopyrrolidine	930-55-2
N-Nitrosodibutylamine	924-16-3
1,2-Dichloropropane	78-87-5
Trichloroethylene	79-01-6
4-Methyl-2-pentanone	108-10-1
2,6-Dinitrotoluene	606-20-2
Di(2-ethylhexyl)-phthalate	117-81-7

List of Endocrine Disruptors

Chemical	CASRN
N-Nitrosodimethylamine	62-75-9
1,2-Dichlorobenzene	95-50-1
1,2,4-Trichlorobenzene	120-82-1
4-(1,1,3,3-Tetramethylbutyl) phenol	140-66-9
4-Chloroaniline	106-47-8
4-Nonylphenol	104-40-5
4-Nonylphenol-diethoxylate	20427-84-3
4-Octylphenol	1806-26-4
Aroclor 1254	11097-69-1
BDE 209	1163-19-5
BDE 47	5436-43-1
BDE 99	60348-60-9
Bisphenol-A	80-05-7
Campesterol	474-62-4
Cashmeran (DPMI)	33704-61-9
Di(2-ethylhexyl)-phthalate	117-81-7
DIDP	26761-40-0
DINP	28553-12-0
Galaxolide	1222-05-5
Tonalide (AHTN)	1506-02-1
Trichloroethylene	79-01-6
Triclosan	3380-34-5
Triphenyltin (TPhT)	892-20-6

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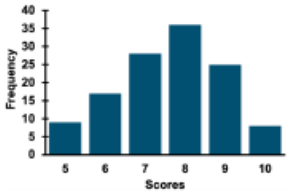
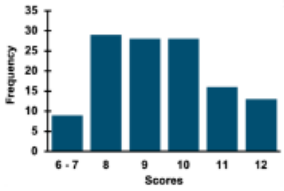
Frequency of Scores for Each Scenario

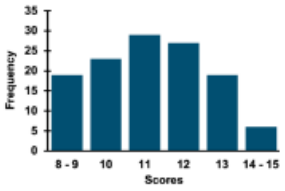
Mobility + Persistence



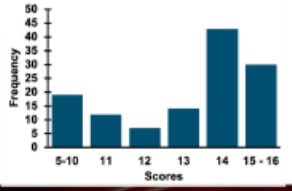
Mobility + Bioaccumulation



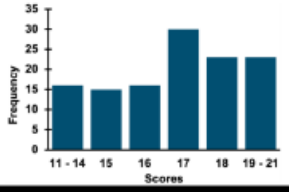
Mobility + Persistence + Toxicity



Persistence + Bioaccumulation + Toxicity



Mobility + Persistence + Bioaccumulation + Toxicity



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UOCs Ranked Top 50 in All Scenarios

Chemical	CASRN	Category
N-Nitrosodimethylamine	62-75-9	Industrial Solvent
Dimethyl sulfone	67-71-0	Industrial Solvent
Minocycline	10118-90-8	Antibiotic
Desmosterol	313-04-2	Other Organics
Campesterol	474-62-4	Other Organics
4-Chloroaniline	106-47-8	Other Organics
Ergosterol	57-87-4	Pharmaceutials
Triphenyltin (TPhT)	892-20-6	Organotins
BDE 209	1163-19-5	PBDEs
Bis(1,3-dichloropropan-2-yl)-hydrogen-phosphate	72236-72-7	Flame Retardant
Monobutyltin (MBT)	78763-54-9	Organotin

Carcinogen

Endocrine disruptors

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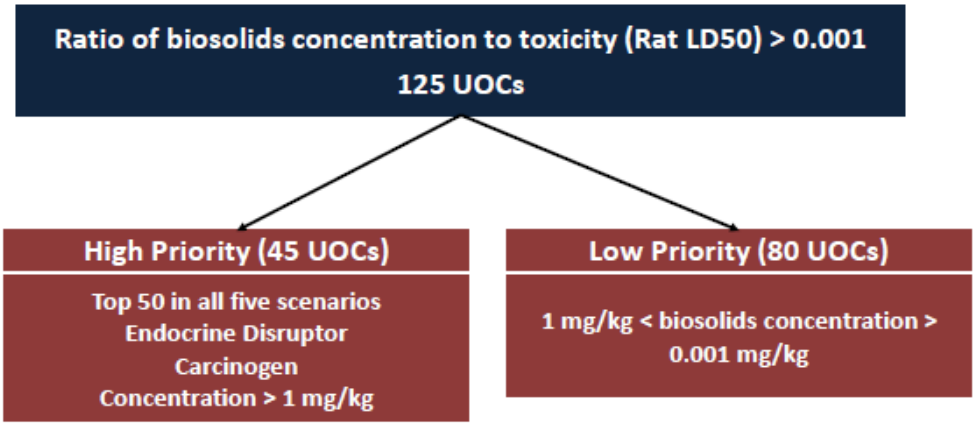
Prioritization



Comparison with other priority lists

- Higgins et al. (2011) – 20 UOCs in common
- Scottish EPA (2019) – 14 UOCs in common
- Texas Commission of Environmental Quality (2021) – 12 UOCs in common

Chemical	CASRN	Higgins et al. 2010	SEPA, 2019	TCEQ, 2021
Desmosterol	313-04-2			x
BDE 209	1163-19-5	x		x
Minocycline	10118-90-8	x		
BDE 47	5436-43-1	x	x	
Tetracycline	60-54-8	x		
Doxycycline	564-25-0	x		
Epitetracycline	79-85-6			x
Coprosterol	360-68-9			x
Cholestan-3-ol,-(3.beta.,5.alpha.)	80-97-7			x
(3alpha,5beta)-Cholestan-3-ol	516-92-7			x
Cholesterol	57-88-5			x
BDE 99	60348-60-9	x	x	
Chlortetracycline	57-62-5		x	
Tonalide	21145-77-7	x	x	
Stigmasterol	83-48-7			x
Gemfibrozil	25812-30-0		x	
Naproxen	22204-53-1		x	
Miconazole	22916-47-8	x		
Sulfanilamide	63-74-1	x	x	
Diphenhydramine	58-73-1	x		
Tributyltin (TBT)	688-73-3	x		
Estrone	53-16-7	x		
Ofloxacin	82419-36-1	x	x	
Ibuprofen	15687-27-1	x		
Diclofenac	15307-86-5		x	
Musk-ketone	81-14-1	x		
Amitriptyline	50-48-6			x
Cimetidine	51481-61-9	x		
Bisphenol-A	80-05-7	x		
4-Nonylphenol	104-40-5			x
Cashmeran (DPMI)	33704-61-9		x	
Stigmastanol	138126-65-5			x
Galaxolide	1222-05-5		x	
Triclocarban	101-20-2	x	x	
Norverapamil	67018-85-3			x
4-[1,1,3,3-Tetramethylbutyl]phenol	140-66-9	x		
Triclosan	3380-34-5	x	x	
Di[2-ethylhexyl]-phthalate	117-81-7		x	

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Conclusions

- Reduction via filtering from database
  - 910 => 450 => 297 =>125
- Prioritization screening based on five parameter
  - Occurrence
  - Mobility
  - Persistence
  - Bioaccumulation
  - Toxicity
- Comparison with other biosolids priority lists
- Derived high priority list of UOCs

Thank you!

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Appendix B: Maile Lono- Batura CV

Maile Lono-Batura, MNPL

601 Wythe St., Alexandria, VA, 22314-1994 | mlono-batura@wef.org | 206-395-8585

EDUCATION

Seattle University

Masters of Not-for-Profit Leadership, College of Arts and Sciences, Seattle, WA, 2004

Concentrations: Non-profit business and project planning, cultural preservation

Thesis: Hana Ho'oilina: The Hawaiian Heritage Project – Bridging New Video Technology with Traditional Hawaiian Storytelling.

Advisor: Michael Bisesi

University of Washington

B.A. Community & Environmental Planning, College of Built Environments, Seattle, WA, 2000

Concentrations: Sustainable environment, recycling, community development

Senior Project: The Sustainable Resource Display – A simple vision of some of the practical and beneficial applications of various recycled materials.

Advisor: Charles Henry

Minor in Environmental Studies, Program on the Environment, Seattle, WA, 2000

PROFESSIONAL EXPERIENCE

Water Environment Federation

Director of Sustainable Biosolids Programs, 2021 - present

Serve as network leader for sustainable biosolids programs. Working in concert with partnering organizations and stakeholders to identify issues and resources necessary to elevate the voice for biosolids as a solution. Finding synergies across organizations to create a unified voice around a common cause such as growing a circular economy.

Northwest Biosolids

Executive Director, 2000-2021

Lead all organizational efforts in outreach, research collaboration, regulations development, strategic planning and volunteer and membership management.

Program Coordinator, 1999-2000

Create support network that engages volunteers to realize organizational goals.

University of Washington

Research Assistant, 1998-1999

Assist in developing outreach materials for the Sustainable Resource Science program.

CERTIFICATIONS

Compost Facility Operators Certification, Washington Organics Recycling Council, 2018

Board Certified Environmental Scientist, American Academy of Environmental Engineers & Scientists, 2021-2023

PROFESSIONAL SERVICE

KBCS Community Radio Program Host, November 2012 - present

Wing Luke Asian Museum Community Advisory Group, January 2018 – September 2018

Wing Luke Asian Museum Community Advisory Group, October 2007 – May 2009

Seattle Tilth Board Member, January 2002 – January 2005

City of Issaquah Resource Conservation, Community Garden Team Member, 2001

Mountains to Sound Greenway, Community Service Coordinator, 1999-2000

Youth Corps of America, Summer Program Volunteer, 1995

RELEVANT EXPERIENCE

Contributing Editor, BioCycle Magazine, 2019-2021

Advisory Team Member, Water Research Foundation, 2020

Project Team Member, National Biosolids Data Project, 2004 & 2020

Compost & Worm Bin Instructor, Spring Sessions, King County, 2001 & 2002

Project Team Leader, University of Washington, 1999
Led design and implementation of a university-wide recycling program

PUBLISHED REPORTS

Brown, S., L. Kennedy, M. Cullington, A. Mihle, and M. Lono-Batura. 2019. Relating pharmaceuticals and personal care products in biosolids to home exposure. Urban Agric. Reg. Food Syst. 4:180005. doi: 10.2134/urbanag2018.12.0005

Lono-Batura, M., Ki, Yinan and Beecher, N. Dec. 2012. Biogas Production and Potential from U.S. Wastewater Treatment. BioCycle Magazine.

Lono-Batura, M. Aug. 2009. A Tale of Trials, Tribulations & Triumph: Biosolids Recycling in the Pacific Northwest. Water Environment & Technology.

Beecher, N., Crawford, K., Goldstein, N., Kester, G., Lono-Batura, M. and Dziezyk, E. 2007. A National Biosolids Regulation, Quality, End Use, and Disposal Survey. U. S. Environmental Protection Agency.

Beecher, N., Goldstein, N., Lono, M. and O'Connell, B. 2004. Public Perception of Biosolids: Developing Public Participation & Earning Trust. Water Environment Research Foundation.

Appendix C: WRF Collaborative Utility Wastewater Workshop in Conjunction with the Annual W4170 Meeting

PFAS Management for Wastewater Treatment Utilities
June 28-29, 2023
Marriott Chicago-Midway
Chicago, IL

Register for this Workshop

This workshop is free and open to all wastewater treatment agencies; however, registration is required by June 21, 2023.

This workshop will be held on the afternoon of June 28 and morning of June 29 at the Marriott Chicago-Midway in Chicago, IL, and will feature presentations and panel discussions on the current science around per-and polyfluoroalkyl substances (PFAS). Experts from The Water Research Foundation along with other top organizations will cover topics such as occurrence of PFAS in wastewater treatment plants, transport of PFAS in biosolids, composting and agricultural implications, and recent research on destruction of PFAS in biosolids.
Background
Recently, the EPA has been moving forward with many actions regarding PFAS, including proposing the first-ever national drinking water standard to limit six per- and polyfluoroalkyl substances. It is critical for wastewater utilities to understand the ongoing research on PFAS and be able to hear the management strategies of peer organizations. The Water Research Foundation (WRF) has funded many projects researching multiple aspects of PFAS for water and wastewater utilities, and research results from several recent and ongoing WRF projects will be featured in this workshop.

Please contact Jason Finehout at jfinehout@waterrf.org with any questions.