Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-384

Proposal Title: Alleviating PFAS Impacts of Biosolids on Agricultural Lands

Project Manager Information

Name: Jiwei Zhang

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

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Project Basic Information

Project Summary: This project aims to monitor the impacts of PFAS-containing biosolids on farmland health and beneficial agricultural microbial species and develop a cost-effective PFAS bio-treatment method for remediating affected agricultural soil.

ENRTF Funds Requested: $300,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: Small Projects (G)
Secondary Category: Land (F)

Project Location

What is the best scale for describing where your work will take place?
Statewide

What is the best scale to describe the area impacted by your work?
Region(s): Metro, Central,

When will the work impact occur?
During the Project and In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Biosolid fertilizers derived from treated sewage sludge in wastewater treatment plants are significant sources of Per- and Polyfluoroalkyl Substances (PFAS), and their applications have led to the contamination of 70 million acres of U.S. farmland with these "forever chemicals," a widely recognized term for PFAS. Although states have implemented PFAS biosolid strategies to regulate the land application of biosolids and prevent the spread of PFAS, managing affected biosolids in accordance with state regulations adds considerable costs – over 37% more than previous expenses. First, providing stakeholders with the required PFAS analytical data for biosolids using Liquid Chromatography–Mass Spectrometry (LC-MS) is expensive. This method involves complex sample processing to eliminate interference from the sample background matrix that can lead to quantification errors. This complexity hampers the timely monitoring of PFAS levels in both biosolid products and the farmlands where they are applied. Second, there is a lack of information regarding the impacts of PFAS-laden biosolids on land health. Specifically, we know very little about how PFAS affects microbial communities, which are essential for maintaining agricultural productivity. Finally, removing PFAS from contaminated biosolids or affected lands can be costly, and there is currently no reliable, low-cost method for remediating these impacted

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

New techniques need to be developed to manage the costly processes associated with PFAS biosolids in light of recently implemented state regulations, as mentioned above, and mitigate the hazardous impacts of PFAS on agricultural lands. To achieve this, we will first create a 19F Nuclear Magnetic Resonance (NMR)-based detection method for PFAS. This method will incorporate streamlined sample processing to enable rapid monitoring of PFAS levels in biosolids and affected farmlands. Our detection will focus on measuring the regulated concentrations of six PFAS compounds highlighted by the U.S. EPA at Tiers 1-3 (less than 50 µg/kg in Minnesota). To assess the impact of PFAS biosolids on soil health in farmland, we will conduct a microbial community analysis. We will measure and compare the activities of beneficial microbes in impacted farmlands with those in non-impacted areas. Lastly, to treat the PFAS biosolids and the contaminated farmland soils, we will develop a mycorrhizal fungi-enhanced phytoextraction method aimed at removing PFAS. Through this research, we propose to alleviate the hazardous impacts of PFAS on agricultural lands by reducing the management costs of biosolids at various stages of its application, from PFAS forensic analysis to treatment.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

This project will develop a fast and effective method for diagnosing PFAS in biosolids and farmland soils. By providing stakeholders with timely PFAS analytical information, we can reduce the management costs associated with PFAS biosolids and protect Minnesota's agricultural soils from contamination. While monitoring the impacts of PFAS biosolids on soil health, the research will also be creating a low-cost treatment method to remove PFAS from affected soils. The findings will offer valuable guidance to environmental regulators and farmers on how to manage the application and disposal of PFAS-laden biosolids, thereby minimizing their environmental impact.

Activities and Milestones

Activity 1: Creating a cost-effective 19F NMR method for diagnosing PFAS in biosolids and farmland soils

Activity Budget: $95,338

Activity Description:
This task will develop a cost-effective 19F NMR method to quantify PFAS levels in biosolids and farm soils, facilitating compliance with PFAS regulations for environmental agents and farmers. Compared to the standard LC/MS method, which costs approximately $200 per sample, our NMR approach, estimated at $5-10 per sample, will significantly reduce costs, enhance throughput, and eliminate quantification errors from sample processing and background matrix interferences. Our previous research, currently under revision, has demonstrated the robustness of NMR in quantifying PFOA and Crotonic PFCA (see attachment Pub 1,2). Here, we will expand its application to other PFAS species identified in the U.S. EPA regulations. To prepare samples for NMR analysis, we will mix a 90% aqueous PFAS solution with 10% D2O and acquire F-19 spectra using the Bruker Advance III HD 400 MHz equipped with a SampleXpress autosampler at the University of Minnesota facility. We will add 100 µM Trifluoroacetic acid (TFA) as an internal reference for accurate PFAS quantification. We will develop a rapid methanol-based extraction method to isolate PFAS from biosolids and soils, followed by a freeze-drying step to optimize detection limits. The results from NMR quantification will be validated against LC/MS to ensure reliability.

Activity Milestones:

Description	Approximate Completion Date
Build up the 19F NMR method for quantifying U.S. EPA regulated PFAS chemicals	August 31, 2026
Contact the farmland owners for soil sample collection for research-only purposes	September 30, 2026
Build up and validate the 19F NMR method for PFAS quantification in mocking soil samples	December 31, 2026
Detect and provide the analytical information of the PFAS tiers in biosolids	March 31, 2027
Detect and provide the analytical information of the PFAS tiers in farmland soils	July 31, 2027

Activity 2: Assessing the impact of PFAS biosolids on soil health in farmland by microbial community analysis

Activity Budget: $102,127

Activity Description:
This task aims to assess the impacts of PFAS-containing biosolids on soil health by monitoring the dynamic changes in microbial communities across various farmlands. Before sample collection and measurements, a comprehensive Quality Assurance Project Plan (QAPP) will be established. Soil samples will be collected from diverse crop fields, including corn and soybean, during different seasons, such as Spring and Fall. The analysis of fungal and bacterial communities will be conducted using the ITS and 16S V4 2x250bp MiSeq sequencing methods at the University of Minnesota Genomics Center. Representative farmlands that PFAS biosolids have impacted will be compared with those unaffected. To analyze PFAS metabolomics in the soils, including regulated PFAS and their transformation products, methanol extraction will be performed, followed by characterization using the SCIEX QTRAP 6500 LC-MS and ThermoFisher Q Exactive Orbitrap mass spectrometer at the Center for Mass Spectrometry and Proteomics at the University of Minnesota. Data analysis of the microbiome will utilize Zhang lab pipelines, correlating microbial community variations with PFAS chemical concentrations. Pearson correlation coefficients will be computed across samples, and microbial networks will be constructed using ‘mcxarray’ and ‘mcxdump’ programs from the MCL-Edge software package to identify keystone microbes.

Activity Milestones:

Description	Approximate Completion Date
Extract and sequence the microbial communities of the PFAS biosolid impacted farmlands (Fall season)	October 31, 2026
Extract and sequence the microbial communities of the PFAS biosolid impacted farmlands (Spring season)	April 30, 2027
Profile the PFAS metabolomics from the biosolid-impacted lands	October 31, 2027
Associate the PFAS impacts with microbial community changes as the indicator for monitoring soil health	March 31, 2028

Activity 3: Developing a mycorrhizal fungi-enhanced phytoextraction method to treat PFAS-laden biosolids

Activity Budget: $102,535

Activity Description:
This task aims to enhance the remediation of PFAS contamination from biosolid applications through the synergistic action of mycorrhizal fungi and phytoextraction of plants. Mycorrhizal fungi, known for their ability to facilitate nutrient exchange with plant roots, have demonstrated the potential to improve phytoremediation efficacy by aiding in the degradation and transport of contaminants. Our initial research has identified two species, Laccaria bicolor and Rhizopogon pseudoroseolus, which exhibit significant tolerance and removal capabilities for PFOA. We will expand our investigation to assess the performance of these fungal species and those identified in task2 in removing additional EPA-regulated PFASs using a sorption test developed in Zhang's lab. 19F NMR and F-ISE will be used to determine PFAS removal and defluorination. Following this, we will collaborate with Dr. Yujie Men at the University of California, Riverside to characterize the transformation products of PFAS through LC/HR-MS. To evaluate the phytoextraction potential, we will culture the selected fungi alongside their host plant species, initially on agar plates and subsequently in soil pots supplemented with PFAS-containing biosolids. We expect that leveraging mycorrhizal fungi in our approach will provide a viable, sustainable method for treating PFAS-impacted agricultural lands, paving the way for more effective remediation

Activity Milestones:

Description	Approximate Completion Date
Screen Mycorrhizal fungal species for PFAS tolerance	June 30, 2027
Test the capacities of Mycorrhizal fungal species to absorb and transform PFAS chemicals	December 31, 2027
Test the Mycorrhizal fungal capacities to enhance phytoextraction of PFAS in a petri dish setup	June 30, 2028
Test the Mycorrhizal fungal capacities to enhance phytoextraction of PFAS in a soil pot setup	December 31, 2028
Final data compilation and project write-up	June 30, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Dr. Yujie Men	University of California, Riverside	PFAS transformation products' characterization	No
Dr. Corbin Dirkx	University of Minnesota Genomics Center	Microbiome & GBS Services; Microbial Community Sequencing.	No
Dr. Timothy J. Griffin	Center for Metabolomics and Proteomics, University of Minnesota	PFAS and metabolite analysis	No

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?

We will pursue the commercialization of the 19F NMR-based forensic analysis of PFAS to monitor PFAS levels in biosolids and affected farmlands. This technique will be further developed to assess PFAS levels in other regulated products and environments as outlined in Minnesota's PFAS Blueprint. Additionally, regarding PFAS bio-treatment, we will leverage the results from our current research to seek more funding from upcoming LCCMR programs, as well as DoD-funded SERDP & ESTCP programs, and NSF-SBIR. The future funding will enable us to demonstrate and further develop field applications and investigate the detailed mechanisms involved in the fungal removal of PFAS.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
PFAS Fungal-Wood Chip Filtering System	M.L. 2022, , Chp. 94, Art. , Sec. 2, Subd. 08f	$189,000

Project Manager and Organization Qualifications

Project Manager Name: Jiwei Zhang

Job Title: Assistant Professor

Provide description of the project manager's qualifications to manage the proposed project.

Dr. Jiwei Zhang, the project manager, oversees a well-established laboratory at U of Minnesota dedicated to studying biodegradation mechanisms and their applications in environmental engineering and conservation. He is currently an Assistant Professor in the Department of Bioproducts and Biosystems Engineering, with a promotion to tenure and Associate Professor expected in Fall 2025. Dr. Zhang leads a research team consisting of postdocs and graduate students as they investigate and utilize the biodegradation capabilities of fungal species and other microbes for environmental engineering, with the aim of sustaining and conserving local and national environments.

Effectively managing PFAS biosolids in compliance with state regulations while minimizing their impact on agricultural lands has become a significant research priority. Dr. Zhang and his team are well-equipped to address these challenges. Through previous research, Dr. Zhang has gathered extensive data and developed a strong understanding of PFAS bioremediation. Relevant to this proposal, his lab has created a comprehensive toolkit that includes techniques such as

19F-NMR analysis, microbial community assessments, and investigations into the sorption and degradation of PFAS by fungal organisms, all of which will contribute to the success of the proposed project. Dr. Jiwei Zhang has a wealth of project management experience, including leading an LCCMR project titled “PFAS Fungal-Wood Chip Filtering System (2022).”
From a project management perspective, the roles of project managers, partners, and collaborators have been clearly defined to prevent 'scope creep,' and feasibility, potential pitfalls, and alternative approaches are addressed. We also plan to foster a science-driven and collaborative team environment, characterized by consistent data handling, hands-on involvement from all researchers, and transparent sharing of results through lectures and data dissemination. We anticipate this project will yield significant findings for effectively managing PFAS biosolids. Our experience supports this, and our proposal is geared towards high-quality, relevant scientific outcomes.

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

Organization Description:
The College of Food, Agricultural, and Natural Resource Sciences (CFANS) is one of seventeen colleges and professional schools at the University of Minnesota. The Department of Bioproducts and Biosystems Engineering of CFANS, where Dr. Zhang serves as a faculty, is organized for discovering and teaching solutions for the sustainable use of renewable resources and the enhancement of the environment. These missions well align with this proposal, and the facilities, equipment, and other resources owned by both the College and Department will ensure the success of this project.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Lead PI - summer salary only		Direct all research and personnel, conduct analysis			36.6%	0.42		$68,145
Postdoc		Conduct research, data interpretation, and result dissemination			25.9%	2.4		$195,626
							Sub Total	**$263,771**
Contracts and Services								
U of Minnesota	Internal services or fees (uncommon)	Microbial community sequencing at UMN Genomics Center (UMGC)				0		$4,000
U of Minnesota	Internal services or fees (uncommon)	NMR tests at the Dept. of Chemistry				-		$2,000
Yujie Meng's lab at U of California, Riverside	Internal services or fees (uncommon)	PFAS and transformation products quantification and characterization by MS				0		$4,000
							Sub Total	**$10,000**
Equipment, Tools, and Supplies								
	Tools and Supplies	Task 1: Chemicals, PFAS, NMR tubes, falcon tubes, dishes, flasks, and other lab consumables for measuring NMR	To create the 19F NMR method to quantify the PFAS levels in biosolids and farm soils.					$6,029
	Tools and Supplies	Task 2: Molecular reagents and DNA extraction kits used for extracting microbial DNA for community sequencing; PFAS extraction and purification kits; Chemicals, falcon tubes, dishes, flasks, and other lab consumables for DNA sequencing and PFAS purification.	To sequence the microbial communities on farmlands, and to characterize PFAS metabolomics.					$8,100

	Tools and Supplies	Task 3: Chemicals, PFAS, dishes, flasks, and other lab consumables for growing fungi and plants; PFAS extraction and purification kits for testing fungal removal rates of PFAS.	To develop the mycorrhizal fungi-enhance phytoremediation of PFAS from soils.					$8,100
							Sub Total	**$22,229**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
							Sub Total	**-**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Publication fee in professional journals at Year 2	To disseminate research results: An 19F NMR method for diagnosing PFAS levels in biosolids and impacted soils					$2,000
	Publication	Publication fee in professional journals at Year 3	To disseminate the research results: The mycorrhizal fungi enhance phytoremediation of PFAS					$2,000
							Sub Total	**$4,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$300,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	Waived UMN overhead	Waived UMN overhead	Secured	$165,000
			Non State Sub Total	**$165,000**
			Funds Total	**$165,000**

Total Project Cost: $465,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 3b3dea09-59d.pdf

Alternate Text for Visual Component

PFAS in biosolids is polluting agricultural lands, and their management requires new, cost-effective solutions. This project aims to address the impacts of PFAS in biosolids by developing an affordable diagnostic method, monitoring the effects on farm soil health, and creating an economical fungal-enhanced treatment solution....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
Support letter from UC, Riverside	f7d5f249-b89.pdf
Support letter from CMSP	f5abb7ba-dc0.doc
Pub 2	fd3690c7-da3.pdf
UMN authorization letter for submission_2026_384	eaad9d88-9d5.pdf
Support letter from UMGC	93c667cf-9aa.doc
Audit	e855411d-13b.pdf
Pub 1	7fa36efb-d47.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

N/A

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

Yes

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

Yes

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

No

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

Wendy Moylan, accountant at the Department of Bioproducts and Biosystems Engineering at U of Minnesota

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A