Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-504

Proposal Title: Microalgal Consortium for Bioremediation of PFAS in Minnesota

Project Manager Information

Name: Prasanth Kumar Sasidharan Pillai

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

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Project Basic Information

Project Summary: This project evaluates microalgal–bacterial consortia as a nature-based strategy to remove PFAS from Minnesota freshwater systems by isolating cold-adapted species and quantifying contaminant removal under laboratory and mesocosm conditions.

ENRTF Funds Requested: $294,000

Proposed Project Completion: June 30, 2030

LCCMR Funding Category: Small Projects (G)
Secondary Category: Water (B)

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?
Statewide

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.

Per- and polyfluoroalkyl substances (PFAS) are persistent synthetic chemicals widely used in industrial and consumer products such as firefighting foams, nonstick coatings, and water-repellent materials. Because of the extremely strong carbon–fluorine bonds in their structure, PFAS compounds are highly resistant to natural degradation and are commonly referred to as "forever chemicals." These substances are now widely detected in groundwater, surface waters, and sediments across the United States. Minnesota is among the regions most affected due to historic fluorochemical manufacturing and disposal activities, resulting in contamination of several freshwater systems and raising concerns about ecosystem health and drinking water safety. Conventional PFAS treatment methods such as activated carbon adsorption, ion exchange, and membrane filtration are effective but costly and difficult to apply at the scale of natural lakes and rivers, creating a need for sustainable remediation strategies. This project explores the use of microalgal consortia as a nature-based approach for PFAS removal. Microalgae possess high surface-area cell structures capable of adsorbing contaminants, and their interactions with bacteria can enhance pollutant removal through biosorption, bioaccumulation, and microbial transformation. Developing cold-adapted microalgal systems could provide a sustainable strategy for mitigating PFAS contamination in Minnesota freshwater ecosystems.

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.

Our proposed solution is to develop and evaluate cold-adapted microalgal–bacterial consortia as a nature-based strategy for PFAS removal from contaminated Minnesota freshwater systems. Unlike most previously funded LCCMR PFAS projects that primarily focus on contamination monitoring, risk assessment, or engineered treatment technologies such as activated carbon filtration and ion exchange systems, this project explores a biological remediation approach capable of operating within natural aquatic environments. The research will begin by collecting water and sediment samples from PFAS-affected Minnesota lakes to isolate native cold-tolerant microalgae capable of tolerating and adsorbing PFAS compounds. Promising algal strains will then be combined with pollutant-tolerant bacteria to construct synthetic microalgal–bacterial consortia designed to enhance PFAS removal through complementary mechanisms including biosorption, bioaccumulation, and microbial transformation. These consortia will be evaluated through laboratory-scale bioreactor experiments followed by controlled mesocosm studies that simulate natural freshwater conditions. PFAS removal efficiency will be quantified using LC–MS/MS, while algal growth, biomass production, and contaminant accumulation will also be monitored. This research will generate critical data on the feasibility of phycoremediation for PFAS-contaminated lakes and identify microbial systems adapted to Minnesota's cold climate, supporting the development of scalable, environmentally sustainable remediation strategies for protecting the state's freshwater

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 generate scientific data on the feasibility of using microalgal consortia as a nature-based solution to reduce PFAS contamination in Minnesota freshwater systems. The research will identify cold-tolerant microalgae capable of binding and accumulating PFAS and evaluate their effectiveness under environmentally relevant conditions. Outcomes will provide guidance for developing sustainable remediation strategies that help protect water quality, aquatic ecosystems, and drinking water resources. By advancing environmentally compatible treatment approaches for contaminated lakes, the project supports the protection, conservation, and long-term preservation of Minnesota's freshwater resources and natural ecosystems while informing future large-scale remediation efforts.

Activities and Milestones

Activity 1: Isolate and characterize cold-tolerant microalgae from Minnesota freshwater ecosystems capable of PFAS adsorption and accumulation

Activity Budget: $100,000

Activity Description:
Water and sediment samples will be collected from Minnesota freshwater systems with documented PFAS monitoring or contamination, including Lake Elmo, Bde Maka Ska, and segments of the Mississippi and St. Croix Rivers. These locations represent aquatic environments impacted by historical PFAS releases and monitored by state agencies, making them suitable for identifying microorganisms adapted to PFAS exposure. Sampling will be conducted during ice free months (late spring through early fall) to ensure safe access and to capture active microbial communities during periods of higher biological productivity. Native microalgae will be isolated using serial dilution, selective culturing, and microscopic screening. Molecular techniques including rRNA gene sequencing and microbiome analysis will be used to identify algal species and characterize associated microbial communities. Candidate microalgae may include Chlorella vulgaris, Scenedesmus obliquus, Desmodesmus armatus, Chlamydomonas reinhardtii, and Navicula species, which are known for pollutant adsorption capacity. Associated pollutant tolerant bacteria may include Pseudomonas, Rhodococcus, Comamonas, and Acidimicrobium species. Selective enrichment and plating will isolate microorganisms capable of growing in the presence of PFAS. This activity will identify cold adapted microalgae and microbial partners suitable for developing PFAS removing consortia.

Activity Milestones:

Description	Approximate Completion Date
Collect water and sediment samples from selected Minnesota lakes and establish enrichment cultures of native	September 30, 2027
Isolate and identify dominant cold-tolerant microalgal strains using microscopy and molecular identification methods.	December 31, 2027
Screen isolated strains for PFAS tolerance, adsorption capacity, and growth performance to select the most	March 31, 2028

Activity 2: Construct and evaluate synthetic microalgal–bacterial consortia optimized for PFAS removal

Activity Budget: $94,000

Activity Description:
This activity will focus on constructing synthetic microalgal–bacterial consortia to enhance PFAS removal efficiency. Microalgal strains identified in Activity 1 with high PFAS tolerance and adsorption capacity will be selected as primary biosorbent organisms. These strains will be combined with pollutant-tolerant bacteria isolated from the same freshwater environments to develop stable microbial consortia capable of complementary contaminant removal processes. Candidate bacterial partners may include Pseudomonas, Rhodococcus, Comamonas, and Acidimicrobium species, which are commonly associated with pollutant transformation and biofilm formation. These bacteria can enhance PFAS removal by promoting biofilm development, microbial interactions, and modification of the microenvironment surrounding algal cells, which may increase contaminant binding and accumulation. Laboratory experiments will establish stable co-culture conditions and evaluate microbial compatibility, growth dynamics, and system stability. The performance of the developed consortia will be compared with monoculture algal systems to determine whether microbial interactions improve PFAS adsorption and accumulation. The outcome of this activity will be the identification of optimized microalgal–bacterial consortia capable of enhanced PFAS removal. These microbial systems will then be used in subsequent laboratory and mesocosm experiments to evaluate their effectiveness under environmentally relevant conditions.

Activity Milestones:

Description	Approximate Completion Date
Identify and culture pollutant-tolerant bacterial strains associated with microalgal isolates.	July 31, 2028
Develop synthetic microalgal–bacterial consortia and establish stable co-culture conditions.	November 30, 2028
Evaluate PFAS adsorption, bioaccumulation, and system stability compared to monoculture microalgal systems.	March 31, 2029

Activity 3: Quantify PFAS removal efficiency under lab-scale and mesocosm conditions

Activity Budget: $100,000

Activity Description:

This activity will evaluate the effectiveness of the developed microalgal–bacterial consortia for PFAS removal under controlled laboratory and mesocosm conditions. Initial experiments will be conducted in laboratory-scale reactors containing PFAS-contaminated water to quantify removal performance under controlled light, temperature, and nutrient conditions. These experiments will determine PFAS adsorption capacity, removal kinetics, and microbial growth dynamics. Following laboratory optimization, mesocosm-scale experiments will be conducted using controlled tank systems designed to simulate natural freshwater environments. These systems will allow evaluation of microbial consortia performance under more realistic environmental conditions, including temperature variation, natural light cycles, and fluctuating nutrient conditions typical of Minnesota lakes. Key parameters monitored during these experiments will include PFAS concentration, removal efficiency, algal biomass productivity, microbial community composition, and changes in water quality indicators. PFAS concentrations will be measured using liquid chromatography–tandem mass spectrometry (LC–MS/MS) to accurately quantify contaminant removal and accumulation in microbial biomass. The results of this activity will provide quantitative data on PFAS removal efficiency and system stability under environmentally relevant conditions. These findings will help determine the feasibility of nature-based phycoremediation strategies and guide the development of scalable approaches for PFAS mitigation in Minnesota freshwater systems.

Activity Milestones:

Description	Approximate Completion Date
Conduct laboratory-scale bioreactor experiments to measure PFAS removal efficiency using selected microbial consortia.	August 31, 2029
Monitor PFAS concentration, adsorption kinetics, and biomass accumulation using LC–MS/MS analysis.	December 31, 2029
Perform controlled mesocosm experiments to validate PFAS removal performance under environmentally relevant conditions.	June 30, 2030

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Steven Bowden	University of Minnesota	Co-Principal Investigator	Yes

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
Project results will be disseminated through peer-reviewed publications, conference presentations, stakeholder workshops, and outreach to Minnesota industry and agricultural partners. All dissemination materials will acknowledge support from the Environment and Natural Resources Trust Fund (ENRTF) in accordance with the ENRTF Acknowledgment Guidelines.

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?
Project results will identify microalgal species and microbial consortia capable of removing PFAS under Minnesota environmental conditions. Findings will be shared with state agencies, water resource managers, and environmental organizations to guide future remediation strategies. Data generated from this study will support the design of pilot-scale phycoremediation systems for contaminated lakes and wetlands. Following project completion, additional research and field-scale implementation will be pursued through external funding from federal and state agencies, as well as partnerships with environmental organizations and water management programs focused on PFAS mitigation and freshwater ecosystem protection.

Project Manager and Organization Qualifications

Project Manager Name: Prasanth Kumar Sasidharan Pillai

Job Title: Assistant Professor

Provide description of the project manager's qualifications to manage the proposed project.
Dr. Prasanth K. S. Pillai has established a strong research portfolio in biotechnology, upcycling, and bioconversion, focusing on transforming agricultural and food processing byproducts into high-value food ingredients. His research uses microbial fermentation and enzymatic processes to improve the quality and functionality of plant-based materials and agricultural residues for food applications. A major focus of Dr. Pillai's work is the use of beneficial microbes to detoxify and improve flours and plant protein ingredients. Through controlled fermentation using food-grade microorganisms, his research aims to reduce undesirable compounds such as off-flavor precursors, antinutritional factors (e.g., phytate and tannins), and other inhibitory components commonly present in legume and cereal flours. These microbial processes enhance flavor, nutritional value, digestibility, and functional properties, making plant-based ingredients more suitable for diverse food formulations. His research integrates bioprocessing, fermentation optimization, and ingredient characterization to convert underutilized plant materials and food byproducts into cleaner, nutritionally improved, and more functional food ingredients. By applying microbial biotechnology to food systems, Dr. Pillai's work supports the development of sustainable food ingredients and circular food systems, enabling the effective utilization of agricultural resources while reducing waste.

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

Organization Description:
The College of Food, Agricultural and Natural Resource Sciences (CFANS) at the University of Minnesota is a leading research and education institution dedicated to advancing sustainable food systems, agricultural productivity, and environmental stewardship across Minnesota. CFANS integrates expertise in soil science, water quality, agronomy, food systems, environmental chemistry, and bioproducts engineering to address challenges at the intersection of agriculture and natural resource protection.

CFANS maintains advanced laboratory facilities, field research stations, and environmental monitoring capabilities that support rigorous evaluation of nutrient dynamics, soil health, and watershed impacts. Faculty collaborate closely with farmers, watershed districts, state agencies, and industry partners to develop and implement science-based solutions that reduce nitrogen and phosphorus losses, improve nutrient management, and protect surface and groundwater resources.

Through interdisciplinary research and strong stakeholder engagement, CFANS delivers measurable, data-driven outcomes that align with the Legislative-Citizen Commission on Minnesota Resources (LCCMR) mission to protect and enhance Minnesota's land, water, and natural resources.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Assistant Professor		Principal Investigator			26.7%	0.09		$16,251
Assistant Professor		Co-Principal Investigator			26.7%	0.06		$11,438
Postdoc Associate		Conducting experiment and collect data			20.6%	1.5		$123,697
Graduate student		Conduct experiment, collect data			12.9%	2		$113,488
							Sub Total	**$264,874**
Contracts and Services								
lab Service	Internal services or fees (uncommon)	To quantify PFAS and evaluate removal in the microalgal system. LC-MS/MS will measure PFAS in water, biomass, and media after solid phase extraction. Additional analyses may include high resolution mass spectrometry, 16S rRNA sequencing, SEM imaging, and supporting FTIR and water chemistry measurements through institutional core facilities				-		$6,126
							Sub Total	**$6,126**
Equipment, Tools, and Supplies								
	Tools and Supplies	Lab supplies	The requested $23,000 supply budget will support laboratory and field activities required to develop and evaluate microalgal consortia for PFAS remediation in Minnesota freshwater systems. Supplies will include culture media, microbial strains, reagents for algal and bacterial cultivation, PFAS analytical standards, chromatography solvents, filtration materials, and general laboratory consumables					$23,000

			necessary for microbial growth, consortium development, and PFAS analysis. In Year 1, supplies will support the collection and processing of water samples from Minnesota lakes and the isolation and cultivation of native microalgae capable of PFAS adsorption. This phase will require culture media, microbial starter cultures, sterile sampling containers, filtration supplies, molecular and microbiological reagents for microbial identification, and consumables for microscopy and growth monitoring. In Years 2 and 3, supplies will support the development and optimization of microalgal–bacterial consortia and controlled cultivation experiments in flasks and 6 L bioreactors. This includes bioreactor consumables, probes and sensors for monitoring pH, dissolved oxygen, temperature, and aeration, tubing, filters, and components necessary for bioreactor operation. Additional materials will support biomass harvesting, filtration, centrifugation, and sample preparation for PFAS quantification using LC-MS/MS. Across all years, funds will also cover microbiological and biochemical analysis reagents, culture vessels, glassware, chromatography standards, solvents, and routine consumables required for microbial growth monitoring, biomass characterization, and analytical measurements, ensuring reliable and reproducible experimental data throughout the project.					
							Sub Total	**$23,000**
Capital Equipment								

							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
							Sub Total	**-**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$294,000**

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				
			Non State Sub Total	**-**
			Funds Total	**-**

Total Project Cost: $294,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 6ffa1842-4b4.pdf

Alternate Text for Visual Component

Visual of the project Microalgal consortium for PFAS removal...

Supplemental Attachments

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

Title	File
Letter from Organization	6d63035f-0d2.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:

Dr. Prasanth K.S. Pillai (Principal Investigator and Lead)
Dr. Steve Bowden (Co-Principal Investigator)

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