



Environment and Natural Resources Trust Fund

2023 Request for Proposal

General Information

Proposal ID: 2023-122

Proposal Title: Biological Methods for Nitrogen Removal from Contaminated Waters

Project Manager Information

Name: Brett Barney

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

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Project Basic Information

Project Summary: Our project will construct demonstration scale bioreactors using native microbes to remove nitrates accumulating in rural water systems.

Funds Requested: \$269,000

Proposed Project Completion: October 31, 2025

LCCMR Funding Category: Methods to Protect, Restore, and Enhance Land, Water, and Habitat (F)

Project Location

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

Region(s): SW, Metro, SE,

What is the best scale to describe the area impacted by your work?

Region(s): SW, SE, Metro,

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.

Nitrogen accumulation in surface and well waters as a result of agricultural runoff is a continuing issue in Minnesota. High concentrations of nitrate in drinking water has been linked to blue baby syndrome, and as a result, specific standards have been developed to set acceptable limits that protect the public from this potential pollutant that is particularly harmful to infants. Nitrate accumulation is rarely linked to natural processes, as microbes either utilize nitrogen or convert it into nitrogen gas, a safe and inert gas which is the primary component of our atmosphere. Nitrate accumulation is generally caused by the interactions of humans (farmers and property owners) applying amounts of nitrogen fertilizers that exceed the needs of agriculture and the ability of these denitrifying microbes to convert nitrate into safer forms of nitrogen. Several communities, including the city of Fairmont, Minnesota have emerged as "hot spots" in the state as a result of exceeding the safe standards that have been established for nitrate in drinking water. Other communities are expected to experience similar increases as a result of current practices and geological and geographical features of the Minnesota topography.

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.

We have developed a reactor system that screens native algae collected from contaminated water systems across Minnesota for specific algae that rapidly sediment or settle from our bioreactors, enabling easy removal from engineered bioreactor systems. We will construct a pilot demonstration reactor system that operates autonomously in a field setting to remove nitrates from contaminated surface water. We will then utilize these natural algae strains to remove nitrate from contaminated water systems. The ability to rapidly sediment will allow us to efficiently remove the algae, which can be further utilized as a suitable biofertilizer in agricultural settings, creating an additional value for this waste product of the system. Our project will involve young engineering students and high school students who will participate in the research project and assist in managing and monitoring these systems in the field.

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?

Water is a key natural resource for the State of Minnesota. Our project will protect, preserve and enhance this natural resource by reducing nitrate levels through natural processes with algae that can be quickly and effectively removed from a continuous reactor system. Waste nitrogen will accumulate as algal biomass, which will be used as a soil implement or animal feed to provide additional value.

Activities and Milestones

Activity 1: Enrichment of Natural Algae that Rapidly Sediment

Activity Budget: \$120,000

Activity Description:

In this first activity, we will perform laboratory studies to enrich natural populations of algae for specific algae that rapidly sediment when grown on nitrate contaminated water from locations across the state. Our laboratory has developed custom bioreactor systems that will be specifically utilized in this activity. Algae will be identified and characterized to determine the potential rates of nitrate removal that can be obtained, and to assure that these strains will not have any adverse effects on the treated water. Algae will be drawn from environmental samples taken from the same local watersheds that serve the city of Fairmont or other selected sites, so that no foreign algae are introduced to these ecosystems. The algae that are obtained from laboratory studies and from field studies described in the following aim will be further characterized to determine their potential to serve as a fertilizer for agricultural crops or as feed for livestock.

Activity Milestones:

Description	Completion Date
Construct Additional Laboratory Bioreactors to Screen Multiple Sites for Suitable Algae.	December 31, 2023
Identify and Characterize Specific Algae for the Ability to Rapidly Remove Nitrate.	August 31, 2024
Prepare Reports on Identification of Algae that Rapidly Sediment and Evaluate Potential as a Biofertilizer.	June 30, 2025

Activity 2: Operate Pilot-Scale Reactor System to Evaluate the Removal of Nitrate

Activity Budget: \$149,000

Activity Description:

We will construct several pilot-scale demonstration systems for autonomous operation near Fairmont, Minnesota or other strategically selected locations across the state. The goal of this effort will be to evaluate the potential to expand these sites and effectively operate these systems with minimal interaction. If we achieve suitable success in the first year, we will expand on this effort to operate as many as three total sites to obtain data for several different geographically diverse locations. These will be operated between early spring and late fall, to obtain performance parameters throughout the year, and will be drained during winter months. Samples will be drawn throughout the season to characterize the performance of the systems and make further modifications, and nitrogen-rich algal biomass will be collected for future characterization and applications such as soil supplements or animal feeds.

Activity Milestones:

Description	Completion Date
Construct Pilot Scale Reactor System and Operate on Site at University of Minnesota.	September 30, 2023
Operate Pilot-Scale Bioreactor System at Initial Field Site During Spring to Summer 2024.	October 31, 2024
Expand Pilot-Scale Reactor Systems to Three Total Systems Based on Success of Milestone 2.	October 31, 2025

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Troy Nemmers	Director of Public Works/City Engineer for City of Fairmont	We will be partnering with Troy Nemmers and the City of Fairmont Minnesota if this project is funded.	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?

This project is intended to be an initial proof of concept project based on bioreactors we have developed in the laboratory that allow us to enrich natural populations of microbes with specific features that enable their application in our larger reactor systems. Specific algae will be identified to assure these do not pose a risk to these water systems or communities. Selected algae will be cultivated in the field to quantify the effectiveness of the system. Further funding will be sought based on the success of these studies and efforts.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Transformation of Plastic Waste into Valued Resource	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04j	\$225,000

Project Manager and Organization Qualifications

Project Manager Name: Brett Barney

Job Title: Associate Professor and Director

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

Dr. Brett Barney (Project Manager) received his PhD in 2003. He spent six years in the medical device manufacturing sector, and another six years as a postdoctoral fellow and project manager. He has been a professor with the Department of Bioproducts and Biosystems Engineering and a member of the Biotechnology Institute at the University of Minnesota since 2009. He has been the Director of the Microbial and Plant Genomics Institute since 2020. The Bioproducts and Biosystems Engineering Department serves as a core department combining Agricultural Engineering, Biological Engineering and Environmental and Ecological Engineering. The University of Minnesota provides a range of facilities and sufficient laboratory space to perform each of the activities described in this proposal. Additionally, controlled environments including greenhouse space sufficient for this work is conveniently located in close proximity to Dr. Barney's laboratory space.

Dr. Barney's laboratory is focused on minimizing the environmental impacts associated with biofuels and agriculture, and finding innovative methods to remove contaminants from water and wastewater. Dr. Barney has 30 years of experience in both basic and applied research in both academia and industry, including experience managing projects and laboratories in a range of settings. Previous research funding has come from the National Science Foundation (NSF), the United States Department of Agriculture (USDA), the United States Department of Energy (DOE), the Defense Advanced Research Projects Agency (DARPA), the Legislative-Citizen Commission on Minnesota Resources (LCCMR),

Minnesota's Discover, Research and Innovation Economy (MnDRIVE) and the Initiative for Renewable Energy and the Environment (IREE).

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

Organization Description:

The University of Minnesota (UMN) was founded in 1851, and is the state's primary research university. UMN is the land-grant university in Minnesota, with strong ties to agriculture, medicine, science, engineering and the arts. UMN has a strong tradition of education and public service, with faculty of national and international reputation. UMN is an R1 Research Institution, and ranks among the nations top 10 public research universities, as assessed by the National Science Foundation's Higher Education Research and Development survey (HERD). The UMN Sponsored Projects Administration (SPA) is the entity authorized by the Board of Regents to manage project agreements with the LCCMR program.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Brett Barney		Principal Investigator, one week of summer support for two years of the project duration.			33.5%	0.04		\$15,000
Graduate Research Assistant		Research Assistant, Performing Laboratory Experiments and Data Analysis, supervised by the project manager			23.6%	1		\$107,000
Undergraduate Research Assistant		Research Assistants for Laboratory Experiment and Field Study Data Collection, supervised by the project manager and graduate student.			0%	1.5		\$64,000
							Sub Total	\$186,000
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	Non-Capitalized Lab Scientific or Field Supplies	Laboratory Supplies: General Laboratory Chemicals, Media, Reagents and safety materials for students, including gloves (\$400 per month) and Kits for Performing Routine Molecular Biology (\$100 per kit), Analytical Reagents (\$300 per month), Liquid Nitrogen for Strain Storage (\$400 per year).					\$20,000
	Tools and Supplies	Non-Capitalized Lab Scientific or Field Equip	Bioreactor components and parts to operate field studies (Fabricated components, culture vessels, Reactor components, air and water pumps, monitoring equipment, microprocessors).					\$20,000
	Equipment	One Ion Chromatography System	Routine analysis of nitrate levels in incoming and treated water in both laboratory and field settings. Based on					\$36,000

			quote to purchase instrument that would be dedicated to this project.					
							Sub Total	\$76,000
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Miles/ Meals/ Lodging	Travel to and from Fairmont Minnesota	Travel by Brett Barney and students to and from Fairmont Minnesota and associated field sites, to be reimbursed by the University Compensation Plan.					\$4,000
							Sub Total	\$4,000
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
	Publication	Publications of two papers in Scientific and Engineering Journals	Many engineering journals have charges associated with publications, generally around \$1500 per journal.					\$3,000
							Sub Total	\$3,000
Other Expenses								
							Sub Total	-
							Grand Total	\$269,000

Classified Staff or Generally Ineligible Expenses

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

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	-
Non-State				
			Non State Sub Total	-
			Funds Total	-

Attachments

Required Attachments

Visual Component

File: [d60ec551-2ae.pdf](#)

Alternate Text for Visual Component

Graphic illustrating nitrate removal from Contaminated Waters...

Optional Attachments

Support Letter or Other

Title	File
audited financial statements	20eccf61-a59.pdf
Institutional Approval for Submission	5749f7f7-03d.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

No

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

N/A

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

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

BIOLOGICAL METHODS FOR NITROGEN REMOVAL FROM CONTAMINATED WATERS



Utilization of rapidly sedimenting algae for nitrate removal and separation from treated water. Algae can serve as a soil supplement or animal feed.

