Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-283

Proposal Title: Engineered Solutions to Remove Nitrates 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 aims to develop new engineering practices through the application of native microbes to lower the high levels of nitrate accumulating in rural water systems.

Funds Requested: $234,000

Proposed Project Completion: 2024-06-30

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,

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.

Nitrate accumulation in surface and well waters as a result of agricultural runoff is an emerging 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 biological processes associated with microbes know as denitrifiers convert nitrate 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? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.

Our work is aimed to develop approaches that are easily scaled and applied across the state that will increase the rates of nitrate retention on agricultural lands, or increase the rates of conversion of nitrates into nitrogen gas once the nitrate has migrated into drinking water sources. A key feature of nitrate accumulation, is that it often peaks in the early spring when runoff is high, temperatures are low, and biological denitrification processes are sub-optimal. This occurs because many of the microbes that perform this role in nature are not acclimated to functioning at these temperatures. Our two aims seek to identify and cultivate natural microbes that function well at low temperature to naturally remove nitrate from these contaminated waters and lower the levels of nitrate back to acceptable levels. We would also seek to capture and bind the nitrate to soils during early spring so that migration of nitrate into these water supplies is diminished, while also lowered needs to apply additional nitrogen fertilizer in the future.

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 seeks to protect, preserve and enhance this natural resource by enhancing natural biological processes already at work in nature to increase natural recovery of these waters during peak nitrate accumulation while also assisting the farming communities by lowering the needs to apply additional nitrogen fertilizers due to increased runoff and loss of this valuable resource.

Activities and Milestones

Activity 1: Enrichment of Natural Populations of Denitrifying Microbes

Activity Budget: $142,000

Activity Description:
The aim of this first activity is to utilize a bioreactor system to enrich natural populations of beneficial microbes that are able to convert harmful nitrates accumulating in the drinking water that serves the city of Fairmont, Minnesota into harmless nitrogen gas returned safely to the atmosphere. These microbial populations will be drawn from environmental samples taken from the same local watersheds that serve the city of Fairmont, so that no foreign microbes are introduced to the system. By enriching for microbes that are able to serve in this role and function optimally at low temperatures, we will decrease the load of nitrates in the chain of lakes that serves as drinking water sources for the communities around Fairmont, Minnesota using established natural processes. Isolated strains will be characterized and sequenced, to confirm that these pose no danger to these local communities, and will be cultivated using different bioreactors, including efforts to utilize current systems or cheap field bioreactors that can be applied to reintroduce these strains during the spring thaw when runoff is maximized.

Activity Milestones:

Description	Completion Date
Adapt Current Bioreactors for the Enrichment of Cold-Hardy Denitrifying Microbes	2021-12-31
Enrich and Identify Natural Denitrifying Microbes for Field Studies	2022-08-31
Implement Field Scale Demonstration Systems to Lower Nitrate During Spring Thaw	2024-02-28

Activity 2: Apply Cold-Hardy Algae to Recapture Agricultural Nitrogen Prior to Spring Runoff

Activity Budget: $92,000

Activity Description:
We propose the use of indigenous cold-tolerant microalgae as an interim “cover crop” to prevent nutrient loss during late fall and early spring. Our project will investigate alternative strategies that mirror Asian rice cultivation practices, in an effort to exploit those times when traditional cover crops struggle based on low temperatures. By seeding and growing indigenous cold-tolerant algae strains on the fields, we will trap essential nutrients within the topsoil, contributing to overall soil health and diminishing losses of nitrogen to runoff that results in the eutrophication of our lakes and rivers. We will target several demonstration projects in the agricultural fields surrounding Fairmont's water source that result in water runoff into the tributaries that feed the chain of lakes serving Fairmont, Minnesota.

Activity Milestones:

Description	Completion Date
Isolate and identify 5-10 strains of native algae capable of rapid growth at low temperatures.	2023-07-31
Determine the ability of native cold-tolerant algae to bind to soils	2023-12-31
Complete pilot-scale field studies to establish cold-tolerant algae as an agricultural cover crop.	2024-05-31

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 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 that show improved growth and function at low temperatures. Once enriched, specific microbes will be isolated and sequenced to assure these do not pose a risk to these water systems or communities. These will then be cultivated and introduced in a controlled manner to determine the potential benefits. 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. 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 next door to Dr. Barney's laboratory space.

Dr. Barney's laboratory is focused on processes associated with nitrogen cycles and environmental impacts associated with biofuels and agriculture. 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), Minnesota's Discover, Research and InnoVation Economy (MnDRIVE) and the Initiative for Renewable Energy and the Environment (IREE).

Organization: U of MN - Twin Cities

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 all three years or the project duration.			36.5%	0.06		$11,708
Graduate Research Assistant		Research Assistant, Performing Laboratory Experiments and Data Analysis, supervised by the project manager			45%	1.5		$149,334
Undergraduate Research Assistant		Research Assistants for Laboratory Experiment and Field Study Data Collection, supervised by the project manager and graduate student.			0%	1.5		$36,000
							Sub Total	**$197,042**
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, and Reagents ($400 per month) and Kits for Performing Routine Molecular Biology ($400 per kit), Analytical Reagents, DNA Synthesis of Primers ($100 per month), Liquid Nitrogen for Strain Storage ($400 per year).					$30,000
	Tools and Supplies	Non-Capitalized Lab Scientific or Field Equip	Bioreactor components and parts to culture cold-tolerant microbes associated with the goals of Objective One.					$3,958
							Sub Total	**$33,958**
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.					$3,000
							Sub Total	**$3,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$234,000**

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	**-**

Attachments

Required Attachments

Visual Component

File: 2a0b2585-378.pdf

Alternate Text for Visual Component

Graphic illustrating nitrate removal from Contaminated Waters

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

No

Does your project include research?

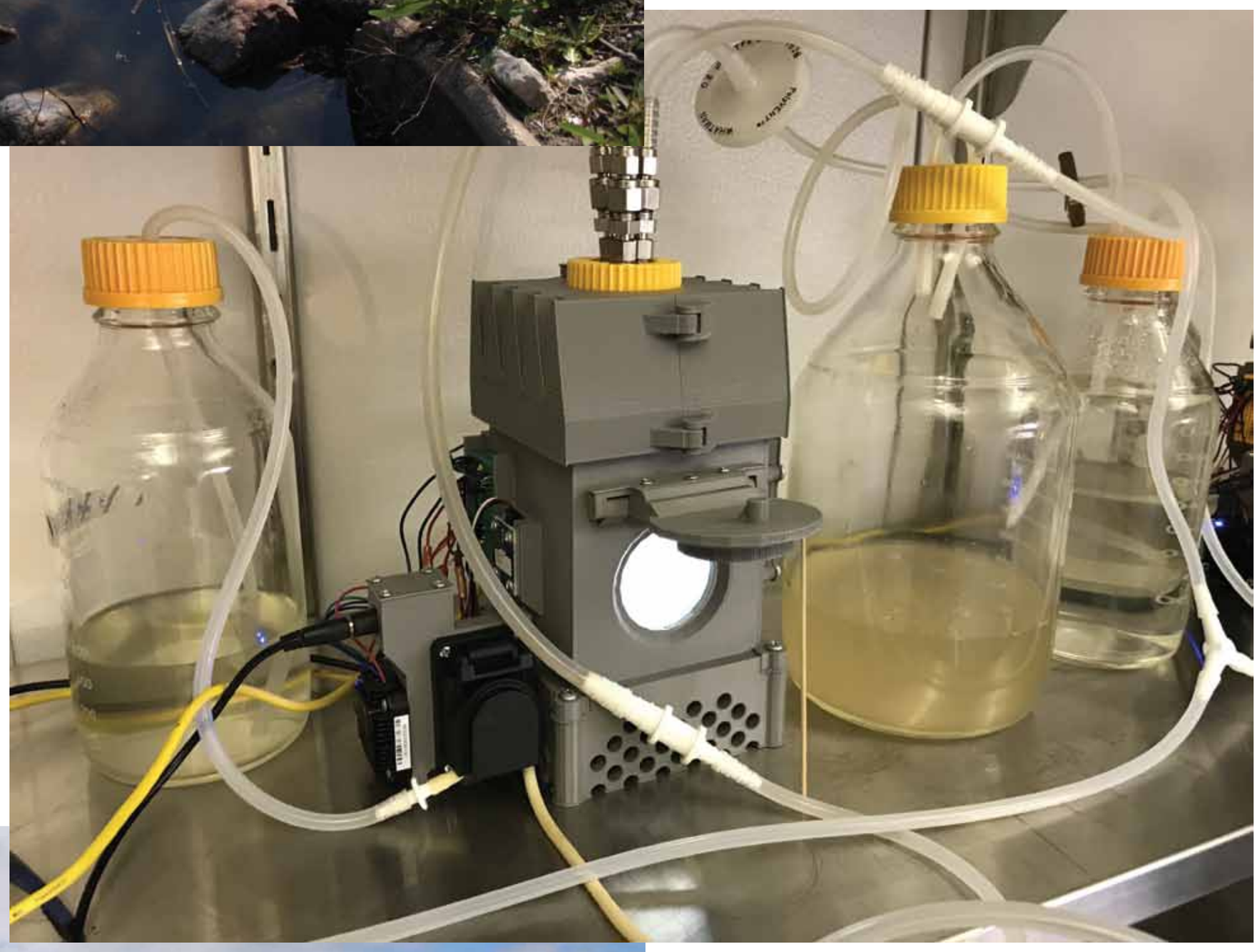
Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Engineered Solutions to Remove Nitrates from Contaminated Waters

High Nitrate Contaminated Waters



Low Temperature Tolerant Denitrifying Microbes

Safe Drinking Water