Environment and Natural Resources Trust Fund

2025 Request for Proposal

General Information

Proposal ID: 2025-181

Proposal Title: Highly Efficient Nutrient Removal Technology for Agricultural Drainage

Project Manager Information

Name: Satoshi Ishii

Organization: U of MN - College of Biological Sciences

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Project Basic Information

Project Summary: This project will apply our novel highly efficient nutrient removal technology for the treatment of agricultural drainage in the field.

ENRTF Funds Requested: $460,000

Proposed Project Completion: June 30, 2028

LCCMR Funding Category: Water Resources (B)

Project Location

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

Region(s): SW

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.

Nutrient pollution can cause eutrophication in rivers, lakes, and oceans. Nitrate/nitrite contamination in groundwater wells can also cause human diseases such as blue baby syndrome, and is, therefore, a serious public health concern as well. Agricultural drainage is one of the major non-point sources of nutrients to the environment. Efforts have been made to reduce nutrient production from agricultural drainage; however, the nutrient removal efficiency of the existing technologies such as woodchip bioreactors and constructed wetlands is not satisfactory, especially in early spring when water temperature is low and large quantities of water and nitrate are discharged into waterways. The emission of nitrous oxide (N2O), a potent greenhouse gas, from woodchip bioreactors and wetlands is also of concern.

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.

The overall goal of this project is to improve water quality and mitigate global warming by removing nutrients, especially nitrate, from agricultural drainage with minimal emission of N2O. We will achieve this goal by applying our novel bioreactor technology, which uses corn cobs (a sustainable bioreactor medium), microbial immobilization technology, lignin-degrading microbes, and cold-adapted, nitrate and N2O-removing bacteria, to treat drainage in agricultural ditches.

The specific objectives of this research are to (1) test laboratory-scale bacteria-coated corncob bioreactor with actual agricultural drainage, (2) install and operate field-scale bacteria-coated corncob bioreactors in agricultural drainage ditches, and (3) disseminate the results to farmers and the public.

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?

The specific outcome of this project is the novel highly efficient bioreactors installed in ditches for the treatment of agricultural drainage. These bioreactors can be used to remove nitrate and other nutrients with minimal emission of N2O, thereby contributing to improving Minnesota's water quality and easing global warming. The same technology can be also applicable for the treatment of other non-point sources such as urban stormwater and septic leakages.

Activities and Milestones

Activity 1: Test laboratory-scale bacteria-coated corncob bioreactor with actual agricultural drainage

Activity Budget: $142,000

Activity Description:
The objective of this activity is to analyze the nitrate removal efficiency of laboratory-scale bacteria-coated corncob bioreactors fed with actual agricultural drainage.

Task 1: We will design and operate laboratory-scale column reactors filled with bacteria-immobilized corn cobs. These bacteria were previously isolated from soil by the research team and characterized as being able to reduce nitrate and N2O to harmless N2 gas under cold conditions. We will also immobilize lignin-degrading microbes on the surface of corn cobs to provide more readily available carbon to the nitrate/N2O-removing bacteria. The reactors will be fed with agricultural drainage collected from the Southwest Research and Outreach Center (SWROC) and operated under field-simulated conditions. The nitrate and N2O concentrations of the effluent from the reactors will be measured over time. Based on these measurements, we will calculate nitrate removal and N2O emission rates.
Deliverable 1: The laboratory-scale nitrate-removing corncob bioreactors and their nitrate removal and N2O emission rates.

Task 2: We will operate the laboratory-scale bioreactors for >2 months to examine the longer-term stability of the reactors. Corn cob samples will be periodically collected to analyze the amount of bacteria remaining on the corn cobs.
Deliverable 2: The long-term bioreactor operation data

Activity Milestones:

Description	Approximate Completion Date
Demonstrate high nutrient removal efficiency of the laboratory-scale nitrate-removing corncob bioreactors	December 31, 2025
Long-term (>2 months) stable operation of the bioreactors	June 30, 2026

Activity 2: Install and operate field-scale bacteria-coated corncob bioreactors in agricultural drainage ditches

Activity Budget: $234,000

Activity Description:
This activity aims to examine the performance of our bacteria-coated corncob bioreactors in the field.

Task 1: We will install bacteria-coated corncob bioreactors (n=6) in the agricultural ditches at the SWROC. The bioreactor influent and effluent samples will be collected over time for the analysis of nitrate. Various environmental parameters such as temperature, pH, redox potential, flow rate, chemical oxygen demand, etc., will be also measured. Corn cob samples will be periodically collected to analyze the amount of bacteria remaining on the corn cobs. The field testing will be done in spring and fall (2 months each) over two years (2026 and 2027).
Deliverable 1: Nitrate removal data of the bioreactors installed in the field

Task 2: We will statistically analyze the data collected in the field to identify the factors influencing nitrate removal. We will also try to construct a model to predict nitrate removal based on environmental parameters. This information is important and useful for designing and implementing field-scale bioreactors in other locations.
Deliverable 2: Summary of statistics

Activity Milestones:

Description	Approximate Completion Date
Demonstrate high nutrient removal of the field-scale corncob bioreactors	December 31, 2027
Identify the factors influencing nutrient removal efficiency of the field-scale bioreactors	June 30, 2028

Activity 3: Disseminate the results to farmers and the public

Activity Budget: $84,000

Activity Description:
This activity aims to disseminate the results to farmers and the public.

Task 1: We will reach out to farmers to disseminate our bioreactor technology and receive their feedback through U of M's extension activities, such as webinars, blog posts, and field days. We will also conduct outreach activities to introduce our bioreactor technology to the public, including K-12 students, at various venues such as the Minnesota State Fair.
Deliverable 1: Webinars, blog posts, field days, and other outreach events

Task 2: We will present our results at the Minnesota Water Resources Conference. We will also produce scientific manuscripts in open-access journals.
Deliverable 2: Presentations and publications

Activity Milestones:

Description	Approximate Completion Date
Conduct outreach activities	June 30, 2028
Publications and presentations	June 30, 2028

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Paige Novak	University of Minnesota	Co-Investigator	Yes
Jeffery Strock	University of Minnesota	Co-Investigator	Yes
Nigel Pickering	Geosyntec Consultants	Co-Investigator	Yes
Laura Christianson	University of Minnesota	Collaborator	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 includes a field demonstration of our technology. We will invite farmers, industries, agencies, and other interested parties to the field sites to show our technology. The results will be disseminated to the public through open-access publications and conference presentations. If additional work is needed, funding from federal sources will be sought.

Project Manager and Organization Qualifications

Project Manager Name: Satoshi Ishii

Job Title: Associate Professor

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

Dr. Satoshi Ishii is an Associate Professor at the Department of Soil, Water, and Climate as well as the BioTechnology Institute in the University of Minnesota. Dr. Ishii's research focuses on environmental microbiology and biotechnology, including nitrogen removal from wastewater and agricultural drainage. Dr. Ishii has managed multiple projects related to the proposed subject.

Organization: U of MN - College of Biological Sciences

Organization Description:

The University of Minnesota is the main research and graduate teaching institution in the state of Minnesota. The BioTechnology Institute provides advanced research, training, and university-industry interaction in biological process technology. In the Department of Soil, Water, and Climate, we seek to improve and protect the quality of soil, air, and water resources in natural and managed ecosystems, through research, teaching, and extension.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Satoshi Ishii		Lead and manage the project			27%	0.24		$52,803
Paige Novak		Advise/supervise researchers			27%	0.12		$43,475
Jeffery Strock		Manage fieldwork			27%	0.09		$15,130
1 Postdoctoral research associate		Perform experiments and data analysis			21%	3		$225,163
2 Field crews		Collect water samples from the field			7%	0.45		$33,629
2 Undergraduate researchers		Collect water samples and analyze data			0%	0.87		$28,800
							Sub Total	**$399,000**
Contracts and Services								
Nigel Pickering (Geosyntec Consultants)	Professional or Technical Service Contract	Technical advice on bioreactor design and operation				0.03		$10,000
							Sub Total	**$10,000**
Equipment, Tools, and Supplies								
	Tools and Supplies	Materials for reactor construction	Pumps, reactors, and corn cobs necessary to constuct laboratory and field-scale bioreactors					$6,500
	Tools and Supplies	Chemicals for water quality analysis	Necessary to measure nitrate and N2O concentrations					$8,000
	Tools and Supplies	Microbiological analysis	Necessary to grow bacteria and quantify their abundance					$5,500
	Tools and Supplies	Field supplies and consumables	Various supplies and consumables are needed to collect and process samples (chemicals, glassware, plastic consumables, etc.)					$10,000

							Sub Total	**$30,000**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	A total of 17 trips (~5,100 miles) are planned (~300 miles/trip to visit SWROC from the University of Minnesota St. Paul campus at a rate of $0.67/mile.	Necessary to collect samples from the field site at SWROC					$3,400
	Conference Registration Miles/ Meals/ Lodging	Trips and registration fees to present our research results at a conference in MN ($300/person x 2 researchers)	To disseminate the results					$600
							Sub Total	**$4,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Open access publication fee	Necessary to make our results publicly available					$6,000
							Sub Total	**$6,000**
Other Expenses								
		DNA sequencing analysis (University of Minnesota Genomics Center)	Necessary to analyze microbial communities on the corn cob samples					$3,000
		Mass production of microbial cells (University of Minnesota BioTechnology Resource Center)	Necessary to produce large volumes of bacterial cells to coat corn cobs					$8,000
							Sub Total	**$11,000**
							Grand Total	**$460,000**

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				
In-Kind	University of Minnesota	The University of Minnesota is not allowed to charge the State of Minnesota its typical overhead rate of 55% of the total modified direct costs. We are listing our unrecoverable indirect cost as in-kind contribution.	Secured	$253,005
			State Sub Total	**$253,005**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**$253,005**

Total Project Cost: $713,005

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: d4853bbe-8b5.pdf

Alternate Text for Visual Component

Special bacteria immobilized on the surface of corn cobs break down nitrate into harmless N2 gas under cold conditions....

Supplemental Attachments

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

Title	File
Authorization letter from the U of M SPA	5d95635b-023.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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?

No

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?

Yes, Sponsored Projects Administration

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:

NA