Environment and Natural Resources Trust Fund

2024 Request for Proposal

General Information

Proposal ID: 2024-108

Proposal Title: Minnesota Microbes for Enhanced Biodegradation of Microplastics

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: We will investigate the potential of natural microbes indigenous to Minnesota to biodegrade conventional plastics in the environment as a means for cleaning contaminated soils and waters across the state.

Funds Requested: $524,000

Proposed Project Completion: June 30, 2027

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?

Statewide

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

Statewide

When will the work impact occur?

During the Project

Narrative

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

Microplastics are small particles added to exfoliating soaps and skincare products or the result of the physical degradation process of larger plastics in our environment that results from exposure to sunlight and weathering. These are often invisible to the naked eye, but become apparent under a microscope based on collection techniques with precision screens. Microplastics have permeated into the food chain and also concentrate environmental pollutants. Recent reports citing high levels of microplastics in the Great Lakes confirmed concerns that the accumulation of microplastics in the environment is not only an issue facing the Pacific Ocean, where this topic has been highlighted as a key element of the Great Pacific Garbage Patch. Indeed, microplastics have infiltrated many standing bodies of water throughout the world and across the state of Minnesota. Plastic waste within the environment contributes to the illness and deaths of countless fish, amphibians, marine mammals and bird species, and also diminishes the pristine nature of our public waters which are a valuable aspect of recreation in Minnesota. This unanticipated and detrimental result of our wide-scale adoption of plastics over the past century is an issue that will face generations to come.

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.

Conventional plastics are widely believed to be non-biodegradable. Recent reports have identified microbes capable of degrading common plastics such as those found in beverage bottles (PETE). These studies are important because they have identified specific microbes that slowly degrade a common plastic, shattering the misconception that all petroleum-derived commodity plastics are non-biodegradable. Significantly less progress has been made in relation to polyethylene (HDPE or LDPE) and polypropylene used to store everything from milk to household chemicals. Our prior LCCMR project identified a class of microbes found throughout Minnesota that are capable of degrading chemicals like polyethylene, laying the framework to develop approaches to treat contaminated soils and waters across the state. This prior project demonstrated that microbial communities are better at degrading complex chemicals like plastics, but also identified key microbes that have emerged to be the primary degraders of these plastics. Understanding the mechanisms used by these microbes will lead to the development of new methods to increase rates of degradation. Coupled with efforts to make the public more aware of the emerging issue of microplastics that have proliferated into our environment and food systems, we aim to develop approaches to enhance biodegradation of microplastics using native microbes.

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?

Our project aims to understand the mechanisms used by specific microbes to biodegrade plastics like polyethylene found in the environment. Using the techniques developed in our prior project, we will also identify microbes capable of degrading polystyrene (including styrofoam). We will further investigate methods to enhance the rates of biodegradation and use these microbes to treat contaminated environments to increase plastic biodegradation in a manner that is safe and effective. We will also develop an educational component to educate students across the state of Minnesota.

Activities and Milestones

Activity 1: Identify the Mechanisms used by Specific Microbes to Biodegrade Polyethylene

Activity Budget: $190,000

Activity Description:
Our prior LCCMR project successfully identified a specific class of microbes native to Minnesota that are able to degrade polyethylene over the course of several weeks, enabling more detailed studies to understand how these microbes are accomplishing this very difficult task. Now that these microbes have been identified, we aim to apply genetic methods to identify the genes, biochemical pathways and enzymes that result in the biodegradation of polyethylene plastics. Equipped with this information, we will identify other additional microbes that might share the same suite of genes and characteristics to develop enhanced microbial communities to further improve the rates of biodegradation. These microbes could then be applied to a range of treatment options, for seed innoculums to large-scale treatment of plastic wastes, to recycling chemicals and energy production. These studies would establish the foundations for each of these potential outcomes. Modern genetic approaches can be applied to this class of microbes, and using next-generation sequencing, genetic and biochemical characterization techniques, we will identify the features of these microbes that may provide a long-term solution to our microplastics problem.

Activity Milestones:

Description	Approximate Completion Date
Sequence various Minnesota microbes that degrade polyethylene plastics.	June 30, 2025
Use genetic techniques to identify the genes involved in polyethylene biodegradation	June 30, 2026
Characterize enzymes responsible for polyethylene biodegradation.	June 30, 2027
Develop educational components to teach Minnesotans about the bioplastic problem.	June 30, 2027

Activity 2: Identify Minnesota Microbes Capable of Degrading Polystyrene

Activity Budget: $185,000

Activity Description:
Polystyrene is a common plastic with physical characteristics that are similar to polyethylene, but has a different chemical structure that is slightly more complicated than polyethylene for biodegradation. Using the approaches we previously applied to successfully identify microbes that biodegrade polyethylene, we will pursue similar efforts using microbial community approaches to identify communities that can biodegrade polystyrene. Polystyrene is used in everything from packaging materials to yogurt containers, and is a common plastic in many home appliances (refrigerators). When inject with air, it produces styrofoam, which is a prolific contaminant in the environment. In this second effort, we will apply the approaches that successfully identified microbes capable of degrading polyethylene to polystyrene. Identification of microbes capable of effectively degrading polystyrene is a first step toward addressing this microplastic in the environment.

Activity Milestones:

Description	Approximate Completion Date
Isolate communities of microbes capable of polystyrene degradation and enrich to identify specific strains	August 31, 2025
Identify common microbes from community analysis that are able to biodegrade polystyrene	December 31, 2026

Activity 3: Develop Biofilters to Treat Microplastic Polutions in Contaminated Waters

Activity Budget: $149,000

Activity Description:

Based on a clearer understanding of key parameters that result in improved biodegradation of polyethylene and polystyrene microplastics, we will construct a biofilter system to capture and treat the microplastics in order to effectively remove them from contaminated water systems. Investigators will explore various biofilter designs to enhance microbial processes and maintain an active community of plastic degrading microbes.

Activity Milestones:

Description	Approximate Completion Date
Construct initial bioreactor designs to capture microplastics for further treatment.	August 31, 2026
Test and improve biofilter design to optimize biodegradation and maintain microbial communities	June 30, 2027
Develop education component to teach Minnesotans about potential bioremediation efforts	June 30, 2027

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Bo Hu	University of Minnesota	co-PI	Yes

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 also seek funds from additional federal funding sources including the Environmental Protection Agency and the National Science Foundation.

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: Professor

Provide description of the project manager's qualifications to manage the proposed project.
Dr. Brett Barney (Project Manager) received his PhD in 2003. Prior to his PhD work, he spent six years in the medical device manufacturing sector. Following his PhD, he spent 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 was the Director of the Microbial and Plant Genomics Institute from 2020 to 2022. 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:
In the College of Food, Agricultural and Natural Resources Sciences (CFANS) at the University of

Minnesota, we look at the bigger picture. When we envision a better tomorrow, it includes disease-resistant crops, products that protect our health, lakes free from invasive species, and so much more. We use science to find answers to Minnesota and the world's grand challenges and solve tomorrow's problems. Almost 93 percent of students who earn CFANS undergraduate degrees find jobs in their career field or enter graduate school within six months of graduation.

The Department of Bioproducts and Biosystems Engineering, in CFANS, discovers and teaches solutions for the sustainable use of renewable resources and the enhancement of the environment. We discover innovative solutions to address challenges in the sustainable production and consumption of food, feed, fiber, materials, and chemicals by integrating engineering, science, technology, and management into all degree programs.

We have a public impact through community engagement and extension efforts. We develop and deliver high quality, regionally and nationally-recognized research-based programs to meet current and emerging needs of industry and communities. We also have a long-standing tradition of close partnerships with alumni, industry professionals, organizations, government agencies, donors, and community members.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Lead Principal Investigator		Project design and management, two weeks of summer salary support per year.			36.8%	0.12		$23,954
co-Principal Investigator		Project design and management, one week of summer salary support per year.			36.8%	0.06		$13,690
Graduate Research Assistant		Research Assistant, Performing Laboratory Experiments and Data Analysis, supervised by the project manager, education			24%	3		$163,993
Undergraduate Research Assistant		Research Assistants for Laboratory Experiment and Field Study Data Collection, supervised by the project manager and graduate student. Primarily summer research work for two students to learn about the research field.			0%	1.5		$68,182
Postdoctoral Associate		Research Supervision, Performing Laboratory Experiments and Data Analysis, in collaboration with the Project Managers			25.7%	3		$215,165
							Sub Total	**$484,984**
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 ($300 per month) and Kits for Performing Routine Molecular Biology ($200 per kit), Analytical Reagents ($300 per month), Liquid Nitrogen for Strain Storage ($400 per year).					$36,016
							Sub Total	**$36,016**

Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
							Sub Total	**-**
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	**$524,000**

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: 9dd32f67-2bc.pdf

Alternate Text for Visual Component

Graphic showing plastic materials in Minnesota environment and describing the aims of the proposal...

Optional Attachments

Support Letter, Photos, Media, Other

Title	File
2022 Audit	6b1ff9b2-8f0.pdf
Authorization	e256e5b0-b7e.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?

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 design, construction, or renovation of a building, trail, campground, or other capital asset costing $10,000 or more?

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?

No