Environment and Natural Resources Trust Fund

M.L. 2024 Approved Work Plan

General Information

ID Number: 2024-108

Staff Lead: Noah Fribley

Date this document submitted to LCCMR: June 6, 2024

Project Title: Minnesota Microbes for Enhanced Biodegradation of Microplastics

Project Budget: $524,000

Project Manager Information

Name: Brett Barney

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

Office Telephone: (612) 562-3061

Email: bbarney@umn.edu

Web Address: https://cfans.umn.edu/

Project Reporting

Date Work Plan Approved by LCCMR: June 20, 2024

Reporting Schedule: June 1 / December 1 of each year.

Project Completion: June 30, 2027

Final Report Due Date: August 14, 2027

Legal Information

Legal Citation: M.L. 2024, Chp. 83, Sec. 2, Subd. 08g

Appropriation Language: $524,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to investigate the potential of natural and indigenous microbes to biodegrade conventional plastics in contaminated soils and waters across the state. This appropriation is subject to Minnesota Statutes, section 116P.10.

Appropriation End Date: June 30, 2027

Narrative

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.

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.

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

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 these classes 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. Specific enzymes will also be characterized by graduate students and shared with the scientific community.

Activity Milestones:

Description	Approximate Completion Date
Collect additional microbial communities able to degrade polyethylene plastics for characterization and isolation.	December 31, 2024
Sequence various Minnesota microbes that degrade polyethylene plastics and publish these genomes to public databases.	June 30, 2025
Publish first manuscript related to this aim in a peer-reviewed scientific journal.	December 31, 2025
Use genetic techniques to identify the genes involved in polyethylene biodegradation and publish findings.	June 30, 2026
Develop educational components to teach Minnesotans about the bioplastic problem and share through social media.	June 30, 2027
Characterize specific enzymes responsible for polyethylene biodegradation and publish findings in peer-reviewed literature.	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
Construct devices to collect communities capable of polystyrene reaction from locations across Minnesota.	December 31, 2024
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 for publication.	December 31, 2026
Publish second manuscript on scientific journal related to polystyrene biodegradation.	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. This aspect of the project is dependent upon data obtained from Activity 1 and 2, and will begin later in the funding period once sufficient information is available from the first two activities.

Activity Milestones:

Description	Approximate Completion Date
Perform literature review and develop reactor concept ideas for design and testing.	March 31, 2025
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

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.
We will share results from this research with the broader scientific community through publications in open access journals. Genome sequences for any strains sequenced as part of this project will be submitted to the National Center for Biotechnology Information. Strains will be made available to fellow scientists for research purposes or submitted to strain banks or culture collections for long-term storage. Our laboratory also maintains stocks of these strains in cryogenic storage and provides these to other entities upon reasonable request. Work from this research project will also be shared with students across the state through various outreach aspects that will be overseen by the Principal Investigators, Postdoc and Graduate Student. This outreach will include the development and maintenance of an expanded website related to this project, where we will share information related to the status of the project. We will also develop various short descriptive videos to showcase some of the work and accomplishments of the project, which will be shared through outlets such as YouTube and other social media outlets. The Environmental and Natural Resources Trust Fund will be acknowledged through attribution in the acknowledgements section of any peer reviewed research. The use of the trust fund logo will be used in any presentation or electronic media, publications and signage as detailed in the ENTRF Acknowledgement 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?
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

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. We plan to publish one manuscript before the end of 2025, and another before the end of 2026.					$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...

Supplemental Attachments

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

Title	File
2022 Audit	6b1ff9b2-8f0.pdf
Authorization	e256e5b0-b7e.pdf
Research Addendum revised 2024-108 final	f2788502-31c.pdf

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

Added a general description of the dissemination component that is new in the work plan. No other changes were made to the proposal in going to the workplan stage. Addressed additional revision requests from LCCMR staff.

Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?

N/A

Do you agree travel expenses must 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