Environment and Natural Resources Trust Fund
2020 Request for Proposals (RFP)

Project Title: **ENRTF ID: 220-F**

Transformation of Plastic Waste into a Valued Resource

Category: F. Methods to Protect, Restore, and Enhance Land, Water, and Habitat

Sub-Category:

Total Project Budget: $ 308,000

Proposed Project Time Period for the Funding Requested: June 30, 2023 (3 yrs)

Summary:

We will develop technologies that utilize indigenous microbes to convert waste plastics into useful chemical compounds and fuels.

Name: Brett Barney

Sponsoring Organization: U of MN

Job Title: Professor

Department: Bioproducts and Biosystems Engineering

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Location:

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Graphic illustrating the process of converting plastic wastes into fuels

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Transformation of Plastic Waste into a Valued Resource

I. PROJECT STATEMENT

CONCEPT – We will develop technologies that utilize indigenous microbes to convert waste plastics into useful chemical compounds and fuels. By converting this waste stream into valuable commodity chemicals and a potential source of energy, we will increase the demand for this material, which will lower the likelihood that these materials to end up in our natural waters following disposal. This effort will also lay the groundwork for developing future methods to remediate plastics from contaminated soils and waters by identifying natural species from Minnesota that have the ability to degrade these undesirable contaminants.

BACKGROUND – Microplastics are small plastic beads that have been added to exfoliating soaps or skincare products, and also result from the general photochemical degradation process of plastics in our environment that results from exposure to sunlight. These are often unseen based on a visual inspection, but quickly become apparent when viewed under a microscope and based on collection techniques with precision screens. These microplastics have permeated into the food chain and act to concentrate environmental pollutants. Recent reports citing high levels of microplastics in freshwater lakes such as the Great Lakes have confirmed concerns that the accumulation of microplastics in the environment is not an issue facing only water bodies such as 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, reptiles, 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.

Conventional plastics are widely believed to be non-biodegradable. Various reports of microbes that are capable of degrading common plastics such as those found in beverage bottles (PETE), Styrofoam (polystyrene) and those used to store everything from milk to household chemicals (polyethylene; HDPE or LDPE) are now challenging this belief. These studies are important because they have identified specific bacteria and fungi that can degrade many current common plastics, shattering the misconception that all petroleum-derived commodity plastics are non-biodegradable. Our project will build upon the foundations of these reports and preliminary studies in our own laboratories, and further incorporate the emerging realization that diverse microbial communities are better adapted than single organisms to degrading complex chemicals such as those that are found in conventional plastics.

GOAL – The goal of this project is to develop alternatives for disposing of problem-plastics by converting plastic waste materials into a valuable resource using conditions similar to what is commonly found in the lower gut of many plastic-degrading insects. Through this approach, we will create new markets for many of the problematic plastics found in our recycling and waste streams. By adding value and incentive to repurpose the waste, we will decrease levels of plastics reaching the environment, including our lakes and rivers.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Collection and Analysis of Plastic-Degrading Microbial Communities* **Budget: $ 146,000**

We will enrich several microbial communities collected from Minnesota with the greatest ability to biodegrade targeted plastics. This effort will build upon current studies already underway that have resulted in several microbial communities that biodegrade targeted problem-plastics. This effort will include outreach with secondary school teachers across the state to increase the breadth of sites sampled and also educate students and their communities about the environmental impacts of poor plastic waste management and the impacts on our waters and the environment. This effort will expand our sample size and geographical diversity, while also educating future generations of Minnesotans.

Outcome	Completion Date
1. Construct laboratory reactors to enrich microbial communities for the biodegradation of problematic plastics such as polyethylene (HDPE and LDPE), polystyrene (Styrofoam) and PETE (Water bottles).	Dec 15, 2020
2. Prepare sites to house simple microcosms to enrich natural organisms capable of using different plastics as a growth substrate (including insects, soil and water samples).	May 1, 2021
3. Determine the composition of enriched microbial communities to identify the diversity and abundance of plastic degrading organisms across Minnesota.	July 30, 2022

Activity 2: ***Construction of Model Insect Gut Digesters to Transform Plastic Waste*** **Budget: $ 162,000**

We will construct a laboratory-scale continuous system that will utilize waste plastics as a feedstock supply to produce useful commodity chemicals, methane and hydrogen gas. The goal of this activity will be to provide a proof of concept for the reactor design and approach, which could then be deployed across the state in the future as an alternative solution to landfilling waste plastics. Our efforts will target problem-plastics that do not have sufficient markets for recycling, and which are often found as contaminants in our lakes and rivers. Through the development of these reactors and the enrichment of strains able to biodegrade these problem-plastics, we will also isolate natural strains that could be used in future efforts to treat contaminated areas. Additional reactor designs will be tested as well to determine optimal methods to treat microplastics.

Outcome	Completion Date
1. Construct a laboratory-scale insect gut digesters to convert target plastic materials into methane and hydrogen for energy production.	Oct 15, 2021
2. Construct aerobic reactors to determine the potential to apply indigenous microbes as a means of bioremediation to plastics in the environment.	Feb 15, 2022
3. Analyze genes and genomes of different species from isolated communities to identify genes involved in plastic waste degradation.	June 1, 2023

III. PROJECT PARTNERS:

The research team includes Professor Brett Barney from the Department of Bioproducts and Biosystems Engineering and the BioTechnology Institute at the University of Minnesota, who will oversee the project. Professor Barney's lab has been isolating natural communities of microbes capable of biodegrading plastics for several years. Professor Jeff Gralnick from the Department of Plant and Microbial Biology will grow anaerobic communities and assist with metagenomics studies. Professor Bo Hu from the Department of Bioproducts and Biosystems Engineering is an expert in the area of anaerobic digestion, and will help with reactor design. We are also working with several industry partners that produce commodity plastics. These industry partners will provide materials that are key to enriching our cultures and confirming that strains are biodegrading the targeted plastics.

IV. LONG-TERM- IMPLEMENTATION AND FUNDING:

We expect this to be a long-term project. The goals of the project are not the immediate cleanup of any specific site, as it does not make sense to clean a site until we determine ways to eliminate the further addition of these plastics to the environment. Our belief is that the best solution to this problem is to create an incentive for these problem materials to be directed away from the current waste streams. While some of these materials are recyclable, these tend to be difficult recycling streams that are not fully utilized. By developing a technology that converts these materials into a fuel, we are creating new markets and solutions. The research will also contribute to other future directions that could be applied to site specific cleanup strategies.

V. TIME LINE REQUIREMENTS:

This project has a target for completion of 3 years. Certain proof-of-concept aspects have already been completed, and precedence for the success of other aspects of this project has been established through recent literature reports. Further support would be sought through additional funding sources based on the overall success of the project.

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Brett Barney
Project Title: Transformation of Plastic Waste into a Valued Resource
Organization:University of Minnesota
Project Budget: $308,000
Project Length and Completion Date: 3 years - June 30, 2023
Today's Date: 4/11/19

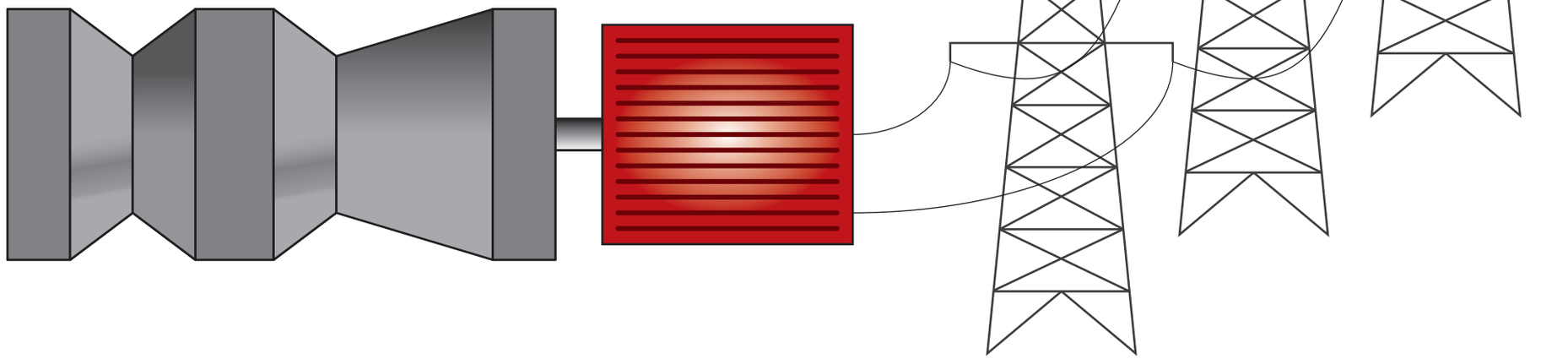
ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 240,000	$ -	$ 240,000
Brett Barney, Project Manage - 0.05 FTE, 3 years, $21,000 (73.5% salary, 26.5% benefits), Summer Salary			
Jeff Gralnick, co-Project Manager- 0.02 FTE, 3 years, $13,000, (73.5% salary, 26.5% benefits), Summer Salary			
Bo Hu, co-Project Manager - 0.02 FTE, 3 years, $12,000 (73.5% salary, 26.5% benefits), Summer Salary			
1 Graduate Research Assistant, 0.5 FTE, 3 years, $149,000 (55% salary/45% fringe)UMN (Twin Cities), Laboratory Experiment Data Analysis, supervised by Barney and Gralnick			
Undergraduate Research Assistants, .38 FTE, 3 years, $45,000 (100% salary)UMN (Twin Cities), Laboratory Experiment and Field Study Data Collection, Supervised by Barney/Gralnick/Hu			
Professional/Technical/Service Contracts			
	$ -	$ -	$ -
Equipment/Tools/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). Combined laboratory supplies for the labs for all 3 PIs (Barney, Gralnick, Hu).	$ 45,000	$ -	$ 45,000
Capital Expenditures Over $5,000			
	$ -	$ -	$ -
Fee Title Acquisition			
	$ -	$ -	$ -
Easement Acquisition			
	$ -	$ -	$ -
Professional Services for Acquisition			
	$ -	$ -	$ -
Printing			
	$ -	$ -	$ -
Travel expenses in Minnesota			
Travel by Brett Barney and students between the Twin Cities campus and various field site across	$ 3,000	$ -	$ 3,000
Other			
Lab services - DNA Sequencing for metagenomics work, performed at University of Minnesota Sequencing Facilities. Eight sequencing runs at $2,500 each.	$ 20,000	$ -	$ 20,000
COLUMN TOTAL	$ 308,000	$ -	$ 308,000

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Unrecovered F&A	Secure	$ 140,000	$ -	$ 140,000

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
		$ -	$ -	$ -

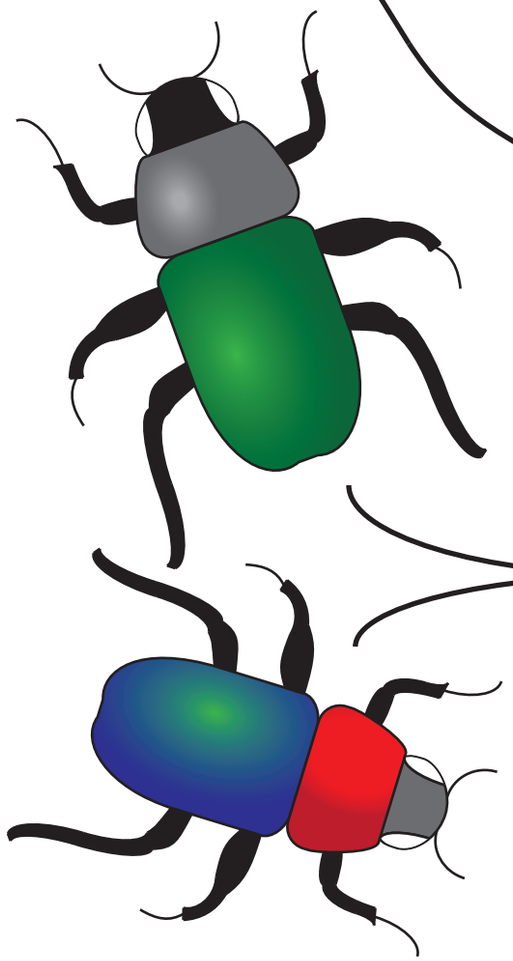
Transformation of Plastic Waste into a Valued Resource

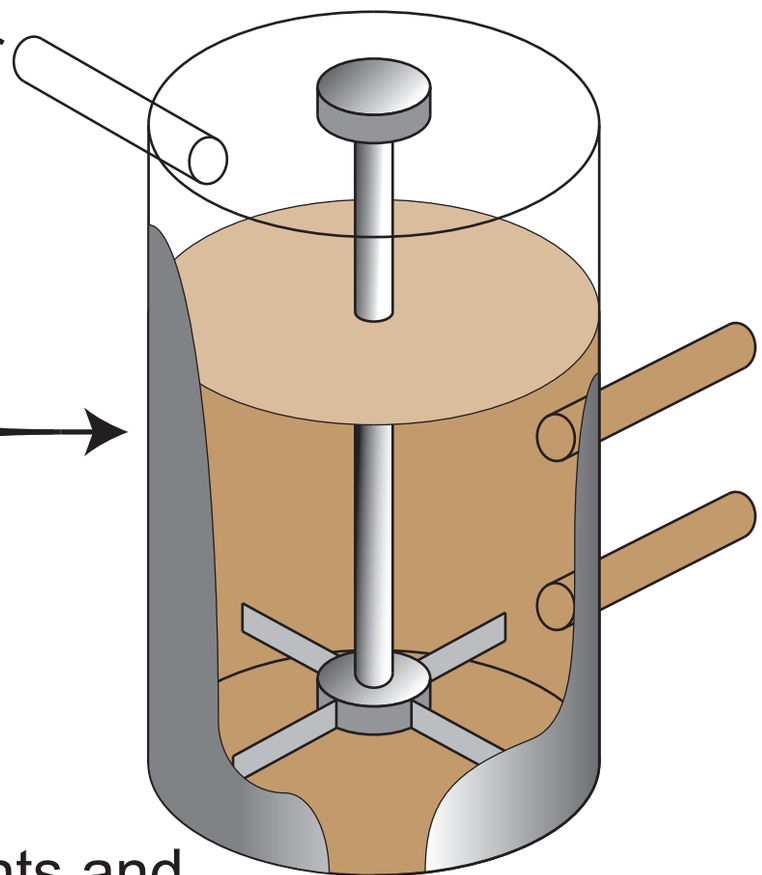
Power Generation



Useful Chemical Products and Fuels

Continuous Bioreactors





Biodegraded Products

Insect-Gut Components and Other Environmental Samples

Problem Plastics

Project Manager Qualifications

Brett Barney, Project Manager

Education:

Ph.D. Biochemistry, Arizona State University, 2003
B.S. Professional Chemistry, Utah State University 1993

Work and Research Experience:

2015 – Present	Associate Professor, Bioproducts and Biosystems Engineering (UMN)
2010 – Present	Faculty Member, BioTechnology Institute and Microbial and Plant Genomics Institute (UMN)
2009 – 2015	Assistant Professor, Bioproducts and Biosystems Engineering (UMN)
2003 – 2009	Research Assistant Professor and USDA Postdoctoral Fellow (USU)
1999 – 2003	Research Assistant and NSF Fellow, Department of Chemistry and Biochemistry (ASU)
1993 – 1999	Fiber Laboratory Manager, Research Chemist, Senior Laboratory Technician and Associate Chemist, Fresenius Medical Care, Ogden, Utah
1991 – 1993	Research Technician, Utah Water Research Laboratory (USU)

Jeffrey Gralnick, co-Project Manager, Associate Professor, Department of Plant and Microbial Biology (UMN)

Jeff brings expertise in the growth of anaerobic organisms and next generation sequencing

Bo Hu, co-Project Manager, Associate Professor, Department of Bioproducts and Biosystems Engineering (UMN)

Bo brings expertise in anaerobic digestion

Dr. Barney's laboratory is focused on microbiology for sustainability. Dr. Barney has more than 25 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).

The Barney laboratory is housed in the Cargill building for Microbial and Plant Genomics at the University of Minnesota. The laboratory contains the primary equipment to perform this research project, including facilities to cultivate various bacteria, autoclaves, analytical instrumentation for analysis (gas chromatography, spectrophotometers, and balances), thermocyclers for PCR reactions, centrifuges, electrophoresis equipment and various incubators. Additional facilities include the Biotechnology Resource Center, the Genomic Sequencing Center and a broad range of additional analytical laboratories which are available as pay services.

Organization Description

Dr. Brett Barney (PI) has been a professor with the Department of Bioproducts and Biosystems Engineering 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. UMN Sponsored Projects Administration (SPA) is the entity authorized by the Board of Regents to manage project agreements with the LCCMR program.