Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-260

Proposal Title: Managing Microplastics in Minnesota's Compost and Soils

Project Manager Information

Name: Naba Kalita

Organization: U of MN - Duluth - NRRI

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Project Basic Information

Project Summary: This project optimizes aerobic composting to ensure that compostable plastics break down fully. By preventing microplastic pollution, it supports cleaner soils, water systems, and more sustainable waste management solutions.

ENRTF Funds Requested: $779,000

Proposed Project Completion: June 30, 2030

LCCMR Funding Category: Land (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?

In the Future

Narrative

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

Minnesota's agricultural and gardening sectors rely on healthy soil. Industrial composting is a sustainable way to turn food and yard waste into nutrient-rich soil amendments. However, microplastics, a hidden contaminant, threatens this cycle. Certain reports worldwide show that some bioplastics fail to fully degrade in industrial composting, leaving microplastics behind. When plastic-contaminated compost is spread on fields and gardens, it disperses microplastics into the environment where they can stunt plant growth, harm soil microbes, and enter the food web. Even "compostable" plastics sometimes fail to break down completely, leaving behind invisible fragments that persist in our soil.

This proposal will promote industrial transformation in Minnesota by enhancing composting processes through identifying and mapping of microbial consortiums that are responsible for degradation of bioplastics in industrial composting sites. This study will provide statistical characterization of baseline occurrence of plastics (both bioplastics and conventional plastics) in compost piles, establishing a reference point for achieving plastic-free compost suitable for both domestic and agricultural use. These datasets will reveal emerging plastic-based contaminants such as microplastics and nanoplastic found in Minnesota compost. These datasets could be adopted statewide by municipal sites, enhancing compost quality and market value while influencing MPCA policies on labeling standards.

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.

This project will protect Minnesota's soil health by quantifying microplastics in industrial compost and identifying natural microbes that can break them down and ensures complete assimilation occurs. We will collect compost samples from industrial composting units managing organic wastes by partnering with industrial composting units across the State, to analyze real world compost samples. We will quantify residual plastic content in current composting systems and develop a microbial "probiotic" enhancement for compost piles. This approach (bioaugmentation) involves identifying and isolating plastic-eating microbial consortia (bacteria and fungi) present in compost piles and reintroducing these plastic-eaters during the compost's maturing phase to promote accelerated degradation of the residual plastics. We will then compare these results by designing lab based simulated industrial composting tests and will determine the biodegradation rate of the most common plastics after the addition of probiotic boost and comparing them with standard compost. These lab tests are needed to understand, identify and control processing parameters and rate-determining factors for producing plastic-free finished compost via bioaugmentation.

Our expected outcome is the accelerated degradation of plastic, and ensuring that finished compost is plastic-free and is truly sustainable making our garden and agricultural soil free from plastics.

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?

Data will lead to improved compost quality free of plastic residues. Since compostable products, which are mostly plastic and other paper based packaging commodities don't degrade completely in some industrial composting setups. Although composting of plastics conducted according to ASTM standards, bioplastics do degrade, but microplastics and other unwanted plastic debris can remain, potentially leading to release of such debris into the environment. This project will lead to conditions that eliminate remaining microplastics and other plastic debris. The methods developed could be deployed by stakeholders throughout the state, such as waste management and resources recovery managers and industrial composters.

Activities and Milestones

Activity 1: Assess potential plastic contamination in Minnesota compost caused by biodegradable and non-biodegradable plastics

Activity Budget: $245,000

Activity Description:
Understanding emerging contaminants (mirco- or nanoplastics) currently entering Minnesota's soils could begin with a clear picture of what is present in our compost that feed our garden and agricultural soils. We need to know what is currently ending up in our soil. We will collect samples from our partner facilities (industrial composting units) at various stages of the composting process. Samples will be physically sorted to separate debris followed by advanced imaging to count and identify microplastics that could be from compostable materials (e.g., polylactic acid) and other extraneous contaminants (e.g., polypropylene). Simultaneously, we will conduct DNA-based microbial analysis of each compost sample to identify the naturally occurring bacteria and fungi present. This biological baseline is essential for understanding how microbial communities interact with plastic residues. Recognizing that Minnesota's composting operations are significantly influenced by seasonal variation, particularly the harsh winters that alter processing temperature and microbial activity inside and outside of compost piles. Since compost facilities have different protocols over the winter season in MN, we will sample compost to evaluate plastics and microbes across multiple seasons. This seasonal approach will ensure our findings reflect the full range of of conditions under which Minnesota's composters operates.

Activity Milestones:

Description	Approximate Completion Date
Quantify and identify microplastics collected in multiple composting locations over different seasons.	October 31, 2028
Genomic profiling of bulk and plastic-associated microbial communities in compost samples.	October 31, 2028

Activity 2: Access bioplastic Breakdown, microplastic persistence and identify "Plastic-Eating" Microbes

Activity Budget: $265,000

Activity Description:
To understand exactly how bioplastics degrade or fail to biodegrade under Minnesota specific composting conditions, we will conduct simulated industrial composting tests at the lab scale. We will introduce common bioplastic items, such as 3D printing filament, compostable cups, and food bags in our respirometer system to monitor the breakdown rate and kinetics of those items, by tracking the release of gases (CO_2) which evolves from mineralization of carbon present in our bioplastics and observing structural changes, including the formation of microplastics. We will also identify the microbes that attach to by forming biofilms and consume the plastic from the surface towards the bulk. Furthermore, we will investigate how the presence of contaminant plastics (e.g., polyethylene or polystyrene) affects composting activity and the degradation performance of compostable plastics. Specifically, we aim to determine how microbial communities break down compostable plastics in the presence of these traditional plastic contaminants. By monitoring maturing compost piles, we can determine if microplastics or nanoplastics inhibit the synergy required for efficient biodegradation of compostable plastics under industrial composting conditions, and evaluate the real-world environmental performance of bioplastics in Minnesota's waste-management infrastructure.

Activity Milestones:

Description	Approximate Completion Date
Assessment of baseline mineralization rates of biodegradable plastics in microcosm systems	June 30, 2028

Quantify the microplastics generated in lab-simulated biodegradation under composting condition	June 30, 2028
Quantify the influence of contaminant plastic on bioplastic mineralization and microplastic generation.	June 30, 2029
Identifying and characterizing microbes colonizing plastic surfaces under simulated industrial composting conditions (lab-scale)	June 30, 2029

Activity 3: Optimize Composting for enhanced plastic degradation via biostimulation and composting process modification

Activity Budget: $269,000

Activity Description:

Building on the baseline assessment of current plastic load in composting facilities (Activity 1) and identification of the conditions that promote or inhibit breakdown of plastic (Activity 2), in this phase we will focus on optimizing various modifications to the composting process to improve the rate of plastic degradation/removal of plastic in the final compost product. We will approach this activity by investigating multiple treatment strategies designed to enhance the breakdown of compostable plastics. We will be augmenting targeted microbial consortium (identified from Activity 1 and activity 2) into the compost (e.g., with mature, commercially available compost). We will strategically modify physical and operational conditions (e.g., mechanical, temperature or aeration) for supporting and sustaining microbial degradation activities. We will extensively evaluate these treatment strategies by running long-term experiments (up to 180 days) comparing standard compost against "boosted" compost. We will use advanced chemical analysis to test whether any plastic residue remains, specifically looking for evidence for plastic residue in the form of micro and nanoplastics, ensuring the final compost meets the criteria for safe soil amendment applications. Overall results will be disseminated through peer-reviewed publication and technical reports.

Activity Milestones:

Description	Approximate Completion Date
Comparative analysis of biodegradability performance of plastics in standard versus microbially augmented composts	May 31, 2030
Identify mechanical, temperature, aeration parameters to optimize microbial degradation activities	May 31, 2030
Quantify microplastic generation after modified and microbially augmented composting of plastics	May 31, 2030
Publish peer reviewed research articles and report on best practices for composting in MN	June 30, 2030

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Melissa Maurer-Jones	University of Minnesota Duluth	Co-Project Manager	Yes
Chan Lan Chun	University of Minnesota Duluth	Co-Project Manager	Yes
Lee Penn	University of Minnesota Twin Cities	Co-Project Manager	Yes
Eric Singsaas	NRRI, UMN Duluth	Co-Project Manager	Yes
Creekside Soils	City of Hutchinson's municipally owned organics processing facility, Creekside Soils	Providing real-world compost samples from their composting facilities for analysis throughout different seasons as required for the project, along with detailed information on operating conditions.	No
Glacial Ridge Compost Facility	Pope/Douglas Solid Waste Management	Providing real-world compost samples from their composting facilities for analysis throughout different seasons as required for the project, along with detailed information on operating conditions.	No
Resource Renew	West Lake Superior Sanitary District	Providing real-world compost samples from their composting facilities for analysis throughout different seasons as required for the project, along with detailed information on operating conditions.	No

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 disseminate results via open-access publications, and archived SOPs, ensuring long-term accessibility. We will produce technical briefs for Minnesota composters, agencies, translating findings into actionable process guidance. Physical sample collections will be curated in institutional facilities for future research. All products will acknowledge the Environment and Natural Resources Trust Fund using required logos and attribution language for visibility.
Funds supporting dissemination (e.g., open-access article fees), conference presentations and these activities will be explicitly included in our workplan and budget.

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 serves as a statewide initial baseline for cleaner compost by developing protocols that can be readily adopted by municipal composting sites across Minnesota. Beyond its environmental benefits, the data generated will have a direct policy impact, helping the MPCA and the legislature determine current "compostable" labelling standards are strict enough to protect local soils and the integrity of commercial compost. The project also presents a strong economic advantage, as reducing contamination yields cleaner compost with significantly higher market value.

Subsequent work may be supported by federal resources (USDA, NSF) to support broadening results to nationwide composters.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Citizen Scientists Capture Microplastic Pollution Around State	M.L. 2025, First Special Session, Chp. 1, Art. 2, Sec. 2, Subd. 04p	$419,000

Project Manager and Organization Qualifications

Project Manager Name: Naba Kalita

Job Title: Biomaterial Research Scientist

Provide description of the project manager's qualifications to manage the proposed project.
Dr. Naba Kumar Kalita is exceptionally qualified to manage this project as Biomaterial Research Scientist at the Natural Resources Research Institute (NRRI), University of Minnesota Duluth, where he leads biodegradation research programs. At NRRI, Dr. Kalita directs the Biodegradation Lab's commissioning and operations, managing automated 60-channel respirometers for compost, soil, and aquatic environments. This hands-on leadership demonstrates proven expertise in facility oversight, team coordination, data quality assurance, equipment maintenance, and regulatory compliance - critical for executing project timelines, budgets, and deliverables. Dr. Kalita excels in multidisciplinary management, training research staff, and fostering partnerships across the University of Minnesota system.

Dr. Kalita's has extensive publication track record in the field of biodegradation of materials under composting conditions and fabrication and characterization of enzyme-embedded biodegradable polymers, biodegradation kinetics, and other sustainable materials. He primarily works on creating plastics and materials that safely break down in the environment instead of turning into long-lasting waste. His work helps design everyday products like packaging - so they can decompose more quickly and does not leave behind any unwanted residues (microplastics etc.,) and fit into a truly circular, eco-friendly system, which is a real step forward for sustainable living.

Organization: U of MN - Duluth - NRRI

Organization Description:
The Natural Resources Research Institute (NRRI) is a state-chartered applied research institute of the University of Minnesota's Research and Innovation Office. NRRI maintains three sites in Northern Minnesota, focused on informing sound, long-term decisions on the use and stewardship of natural resources.

Our mission: Deliver integrated research solutions that value our resources, environment and economy for a sustainable and resilient future.

NRRI collaborates broadly across the University system, the state and the region to address the challenges of a natural resource-based economy. Research is developed via extensive partnerships with industry, state and federal agencies and governmental units.

As an impartial, science-based resource, NRRI develops and translates knowledge through large-scale, interdisciplinary research. Our expertise focuses on defining resource opportunities, minimizing waste and environmental impact, maximizing natural resource value, and maintaining or restoring ecosystem function.

Major outcomes from NRRI projects include informing environmental management and policy and assisting industry and

communities in defining and maintaining the social license to operate in natural systems. NRRI has established mechanisms for sharing outcomes through press releases, peer-reviewed journals, technical reports, annual reports, periodicals, and social media.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Research Scientist: Naba Kalita - NRRI Duluth		Project manager: Leading, conceptualization, simulated composting of plastics, result dissemination and collaborating with colleagues for successful completion and report writing.			26.8%	0.36		$48,467
Professor R Lee Penn - UMN Twin Cities		Co-Project manager: Analysis of microplastics utilizing advanced microscopy techniques, guiding/training of graduate students, report writing and review			26.8%	0.12		$44,824
Professor Chan Lan Chun - NRRI Duluth		Co-project manager: Microbial analysis of compost and plastic samples, DNA mapping and training/guiding graduate/undergraduate student			26.8%	0.12		$25,662
Research Group Leader Eric Singsaas - NRRI Duluth		Co-project manager: Maintaining Collaboration efficiency, overviewing result dissemination and technical support			26.8%	0.03		$6,911
Professor Melissa Maurer-Jones - UMD Duluth		Co-project manager: Overseeing the microplastic contamination research, analysis of microplastic, guiding/training graduate student, result dissemination and overlooking for successful completion of the project			26.8%	0.12		$24,404
Environmental Microbiologist: Katarina Edblad - NRRI Duluth		Other personnel: Microbial mapping and DNA analysis of test samples from compost and on plastic surface			24.4%	0.08		$20,664
Graduate Research Assistant - UMD Duluth		Researcher			19.5%	1.5		$189,630
Graduate Research Assistant UMN-Twin Cities (Beginning)		Researcher			19.5%	0.75		$102,573

Undergraduate Student - NRRI Duluth		Researcher			0%	0.15		$5,148
Undergraduate student (to be determined) - UMD Duluth		Researcher			23%	1.02		$33,323
							Sub Total	**$501,606**
Contracts and Services								
University of Minnesota, Natural Resources Research Institute	Internal services or fees (uncommon)	Compostability Suite, it included simulated industrial composting of plastic using a 60-channel automatic respirometer.				0.03		$178,662
University of Minnesota, Natural Resources Research Institute	Internal services or fees (uncommon)	Environmental scanning electron microscopy (ESEM), Energy-Dispersive X-ray Spectroscopy EDS				0.03		$1,551
University of Minnesota, Natural Resources Research Institute	Internal services or fees (uncommon)	Sequencing cost, microbial mapping				0.02		$8,000
University of Minnesota Duluth	Internal services or fees (uncommon)	lab services for materials characterization including microplastic analysis and counting and bulk material characterization such as DSC, FTIR microscopy, H NMR and TGA.				0.03		$9,000
University of Minnesota Twin Cities	Internal services or fees (uncommon)	Shops, characterization facility, NMR				0.03		$12,425
							Sub Total	**$209,638**
Equipment, Tools, and Supplies								

	Tools and Supplies	NRRI: Molecular analysis reagents, plasticware, extraction kits	Required for microbial DNA analysis, microbial mapping of compost samples and identification of microbial biofilms formed on the plastic surfaces					$28,000
	Tools and Supplies	NRRI: One Soil conductivity meter, one carbon dixoide detector and one soil pH meter will be purchased.	The following tool kits are necessary for analyzing compost quality. By evaluating decomposition stability, soluble salt concentrations, and nutrient availability, the purchase of carbon dioxide detectors, soil conductivity, and pH meters will permit thorough compost quality study which offers vital information for environmental management plans and maintaining a standard compost media for our biodegradation/composting experiments.					$6,500
	Tools and Supplies	UMN Duluth: supplies (reagents and filters) for microplastic extractions and general lab supplies (e.g., gloves, solvents)	Microplastic extractions will require purchase of reagent chemicals such Fenton's reagent, hydrogen peroxide, ZnCl2 which allow for chemical processing of compost to remove non-plastic debris. Further supplies such as filters, nylon mesh, and glassware are needed to isolate the microplastics. General lab supplies such gloves and solvents are also needed throughout the course of the grant.					$4,500
	Tools and Supplies	UMN Twin Cities: lab supplies and kits necessary for all microplastic characterizations	lab supplies and kits necessary for all microplastic characterizations and to simulate some of the experiments related to microplastics under laboratory scale.					$7,766
							Sub Total	**$46,766**
Capital Equipment								
							Sub Total	**-**
Acquisitions and Stewardship								

							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Field Travel for sample collections and meetings: 24 trips	This trips are for sample collection in different parts of the state in the composting facilities, travel for meetings and collection of samples among group members in UMN twin cities, NRRI and Duluth campus.					$6,224
	Conference Registration Miles/ Meals/ Lodging	Conference travel for PI or graduate student	Graduate student or PI will travel to a in state conference or meeting held by regional organizations such as Solid Waste Association North America or the Minnesota Composting Council Annual Meeting. Costs covers mileage, accommodations, and meals during travel.					$2,500
	Miles/ Meals/ Lodging	Field Travel	Mileage/transportation and meals are requested for PIs or graduate students to collect compost samples from facilities across the state.					$1,500
							Sub Total	**$10,224**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	NRRI: Cost to publish peer reviewed articles	The results will be disseminated through peer-reviewed publications in journals indexed in the Science Citation Index (SCI).					$3,000
	Publication	UMN Twin Cities: Peer review article publication and other printing charges	Peer review article publication for results mostly conducted in UMN Twin Cities and other printing charges					$3,106
							Sub Total	**$6,106**
Other Expenses								

		UMN Twin Cities: Repairs and Maintenance of Equipment's	Analysis will involve extensive electron microscopy, atomic force microscopy and other calorimetric analysis and due to which these delicate instruments often need service maintenance (repairs and other software related troubleshooting)					$4,660
							Sub Total	**$4,660**
							Grand Total	**$779,000**

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				
In-Kind	UMN unrecovered indirect costs are calculated at the UMN negotiated rate for research of 54% modified total direct costs.	Indirect costs are those costs incurred for common or joint objectives that cannot be readily identified with a specific sponsored program or institutional activity. Examples include utilities, building maintenance, clerical salaries, and general supplies. (https://research.umn.edu/units/oca/fa-costs/direct-indirect-costs)	Secured	$373,925
			Non State Sub Total	**$373,925**
			Funds Total	**$373,925**

Total Project Cost: $1,152,925

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 7f7b946d-bf4.pdf

Alternate Text for Visual Component

This infographic outlines a three-step proposal to manage microplastics in Minnesota's compost and soil: Top : assessing plastic contamination and microbial communities, center: tracking degradation rates to identify "plastic-eating" microbes, and bottom: optimizing composting processes. Goal is to create baseline datasets for statewide best practice guidelines related to composting of plastics....

Supplemental Attachments

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

Title	File
Authorization Letter	dec25c45-d3a.pdf
Support letter from Resource Renew Duluth	27d84fff-daf.pdf
Support letter from Glacial Ridge Compost Facility, Pope/Douglas, Alexandria	4adc0df4-7f8.pdf
Support letter from CreekSide Soils, Hutchison	7807d1fd-07b.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

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

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

This proposal has benefited from feedback and informal review by my collaborators, who provided comments on the concept, methods, and overall framing according to their expertise.

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A