Environment and Natural Resources Trust Fund

2025 Request for Proposal

General Information

Proposal ID: 2025-265

Proposal Title: Impact of Microplastics on Wastewater Treatment in Minnesota

Project Manager Information

Name: Sebastian Behrens

Organization: U of MN - College of Science and Engineering

Office Telephone: (651) 756-9359

Email: sbehrens@umn.edu

Project Basic Information

Project Summary: Research will focus on the fate of microplastics in wastewater treatment plants in Minnesota with emphasis on the impacts of weathered plastics on biological nutrient and contaminant removal processes.

ENRTF Funds Requested: $506,000

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?

Statewide

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.

Microplastics are ubiquitous not just in the ocean. Around 80% of microplastic pollution in the ocean comes from land and freshwater systems. High amounts of microplastics have been found in rivers and soils around the world including freshwater ecosystem across the state of Minnesota. Microplastics are defined as any solid particle made of synthetic plastic ranging from 1 µm to 5 mm and are primarily breakdown products of large plastics. They are a mixture of toxic additives and can adsorb other harmful chemicals and pathogens. The existence of microplastics poses a risk to aquatic and terrestrial creatures, as well as humans, who can inhale or consume them. Wastewater treatment plants are a key entry point for microplastics into the environment. They are major receptors of urban microplastic pollution, and their effluents and sewage sludge are sources of microplastic pollution to water and soil ecosystems. Despite the abundance of microplastics in wastewater, the interactions between microplastics and wastewater treatment processes have rarely been addressed. We do not know how microplastics could impact microorganisms and processes that remove organic matters and nutrients. Neither do we know how the treatment techniques could remove microplastics or impact the properties of microplastics via degradation.

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.

In this project we will study 1) the abundance and removal of microplastics in wastewater treatment plants in Minnesota, 2) how microplastics affect wastewater treatment plant performances, and 3) how different wastewater treatment processes alter microplastics during their passage through the plant. We will survey the abundance of microplastics in various stages of wastewater plants and treatment methods to reveal how well Minnesota's wastewater systems can remove microplastics. Using these isolated microplastic samples, we will study the transformation of microplastics in wastewater and analyze potential degradation products, some of which will be used to assess their impacts on wastewater treatment process. We will evaluate the impact of size, type, degree of weathering, and potential degradation products of microplastics on microbial community composition and changes in the efficiency of essential bacterial nutrient processes we rely on for effective wastewater treatment. In addition, because of their small size and hydrophobic nature, microplastics serve as a breeding ground for other contaminants and microbial pathogens in wastewater treatment plants. We will study the effect microplastics on bacterial degradation of sorbed contaminants of emerging concerns in wastewater.

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 main outcome from this project will be an understanding of how microplastic affect Minnesota's wastewater treatment processes and how microplastics are altered in their passage through plants before they enter our water and soil system via effluent or biosolids. The project will establish a baseline of information that municipalities, plant operators, and policy makers who can use it to develop mitigation strategies and regulations to protect Minnesota's waterways and natural resources from plastics pollution. Additionally, information from this project will be used for community outreach and education on the concerns about microplastics contamination entering Minnesota's waters.

Activities and Milestones

Activity 1: Quantifying microplastics in MN wastewater treatment plants

Activity Budget: $220,996

Activity Description:
Wastewater treatment plants receive microplastics in various types, sizes, and shapes. Depending on a variety of parameters, including the size of the wastewater treatment plant, the kind of influent, the retention time, etc., the abundance of microplastics can differ in each plant. Standardized procedures for sampling, extraction, identification, and quantification of microplastics in distinct plant compartments will be developed based on micro-Fourier Transform Infrared (FTIR) and pyrolysis-gas chromatography-mass spectrometry (py-GCMS). Although wastewater treatment facilities are effective at removing microplastics, they are only transferred from the aqueous to the solid phase and microplastics are returned to the environment by biosolids and/or effluents. We will sample wastewater treatment plants across the state that employ different treatment processes and quantify and compare their microplastic loading in the influent, effluent, sludge, and biosolids. This will provide the first comprehensive data on the abundance and types of microplastics in the wastewater treatment plants in Minnesota and whether our plants can remove microplastics. We will study how different treatment processes impact the abundance of the microplastics, which might vary depending on aeration intensity, UV disinfection irradiation, sludge treatment temperature and pH, and dissolved organic matter.

Activity Milestones:

Description	Approximate Completion Date
Development of procedures for sampling, extraction, and quantification of microplastics from different plant compartments	June 30, 2026
Sampling of plants with different treatment processes	December 31, 2026
Quantification of microplastics in samples from plant influent, effluent, sludge, and biosolids	June 30, 2027
Publication/dissemination	June 30, 2028

Activity 2: Impact of microplastics on microbial nutrient removal and biodegradation processes in activated sludge

Activity Budget: $150,266

Activity Description:
Microplastics have a significant impact on the biological treatment processes used in wastewater treatment plants. This could be due to harmful compounds leaching from and/or sorbed onto microplastics. Furthermore, the presence of microplastic has the potential to induce cellular oxidative stress responses and affect microbial extracellular polymeric substances secretion. This can prevent sludge settling by impairing microbial aggregate formation, thus reducing the efficiency of biological treatment processes. We will study the effect of different types of microplastics on aerobic and anaerobic nutrient removal processes (carbon oxidation, nitrification, denitrification, methane, and hydrogen formation) and biological pollutant degradation. Due to their adsorption capabilities of contaminants of emerging concern in wastewater, microplastics might become more hazardous and could hinder the ability of wastewater treatment plants to remove these contaminants from wastewater. We will conduct experiments to determine the effect of microplastics on removing other contaminants of emerging concern found in wastewater. High-throughput, parallel DNA sequencing will be applied to reveal the impact of microplastic on activated sludge microbial community composition and function.

Activity Milestones:

Description	Approximate Completion Date
Lab wastewater reactor experiments to assess impact of microplastics on aerobic bioprocesses	June 30, 2027
Lab wastewater reactor experiments to assess impact of microplastics on anaerobic bioprocesses	June 30, 2027
Biodegradation of contaminants in the presence of microplastics	December 31, 2027
Comparative sequence analysis to identify shifts in activated sludge microbial community composition and function	December 31, 2027
Publication/dissemination	June 30, 2028

Activity 3: Chemical and physical breakdown of microplastics in wastewater

Activity Budget: $134,738

Activity Description:

The different methods of wastewater and sludge treatment processes, UV-weathering, chemical oxidation, energetic mixing, aerobic and anaerobic digestion, thermal and alkaline treatment can introduce mechanical, biological, thermal, and chemical degradation of microplastics. This would lead to fracturing and flaking, and oxidized surface on microplastics, creating much higher capability of sorbing pollutants when released into the environment. In addition, these processes also could shred microplastics into smaller sizes, which leads to the generation of more toxic nanoplastics. To assess the effects of water treatment processes on the microplastics, we will analyze the surface and size distribution of the micro- and nanoplastics collected from wastewater, sludge, and biosolids with a range of analytical techniques (e.g. particle size distribution analysis, micro-FTIR or Raman Spectroscopy, Scanning Electron Microscopy, X-Ray photoelectron spectroscopy, and Atomic Force Microscopy-IR)

Activity Milestones:

Description	Approximate Completion Date
Sample collection from full scale plants and lab reactors	December 31, 2026
Extract micro- and nanoplastics from wastewater, sludge, and biosolids	December 31, 2026
Analysis of particle size distribution	June 30, 2027
Analysis of the chemical and physical surface properties	December 31, 2027
Publication/dissemination	June 30, 2028

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Dr. Boya Xiong, Assistant Prof.	University of Minnesota, Department of Civil, Environmental, and Geo-Engineering	co-Investigator. Dr. Xiong is an expert on environmental detection, fate, and degradation of plastics and other synthetic polymers. With her work she seeks a better understanding of the mechanisms of environmental plastic degradation. She will lead the microplastic sample collection, weathering, and plastics characterization experiments.	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?

The results will be disseminated to laboratories, agencies, stakeholders and practitioners through open access publications, direct meetings, and conference presentations. If additional work is needed, funding from federal sources will be sought.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Monitoring Emerging Viruses in Minnesota's Urban Water Cycles	M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 04c	$416,000

Project Manager and Organization Qualifications

Project Manager Name: Sebastian Behrens

Job Title: Associate Professor

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

Dr. Sebastian Behrens (PI), Associate Professor, is an environmental microbiologist and an expert in detection, identification, and quantification of diverse microbial target sequences in environmental samples based on massively parallel sequencing technologies, quantitative PCR, and flow cytometry. Dr. Behrens follows an interdisciplinary approach that combines the disciplines environmental engineering, and molecular biology to understand the basic ecological principles driving the biological water treatment processes, the biodegradation of organic contaminants, and the transport and fate of pathogens in the environment. Dr. Behrens will be responsible for plastic biodegradation, quantification of microbial processes in activated sludge, and the metagenomic analysis of the activated sludge microbiome. Dr. Behrens will coordinate the project together with Dr. Xiong. Both will advise the postdoctoral fellow and the graduate students on the experimental research.

Organization: U of MN - College of Science and Engineering

Organization Description:

The University of Minnesota is one of the largest, most comprehensive, and most prestigious public universities in the United States (http://twin-cities.umn.edu/about-us). The College of Science and Engineering is one of the premier public institutes in the country for graduate and undergraduate education and research. The laboratories and offices of the PIs contain the necessary fixed and moveable equipment and facilities needed for the proposed studies.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Dr. Sebastian Behrens/Principal Investigator		Principal Investigator; Project coordination, postdoc and grad student advising, analysis of biological processes, publication, and outreach			37.1%	0.24		$58,820
Dr. Boya Xiong/Co-Principal Investigator		Co-Principal Investigator; Co-advise postdoc and grad students, coordinate sampling and plastics characterization experiments, publication, and outreach			37.1%	0.03		$5,865
Postdoctoral Associate		Data integration, analysis, and publication. Community outreach and education			27.1%	1		$76,163
Graduate Student (1.33 students per year)		One student will focus on the biological experiments the other student will characterize the plastic materials			25.1%	1.5		$233,032
Undergraduate Research Assistant		Support sampling, water analysis, and reactor maintenance			0%	0.9		$28,653
							Sub Total	**$402,533**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Tools and Supplies	Lab Supplies	Chemicals, reagents for water analysis, reactor experiments, DNA extraction and amplification, consumables					$62,967
	Tools and Supplies	Lab Services	DNA sequencing, pyGCMS, SEM-XRF, FTIR					$12,000
	Tools and Supplies	Repairs/Maintenance	General lab equipment, centrifuges, PCR, reactors, pumps, AFM etc.					$15,000
							Sub Total	**$89,967**

Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
							Sub Total	**-**
Travel Outside Minnesota								
	Miles/ Meals/ Lodging	Field sampling, state conferences, presentations; 5-6 sampling trips year 1+2, 800 miles per year, 4 people	WWTP sampling, miles, meals lodging, state conferences					$7,500
							Sub Total	**$7,500**
Printing and Publication								
	Publication	Publication Costs	Open access publication fees					$6,000
							Sub Total	**$6,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$506,000**

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	**-**

Total Project Cost: $506,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: e57988ac-afe.pdf

Alternate Text for Visual Component

Wastewater treatment plants are a key entry point for microplastics into the environment. The treatment techniques employed in wastewater treatment plants simply transfer microplastics from the aqueous to the solid phases, resulting in millions of microplastics being discharged into the environment via effluents and biosolids. Microplastics endanger aquatic, terrestrial organisms...

Supplemental Attachments

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

Title	File
1129396 Behrens LCCMR-signed	d8bf1a61-d82.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?

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?

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:

Dr. Boya Xiong (co-PI), Katie Sauer (CEGE Accountant), Hannah Haley (UMN Sponsored Projects Administration)