Environment and Natural Resources Trust Fund

M.L. 2025 Approved Work Plan

General Information

ID Number: 2025-265

Staff Lead: Lisa Bigaouette

Date this document submitted to LCCMR: June 4, 2025

Project Title: Impact of Microplastics on Wastewater Treatment in Minnesota

Project Budget: $506,000

Project Manager Information

Name: Sebastian Behrens

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Project Reporting

Date Work Plan Approved by LCCMR: June 24, 2025

Reporting Schedule: March 1 / September 1 of each year.

Project Completion: June 30, 2028

Final Report Due Date: August 14, 2028

Legal Information

Legal Citation: M.L. 2025, First Special Session, Chp. 1, Art. 2, Sec. 2, Subd. 04u

Appropriation Language: $506,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to quantify the abundance of microplastics in wastewater treatment plants in Minnesota, determine how microplastics affect wastewater treatment plant performance, and evaluate how different wastewater treatment processes alter microplastics.

Appropriation End Date: June 30, 2028

Narrative

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.

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 for 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.

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

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. All samples will be taken in triplicates. 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	September 30, 2027
Quantification of microplastics in samples from plant influent, effluent, sludge, and biosolids	March 31, 2028
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	December 31, 2027
Lab wastewater reactor experiments to assess impact of microplastics on anaerobic bioprocesses	December 31, 2027
Biodegradation of contaminants in the presence of microplastics	March 31, 2028
Comparative sequence analysis to identify shifts in activated sludge microbial community composition and function	March 31, 2028
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 plastic particles into smaller sizes. To assess the effects of water treatment processes on the microplastics, we will analyze the surface and size distribution of the microplastics 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, 2027
Extract microplastics from wastewater, sludge, and biosolids	June 30, 2028
Analysis of particle size distribution	June 30, 2028
Analysis of the chemical and physical surface properties	June 30, 2028
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

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.
For each of the activities, results will be disseminated by peer reviewed publications in archival journals. Data will also be archived in the open access data repository for the University of Minnesota. In both cases, this will make information from the project widely accessible to Minnesotans and other interested parties that are working on the environmental impacts of microplastics and wastewater treatment processes. Results from the project will also be presented at local/regional conferences. We will also communicate key findings to scientists in the Minnesota Pollution Control Agency directly. The Environment and Natural Resources Trust Fund will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and presentations.

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

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								
Lab Services	Internal services or fees (uncommon)	DNA sequencing at UoM Genomics Center, instrument time and service fees for measurements at pyGC-MS, SEM-XRF, FTIR (all University of Minnesota labs and general equipment facilities)				0		$12,000
							Sub Total	**$12,000**
Equipment, Tools, and Supplies								
	Tools and Supplies	Lab Supplies	Chemicals incl. plastic additives, reagents for water analysis, reactor experiments, DNA extraction and amplification, consumables					$62,967
	Tools and Supplies	Repairs/Maintenance	General lab equipment, centrifuges, PCR, reactors, pumps, AFM etc.					$15,000

							Sub Total	**$77,967**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Sampling trips to WWTPs (8 trips each in years 1+2, 1200 miles per year)	WWTP sampling, miles, meals lodging					$5,000
	Miles/ Meals/ Lodging	Travel and registration for state conferences for project presentations	Dissemination of project outcomes					$1,000
							Sub Total	**$6,000**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Travel of project PI to outside MN conference (e.g. Association of Environmental Engineering and Science Professors (AEESP) Research and Education Conference)	Project presentation and dissemination of outcomes					$1,500
							Sub Total	**$1,500**
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
Research_Addendum_2025-265_revised Final.pdf	d8ece688-39c.pdf

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

Updated work plan according to revisions requested on 04/11/2025:

Comment ID 12): Costs for plastic additives were accounted for in Lab Supplies line item under Tools and Supplies. Under 'Purpose' we now state 'Chemicals incl. plastic additives'.

Comment ID 13): Activity 1 has been aligned with changes made to research addendum and we now state that all samples will be taken in triplicate. All references to nanoplastics have been removed from objectives. Approximate completion dates of the milestones have been adjusted to align with the timetable in your research addendum.

All information has been checked for accuracy. No information has been changed from the original work plan. Only one typo has been corrected. A description of planned dissemination efforts has been added as requested.

Work Plan revisions as requested January 27, 2025:

1) DNA sequencing lab services have been move under "Service Contract" under Services and Subawards.

2) Travel expenses have been separated into "in state', "outer state', WWTP sampling, and conferences.

3) Only one person will travel to one 'out state' conference during the project.

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 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?

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 project:

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

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