Environment and Natural Resources Trust Fund

2024 Request for Proposal

General Information

Proposal ID: 2024-189

Proposal Title: Preventing PFAS and Microplastics Contaminants across Minnesota

Project Manager Information

Name: Roger Ruan

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

Office Telephone: (612) 804-2270

Email: RUANX001@UMN.EDU

Project Basic Information

Project Summary: This project helps Minnesota entities that directly or indirectly cause PFAS and microplastics contamination stop the flow of the contaminants by developing strategies to manage solid waste streams.

Funds Requested: $722,000

Proposed Project Completion: June 30, 2027

LCCMR Funding Category: Methods to Protect, Restore, and Enhance Land, Water, and Habitat (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?

During the Project and In the Future

Narrative

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

As PFAS and plastic products bring benefits to our daily life, the risks of them ending up contaminating land and water has grown significantly. Environmental contamination of PFAS and microplastics in our living environment is currently a widespread issue of concern, posing a great threat to human and ecological health. It was reported that microplastic particles can be absorbed across membranes in the human body and found in human blood and PFAS compounds have been detected above the recommended attention limits in food. Most studies focus on removing the PFAS and microplastics from soils and water, but very little research data or practical solution currently exists on how to stop the continuous flow of these contaminants into our environment. As documented in the literature and reports, the major sources of PFAS and microplastics contamination in drinking water, groundwater, soils, and air include industrial sites, landfills, and wastewater treatment plants. Unfortunately, we don't know how to effectively mitigate them by securing the major source in Minnesota. This project will guide us to proactively dispose of waste streams which play a vital role in releasing PFAS and microplastics in a way that intercepts the migration of environmental contanminates.

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.

PFAS and microplastics usually get into lands, rivers, and lakes mainly due to improperly disposal of PFAS/microplastics-containing waste streams. Minnesota waste managers have an immediate need of techniques and equipment to mitigate the effect of PFAS/microplastics-containing waste streams on the environment. This project will focus on developing an advanced mobile catalytic microwave-assisted pyrolysis (cMAP) system to achieve on-site treatment of specific waste streams and minimize the environmental impacts under read-world conditions. First, we will secure partnerships with local fire training sites, industrial sites, materials recovery facilities, landfills, and wastewater treatment plants to identifying the source of PFAS and microplastics across Minnesota. The next activity will test the feasibility of treating various waste streams in the lab by developing the bench-top scale cMAP system and examine how the contaminants evolve during this process. The optimal design and parameters will be used to construct a 200 kg/day mobile pilot-scale cMAP system for on-site demonstration and the techno-economic analysis and life cycle assessment will be conducted to verify the feasibility.

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?

This project will give the scientific knowledge through this exploratory research and understanding of: 1) the major source of PFAS and microplastics contaminants from solid wastes in Minnesota; and 2) how to cost-effectively stop the flow of PFAS and microplastics contaminants into our environment. We will also develop a cost-effective and practical mobile pilot-scale cMAP system to help state-wide entities cleanly dispose of their PFAS/microplastics-containing solid wastes to prevent environmental contamination and protect the state's water resource, aquatic lives, and human safety.

Activities and Milestones

Activity 1: Laboratory investigation of treating PFAS/microplastics-containing solid wastes

Activity Budget: $200,000

Activity Description:
By chemically converting solid wastes to valuable products, potential pollutants can be intercepted and solid wastes can be re-used, greatly reducing potential environmental and ecological impacts. This activity is designed to develop an advanced cMAP system for converting solid wastes into solid, liquid and gas products. Solid product can be used for absorbents, soil amendment, or catalysts; liquid product is a precursor that can be refined into transportation fuels or polymer monomers; the non-condensable pyrolytic gas, a byproduct of the pyrolytic process, can be used to produce electricity to offset the energy need of the processes. Optimal process conditions, including the load of microwave absorbents, control pattern of the microwave output power, pyrolysis/catalysis temperatures, loading of catalyst, feedstock input rate, and vapor residence time, will be established for maximizing the quality of desirable products. The fate and transport of PFAS and microplastics during the cMAP will be assessed in detail. Specifically, an understanding of fluorine migration into final products will be obtained through an analysis of fluorine occurrence form by liquid chromatography-tandem mass spectrometry (LC-MS/MS) and mass spectrometry (MS). Through this technology, we are truly able to prevent PFAS and microplastic contaminants from entering Minnesota lands and waters.

Activity Milestones:

Description	Approximate Completion Date
Collection and characterization of solid wastes	September 30, 2024
Develop an advanced cMAP system	December 31, 2024
Conduct solid waste pyrolysis studies and process optimization	June 30, 2025
Analyze the fate and transport of PFAS and microplastics	June 30, 2026

Activity 2: Developing a mobile demonstration pilot-scale cMAP system that will enable on-site verification of the PFAS/microplastics-containing solid wastes treatment

Activity Budget: $400,000

Activity Description:
With the cMAP system and process optimization in Activity 2, a 200 kg/day pilot-scale system will be designed, constructed, and demonstrated. This pilot cMAP system will be installed on a trailer which can be hauled by a truck, so the system can be demonstrated at a specific site. In this activity, related technical issues with the 200 kg/day system to be built will need to be addressed, including potential polymer melting and blockage at the feeding tube, insufficient mixing of the ball bed, and complete separation of pyrolytic vapor from ash and char before entering the catalytic reactor. This pilot-scale cMAP system will be used to 1) confirm the feasibility of treating PFAS/microplastics-containing solid wastes at a larger throughput; 2) optimize the system to maximize the treatment efficiency and minimize the environmental impacts under read-world conditions; 3) determine product yield, quality, pollutants/greenhouse gas emissions, and energy consumption for the subsequent techno-economic analysis and life cycle assessment.

Activity Milestones:

Description	Approximate Completion Date
Design and construction of a 200 kg/day mobile pilot-scale cMAP system	September 30, 2026
Pilot system improvement and demonstration	December 31, 2026

Activity 3: Conducting techno-economic analysis and life cycle assessment for the proposed technology

Activity Budget: $122,000

Activity Description:

In this activity, we will design end-to-end conversion process and build the simulations to generate mass and energy balances and information about energy consumption and operational costs for a techno-economic analysis. Pollutants and greenhouse gas emissions will be determined by measuring primarily fluorine-containing compounds, CO2 and CH4 released during the operation of the pilot system at a specific site. This information will serve as life cycle assessment inputs in this activity. In addition, the potential impact of organic gases and aerosols emitted by the system on air quality will be evaluated with continuous monitoring and point measurements.

Activity Milestones:

Description	Approximate Completion Date
Generate information for a techno-economic analysis	March 31, 2027
Monitor pollutants and greenhouse gas emissions for life cycle assessment	March 31, 2027
Final Report on this project with outreach materials	June 30, 2027

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Paul Chen	University of Minnesota	Co-PI	No
David Brummel and Michael Reed	Ramsey/Washington Recycling & Energy	R&E will support the project by suppling various waste feedstock samples and sharing input, feedback and subject matter expertise of soild waste management systems throughout the project.	No

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 long-term goal of this work is development of a cost-effective and practical mobile pilot-scale cMAP system that meets the needs of environmentally friendly treating specific waste streams and the environmental needs of Minnesotans. The managers of fire training/fire response sites, industrial sites, landfills, and wastewater treatment plants who are interested in limiting PFAS and microplastics contaminants will be reached out to tackle this problem. Furthermore, Metropolitan Council Environmental Services and EPA will be interested in the proposed technologies.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Methods to Destroy PFAS in Landfill Leachates	M.L. 2022, , Chp. 94, Art. , Sec. 2, Subd. 04a	$200,000

Project Manager and Organization Qualifications

Project Manager Name: Roger Ruan

Job Title: Professor and Director

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

Dr. Roger Ruan, Professor and Director of Graduate Studies, Department of Bioproducts and Biosystems Engineering, and Director of Center for Biorefining at University of Minnesota, is a Fellow of ASABE and a Fellow of IFT. Dr. Ruan's research focuses on renewable energy and environment technologies for sustainable development and circular economy. Specifically, he has conducted research and published his findings in the areas of municipal, agricultural, and industrial wastewater treatment and utilization through novel anaerobic digestion, microalgae cultivation, and hydroponic cultivation, biomass and solid wastes (including plastics) pyrolysis and gasification, airborne and other pathogen disinfection and pollutant control, catalysis, non-thermal plasma, and nitrogen fixation, etc. He is a top-cited author with an h-index of 88, i10-index of 443, and over 30,000 citations. He has supervised over 75 graduate students, 140 post-doctors, research fellows, and other engineers and scientists, and 21 of his Ph.D. students and post-doctors hold university faculty positions. He has also been invited to give over 300 keynote lectures, invited symposium presentations, company seminars, and short courses. Professor Ruan has received and managed over 200 projects totaling over $45 million in various funding for research, including major funding from USDA, DOE, DOT, DOD, LCCMR, and industries. He has served as guest editor or editorial board member of Bioresource Technology, Renewable Energy, Engineering, Applied Catalysis and Chemical Engineering, Journal of Food Process Engineering, The Open Plasma Physics Journal, and Associate Editor of Transactions of ASABE, Engineering Applications in Agriculture, and Transactions of CSAE, and Chairman of Editorial Board and Editor-in-Chief of International Journal of Agricultural and Biological Engineering, etc. His earlier LCCMR funded projects have resulted in several patented technologies which have been

successfully licensed to the industry. Therefore, he has the technical expertise and project management experience to ensure the execution of proposed projects.

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

Organization Description:
The Center for Biorefining is a University of Minnesota research center affiliated with the College of Food, Agricultural and Natural Sciences and helps coordinate the University efforts and resources to conduct exploratory fundamental and applied research and provide education on science and technology for environment protection and circular economy; stimulate collaboration among the University researchers, other public sector investigators, and private investigators involved in biobased production technology development; promote technology transfer to industries; and foster economic development in rural areas. The Center's research programs are founded by DOE, USDA, DOT, DOD, LCCMR, IREE, Xcel Energy, and other federal and state agencies, NGOs, and private companies. The Center is equipped with state of the arts analytical instruments, and processing facilities ranging from bench to pilot scale.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Professor/faculty		PI - 2.5 weeks summer salary - direct all research, analysis, admin and personnel			36.8%	0.15		$41,371
Professor/faculty		Co-PI - contract faculty - co-direct all aspects of project - supervise post doc and student			36.8%	0.48		$72,087
Graduate Research Assistant		One researcher to conduct experiments, analyis, education			47%	3		$162,682
Post Doc Researcher		Conduct research and analysis			25.7%	3		$215,166
							Sub Total	**$491,306**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Tools and Supplies	Purchase of lab and miscellaneous supplies, including feedstock, catalysts, chemicals, consumable supplies for analytical instruments, gloves, masks, PPE	For running experiments and operating conversion systems, chemical and physical analyses					$27,922
	Equipment	Components for fabrication of a small pilot system including reactor vessel, insulation materials, magnetrons, control, motors, mixer, feeder, valves, etc.	To fabricate a small pilot system for extensive testing, cost and emission analysis, and demonsration					$200,000
							Sub Total	**$227,922**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**

Travel In Minnesota								
	Miles/ Meals/ Lodging	12 one-day 2-person trips, 100 miles each round trip ($0.655/mile), meals @$50/person	Visits to waste management sites, feedstock collection and transport					$2,772
							Sub Total	**$2,772**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$722,000**

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: f50d512a-08a.pdf

Alternate Text for Visual Component

Environmental contamination of PFAS and microplastics in our living environment is currently a widespread issue of concern, posing a great threat to human and ecological health. The schematic highlights the research approach of this project. We propose to remove PFAS and microplastics across Minnesota by reducing their sources....

Optional Attachments

Support Letter, Photos, Media, Other

Title	File
2022 Audit	93261535-b00.pdf
Support letter from Clean Water Action Minnesota	9e0d8aab-3b7.pdf
Support letter from Ramsey/Washington Recycling & Energy	65cd4582-532.pdf
Authorization	98bffa13-22e.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

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 design, construction, or renovation of a building, trail, campground, or other capital asset costing $10,000 or more?

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?

No