



Environment and Natural Resources Trust Fund

2023 Request for Proposal

General Information

Proposal ID: 2023-197

Proposal Title: Remove Chemical and Biological Contaminants from Minnesota Soils

Project Manager Information

Name: Roger Ruan

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

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Project Basic Information

Project Summary: Develop and examine the feasibility of using a continuous low-cost microwave-assisted treatment system for destruction of organic contaminants in Minnesota soils.

Funds Requested: \$200,000

Proposed Project Completion: June 30, 2025

LCCMR Funding Category: Small Projects (H)

Secondary 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.

Chemical products used by human activities produce lots of organic contaminants, such as microplastics, pesticides, VOCs, PFASs, antibiotics, etc., posing a significant threat to our ecosystem and health. For example, the MDH and MPCA found several east metro sites including the 3M Cottage Grove manufacturing facility and large waste disposal facilities where PFAS-bearing wastes were disposed of. On March 22, 2022, the MPCA said it would collect monitoring data from 379 facilities identified as potential emitters of PFAS. The list includes 137 manufacturing or industrial facilities, 91 city sewage treatment plants and 143 landfills or solid waste sites. Any economically viable technology to remove these organic contaminants from soil would significantly reduce pollution and improve food and drinking water safety. Currently, the most common physicochemical soil remediation technologies include extracted washing, electrokinetic remediation, chemical oxidation, nanomaterials remediation and biological remediation. However, these methods have many limitations including the requirement of strict acidic conditions, infeasibility to deconstruct refractory organic pollutants, making them unattractive. Owing to the different physical and chemical properties of diverse pollutants, their responses to the remediation technology are different. Therefore, developing a robust remediation technology for complicated organic-contaminated soil is urgently needed to protect public health and environment.

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.

Microwave-assisted pyrolysis is one such promising and economically viable approach to the destruction of complicated organic contaminants. Our previous studies show that the microwave-assisted pyrolysis relies on both thermal and catalytic cracking mechanisms in degrading organic contaminants. This project is designed to develop a continuous microwave-assisted pyrolysis system for complicated organic-contaminated soil remediation. The project addresses Priority H: Methods to Protect or Restore Land, Water, and Habitat.

The overall goal of our research program is to demonstrate proof-of-concept of the proposed method for removing complicated organic contaminants and assess the potential generation of toxic byproducts during the treatment. The proposed technology treats contaminated soil via a continuous microwave-assisted pyrolysis process, and uses biochar or silicon carbide to enhance microwave absorption. The specific objectives of the project include:

- Process development: develop the processes and apparatuses for the evaluation; examine the effectiveness of the process and system in degrading organic contaminants in soil samples; optimization of the process.
- Impact assessment: assess the potential generation of toxic byproducts; conduct preliminary analysis of economic feasibility and energy efficiency.

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 specific project outcomes will include the understanding of how organic contaminants in Minnesota soil respond to the proposed treatment, the potential of microwave-assisted pyrolysis technology to become technically and financially viable for complicated organic contaminated soil remediation and restoration and generation/mitigation of toxic byproducts during the treatments, protecting the Minnesota's soil resource, drinking water and food safety, and human health.

Activities and Milestones

Activity 1: Initial test of continuous microwave assisted pyrolysis of contaminated soil

Activity Budget: \$150,000

Activity Description:

It is known that high temperature treatment could result in the formation of new contaminants that can be more toxic and persistent than the parent compounds. This leads to high operating costs because of increased treatment time or disposal of formed byproducts. Therefore, how the proposed method behaves in terms of complete removal of organic contaminants and the generation of toxic byproducts needs to be studied in detail. To understand this, we will analyze some key intermediates and flue gas of organic contaminants breakdown during the microwave-assisted pyrolysis. Using this information, we will attempt to optimize the microwave-assisted pyrolysis processes to minimize the generation of toxic byproducts. The secondary ex-situ catalytic reactor may be designed to destruct hazardous volatiles generated during the microwave-assisted pyrolysis treatment, further minimizing any potential risk of hazardous gasses escaping from the treatment system.

Activity Milestones:

Description	Completion Date
Analyze the compositions of gas product	June 30, 2024
Ex-situ catalytic reactor development	June 30, 2024
Further optimization of the proposed process	December 31, 2024

Activity 2: Evaluate the potential economic, environmental and ecological impacts of the proposed technology

Activity Budget: \$50,000

Activity Description:

For this small project, we plan to conduct preliminary studies to provide big pictures of the potential economic, environmental and ecological impacts of the proposed technology. Additional data on mass and energy balance will be collected. Greenhouse gas emission and other potential toxic pollutants during the process will be monitored. An input-output model will be used for economic analysis. The energy consumption will be also considered in the assessment of environmental and ecological impacts of the technology.

Activity Milestones:

Description	Completion Date
Collection of mass and energy balance data	December 31, 2024
Preliminary assessment of economic, environmental, and ecological impacts	June 30, 2025

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Paul Chen	University of Minnesota	Co-PI	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 results of this effort will be used for seeking funding from external agencies such as the National Science Foundation and the US Department of Energy. The potential economic, environmental and ecological impacts will be also presented to the stakeholders to raise their awareness and attract their support. We will seek industry partners and private, state, and federal funding to further develop and eventually implement the technology.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Demonstrating Innovative Technologies to Fully Utilize Wastewater Resources	M.L. 2014, Chp. 226, Sec. 2, Subd. 08c	\$1,000,000
Development of Innovative Sensor Technologies for Water Monitoring	M.L. 2016, Chp. 186, Sec. 2, Subd. 04j	\$509,000

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. Ruan, Professor and Director of Graduate Studies of Bioproducts and Biosystems Engineering Department, and Director of Center for Biorefining at University of Minnesota, is a Fellow of ASABE, IFT, Vebleo, and IAAM, and has received many other awards, including CAFS Professional Achievement and Scientist of IAAM, etc. He is a top cited author in engineering and technology with an h-index of 80, i10-index of 392, and has over 25,000 citations. Dr. Ruan's research include renewable energy and environment technologies for sustainable development. He has published over 500 referred journal articles, two books, 24 book chapters, and holds 20 US patents in the areas of municipal, agricultural, and industrial liquid and solid waste including biomass and waste plastics treatment and utilization through novel anaerobic digestion, microalgae and hydroponic cultivation, pyrolysis and gasification, airborne and other pathogen disinfection and pollutant control, catalysis, non-thermal plasma, and nitrogen fixation, etc. He has received over 200 grants totaling over \$45 million in various funding for research, including major grants 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. He has supervised over 75 graduate students, 140 post-doctors, research fellows, and other engineers and scientists. He has given over 300 keynote lectures, invited symposium presentations, and short courses. His earlier LCCMR funded projects have resulted in several patented technologies which have been successfully licensed to the industry. 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 help 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		Primary Investigator - project lead, advises researchers, plans and directs research, oversees budget, monitors and reports progress			33.5%	0.08		\$26,302
Professor/faculty		Co-Primary Investigator - advises researchers, designs and directs experiments, conducts data analysis, writes reports and publications			33.5%	0.16		\$28,490
1 Graduate Research Assistant		Researcher - carries out experiments, collects and analyzes data, prepares reports and manuscripts			45%	1		\$105,699
1 Technician		Researcher - sets up equipment and apparatuses, carries out experiments and collects data.			7.5%	0.7		\$23,650
							Sub Total	\$184,141
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	Purchase of lab and miscellaneous supplies, including parts and components for reactor fabrication and modification, catalysts, chemicals, consumable supplies for analytical instruments	For running experiments and operating treatment systems					\$14,859
							Sub Total	\$14,859
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								

	Miles/ Meals/ Lodging	4 one-day 3-person trips, ~100 miles each round trip (\$0.585/mile), meals @\$49/person	Visits to contaminated soil sites, collect samples, conduct experiments on site					\$1,000
							Sub Total	\$1,000
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
							Sub Total	-
							Grand Total	\$200,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
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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: [5424adb5-3f3.pdf](#)

Alternate Text for Visual Component

Shows background and summary of the project, technical approaches, and outcomes and benefits of the project...

Optional Attachments

Support Letter or Other

Title	File
Financial audit	5cdf49ea-095.pdf
Institutional Authorization to Submit	d45475a0-732.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

Remove organic contaminants from Minnesota soil

Roger Ruan, University of Minnesota

Background

Chemical products used by human activities produce lots of organic contaminants, such as microplastics, pesticides, VOCs, PFASs, antibiotics, etc., posing a significant threat to our ecosystem and health. The existing physicochemical soil remediation technologies have many limitations including the requirement of strict acidic conditions, infeasibility to deconstruct refractory organic pollutants, making them unattractive.

Project summary

- *Develop a continuous microwave-assisted pyrolysis (MAP) system for destruction of organic contaminants in Minnesota soil*
- *Conduct techno-economic and environmental impact analyses*

Outcomes of the project

- *An advanced MAP system will be developed for soil remediation.*
- *Potential economic and environmental impacts of the proposed strategy will be evaluated.*
- *Findings will be used for seeking industrial partnerships and external funds for further R & D efforts.*

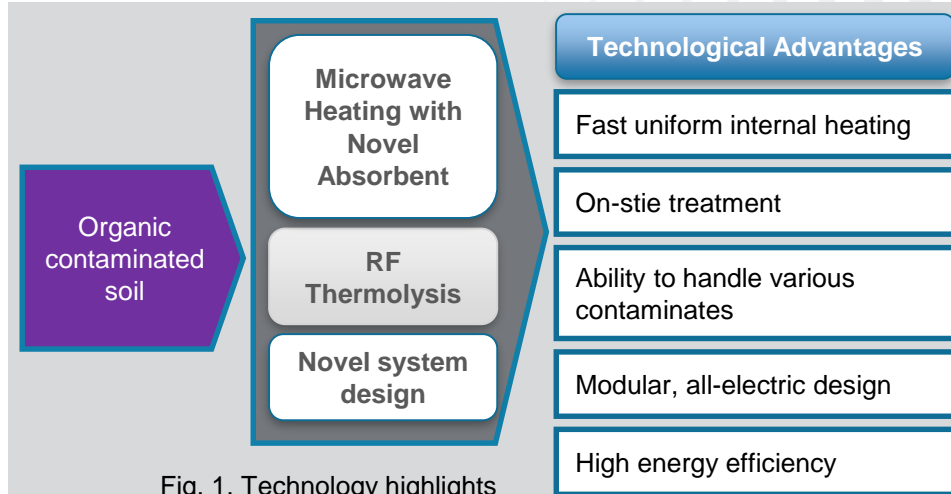
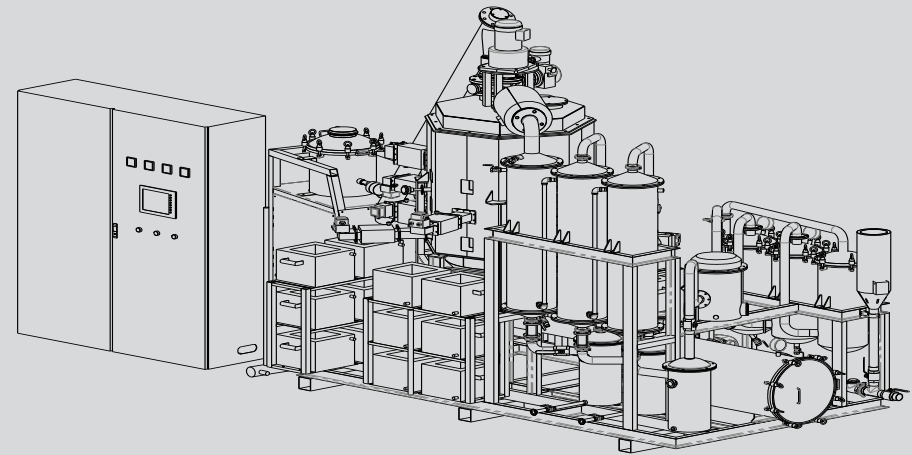


Fig. 1. Technology highlights



Highly efficient MAP system for complicated organic-contaminated soil remediation

