Environment and Natural Resources Trust Fund

2022 Request for Proposal

General Information

Proposal ID: 2022-265

Proposal Title: Innovative Technology for PFAS Destruction in Drinking Water

Project Manager Information

Name: Shaobo Deng

Organization: U of MN - Southern Research and Outreach Center

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Project Basic Information

Project Summary: Develop and demonstrate a novel and efficient process based on continuous liquid-phase plasma discharge technology to decompose /destroy Perfluoroalkyl and Polyfluoroalkyl substances (PFAS) in drinking water.

Funds Requested: $500,000

Proposed Project Completion: June 30 2025

LCCMR Funding Category: Water Resources (B)

Project Location

What is the best scale for describing where your work will take place?

Region(s): SE

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project

Narrative

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

Per- and poly-fluoroalkyl substances (PFAS) are a group of anthropogenic chemicals, which are used in the production of fire-fighting foams, stain repelling agents, fluoropolymers, pesticides, lubricants, paints, and medicines for decades. PFAS are not biodegradable and can bioaccumulate, thus hazardous to humans and ecological systems. At relatively low concentrations, PFAS could lead to serious health effects such as kidney cancer, liver damage, immunotoxicity, neurotoxicity, and testicular cancer. In 2016, EPA has recommended a health advisory level of 70 ng/L (ppt) for combined Perfluorooctanoic acid (PFOA) and Perfluorooctanesulfonic acid (PFOS). In 2019, the Minnesota Department of Health (MDH) adopted values as low as 15 parts per trillion (ppt) for PFOS.

Managing and removing PFAS in drinking water is one of the most pressing issues facing the government and industry. The current ex-situ technologies such as sorption, reverse osmosis (RO), and nanofiltration are used to concentrate PFAS from very diluted water. These sorption-and membrane-based treatments do not really destroy PFAS and will need further in-situ destroying or land application. Most in-situ tests were conducted at a lab-scale using advanced oxidation processes (AOPs) such as UV/H2O2, Fenton reaction, zero-valent iron, photochemical, which showed mixed and unsatisfying results on PFAS decomposition.

What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.

The lack of technologies to treat water contaminated by PFAS is extremely outstanding. To address this issue, we propose a novel and efficient solution based on liquid-phase plasma discharge technology to decompose PFAS in drinking water. The liquid phase plasma discharge is a patent-pending technology and originally developed in Southern Research and Outreach Center, University of Minnesota. It is currently in the stage of commercialization for biodiesel production. The preliminary research of liquid phase plasma discharge on destroying PFAS in water demonstrates a great promise with high conversion and process efficiencies. The solution recently wins the EAP's "Innovative Ways to Destroy PFAS" challenge award.

The proposed solution spearheads a non-thermal, easy-to-operate process to destroy PFAS without producing hazardous byproducts. Liquid phase plasma has been proved to possess the effect of various reactive species, such as •OH, O•, and H2O2, UV radiation, shockwaves, or high electric field produced by electric discharge, which can independently and synergistically complete chemical reactions rapidly and efficiently. Thus, the liquid plasma process is deemed as a combined physical/chemical process that produces a much stronger effect than the conventional chemical oxidation/reduction processes used to degrade PFAS with multiple recalcitrant C-F bonds.

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 outcome of this project is expected to lead to a new and effective technology to eventually clean up PFAS in drinking waters. This endeavor could bring profound economic and environmental benefits, given the current situation that the problem of PFAS contamination is looming large with no effective treatment techniques available. The advantages of the proposed solution include 1) no chemical addition needed; 2) continuous process for various source streams with different PFAS concentrations; 3) no harmful byproducts produced and HF neutralized; 4) compact equipment size and easy operation and 5) low capital and maintenance costs.

Activities and Milestones

Activity 1: 1. Study the mechanism of effective remediation of typical PFAS substances (PFOA and PFOS) by the liquid-phase plasma discharge process.

Activity Budget: $193,635

Activity Description:
A lab-scale experimental system will be set up to study this new process. The system is composed of a high-voltage power supply, the liquid phase plasma reactor, a pump, and the instruments and control modules including plasma discharge detection, water/gas flow monitoring, and power measurement. A venturi injector will be added and introduce argon and other gases to the reactor to enhance the activated radical generation in the water. PFOA and PFOS will be used as the test chemicals. The system parameters, such as water and gas flow rate, input power, treatment time, and the PFAS concentration will be tested. The plasma properties during electric discharge in water will be characterized, and the formation of reactive species will be verified. The removal rate and efficiency for PFOA and PFOS as well as their degradation pathways will be analyzed to confirm the mechanism of PFAS remediation. Four different operational modes, i.e., circulation, one-pass, two-pass, one-pass with two reactors connected in series, will be compared for the PFOA/PFOS degradation. Finally, the significant operating and design parameters of the process and the best operational mode for PFAS removal efficiency and preservation of drinking water quality will be determined.

Activity Milestones:

Description	Completion Date
Design, improve and set-up a lab-scale plasma discharge experimental system for water/PFAS treatment	December 31 2022
Investigate and Identify significant factors and parameters that influence the PFAS degradation and water quality	August 31 2023
Determine the best operational mode for PFAS removal efficiency by the liquid plasma discharge process.	December 31 2023

Activity 2: 2. Develop an on-site demonstration pilot-scale system that will enable verification of the liquid plasma system and process.

Activity Budget: $306,365

Activity Description:
With the determination of operating and design parameters of the process and the best operational mode obtained in Activity 1, a 50 gallon per hour pilot-scale system will be designed, constructed, and installed. This pilot-scale demonstration system will be used to 1) confirm the lab-scale experimental results at a large treatment capacity. 2) test the plasma reactor and basic system reliability by conducting an extensive production run given the goal of operating the system for 8 hr/day for 30 days, 3) Identify failure points, if any, and characterize wear of reactor and system parts, Improve the plasma reactor and system design. 4) optimize the process and operating parameters to maximize the treatment efficiency under production-like conditions, 5) monitor the energy consumption and derive an initial estimate of CAPEX and OPEX and comparison. 6) demonstrate the process and technology to potential customers and investors. After the successful demonstration, a techno-economic assessment of the processing system will be conducted and the implementation path and strategy should be identified.

Activity Milestones:

Description	Completion Date
Design, construction and installation of a 50-gal/hr on-site pilot-scale treatment system.	June 30 2024
Continuous operation and optimization of pilot-scale system treating PFAS contaminated water	December 31 2024

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 be funded?

The purpose of this project is to thoroughly research this new application of liquid phase plasma discharge and develop it into a viable technology. Upon the expected outcome from this research, the technology implementation path and business model will be identified and developed. Minnesota Soybean Research and Promotion Council is the strategic partner to commercialize liquid phase plasma technology for renewable energy and other new applications. If an additional study is needed, funding may be pursued through MSR&PC. The Ecolab, 3M, or other water treatment entities could be the potential investor or users for the implementation of the technology.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Clean Water and Renewable Energy from Beet Processing Wastewater and Manure	M.L. 2014, Chp. 226, Sec. 2, Subd. 08f	$400,000

Project Manager and Organization Qualifications

Project Manager Name: Shaobo Deng

Job Title: Researcher 6

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

Shaobo Deng is a researcher at Southern Research and Outreach Center, University of Minnesota, Leading the plasma technology research and development for agricultural and food process, waste treatment, renewable energy production; designing and scale-up the process from concept to lab-scale and pilot-scale; conducting experiments for process evaluation and validation. Mr. Deng is the inventor of the patent-pending technology for plasma discharge in the liquid and in charge of the environmental engineering and renewable energy research lab at the SROC. He was the Project Manager of the LCCMR project" Clean Water and Renewable Energy from Beet Processing Wastewater and Manure" and the Principle Investigator of three MSR&PC-funded projects on liquid phase plasma discharge technology for biodiesel production and water treatment.

Forrest Izuno will serve as co-Project Manager for this project. Dr. Izuno is the head of SROC and the professor at the bioproducts and biosystems engineering department, University of Minnesota. With active research experience in water management and sustainable system development, he leads the SROC working on a base 1.7 million dollar per year allocation, annual budgets grow to over $4 million through grants and businesses. Recently he heavily involved in the development and commercialization of liquid phase plasma discharge technology. In this project, Dr. Izuno will be responsible for overall project coordination, ensuring the necessary resources, and supervising all the activities.

Organization: U of MN - Southern Research and Outreach Center

Organization Description:

Southern Research and Outreach Center, located in Waseca, MN, is one of the ten University of Minnesota's Research and Outreach Center and dedicate to conduct innovative basic and applied research for broad dissemination and education in the areas of agricultural and food production system, human health, renewable energy, and the environment, and provide extension service and research-based educational information to our clientele about crop production, animal nutrition, horticulture, renewable energy, and waste treatment techniques. The center has a 1,500

sqft laboratory for renewable energy, environmental engineering, and wastewater treatment research, equipped with all the necessary lab equipment and instruments for the proposed project. A lab-scale liquid phase plasma reactor has been built and yielded good preliminary results for PFAS destruction. Gas chromatography with both a TCD and an FID detector is available for the project. The university also has analytical facilities that can be accessed with payment, such as soil, water, and climate research analytical laboratory.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Professor		Co-Principal Investigator, coordinate and supervise the research efforts.			36.5%	0.15		$30,810
Researcher 6		Principal Investigator, system development, experimental design and project reporting			36.5%	1.8		$163,090
Researcher 3		Scientific staff, system operation and data collection			31.8%	0.6		$50,000
							Sub Total	**$243,900**
Contracts and Services								
TBD	Professional or Technical Service Contract	Certified lab for water sample analysis, machine shop for components and parts fabrication.				0		$15,000
							Sub Total	**$15,000**
Equipment, Tools, and Supplies								
	Tools and Supplies	Chemicals, analysis kits, glassware and personal protection supplies	Materials for lab experiments					$25,000
	Equipment	Build a lab scale system for research and a pilot scale system for demonstration	Test and demonstrate the process and technology					$210,000
							Sub Total	**$235,000**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								

	Other	Trips to site and testing lab using vehicles, standard rate applies	Travel between site and analytical lab for collection and analysis of samples					$1,800
							Sub Total	**$1,800**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Publication cost for three journal articles	Present research results in scientific journals					$4,300
							Sub Total	**$4,300**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$500,000**

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: e25420a3-9e9.pdf

Alternate Text for Visual Component

1. The mapping of PFAS contamination sites in US
2. News: 3M pay the city of Bemidji, Minn., $12.5 million to help fund operations of a new water treatment facility capable of removing PFAS from city well water, 2021
3. News: Biden administration looks set regulation to target PFAS, 2021
4. Ecolab seeks treatment solutions that can significantly reduce the amount of PFAS, 2020
5. EPA's challenge for Innovative Ways to Destroy PFAS, 2020
6. Liquid phase plasma discharge solution process diagra...

Optional Attachments

Support Letter or Other

Title	File
UMN Authorization of Proposal	1d1c0a82-f36.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?

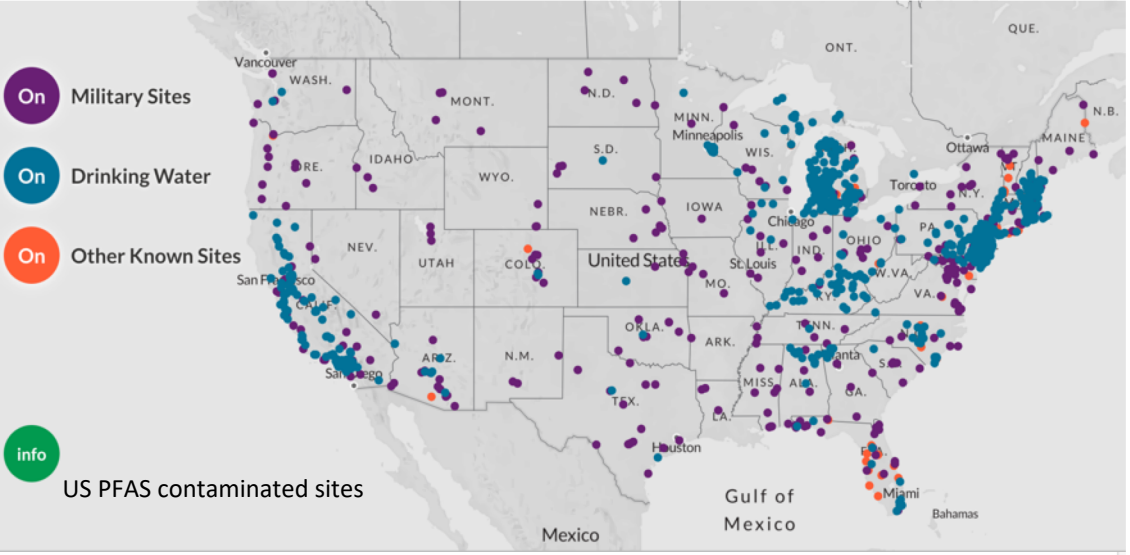
No

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration



US PFAS contaminated sites

TODAY'S NEWS

3M to pay $12.5M to support Minn. water treatment facility

3M has agreed to pay the city of Bemidji, Minn., $12.5 million to help fund operations of a new water treatment facility capable of removing PFAS from city well water. The plant is scheduled to open this month. **Full Story:** Duluth News Tribune (Minn.) (free registration) (3/10)

PFAS Drinking Water Issues

Medill News Service

Biden administration looks set to target 'forever chemicals,' as 3M warns about 'onerous regulation'

Last Updated: Jan. 27, 2021 at 4:10 p.m. ET
First Published: Jan. 25, 2021 at 2:59 p.m. ET

By Dalia Faheid

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Environmentalists optimistic about increased PFAS regulation under new administration

EPA Innovation Home
Innovation at EPA
Innovation News
Science and Technology

Treatment of Perfluoroalkyl Substances

Ecolab presented a challenge entitled "Treatment of Perfluoroalkyl Substances (PFAS)" which looks to identify treatment solutions that can significantly reduce the amount of Perfluoroalkyl substances (PFAS) in water entering food and beverage manufacturing facilities.

Despite PFAS production being phased-out in many countries, its persistence in the environment will result in these compounds continuing to be a concern for many years to come. Water is often used within the food and beverage industry as an ingredient, so ensuring this water is PFAS-free is an important food safety consideration.

Innovative Ways to Destroy PFAS Challenge

On this page:

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- Eligibility
- Judging Criteria
- Terms and Conditions
- Contact Information

Challenge

Background

Industry Demands

Liquid Plasma Solution