Environment and Natural Resources Trust Fund
2020 Request for Proposals (RFP)

Project Title: **ENRTF ID: 119-BH**

Cheap Efficient Filter to Remove Organic Compounds

Category: H. Proposals seeking $200,000 or less in funding

Sub-Category: B. Water Resources

Total Project Budget: $ 200,000

Proposed Project Time Period for the Funding Requested: June 30, 2023 (3 yrs)

Summary:

This project is to develop a new filter to remove toxic organic compounds from drinking water. The technology is very cheap and highly efficient to improve Minnesota water quality.

Name: Tianhong Cui

Sponsoring Organization: U of MN

Job Title: Professor

Department:

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Location:

Region: Statewide

County Name: Statewide

City / Township: Minneapolis

Alternate Text for Visual:

Cheap Efficient Filter to Remove Toxic Organic Compounds in Drinking Water, Compared to Current Available Filters

_____ Funding Priorities _____ Multiple Benefits _____ Outcomes _____ Knowledge Base

_____ Extent of Impact _____ Innovation _____ Scientific/Tech Basis _____ Urgency

_____ Capacity Readiness _____ Leverage _______ TOTAL _____%

PROJECT TITLE: Cheap Efficient Filter to Remove Toxic Organic Compounds in Drinking Water

I. PROJECT STATEMENT

Polycyclic aromatic hydrocarbons (PAHs) are a large group of organic compounds mainly released as pollutants from wood burning combustors soluable to water. Every year there are 3,200 tons of PAHs generated in the USA, among which Minnesota takes a big share. PAHs can enter the aquatic ecosystem through direct atmospheric deposition, rain erosion and biosynthesis. PAHs are well known as carcinogens, mutagens, and teratogens. They are highly lipid-soluble and can be absorbed at the lungs, guts and skins of human beings. Once absorbed, their mutagenic and carcinogenic activity through biotransformation can be fatal to one's health. Minnesota Pollution Control Agency (MPCA) works together with other agencies and advocacy groups in developing strategies to prevent, reduce, or mitigate PAHs contaminants, and to alleviate their damage to human health and the environment. In 2009, MPCA collected surficial sediment samples from fifteen storm water ponds in the Minneapolis and St. Paul metropolitian area and analyzed the contamination of PAHs. The results shows that the concentration of PAHs in three of the storm water ponds had risk to benthic invertebrate growth, whereas nine ponds exceeded human health risk benchmarks. The government made efforts to solve the problem by banning the usage of CT-sealant which is one of the main sources of PAHs in Minnesota. However, the treatment of the polluted water could be extremely expensive. The cost could reach $1 billion if 10% of the storm water ponds in the Minneapolis/St. Paul metropolitan area were polluted. This is an important emerging issue not only in Minnesota but also in other states and countries. However, there is no commercial filter that can efficiently remove PAHs from water.

The objective of this project is to develop a new, very cheap, and highly efficient filter to remove polycyclic aromatic hydrocarbons (PAHs) in drinking water. This proposed work is to develop a new water treatment technique that can decompose PAHs very efficiently from water. The proposed PAH filter is formed by carbon nanotubes and zinc oxide nanowires using advanced manufacturing. It is to combine ultraviolet radiation to decompose PAHs, making the water clean and innocuous. Zinc oxide is a semiconductor with a desirable photocatalytic property under ultraviolet light irradiation. Carbon nanotubes, with very large surface area, support the active catalyst, zinc oxide, to react with the PAHs. Currently, research on PAHs remediation techniques is minimal, due to the numerous difficulties associated with decomposition. The proposed PAH filter will fill the research gap, and pave a new way for the development of PAHs remediation. Advanced manufacturing techniques at the University of Minnesota allow development of a suitable instrument for reliable and efficient PAH remediation at a very low cost. In addition, the PAH filter can be installed in water treatment plants, household water purification systems and portable devices to eliminate PAHs contamination before drinking or other further usages.

II. PROJECT ACTIVITIES AND OUTCOMES

Budget: $140,000

Activity 1: *Development of highly efficient filters to remove organic compounds*

The objective of this activity is to develop highly efficient filters using carbon nanotubes and zinc oxide nnowires. They are very cheap, highly efficient, and extremely reliable for PAHs decomposition. The PAH filters will be designed and fabricated to remove PAHs in drinking water. The substrate of filters is transparent plastics to allow ultraviolet light radiation to shine through. The filter will remove 99% PAHs of the original concentration, while the cost is one tenth of reverse osmosis and other filtration systems. The first two years we will focus on the development and assessment of the PAH filters in laboratory so that the filters can be ready for field tests in Year 3.

Outcomes	Completion Date
1. *Layer-by-layer self-assembled carbon nanotubes* and *zinc oxide nanocomposite; filter modeling/ simulation and hardware development for continuous decomposition of PAHs in water; Initial testing results for small-size filters validation in lab*	*6/30/2021*
2. *Decomposition efficiency will be tested in comparison with conventional results in the lab; Improved filters with revised design, fabrication, and testing will be provided; Filter tests of PAHs decomposition of water samples will be conducted*	*6/30/2022*
3. *Comprehensive assessment of the techniques will be completed*	*6/30/2022*

Activity 2: *Standard-size filters and field testing on rivers and lakes* **Budget: $60,000**

Standard-size filters are produced and being used to purify drinking water in Minnesota. Two test sites will be set up to demonstrate the feasibility of the filters. Field tests include simulating water purification in household drinking water systems or water treatment plants, and testing the efficiency of the filter. Upon completion of the project, we will demonstrate the filters to the stakeholders and LCCMR committee members and officials.

Outcomes	Completion Date
1. *Standard size water filters will be designed and developed*	*12/31/2022*
2. *Two test sites in residential drinking water systems or water treatment plants in Minnesota will be set up*	*6/30/2023*
3. *Field tests will be performed, and decomposition efficiency will be tested*	*6/30/2023*

III. PROJECT PARTNERS:

Partners receiving ENRTF funding

Name	Title	Affiliation	Role
Tianhong Cui	**Professor**	**University of Minnesota**	**PI**

Tianhong Cui, the Distinguished McKnight University Professor in Mechanical Engineering at the University of Minnesota, will serve as PI and project manager. He will be responsible for overseeing the project, all reports, and deliverables. He will supervise the design, fabrication and efficiency testing of the PAH filters. The research assistant will work on the design, fabrication, and testing of the PAH filters. Professors Cui and his assistant will conduct in-lab tests, PAHs concentration analysis and field tests of the proposed filters with drinking water from residential drinking water systems or water treatment plants in Minnesota.

IV. LONG-TERM IMPLEMENTATION AND FUNDING:

This proposal will provide cheap, but high-performance techniques, i.e. a unique photocatalytic filter, for treatment of drinking water from in Minnesota. Upon completion, this project will realize economical and high-performance waterborne pollutant treatment techniques for continuous purification of not only drinking water, but also water in lakes and rivers. The knowledge learned throughout the project will provide a solid foundation for further research and development efforts that would lead to eventual implementation of this novel technique, to a broader treatment of Minnesota's water. This research will reduce the financial pressure brought by water purification, and help implement the MPCA's clear water strategy, and thus ensure human health in Minnesota. In addition, we plan to file patents on the proposed PAH filters for commercialization in the future. We can extensively use the filters for PAHs decomposition of pollutants in drinking water. As a result, the innovative technology can benefit local residents by purifying the drinking water in Minnesota. We will seek external funding from federal funding agencies or private foundations or sectors to support our efforts, and plan to file patents on the proposed filters for commercialization in the future.

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Dr. Tianhong Cui
Project Title: Cheap Efficient Filter to Remove Toxic Organic Compounds in Drinking Water
Organization: University of Minnesota-Twin Cities
Project Budget: $200,000
Project Length and Completion Date: 3 years; completion date of 6/30/2023
Today's Date: 04/15/2019

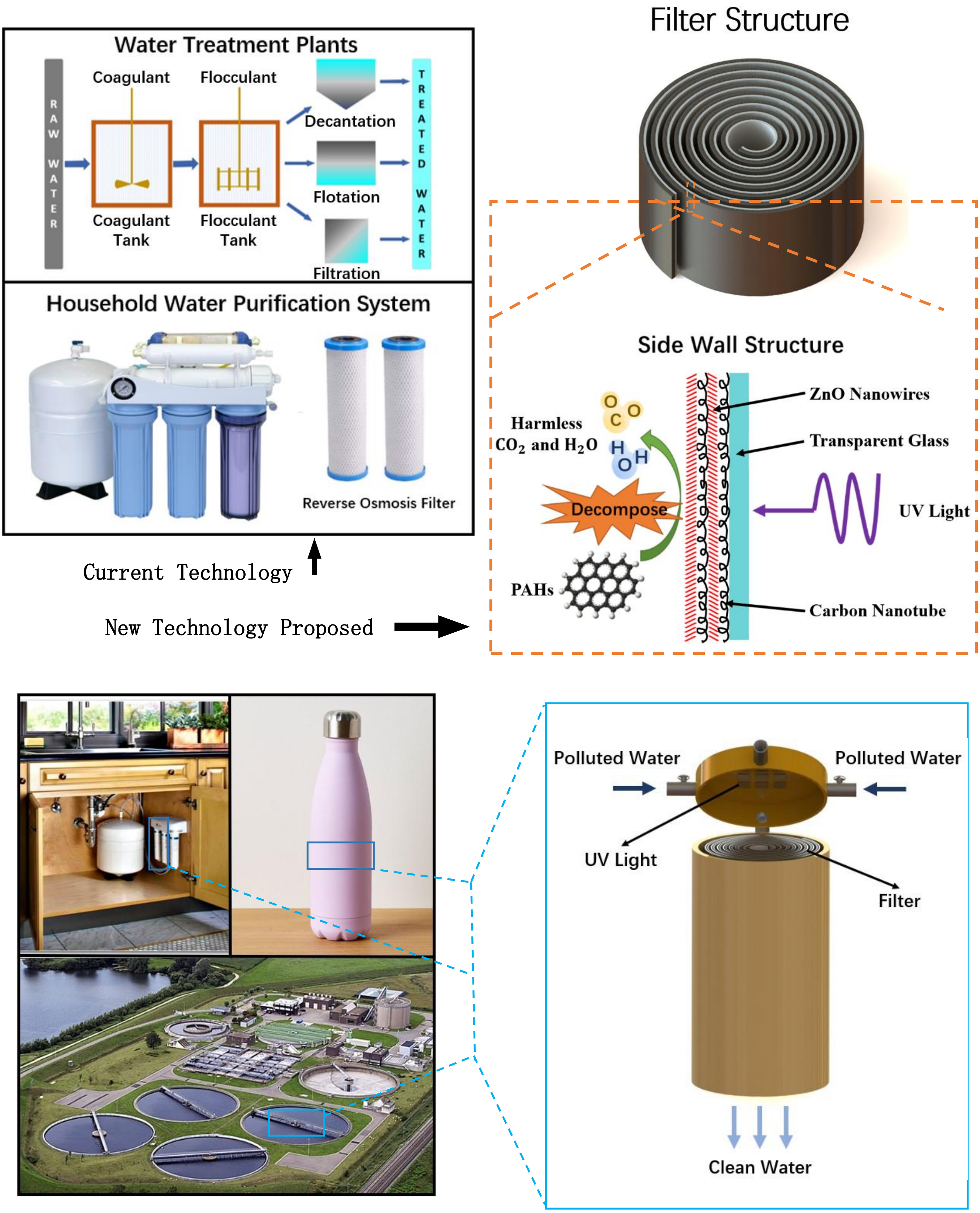
ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 172,000	$ -	$ 172,000
Tianghong Cui, PI/PD, 0.25 months/year, 3 years, including 36.0% benefits. He manages the overall project, leading the design, fabrication, and testing of PAH filters and supervising Ph.D. students.	$ 19,000		
1 ME Graduate Research Assistant, 50%, 3 yrs, including 16.1% benefits plus tuition, conducting design, fabrication, testing, and demonstration of PAH filters.	$ 153,000		
Professional/Technical/Service Contracts			
	$ -	$ -	$ -
Equipment/Tools/Supplies			
Lab supplies, instrument and equipment consumables, minor equipments for setting up lab and field experimental and testing systems and equipment repairs and calibration costs for the development of PAH filters	$ 9,000	$ -	$ 9,000
Capital Expenditures Over $5,000			
	$ -	$ -	$ -
Fee Title Acquisition			
	$ -	$ -	$ -
Easement Acquisition			
	$ -	$ -	$ -
Professional Services for Acquisition			
Scientific Services (i.e. Characterization Facility and MN Nano Center to fabricate PAH filters)	$ 19,000	$ -	$ 19,000
Printing			
	$ -	$ -	$ -
Travel expenses in Minnesota			
	$ -	$ -	$ -
Other			
	$ -	$ -	$ -
COLUMN TOTAL	$ 200,000	$ -	$ 200,000

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Indirect Cost at the University of Minnesota		$ 82,000	$ -	$ 82,000

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
		$ -	$ -	$ -

PI/PD: Tianhong Cui and Terrence Simon, University of Minnesota
Project Title: Cheap Efficient Filter to Remove Toxic Organic Compounds in Drinking Water

There is no commercial filter that can efficiently remove polycyclic aromatic hydrocarbons (PAHs) from drinking water. Current treatment and purification systems are expensive, large and difficult to remove PAHs. The proposed cheap, small, efficient filters can be easily installed in household water purification systems, portable devices and water treatment plants to fully decompose toxic organic compounds for cleaner drinking water in Minnesota.



Project Manager Qualifications

Tianhong Cui is currently Distinguished McKnight University Professor at the University of Minnesota. He is a Professor of Mechanical Engineering and an Affiliate Senior Member of the graduate faculty in Department of Electrical and Computer Engineering. He joined the faculty of the University of Minnesota in 2003. He was also a visiting professor at University of Freiburg in Germany and University of Paris East in France. He is an international leading expert on micro devices and advanced manufacturing with 26 years of research experience. He has more than 310 publications and 8 US patents. His research has been sponsored for more than 8 million dollars in the last few years by NSF, DARPA, NASA, DOE, and companies. As an editor-in-chief, he is also responsible for a Nature Journal, *Light: Science & Applications*, and recently he founded the first engineering journal of Nature Publishing Group titled *Microsystems & Nanoengineering*. He is also serving as an associate editor for *Journal of Nanoscience and Nanotechnology* and *Journal of Nano Research*, and he was a past editor for *IEEE Sensors Journal*.

Organization Description

Professor Tianhong Cui in Mechanical Engineering will serve as PI and project manager. He will be responsible for overseeing the project, all reports, and deliverables. He will supervise one Ph.D. student to work on design, fabrication, and characterization of small cheap filters to remove PAHs. Professor Cui will hold weekly meetings with his advisees to ensure good progress of this proposed work, in addition to some daily technical discussion with his graduate research assistant.

Filters to remove PAHs including manufacturing and characterization will be performed at the University of Minnesota in the Technology Integration & Advanced Nano/Microsystems Laboratory (TIAN Lab), located in room ME4128 of the Mechanical Engineering Building, on the Minneapolis campus of the University of Minnesota. Professor Cui is the director of TIAN Lab equipped with the state-of-the-art instrument and facilities to conduct the proposed research, with a variety of fabrication and characterization equipment and tools, sufficient for Professor Cui, his Ph.D. student to design, fabricate, characterize and analyze the proposed filters to remove PAHs.

The proposed other part of fabrication work of PAH filters will be partially done in Minnesota Nano Center (www.nfc.umn.edu) at the University of Minnesota in a 7000 square foot facility, including 3000 square feet of class 10 clean room. The Lab contains all of the major pieces of processing equipment. Minnesota Nano Center well maintains these systems, keeps safe operating procedures, and trains students. State support, support from NSF through the National Nano Coordinated Infrastructure Network (NNCI), and industry usage allows Minnesota Nano Center to offer academic rates that are normally less than half of the actual cost of operation. In 2014, NFC took possession of a second clean room as part of a new Physics and Nanotechnology Building. The new building is across the street from the ECE Building which houses the existing clean room. At 5000 square feet under filter and almost 10,000 square feet gross, it is more than double the existing space. In addition to expanding the suite of clean room tools available, the lab will also operate two new non-clean core labs that support research in nanomaterials and nanotechnology.