Environment and Natural Resources Trust Fund
2018 Request for Proposals (RFP)

Project Title: **ENRTF ID: 048-B**

Small Cheap Purification System for Cleaner Drinking Water

Category: B. Water Resources

Total Project Budget: $ 496,788

Proposed Project Time Period for the Funding Requested: 3 years, July 2018 to June 2021

Summary:

This project is to develop a small cheap purification system for community drinking water facilities to remove toxic contaminants. The technology is highly efficient to improve current drinking water quality.

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Sponsoring Organization: U of MN

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Web Address

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Current Technology and New Technology

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Small Cheap Purification System for Cleaner Drinking Water

I. PROJECT STATEMENT

The objective of this project is to develop a small cheap purification system for cleaner community drinking water. Existing drinking water purification systems for community water are usually large, expensive, and difficult to operate. The proposed community water systems are very small and low-cost, but more efficiently to remove organic and inorganic contaminants. The water purification system is composed of porous activated carbon, columnar UV light source, and a roll of multilayer purification film. The multilayer purification film is made of an electrically conductive film, by self-assembly of graphene and titanium oxide nanoparticles on the surface of plastic. When water purification is in progress, a small biased potential is applied to the conductive plastic film, and the UV light is turned on. Water flowing into the system will be firstly pre-treated by the activated porous carbon, and some microbes, organic matters, and small particles are removed. Next, the pretreated water enters the multilayer purification film, where microbes can be further deactivated by the UV light and the porous structures. Water soluble ions, such as lead, cadium, or nitrates, can be reduced electrochemically or absorbed by the electric field. Titanium oxide, as a photosensitive material, will have photochemical behavior under UV illumination, to detoxify some organic matters. Through the above process, much cleaner drinking water can be obtained very efficiently.

This project is intended to develop small, cheap, but efficient purification system for cleaner community drinking water. In the next phase of the research, we will closely work with state agencies, water pollutant researchers, and industry to develop an implementation plan for pollutants reduction of drinking water in heavy industrial regions in Minnesota.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Development of small cheap community water purification systems* **Budget: $322,546**

The objective of this activity is to develop water purification systems using plastic, graphene and titanium oxide nanoparticles. The system is very small, cheap, and reliable to remove organic and inorganic contaminants in Minnesota community waters. The system will reduce the water contaminants to meet the EPA and Minnesota standards, while the cost is one tenth and the room is one fifth of the traditional systems at most.

Outcomes	Completion Date
1. Layer-by-layer self-assembly of graphene/titanium dioxide nanocomposites; hardware will be developed for water purification systems; Initial testing results of water purification to remove organic and inorganic particles	*6/30/2019*
2. Purification efficiency will be tested in comparison with conventional results in lab; Improved systems with optimized design, fabrication, and testing; Systems testing of water in Minnesota	*6/30/2020*
3. Comprehensive assessment of the techniques will be completed	*6/30/2020*

Activity 2: *Development of standard size water purification systems and field testing* **Budget: $174,242**

Standard size purification systems to be assembled with the community water supply will be designed and constructed. Test sites will be set up to demonstrate the feasibility of the systems. Field testing will include picking up community sites and testing the efficiency of the systems in the field. Upon completion of the project, we will demonstrate the purification systems to the stakeholders and LCCMR committee members and officials.

Outcomes	Completion Date
1. Standard size systems will be designed and developed	*6/30/2021*
2. Test sites with residential community water sites will be set up	*6/30/2021*
3. Field testing will be performed with filed sites, and purification efficiency will be tested	*6/30/2021*

III. PROJECT STRATEGY

A. Project Team/Partners: Tianhong Cui, Distinguished McKnight University Professor at the University of Minnesota, will serve as PI and project manager. Professor Cui is a leading expert on advanced manufacturing and micro devices. He will be responsible for overseeing the project, all reports, and deliverables. Mr. Jungyoon Kim, a research assistant, and another post-doc will develop the systems, in-lab test sites with dirty water, and set-ups for field testing of the proposed purification systems for community drinking water.

B. Project Impact and Long-Term Strategy

Minnesota Pollution Control Agency (MPCA) works together with other agencies and advocacy groups in developing strategy to keep clean drinking water, reducing their impacts on human health and the environment. Water is one of the most valuable natural resources in the world. In everyday life, people use water in many ways, such as drinking, cooking, washing, etc. It is very important to ensure the supplied water is clean, especially the drinking water for daily life. Although tap water meeting federal and Minnesota state standards is usually safe to drink, people are still confronted with an increasing threat to contaminated water. It has been reported that over 200,000 violations to federal drinking water standards each year, among which more than 20% are due to poor water treatment facilities. Therefore, a small cheap but efficient community water purification system is very important to ensure a healthy drinking water supply, especially for those who are vulnerable to waterborne diseases. Commercially available community water treatment systems utilize various water cleaning technologies with several components, including activated carbon filter unit, ion exchange unit, reverse osmosis unit, and distillation unit. The purification system consists of a sediment pre-filter, a carbon block pre-filter, a reverse osmosis cartridge, and a total defense advanced filtration cartridge. Through the above units, contaminants, such as heavy metal ions, microbes, dissolved solids, organic pollutants can be removed from the water, so that clean drinking water can be obtained. The commercial systems provide the users with purified drinking water, but the price is relatively high, ranging from hundreds to thousands dollars. In addition, due to the large volume of the purification systems, it occupies much room. The proposed new purification system will provide a solution to current ineffective and expensive community water treatment systems, and thus ensure people's cleaner drinking water in Minnesota.

The knowledge learned throughout the project will provide a solid foundation for further research and development that would lead to eventual implementation of the new technique practically enabling broader treatment of Minnesota's water. This will provide a solution to current ineffective water treatment, ultimately help implement the MPCA's clean water strategy, and thus ensure people's safety in Minnesota.

In addition, we will plan to file patents on the proposed community drinking water purification system for commercialization in the future. We can also use the new technology for treatment of natural water, waste water, etc. As a result, the innovative technology can benefit the local residents and society by purifying the waters in Minnesota.

C. Timeline Requirements

This project is planned for 3 years beginning on July 1, 2018 and ending on June 30, 2021. The first two years will be focused on development of the water purification system, and Year 3 will be focused on development of standard size system and field test. The results of this study will be disseminated through oral and poster presentations by faculty and students involved in the project, briefings to the LCCMR as requested, and peer-reviewed publications. We also intend to present progress on this project periodically to relevant personnel who have been aware of this project and may be interested in the results, specifically at the Minnesota Pollution Control Agency and environment protection advocacy groups.

2018 Detailed Project Budget

Project Title: Small Cheap Purification System for Cleaner Drinking Water

IV. TOTAL ENRTF REQUEST BUDGET: 3 Years

BUDGET ITEM	AMOUNT
Personnel:	
Dr. Tianhong Cui, PI, 1 month summer salary (11% FTE) & 33.5% fringe for 3 years	$ 69,512
Post-Doc, 12 months (100% FTE) plus 21.4% fringe for 3 years	$ 180,113
Graduate Research Assistant, 50% FTE (fall & spring semesters include 15% fringe plus $19.32/hour tuition, summer 16.6% fringe only) for 3 years	$ 144,563
Equipment/Tools/Supplies:	
Lab Materials & Supplies: fabrication materials & supplies including polymer substrates ($5,000), nanomaterials and chemicals ($15,000), roll-to-roll manufacturing set-up items ($8,000), bottles, gloves, other electronics for testing, etc. ($5,000)	$ 33,000
Sceintific Services: User fees at Minnesota Nano Center and Characterization Facility at the University of Minnesota. The cost is about $1,000 per month for the Post-Doc, and $750 per month for the research assistant for 3 years.	$ 63,000
Travel:	
Travel- Cui Domestic travels: Mileage, lodging, and meals for travel to and between the solar testing sites and the university based on the university compensation policy	$ 6,600
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 496,788

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: *N/A*		
Other State $ To Be Applied To Project During Project Period: *The University Overhead*	$ 175,039	*Secured*
In-kind Services To Be Applied To Project During Project Period: *N/A*		
Funding History: *N/A*		
Remaining $ From Current ENRTF Appropriation: *N/A*		

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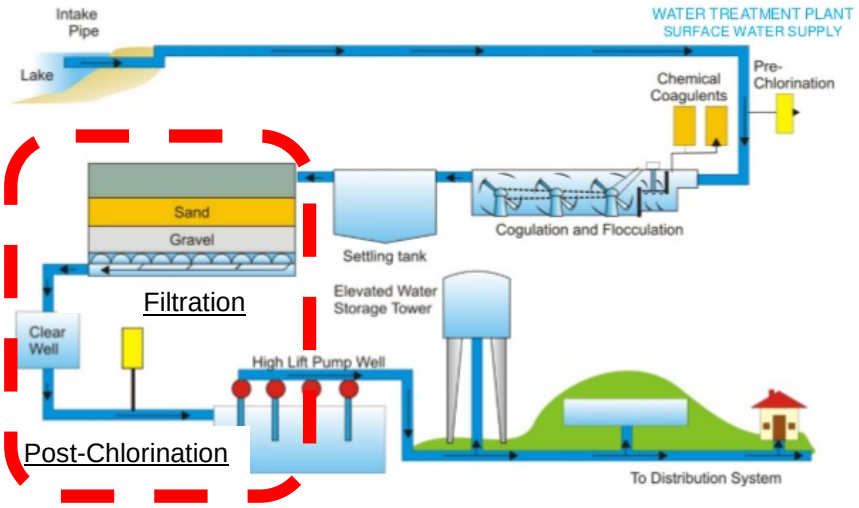
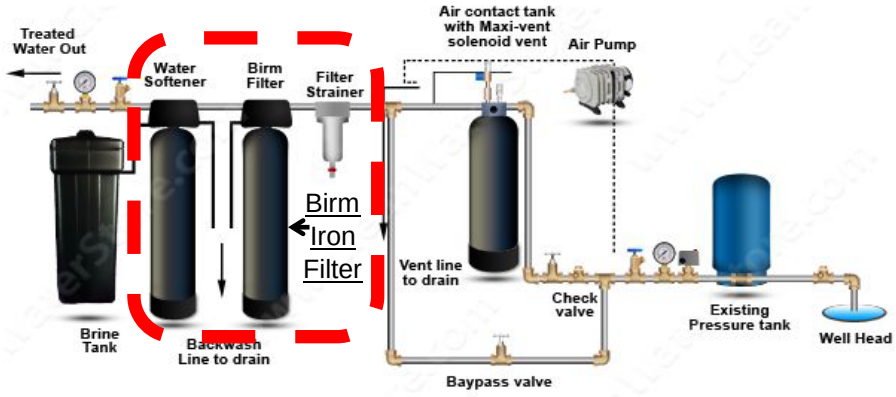
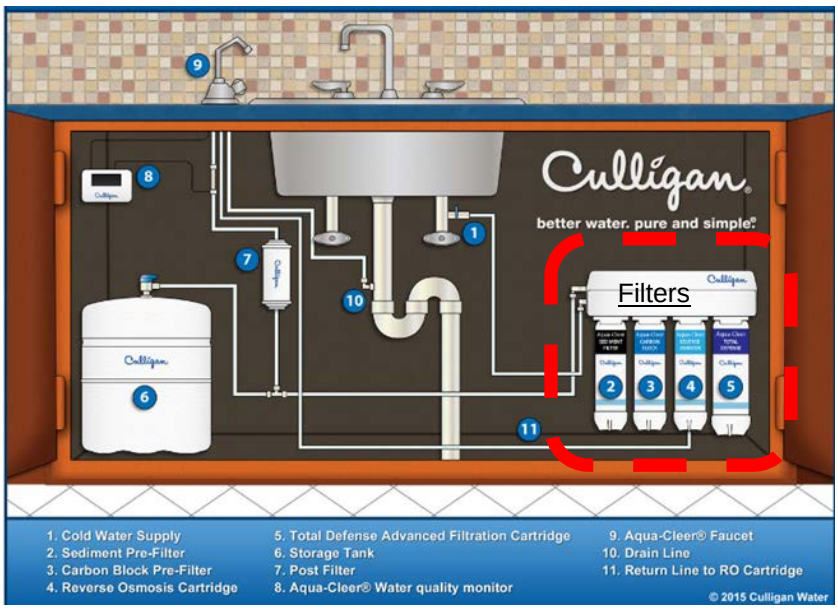
Current Technology
(Parts in Dashed Boxes Replaced by New Technology)



Surface Water Purification System

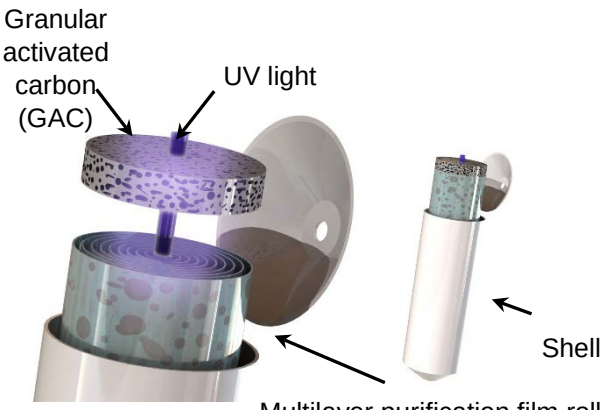


Home Well Water Purification System

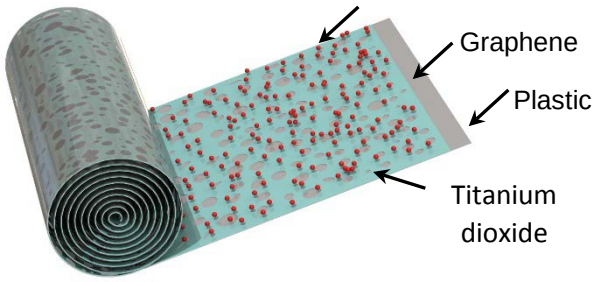


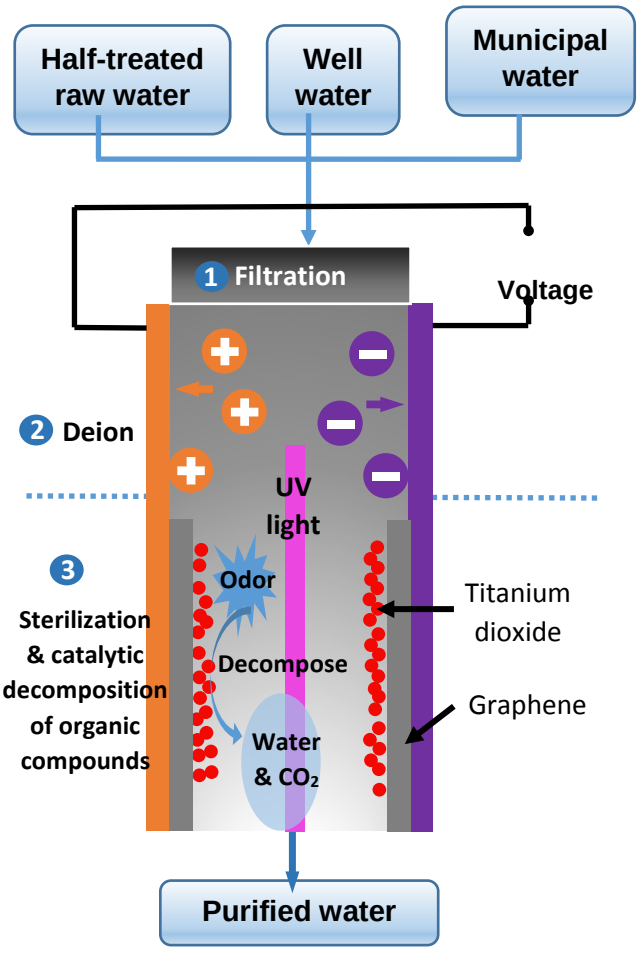
Home Municipal Water Purification System

New Technology



Multilayer purification film roll





Principle of Water Purification

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. He has more than 285 publications and 7 US patents. His research has been sponsored for more than 6 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 post-doc and one Ph.D. student to work on design, fabrication, and characterization of small cheap purification systems for cleaner drinking water. 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 post-doc and graduate research assistant.

Purification systems for drinking water including roll-to-roll 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 post-doc, and Ph.D. student to design, fabricate, characterize and analyze the proposed purification system for cleaner drinking water.

The proposed other part of fabrication work 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 NNIN, 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.