Environment and Natural Resources Trust Fund
2016 Request for Proposals (RFP)

Project Title: **ENRTF ID: 041-B**

Sponge Technology to Remove Mercury from Wastewater/Surface Waters

Category: B. Water Resources

Total Project Budget: $ 146,609

Proposed Project Time Period for the Funding Requested: 2 years, July 2016 to June 2018

Summary:

We propose an efficient and cost-effective sponge technology to remove mercury from wastewater and surface waters, and improve water quality and aquatic life in Minnesota

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Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

A Novel Sponge for Rapid and Cost-effective Mercury Removal from Water. (The visual shows photographs of the developed sponge and its efficiency)

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

PROJECT TITLE: Novel Sponge Technology to Remove Mercury from Surface and Waste Waters

I. PROJECT STATEMENT

Objective: The main objective of this proposal is to improve water quality by providing environmental agencies and industries with an efficient and cost-effective technology for mercury removal from wastewater and surface waters. Recently, our research laboratory developed a novel and cheap sponge capable of removing 99.95 % of mercury from water within a few minutes. Specifically, the current proposal seeks to:

- Optimize the performance and cost of the novel sponge technology;
- Scale up the technology to surface and wastewater levels by developing systems and devices to capture mercury in stormwater ponds, wetlands and wastewater treatment plants. The development of systems for mercury removal directly from lakes or rivers using floating booms will also be explored.

Statement of Need and Significance: The urgent need for cost-effective mercury removal technologies is clearly justified by the major threat that mercury causes to aquatic life but also to human health by entering the food chain. Two thirds of the waters on Minnesota's 2004 Impaired Waters List are impaired because of mercury contamination that ranges from 0.27 to 12.43 ng/L (the EPA limit is 2 ng/L).[1] Mercury contamination of lake waters results in mercury accumulation in fish, leading the Minnesota Department of Health to establish fish consumption guidelines. A number of fish species store-bought or caught in Minnesota lakes are not advised for consumption more than once a week or even once a month. In Minnesota's North Shore, 10% of tested newborns had mercury concentrations above the EPA reference dose for methylmercury (the form of mercury found in fish).[2] This means that some pregnant women in the Lake Superior region, and in Minnesota, have mercury exposures that need to be reduced.

State of the Art and Novelty: A number of technologies have been developed to remove mercury from water.[3] Beside the high cost of these technologies to operate on a large scale, they are based on capturing mercury with instable complexes that could represent health risk when leaked into the environment. The novel sponge technology is extremely cost-effective and is based on the formation of permanent and non-toxic complexes of mercury with other materials. Due to intellectual property requirements (patent under preparation), specific technical details and real demonstration of the sponge technology will be provided in the full proposal, or can be provided under request in a private document or meeting.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Characterization and optimization of the sponge technology* **Budget: $50,000**

The first step will focus on improving the performance and decreasing the cost of the sponge to allow mercury removal to levels that cannot be detected with current analytical tools. We will characterize the optimal conditions for mercury capture, evaluate the efficiency under different conditions, and develop solutions for sponge disposal or reuse.

Outcome	Completion Date
1. Optimization of the sponge fabrication process and evaluation of its performance	*12/31/2016*
2. Test of the sponge in real-world conditions and optimization of the production cost	*04/30/2017*

Activity 2: *Adaptation of the technology to real-world applications* **Budget: $ 75,500**

To scale up the technology to wastewater and surface water levels, we will study and test the integration of the sponge into wetlands or wastewater treatment plants in collaboration with local partners including the *McCarrons-Villa Park Wetland* and the *Metropolitan Wastewater Treatment Plant*.

Outcome	Completion Date
1. Adaptation of the sponge fabrication process to large scale production	*08/30/2017*
2. Development of containers for the sponge for use in stormwater ponds and	*01/31/2018*

wastewater plants.	

Activity 2: ***Development of a floating boom system for mercury removal from lakes*** **Budget: $ 21,105**

While the mercury transported by air is usually collected by stormwater ponds and constructed wetlands,[4] the mercury that has already accumulated in lakes or mercury that comes from natural sources has so far been ignored due a lack of suitable technologies. The floating boom sponge will be designed to float on lakes and automatically capture mercury from water. Once saturated, the sponge can be collected and replaced.

Outcome	Completion Date
1. Design and fabrication of a floating boom system that can contain the sponge.	*03/31/2018*
2. Test of the floating boom sponge in lab setting and in a selected Minnesota lake	*06/30/2018*

III. PROJECT STRATEGY

A. Project Team/Partners

The project will be conducted in Abbas' research laboratory in the Department of Bioproducts and Biosystems Engineering, College of Food, Agricultural and Natural Resource Sciences at the University of Minnesota Twin Cities. The research group is composed of two postdoctoral Research Associates, one graduate research assistant and 4 undergraduate students. Prof. Abbas will be in charge of the overall project management and experimental design. The research team will seek a close collaboration with the Minnesota Pollution Control Agency (MPCA). Contacts have already been initiated with Mr. Steve Weiss (Supervisor of Effluent Limits at the MPCA), and a meeting will be organized with the MPCA engineers to discuss our technology. This cooperation will be later extended to the *McCarrons-Villa Park Wetland* and the *Metropolitan Wastewater Treatment Plant.*

B. Project Impact and Long-Term Strategy

Impact: In addition to improving water quality, aquatic life and public health, the new technology would have an impact on inspiring new regulations. A number of US federal and state regulations have been established to reduce the levels of mercury in water. The Great Lakes Initiative (GLI) requires wastewater dischargers in the Lake Superior basin to meet a mercury water quality standard of 1.3 ng/L, while the rest of Minnesota lakes have a chronic standard of 6.9 ng/L. The development of efficient and cost-effective technologies will help industries and public agencies reach these goals. In addition, a reduced deposition of mercury is projected to have economic benefits reflected by an annual state willingness-to-pay (WTP) of $212 million.[5]

Long-Term Strategy: The requested funding will help move the sponge technology closer to the market by allowing the demonstration of working and commercially viable prototypes. The undergoing intellectual property protection will help us license the technology to industrial partners or use it to build a Minnesota-based start-up company focused on improving water quality and remediation of our lakes from mercury contamination, in cooperation with public agencies and private stakeholders.

Dissemination: Cooperators and sponsors will receive regular reports on the project advancement. The results will be communicated in seminars, peer-reviewed publications and public media.

C. Timeline Requirements

The project will be completed within 2 years. During year 1, the sponge technology will be optimized and the production cost reduced. Year 2 will be dedicated to scaling up the technology to enable applications in wastewater treatment plants, stormwater ponds, wetlands and lakes.

References

1. Monson, B.; Heiskary, S. *Water Mercury Concentrations in Minnesota Lakes*; wq-nlap-02; Minnesota Pollution Control Agency: 2008.
2. McCann, P. *Mercury Levels in Blood from Newborns in the Lake Superior Basin* GLNPO ID 2007-942; Minnesota Department of Health 2011.
3. Agency, U. S. E. P. *Treatment Technologies for Mercury in Soil, Waste, and Water* EPA-542-R-07-003; 2007.
4. Monson, B. *Effectiveness of Stormwater Ponds/Constructed Wetlands in the Collection of Total Mercury and Production of Methylmercury*; Minnesota Pollution Control Agency: 2007.
5. Hagen, D. A.; Vincent, J. W.; Welle, P. G. *Economic Benefits of Reducing Mercury Deposition in Minnesota*; 1999.

2016 Detailed Project Budget

Project Title: Novel Sponge Technology to Remove Mercury from Surface and Waste Waters

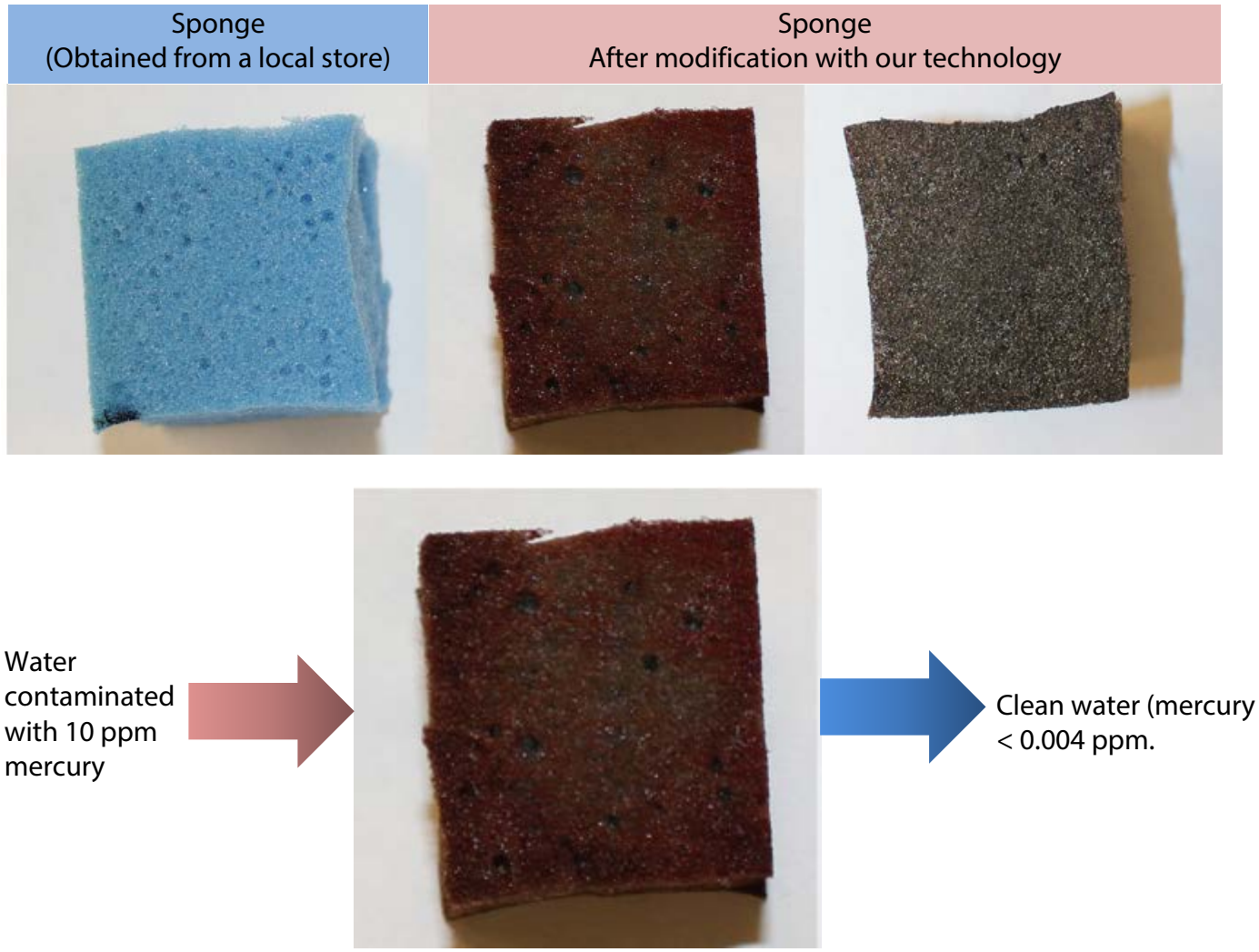
IV. TOTAL ENRTF REQUEST BUDGET 2 years: July 1, 2016-June 30, 2018

BUDGET ITEM	AMOUNT
Personnel:	
Summer faculty salary for University of Minnesota faculty on 9-month appointment: Abdennour Abbas, First year: $8,645 salary and $2,913 fringe Second year: $8,991 salary and $3,030 fringe. The faculty will direct the research, design experiments, establish collaborations with the industry and the MPCA and write reports and publications.	$ 23,579
Academic Graduate Research Assistant: One student for 2 years (0.5 FTE per year) Year 1 $24,865 salary and $18,726 fringe. Year 2: $25,860 salary and $18,899 fringe. The graduate student will optimize the sponge technology, perform experiments, device testing andf data collection and analysis.	$ 88,350
Contracts	
Equipment/Tools/Supplies:	
Laboratory Supplies for 2 years: Chemicals, Reagents, Media and consumables ($15,000), non-capital equipment: pneumatic system, high precision temperature oven, furnace and other minor equipment ($5,400)	$ 20,400
Acquisition (Fee Title or Permanent Easements)	
Travel:	
Travel - to pay transport of equipment for field testing in lakes or wetlands, pay mileage for project personnel to collect field data, organize project team meetings and meet with project cooperators and sponsors.	$ 4,080
Additional Budget Items:	
Lab services: AutoCAD designs and fabrication of sponge-containing devices and floating booms will be requested from other laboratories at the University of Minnesota, Imaging services and 3-D printing of prototypes will be performed in facilities at the University of Minnesota	$ 10,200
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ **146,609**

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: *University of Minnesota MRSEC Seed Grant : Support for a postdocoral research associate*	$ 60,000	*Pending*
Other State $ To Be Applied to Project During Project Period:		
In-kind Services To Be Applied To Project During Project Period:		
University of Minnesota: Indirect Costs/Facilities and Administration (52%)	$ 57,798	Pending
Funding History:		
Remaining $ From Current ENRTF Appropriation:	N/A	

A Novel Sponge for Rapid and Cost-effective Mercury Removal from Water



Project Manager Qualifications

- **Biosketch: Abdennour Abbas** is an Assistant Professor at the University of Minnesota Twin Cities in the Department of Bioproducts and Biosystems Engineering. Prior to his current position he was a research associate at the University of California (2010-2011) and Washington University in St Louis (2011-2013). He received a *Ph.D. degree* in Materials Science and Engineering (2009) and a Master of Science in Physical Chemistry of Biological Systems at *Lille University* (France). Dr. Abbas is an expert in biosensors and bionanotechnology applied to food safety, biodefense and the environment. His current research includes smart food packaging, foodborne pathogen detection technologies and nanotechnologies for precision agriculture and environmental monitoring and remediation. He has given numerous international conferences and a dozen invited lectures and presentations including two TED talks. He is a winner of the *MIT Technology Review Award-France 2013* (Top 10 Innovators under the age of 35 in France), Best Poster Awards at the *Food Defense Conference* (2014) and at the *Nano and Microsystems International School (2010)*, and a Doctoral Fellowship of the *French Ministry of Higher Education and Research*. He is the author of over 25 papers, one book and holds two patents. His latest work has been highlighted in *Nature Photonics, KSTP TV News channel, Minnesota Daily,* and other news media. He is a referee for over 20 international journals and a member of the *American Chemical Society, the American Society for the Advancement of Science, and the American Institute of Chemical Engineers.*

- **Research expertise:** Dr. Abbas directs the Biosensors and Bionanotechnology Laboratory, composed of two postdocs, 1 graduate research assistants and 4 undergraduate students. The development and translation of new sensors and nanotechnologies to real world applications has been the core of his research and expertise for the last 7 years, resulting in 25 publications, two patents and one book. His lab is currently focused on the application of biosensors and nanotechnology to food safety and environmental monitoring. His interdisciplinary background and education in biotechnology, nanotechnology and Materials engineering provides a valuable research visibility that allows him to effectively connect nanoengineering solutions to biological and environmental needs. His previous and fruitful collaborations with researchers from other disciplines demonstrate that he has the expertise, leadership and motivation required to successfully carry out the proposed research with the collaboration of other faculty at the University of Minnesota. This proposal is driven by his belief that any developed technology has to be affordable in order to be commercially viable and have impact on people's life. His previous experience with all aspects of project administration (team building and management, budget, timeline, patenting, and publications) is another major asset for future development of a productive and impactful R&D program with the support of the Minnesota Environment and Natural Resources Trust Fund (ENRTF).

- **Organization Description:** Dr. Abbas is affiliated with the College of Food, Agricultural and Natural Resources Science (CFANS), devoted to the study and enhancement of the ecosystem to ensure the safety of the food and water supply, and strengthen agricultural and natural resource-based industries in Minnesota. CFANS is the home of 7 departments (soil and water, fisheries and wildlife, Bioproducts, horticulture) and several research centers including the Water Resource Center. In addition to the resources and wide faculty expertise available in CFANS, this project will benefit from important core facilities and resources available at the University of Minnesota Twin Cities, including the Soil Testing Laboratory where mercury measurement will be performed.