Environment and Natural Resources Trust Fund
2015 Request for Proposals (RFP)

Project Title: **ENRTF ID:** **046-B**

Autonomous Chemical Sensor for Water Toxicants Monitoring

Category: B. Water Resources

Total Project Budget: $ 320,000

Proposed Project Time Period for the Funding Requested: 3 years, July 2015 - June 2018

Summary:

We propose the development and testing of a portable/autonomous sensor for on-site and cost-effective monitoring of organic toxicants in Minnesota lakes, which will empower different programs of the State agencies.

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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:

Continuous toxicant monitoring and chemical mapping in Minnesota lakes

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

PROJECT TITLE: Autonomous Chemical Sensor for Water Toxicants Monitoring

I. PROJECT STATEMENT

The concentration of water toxicants in large lakes can vary significantly over time, depending on the season, environmental cycles or human activity. Identifying these variations is of great importance to accurately understand the impact of contaminations on aquatic life and human health. **State agencies usually have hand-held or continuous sensors to monitor changes in water pH, turbidity, chlorophyll, oxygen, nitrogen and other ions and nutrients. However, no portable or continuous sensor is currently available for organic chemical toxicants. The current proposal intends to respond to this particular and important need.** Specifically, we will:

- Develop a portable chemical sensor for on-site detection of perfluorinated chemicals (ex. PFOS), chlorinated chemicals (ex. PCBs) and methymercury, which represent serious public health threats for fish consumption and drinking water supply. The portable sensor can be either transported by inspectors to the field for rapid and cost-effective analysis or can be deployed on-site for continuous long-term measurements. In addition to the identification of lake contamination trends, continuous sensing in the lake represents a valuable early detection system to alert State agencies when new contaminations occur.
- Given the number of lakes in Minnesota, the portable sensors can only be deployed in selected large lakes that have a strategic importance to the State. Using the data collected with the sensors in large lakes, we will elaborate computer models and simulations that will help predict the propagation and persistence of contaminants in other lakes without deploying sensors.
- When chemical toxicants are released into the environment and reach lake waters, their concentration is not evenly distributed in different areas of the lake. Studying the distribution and gradient of contaminants is crucial to track back and identify the origin of chemicals, which will help enforce regulation on pollutant load standards. To address this problem, the portable sensor will be embarked and interfaced with a robotic boat (already developed and tested) to perform chemical mapping in the selected lake and provide toxicant distribution in different areas and water depths.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Prototype development of a portable chemical sensor **Budget: $198,000**

A sensor based on fiber optic probes will be developed. The concept offers extremely high sensitivity (10^{-17} M), demonstrated last year by Dr. Abbas and highlighted in online news media. In addition, the sensor offers the ability to rapidly detect multiple toxicants with minimal sample preparation. After lab scale demonstration, the sensor will be tested in lake Harriet by detecting PCBs, PFCs (ex. PFOS) and methylmercury.

Outcome	Completion Date
1. Created a Raman spectra database of the targeted toxicants including PFCs and PCBs	*03/31/2016*
2. Developed a prototype of the portable chemical sensor and tested it at the lab scale	*06/30/2017*
3. Field operation: demonstrated continuous detection of toxicants in lake Harriet	*05/31/2018*

Activity 2: Evaluation of the propagation and gradient of toxicants in the lake **Budget: $ 62,500**

We will use computer simulations to study the motion of water and toxicant molecules in the selected lake under a variety of environmental conditions with different wind speeds and surface wave scenarios, including extreme weather. This study will provide guidance for optimum deployment of the chemical sensors, and will be used to explain and predict propagation and persistence of lake contamination.

Outcome	Completion Date
1. Quantified water currents and turbulence in the selected lake for representative seasons.	*12/31/2016*
2. Assessed and modeled the effects of lake water motions on toxicant transport	*06/30/2017*
3. Cross-compared and validated data obtained with simulation and field measurements	*06/30/2018*

Activity 3: Embarking the chemical sensor on a robotic boat for lake chemical mapping **Budget: $ 59,500**

We will build a computational interface to embark and connect the portable sensor on our robotic boat (already deployed in 3 Minnesota lakes). The robotic boat will be piloted in predesigned trials to allow the chemical sensor to analyze the gradient and spatial distribution of toxicants in the lake. The boat trajectories will be optimized based on computer models developed in Activity 2.

Outcome	Completion Date
1. Optimized boat trajectories with computational models	*08/31/2017*
2. Developed a computational interface between the boat and the portable sensor	*10/31/2017*
3. Field operation: Demonstrated spatial mapping of chemical toxicants in lake Harriet	*07/31/2018*

III. PROJECT STRATEGY

A. Project Team/Partners

This proposal builds on a complimentary expertise of multiple research groups at the University of Minnesota: *Project Partners Receiving Funds:* Prof. Abdennour Abbas (Dept. Bioproducts and Biosystems Engineering, College of Food, Agricultural and Natural Resource Sciences) will be in charge of the design, development and testing of the portable sensor, and coordination/management of the project. Prof. Ibrahim Volkan Isler (Dept. Computer Science) will interface the chemosensor station with an autonomous robotic boat and conduct field operations. Prof. Lian Shen (St. Anthony Falls Laboratory/Dept. Mechanical Engineering) will simulate lake water motions and predict toxicant transport. The University of Minnesota will receive the funds and provide the required space, facilities and administrative resources to conduct the research program. The cooperation of state agencies (MDH and MPCA) is also expected by providing access to sites, information and databases. *Project Partners Not Receiving Funds:* Profs. Matteo Convertino (School of Public Health), Elizabeth Austin-Manor (Large Lake observatory, UM Duluth), Nicholas Phelps (Veterinary Diagnostic Laboratory) and John Nieber (Dept. Biosystems Engineering) will be funded through other programs indicated in III-B.

B. Project Impact and Long-Term Strategy

Impact and long-term strategy: The proposed technological platform would significantly improve the capacity of State agencies to monitor organic toxicants in Minnesota large lakes, and enforce pollution regulations by:

- Tracking the origin, propagation and cycling of chemicals and clarifying the contributions of agricultural and industrial sources.
- Providing portable sensors to pollution control agents, which will enhance State programs such as SLICE (Sustaining Lakes In A Changing Environment) and the Fish Consumption Advisory.
- Enabling early detection of lake water impairment, thus providing the opportunity for the public, scientists, State agencies, and policy makers to take preventive and adaptive actions.

Dissemination: A new website (www.senslakes.com) dedicated to the project will be created to provide public and real-time updates on study progress. In addition, cooperators and sponsors will receive regular reports on the project advancement. The results will be communicated in seminars and peer-reviewed publications. *Funding Strategy:* Support for future development of the project will be requested from: MnDRIVE Transdisciplinary Program (U of M), Water for Agriculture Challenge Area (USDA-NIFA-AFRI), and Fluid Dynamics Program of the Chemical, Bioengineering, Environmental and Transport System Division (NSF).

C. Timeline Requirements

The project will be completed within 3 years. During year 1, a prototype of the sensor will be developed and tested. Year 2 will be dedicated to the optimization and field-testing of the portable sensor. The deployment of a robotic boat and mapping of the distribution of toxicants in the lakes will be conducted during the third year.

2015 Detailed Project Budget

Project Title: Autonomous Chemical Sensor for Water Toxicants Monitoring

IV. TOTAL ENRTF REQUEST BUDGET 3 years

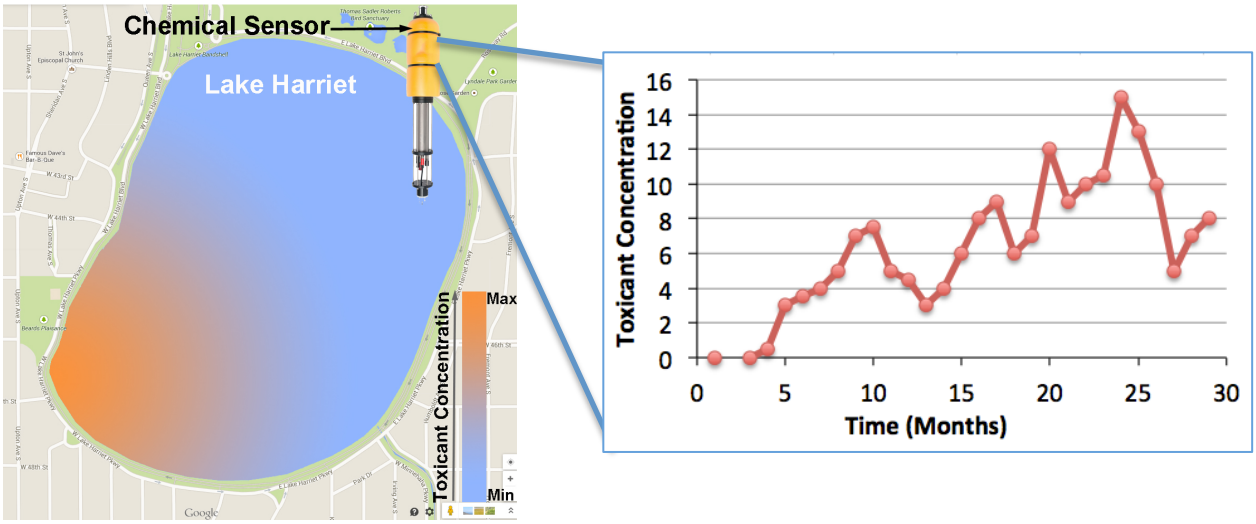
BUDGET ITEM	AMOUNT
Personnel:	
Summer salary for University of Minnesota faculty on 9-month appointment: Abdennour Abbas, Assistant Professor and Project Manager (75% salary, 25% benefits); 0.14 FTE for 2 years: $30,000. Ibrahim Volkan Isler, Associate Professor (Co-PI): $11,500 0.03 FTE for 2 years Lian Shen, Associate Professor (Co-PI): $15,000 0.04 FTE for 2 years	$ 56,500
Academic Graduate Research Assistants: (53% salary and 47% fringe); includes tuition benefit. Two students in year 1 (1.0 FTE; 2x $37,200), one student in Year 2 (0.5 FTE; $37,200), and two students in Year 3 (1.0 FTE; 2x $37,200). The students will be located in three different departments to perform the different activities of the project.	$ 186,000
Summer Graduate Research Assistants: (80% salary and 20% fringe) One student in year 1 (0.5 FTE; $8,500), one student in year 2 (0.5 FTE; $8,500) and two students in Year 3 (1 FTE; $17,000) The graduate students will perform data collection in the lakes during Summer.	$ 34,000
Contracts	
Equipment/Tools/Supplies:	
Laboratory Supplies: 2 customized fiber optics probes ($7,300), 3 Porous ceramic tubes ($8,500) Chemicals, Gloves, Reagents, Media ($15,000 for 3 years)	$ 30,800
Acquisition (Fee Title or Permanent Easements)	
Travel:	
Travel - to pay transport of equipment and robotic boat for field measurement in different lakes, pay mileage for project personnel to collect field data, organize project team meetings and meet with project cooperators and sponsors	$ 9,200
Additional Budget Items:	
Computer services: required by the department of computer science for any project.	3,500
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ **320,000**

V. OTHER FUNDS

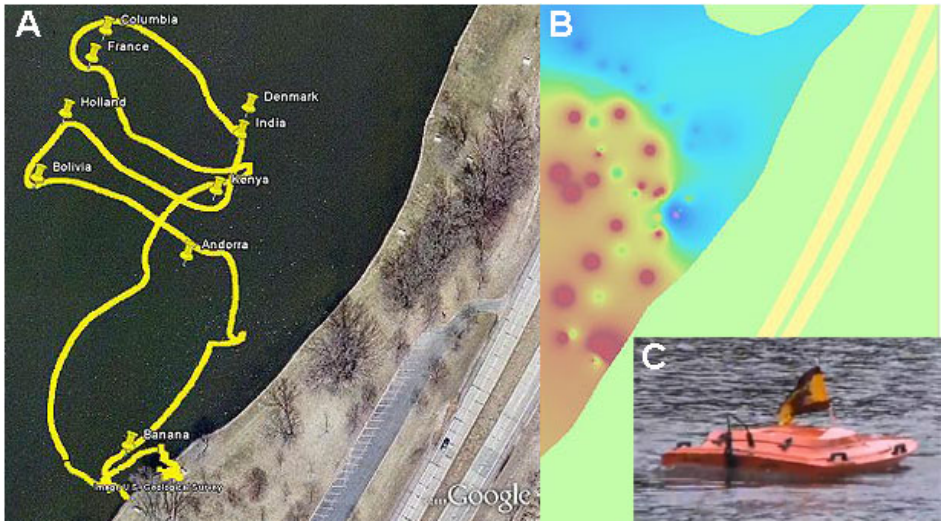
SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: *University of Minnesota IonE Dicovery Grant : Support for a postdocoral research associate*	$ 50,000	*Pending*
Other State $ To Be Applied to Project During Project Period:		
In-kind Services To Be Applied To Project During Project Period:		
University of Minnesota: Indirect Costs/Facilities and Administration (52%)	$ 122,000	Pending
Equipment loaned by BySpec Inc. (California): Agility TM 785/1064 Dual band Raman portable spectrometer.	$ 57,000	Secured
Funding History:		
Remaining $ From Current ENRTF Appropriation:	N/A	

On-site Measurement of Toxicants:

1- Continuous monitoring of changes in toxicant concentration overtime using a portable and continuous chemical sensor.



2- A Robotic sensing boat (Image C) is piloted in pre-designed trajectories (Image A) for sensing and mapping of the spatial distribution of toxicants in the lake (image B). (Isler et al., 2011)



Project Manager Qualifications

Dr. Abbas is an Assistant Professor in the Department of Bioproducts and Biosystems Engineering, College of Food, Agricultural and Natural Resources Science at the University of Minnesota Twin Cities. He directs the Biosensors and Bionanotechnology Laboratory, composed of one postdoc, two graduate research assistants and 4 undergraduate students. The development and translation of new sensors to real world applications has been the core of his research and expertise for the last 5 years, resulting in 23 publications, two patents and one book. His lab is currently focused on the application of sensors 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, particularly in the department of computer science (home department of Prof. Volkan Isler, Co-PI) and the St Anthony Laboratory/department of mechanical engineering (home department of Prof. Lian Chen, Co-PI).

Biographical Sketch:

A one page biographical sketch is attached below