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

Project Title: **ENRTF ID: 038-B**

Increasing Harmful Algal Blooms in Minnesota Lakes

Category: B. Water Resources

Total Project Budget: $ 395,249

Proposed Project Time Period for the Funding Requested: 3 years, July 2016 to June 2019

Summary:

Using field and laboratory measurements we will provide state agencies with a predictive model for harmful algal blooms, and communities with a web-based interface for monitoring algae in Minnesota lakes.

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Sponsoring Organization: U of MN - St. Anthony Falls Laboratory

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Visual schematic of proposed research and educational outreach

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

PROJECT TITLE: INCREASING HARMFUL ALGAL BLOOMS IN MINNESOTA LAKES

I. PROJECT STATEMENT

Harmful algae are photosynthetic organisms that have been populating a growing number of freshwater ecosystems including lakes, rivers, wetlands, and stormwater ponds in Minnesota (Lindon and Heiskary, 2009). Change in land use and agricultural practices have been contributing to the degradation of water quality in Minnesota aquatic ecosystems. Such human-induced activities along with the increasing summer lake water temperatures have been establishing fertile environmental conditions for triggering harmful algal blooms. The blooms are classified as harmful because the algae (e.g. *Microcystis*) release cyclic heptapeptide hepatoxins, called Microcystins, which are harmful to wildlife and humans. Quantifying intra-cellular toxin production and extra-cellular toxin concentrations in Minnesota lakes, under variable meteorological and lake physical conditions, is crucial for understanding, predicting, and mitigating harmful algal blooms. The excessive growth of harmful algae and toxin production presents risk to public health (drinking water supply and recreational activity), has economic importance (water quality and transparency) and has ecologic significance (wildlife survival). Water treatment plants are seriously challenged to mitigate algal toxin production: in Toledo, Ohio, the Collins Park Water Treatment Plant recommended more than 400,000 residents to not drink water as a consequence of Microcystin contamination from Maume River and Lake Erie on August 1st , 2014. The biological and chemical processes that trigger excessive growth of harmful algae have been studied extensively, but the meteorological conditions and corresponding lake physical processes that produce, sustain, and destroy algal growth and toxin production have received relatively little attention. In collaboration with the Minnesota Pollution Control Agency, we propose laboratory and field investigations on harmful algal blooms to develop 1) predictive models, 2) Internet-based infrastructure for forecast and public alert, and 3) state wide education outreach and training programs.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Investigate lake processes and meteorological conditions triggering harmful algal blooms and toxin production **Budget: $259,036**

The proposed research will determine how lake physical processes and meteorological conditions control *Microcystis* bloom and toxin production in Minnesota lakes. The research will be conducted under laboratory and field conditions. Lake George (Blue Earth County) and Halsted Bay of Lake Minnetonka (Hennepin County) are selected for the field measurements. Harmful algal blooms have been documented in both lakes. Additional ten lake field sites, under existing monitoring programs by the Minnesota Pollution Control Agency, will be included in the investigation. Controlled laboratory measurements will be conducted at the St. Anthony Falls Laboratory, University of Minnesota, where we have developed experimental bioreactors and flumes to study *Microcystis* physiology under controlled temperature, light, nutrient, and turbulence conditions. The proposed toxin measurements will be quantified at the Center for Drug Design, University of Minnesota. Filed and laboratory observations will be used to develop methods and tools for detecting and predicting harmful algal blooms and toxin production in Minnesota lakes.

Outcome	Completion Date
1. Quantify meteorological conditions (temperature, wind), lake physical variables (temperature, velocities, light) and nutrient concentrations (nitrate and phosphate) that trigger *Microcystis* bloom and toxin production in Minnesota lakes	Apr *2017*
2. Determine a combination of meteorological-physical-chemical conditions that maximizes intra-cellular and extra-cellular toxin production.	Dec *2017*
3. Test and verify, meteorological-physical-chemical conditions predicting *Microcystis* bloom and toxin production.	Jan *2018*
4. Develop a model for predicting the onset of *Microcystis* bloom and toxin concentrations in Minnesota lakes *(Cloud mapping & Statistics)*	May *2018*

Activity 2: Develop Internet-based infrastructure for tracking harmful algal blooms **Budget: $64,759**

Monitoring harmful algal blooms is difficult because of their patchy and transient distribution in lakes. In addition, toxin detection and harmful algal bloom identification usually take several days after the collection of samples. For the development of real-time predictive models, we plan to use identified and verified proxies emerging from the research outcomes of activity 1. A guiding principle will be to investigate readily available proxies including air and water temperatures, wind speed, lake morphometry, lake stability, and stratification. The overall objective is to develop an Internet-based tool for alerting and predicting harmful algal blooms and toxin production in Minnesota lakes (*algae tracker*). A similar approach has been used to alert and forecast pollen concentration (*allergy tracker*) by the Internet-based weather prediction models.

Outcome	Completion
1. Develop Internet-based interface for tracking harmful algal bloom and toxin production in Minnesota lakes (forecast and public alert)	Jan 2018

Activity 3: Public and education outreach: Prediction, detection, impact mitigation **Budget: $71,452**

Our outreach program will promote and enhance education and communication on harmful algal bloom in freshwater ecosystems, focusing on monitoring and forecast, human and ecological health risk assessment, research and mitigation strategies. The audience will be water quality managers, lake management associations, public and government agencies, and drinking water utilities. The educational programs will include training on 1) the proposed Internet-based harmful algal bloom prediction system: *algae tracker*, 2) field detection and online reporting, and 3) mitigating the detrimental impacts of harmful algal blooms in Minnesota lakes.

Outcome	Completion
1. Assess public awareness, establish focus groups, and produce introductory videos	Dec 2016
2. Development of research-based, and web accessible outreach materials	May 2018
3. Establishment of informational portal on harmful algal blooms on social media	May 2018
4. Demonstration and training of the proposed Internet-based harmful algal bloom detection, identification and prediction techniques.	Oct 2018
5. Dissemination of findings through scholarly publications, media, and workshops.	Jun 2019

III. PROJECT STRATEGY

A. Project Team/Partners

The project team consists of the Principal Investigator (PI) Prof. Miki Hondzo (University of Minnesota) and co-PIs Prof. Michele Guala, Prof. Christine Salomon, and Dr. Shahram Missaghi. Project Partner not receiving funds: Steven Heiskary (Minnesota Pollution Control Agency).

B. Project Impact and Long-Term Strategy

Harmful algal blooms with the toxin-producing cyanobacterium *Microcystis* are a global environmental concern worldwide. A key question in the proposed study is: What combination of environmental non-biological conditions enhances the blooms of *Microcystis* and toxin production in Minnesota lakes? Predictive models of *Microcystis* growth and toxin production in lakes, integrated with weather forecast, will be the core of an Internet-based monitoring and alerting system. The proposed website will assist water quality managers, public, government agencies, and drinking water utilities in the prediction and management of the detrimental impacts of harmful algal blooms in Minnesota lakes.

C. Timeline Requirements

The project will start in July 2016 and end in May 2019. Project investigators will develop and deliver regional workshops on harmful algal bloom identification, reporting, prediction, and mitigation. The educational outreach will be delivered throughout Minnesota through in-person and online presentations.

Reference: Lindon M., and S. Heiskary (2009). Blue-green algal toxin (microcystin) levels in Minnesota lakes, *Lake and Reservoir Management*, 25, 240-252.

2016 Detailed Project Budget

Increasing Harmful Algal Blooms in Minnesota Lakes

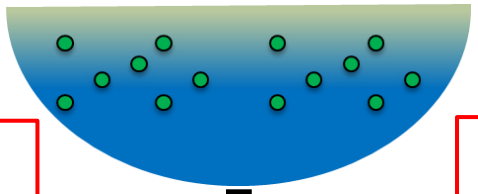
IV. TOTAL ENRTF REQUEST BUDGET: $395,249.00 for 3 years (Itemized budget below)

Personnel: Miki Hondzo, PI (75% salary, 25% benefits); 5% FTE summer salary for years 1 - 3.: Hondzo will be responsible for submitting yearly progress reports to the LCCMR. Hondzo will lead the proposed laboratory and field work on algal growth kinetics and nutrient uptake under variable environmental conditions. He will be responsible for organizing analyses of Microcystis concentration, dissolved oxygen, pH, temperature and nutrient levels. The proposed scaling analyses, integration of laboratory and field measurements will be conducted by Hondzo and Guala.	$	29,988
Michele Guala, CO-PI (75% salary, 25% benefits); 5% FTE summer salary for years 1 - 3.: Guala brings critically important expertise in the fluid dynamics, turbulence, and particle tracking to the project. His laboratory work will be focused on flow measurements and turbulence characterization, in addition to Microcystis velocities and concentration in the experimental setups. The proposed scaling parameters, integration of laboratory and field measurements will be conducted by Guala and Hondzo. Graduate student, Anne Wilkinson, will be advised by Guala and Hondzo.	$	20,225
Christine Salomon, CO-PI (75% salary, 25% benefits); 5% FTE summer salary for years 1 - 3.: Salomon brings crucial experience in the analysis of toxin concentrations to the project. Her work will be focused on the analysis of microcystin concentrations in the proposed laboratory and field setups.	$	22,160
Shahram Missaghi, CO-PI (75% salary, 25% benefits); 15% FTE for years 1 and 2.: Will be reponsible for designing and implementing the proposed educational outreach (Activity 3).	$	33,852
Patrick Arnold, Information Technology (78% salary, 22% fringe): Will be responsible for developing Internet-based prediction models and harful algal blooms reporting	$	12,267
Technician (78% salary, 22% fringe): The technician will be responsible for the daily measurements of microcystin concentrations in the field and laboratory setups.	$	44,740
Graduate student (59% salary, 41% fringe): Anne Wilkinson, NSF Fellow, will be funded during the third year of project (4th year of her PhD). She will be responsible for collecting laboratory data, integrating and presenting the data, and developing and verifying mechanistic theories on Microcystis growth and toxin production under variable	$	134,525
Undergraduate student (100% salary): One undergraduate student will be hired each year for two months during summer. The student contribute to the proposed laboratory measurements, and development of visualization setups for enhanced Microcystis growth and toxin production	$	9,600
Curicullum Design & Editing, Algae testing & sampling kits, video, guides, : Educational outreach	$	9,750
Supplies: General supplies for laboratory and field analyses are quantified based on previous experience. Year 1 & 2 ($12,000), Year 3 ($10,000). The amounts will include 1) optical components for PIV/PTV experiments (one fixed focal macro lens, laser mirrors and mounting posts), 2) chemical components for Microcystis laboratory experiments (BG-11 medium, Microcystis culture, nitrogen gas, carbon dioxide gas, acetone, reagents for nutrient analysis, microcystin detection), and 3) parts and labor for laboratory bioreactor modifications and field deployments.	$	34,000
Supplies: for follow up and confirmation harmful algal bloom tests & needed materials, sampling kits; harful algal bloom identification demonstration sets, & materials, for three state wide citizen workshops and ten on-site traning	$	9,525
Equipment : A laboratory fluorometer (Turner Designs) will be used for the proposed analysis of chlorophyll, nitrate and phosphate concentrations in the laboratory and experimental setups	$	8,792
Travel: Each year one principal investigator and the graduate student will present research data and progress at the state conference and propoed state outreach workshops.	$	7,500
Mileage, lodging and meals for travel (9 member citizen work group, 2 CO-PI trainers) to and between the citizen work groups, on-site training and workshops, and work group meeting to develop HAB guides and	$	12,300
Additional Budget Items: Prinitng, on-line survey fees, food for citizen gatherings and workshops, final report publication and manuscript page fees	$	6,025
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	**$**	**395,249**

V. OTHER FUNDS	**AMOUNT**	**Status**
Unrecovered F & A (amount of overhead required by the UMN, but not applicable to Minnesota LCCMR projects)	$172,713	*Secured*
Funding History: salary and tuition of NSF-funded student Anne Wilkinson that is currently investigating algal blooms for her PhD thesis. The total, for the period prior to the project start date September 2013 to June 2016, is based on the 51,500 yearly NSF contribution.	$ 141,625	Secured

Increasing Harmful Algal Blooms in Minnesota Lakes

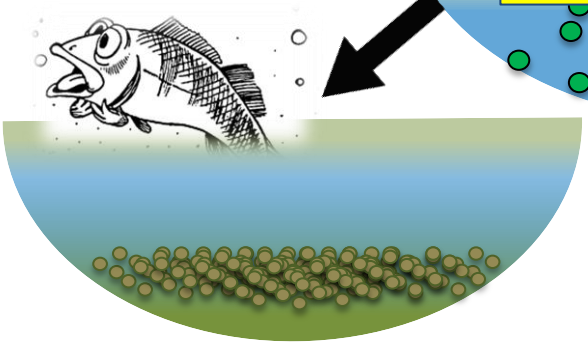
Normal lake conditions with few algae



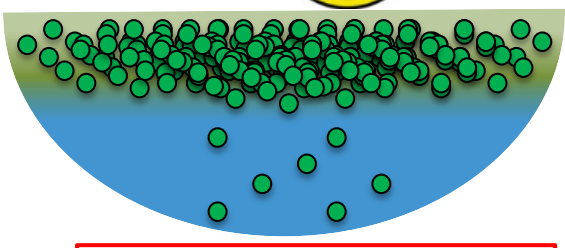
Cause: warm temperatures with changing climate

Cause: excessive phosphorus and nitrogen input

Harmful Algal Bloom



Toxic

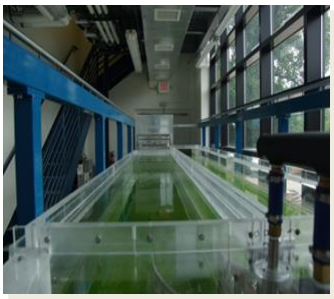


Effects: Dissolved oxygen depletion and fish kill

Effects: Toxin production (human health, wildlife survival, water supply)

Proposed research

Field monitoring → MN LAKES



Controlled ← investigations LABORATORY

Public and education outreach

Online algae tracker (harmful algal bloom reporting and forecast)

Toxin field detection and mitigation

PROJECT MANAGER QUALIFICATIONS

Miki Hondzo, Professor, Department of Civil, Environmental, and Geo- Engineering, University of Minnesota

Education

Postdoctoral	St. Anthony Falls Lab.	Experimental Fluid Mechanics		1993-1995
	Michigan State University	Environmental Engineering		1992-1993
Graduate	University of Minnesota	Civil Engineering	Ph.D.	1992
	Free University of Brussels	Surface Water Hydrology	M.Sc.	1988

Professional experience

Full Prof. University of Minnesota, Department of Civil, Environmental, and Geo- Engineering, 2006-present

Associate Prof. University of Minnesota, Department of Civil, Environmental, and Geo- Engineering, 1999-2006

Assistant Prof. Purdue University, School of Civil Engineering, 1995-1999

Awards/Recognitions

2008 **Samuel Arnold Greeley Award**. Environmental Engineering Division, American Society of Civil Engineers. Award for the best research paper "Modeling heavy metal removal by plant species and sediment."

2006 "**Outstanding** *Limnology and Oceanography* **Reviewer**." Recognized by *Limnology and Oceanography* journal for reviewing service.

2000 **Rudolph Hering Meda**l. Environmental Engineering Division, American Society of Civil Engineers. Award for most valuable contribution to the increase of knowledge in the environmental branch of the engineering profession for the paper, "Diffusional mass transfer at the sediment-water interface."

1997-2002 **CAREER AWARD**, **National Science Foundation**
(Division of Chemical and Transport Systems)

1997 **Founders Award** for the best paper "Long-term lake water quality predictors", appearing in the 1996 year of *Water Research*. The USA National Committee of International Association on Water Quality.

Selected Publications (relevant to this LCCMR proposal; total 71 publications)

Hansen, T.A., M. **Hondzo**, J. Sheng**,** and M.J. Sadowsky (2014). Microscale measurements reveal contrasting effects of photosynthesis and epiphytes on frictional drag on the surfaces of filamentous algae, *Freshwater Biology*, 59(2), 312-324.

Hansen, T.J., M. **Hondzo**, M.T. Mashek, D.G. Mashek, and P.A. Lefebvre (2013). Algal swimming velocities signal fatty acid accumulation, *Biotechnology and Bioengineering*, 110(1), 143-152.

Chengala, M., M. **Hondzo**, and D.G. Mashek (2013). Fluid motion mediates biochemical composition and physiological aspects in the green alga *Dunaliella primolecta* Butcher, *Limnology and Oceanography: Fluids and Environments*, 3, 74-88.

Missaghi S., **Hondzo** M., and C. Melching (2013). Three-Dimensional lake water quality modeling: Sensitivity and uncertainty analyses, *Journal of Environmental Quality*, 42(6), 1684-1698.

Hondzo, M., and A. Wüest (2009). Do microscopic organisms feel turbulent flows?, *Environmental Science and Technology*, 43(3), 764-768.

ORGANIZATION DESCRIPTION

The proposed research will be guided by the St. Anthony Falls Laboratory, University of Minnesota. The laboratory is particularly experienced in conducting and analyzing filed measurements of water quality in lakes, rivers, and reservoirs. Automated data collection, sampling protocols, wireless data transfer and display over the Internet have been developed for several state and federal funding agencies at the laboratory. The EcoFluids Laboratory, developed by PI Hondzo, allows researchers to study the interactions among fundamental fluid mechanics, microalgal metabolism, and chemical processes in aquatic environments.