**PROJECT TITLE: Occurrence of Algal Toxicity in Minnesota Waters**

**I. PROJECT STATEMENT**

*Real-time and cost-effective techniques to quantify the onset, transport and mitigation of algal toxicity in Minnesota waters are urgently needed*. Cyanobacteria are a common component of the algal community in Minnesota’s waters. The rapid growth of cyanobacteria often leads to blooms that cannot only degrade water quality but also produce cyanotoxins. The cyanotoxins can bio-accumulate in fish, mussels, and zooplankton and affect the liver, kidney, and reproductive system of living organisms. The most commonly found cyanotoxin in Minnesota’s water is Microcystin (MC). Over the past three years (2016 ENRTF Appropriation), we have developed and tested unique *in situ* monitoring technologies of water quality and algal biomass and formulated simple predictors of algal biomass based on water temperatures, meteorological conditions, and morphometry in three Minnesota lakes. The funding, ending this year, has helped us increase our understanding of harmful algal blooms (HABs), develop an automated continuous water quality station (buoy), acquire drone technology to measure algal biomass and temperature, and initiate the annual ***MN Harmful Algal Bloom Workshop*** training over 100 water resources professionals and practitioners. An urgent need is to implement the developed technologies and models to a wide range of Minnesota lakes and to document prediction tools to detect the onset, transport, and mitigation of cyanobacterial toxins. Our collaborative team; including Minnesota Pollution Control Agency (MPCA), Minnesota Department of Health (MDH), University of Minnesota (UMN) St. Anthony Falls Laboratory (SAFL), and UMN Extension; proposes to:

1. Quantify Microcystin concentrations using the buoy, spectroradiometer, and drone technologies to develop cyanotoxin early detection protocols and prediction models;
2. Apply and verify the cyanotoxin detection protocols and models in 12 Sentinel lakes in Minnesota; and
3. Disseminate the findings and provide hands-on training to the public, regulators, and stakeholders to detect and mitigate cyanotoxins in Minnesota waters.

**II. PROJECT ACTIVITIES AND OUTCOMES**

|  |  |
| --- | --- |
| **Activity 1:** *Quantify Microcystin concentrations using the buoy, spectroradiometer, and drone technologies to develop cyanotoxin detection protocols and prediction models* In collaboration with MPCA, one lake will be selected for high-resolution algal, water quality, and cyanotoxin monitoring by drone, buoy, toxin (ELISA) testing kits, and real-time spectroradiometer measurements. The spectroradiometer measurements (e.g., ASD FieldSpec) will detect the [solar irradiance](https://en.wikipedia.org/wiki/Solar_irradiance), surface reflectance and water leaving radiances at the different growth stage of cyanobacteria. The measurements will provide a unique opportunity to discover the role of environmental variables in increasing algal biomass and Microcystin concentrations in Minnesota lakes. The unique features within visible and near-infrared (VNIR) bands will specify the most sensitive wavelengths for the detection of cyanobacteria and Microcystin concentrations. The specified wavelengths are crucial for the development of prediction models and accurate detection of algal biomass and Microcystin concentrations by spectroradiometer and drone technologies. The prediction models of cyanotoxin concentrations and algal biomass will be explored by simple Excel spreadsheet models with input from handheld spectroradiometer, and areal models with input from the spectral drone measurements.  |  |
| **Outcome** | **Completion Date** |
| *1.* Water samples collected, analyzed for cyanobacterial biomass and Microcystin concentrations, and the corresponding spectral bandwidth. | 12/1/2021 |
| *2.* Formulate spreadsheet type prediction models (point and areal) for the detection of Microcystin concentration and algal biomass.  | 12/1/2021 |
| **Activity 2:** *Apply and verify the cyanotoxin detection protocols and models* *12 Sentinel lakes*The proposed outcomes of Activity 1 will be verified in 12 Sentinel lakes in collaboration with the MPCA. We will augment the existing sampling protocol of MPCA by simultaneously collecting the handheld spectroradiometer measurements and flying the drone over the specified lakes. The proposed field monitoring over the range of lakes and ecoregions will provide a unique opportunity to verify the proposed models and assess the reliability of using the drone and spectroradiometer technologies to detect real-time Microcystin and algal concentrations.  |  |
| **Outcome** | **Completion Date** |
| *1.* Quantify Microcystin concentration and algal biomass, by collecting water samples, spectroradiometer, and drone technology in 12 Sentinel lakes in Minnesota. | 12/1/22 |
| *2.* Verification and documentation of accuracy of the Microcystin concentrations and algal biomass measurements by the comparison of water sample laboratory analysis, *in situ* spectroradiometer and drone technology detection.  | 12/1/22 |
| *3.* Establish prediction models and protocols for sensing algal biomass and Microcystin concentrations by drone and spectroradiometer technologies. | 06/1/23 |
| 4. Document mitigation strategies (physical/chemical and mechanical) of algal toxicity by implementing real-time and *in situ* spectroradiometer and drone technologies.  | 06/30/23 |
| **Activity 3:** *Educational outreach: Disseminate the findings and provide hands-on training to the public, regulators, and stakeholders to detect and mitigate cyanotoxins in Minnesota waters*.We will actively seek end-users inputs on how they would want to use the proposed spreadsheet-type models, spectroradiometer, and drone technology through the existing HABs website[[1]](#footnote-1). We will do this by delivering an interactive session at the Feb. 2020 MN Extension Lake Workshop series.  We propose to produce a series of tutorial videos to educate potential users on how to a) conduct spectroradiometer and drone measurements, b) upload files, c) visualize the data, d) interpret the cyanobacterial biomass and Microcystin concentrations, and e) apply feasible mitigation strategies including the effectiveness of clays in flocculating and removing the HAB cells, and dispersing the HAB cells by *in situ* aeration. We will offer on-demand online webinars and two in-person training workshops on the use and the proposed technologies. The training will provide the water resource practitioners a much-needed tool for detecting and mitigating cyanotoxins in Minnesota waters.  We will also provide live training on board using the new MN HAB Educational Trailer throughout the State.

|  |  |
| --- | --- |
| **Outcome** | **Completion Date** |
| **1.**User survey and input sessions to identify top desired features among end users |    20/02/20 |
| **2.**Tutorial materials, video productions, and integration in HABs website |    12/1/21 |
| **3.**Online webinar training and hands-on in-person training workshops  |    06/30/23 |

 |  |

**III. PROJECT PARTNERS AND COLLABORATORS: A. Partners receiving ENRTF funding**

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Title** | **Affiliation** | **Role** |
| Miki Hondzo | Professor | U of MN, CEGE | Lead Investigator |
| Ardeshir Ebtehaj | Assistant Prof. | U of MN, CEGE | Co-investigator |
| Shahram Missaghi | Extension Professor  | U of MN, Extension | Co-investigator |

**IV. LONG-TERM IMPLEMENTATION AND FUNDING:** The **outcomes** will lead to predictive models and leverage drone sensing technology for real-time monitoring and forecasting of cyanotoxin and algal biomass in Minnesota’s waters. Through the UMN Extension program, Dr. Missaghi will facilitate **outreach** of the project. In the available website1, we will design an online education module tentatively entitled “Environmental Factors and Drone Sensing of Cyanotoxins.” The project will **benefit the economy** of Minnesota’s recreation industry, water treatment plants, and fisheries by a) ensuring the public can use lakes safely, free from exposure to cyanotoxins, b) establishing **early detection technologies** and forecast models to predict cyanotoxin bloom events with a 1-3 day lead time to resource managers, and c) documenting feasible mitigation strategies. The MPCA supports the project through scientific and field-scale **collaborations**. At least four meetings will be organized with MPCA’s research scientists Dr. Matt Lindon and Dr. Emily Brault for knowledge exchange. The second year of the project will include working with MPCA to validate the spectroradiometer and drone technologies in 12 Sentinel lakes.

**V. TIMELINE REQUIREMENTS:** The proposed project will be completed in three years.

1. https://extension.umn.edu/shoreland-property-owners/blue-green-algae-minnesota-lakes [↑](#footnote-ref-1)