Lake Anita Louise Peroxide Treatment Summary December 2016

Prepared for:
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Abstract

During the winter of 2016, a cyanobacteria bloom of *Planktothrix rubescens* resulted in accumulations of the hepatotoxin microcystin in Lake Anita Louise in Frederick County, Maryland. Microcystin concentrations exceeded 300 ppb, presenting health hazards for residents, wildlife, and domestic animals in the surrounding community. In a preemptive technique to eliminate cyanobacteria and prevent a 2017 winter bloom and accumulation of toxin, 350 pounds of GreenCleanPro® hydrogen peroxide (H_2O_2) was added to the Lake on December 4, 2016. Water quality, plankton abundances, and toxin levels of the lake were tested before, during, and after the addition of H_2O_2. Results indicate that in the short-term, this treatment was effective in limiting cyanobacteria.

Introduction

Toxic cyanobacteria are a world-wide concern, generally increasing in fresh and low brackish waters due to nutrient enrichment, warming temperatures, and stable water columns. This results in potentially dangerous concentrations of toxins that can cause severe illness and occasional death in humans, wildlife, and domestic animals drinking from the water or consuming fish in the bloom-dominated waters (e.g., Paerl and Otten 2013). In 2010 and 2016, a toxin-producing cyanobacterium *Planktothrix* sp. was identified in two Frederick County lakes, Fountain Rock Quarry and Lake Anita Louise, respectively, resulting in microcystin levels in the two systems well over the state's advisory exposure limits of 1 and 10 ppb for drinking water and recreational use.

In Lake Anita Louise, microcystin levels exceeded 300 ppb in the winter of 2016, inducing illness in a local neighborhood dog that drank from the lake. The lake's surface was densely pink from surface aggregations of *P. rubescens* (Fig. 1), a cold water-preferring cyanobacterium common to many European lakes (Kurmayer et al. 2016). As a consequence, the Lake Linganore home owners association (LLA) funded Hood College's Center for Watershed and Coastal Studies (CCWS) to routinely monitor water quality and plankton taxa in the lake from June 2016 to the present. Through discussions of the summer's monitoring results, the LLA decided to reduce potential winter blooms of the cyanobacterium by

Figure 1. Surface bloom on *Planktothrix rubsescens* in Lake Anita Louise, winter 2016 (K.G. Sellner).

lowering the lake's water level and applying hydrogen peroxide (H_2O_2) that has been shown to effectively reduce cyanobacteria and toxin concentrations in several lakes in the Netherlands (Matthijs et al. 2012).

Methods

Sampling of Lake Anita Louise (LAL) was conducted on 12/3/16 to determine ambient water quality conditions and plankton taxa present prior to the addition of 350 lbs of GreenCleanPro® on 12/4/16; similar sampling was undertaken following peroxide additions on 12/4, 12/5, 12/7, and 12/12 (Fig. 2). Surface water samples were collected from 5 locations (Fig. 3) around the lake and at the surface, mid-depth, and immediately above the bottom at the deepest location (vertical station) of the lake.

Figure 2. Hydrogen peroxide application to Lake Anita Louise.

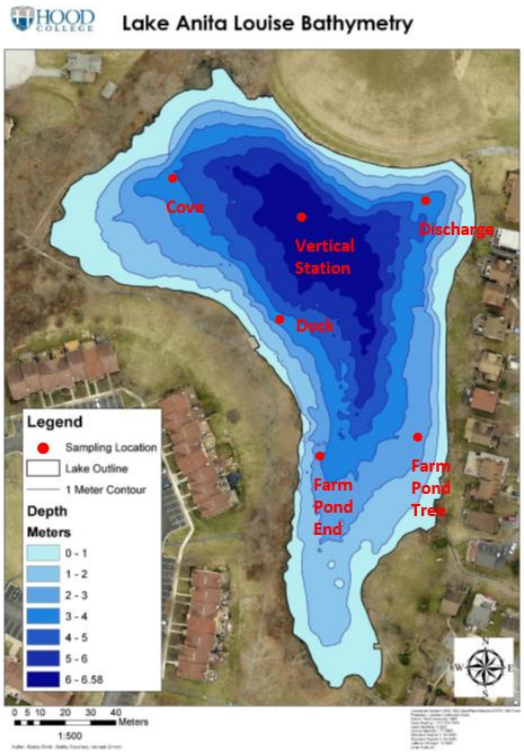


Figure 3. Map of Lake Anita Louise sample locations.

Sampling at the vertical station included determination of total depth, vertical profiles of temperature, conductivity, and dissolved oxygen using a YSI multi meter, secchi depth, and collection of discrete samples at 0.5 ft, 8 ft, and just above the bottom (16 ft - 18 ft). Hydrogen peroxide concentrations at all surface stations as well as mid- and bottom depths for the vertical station were estimated using a Hach HYP-1 Peroxide Titration Kit; fluorescences of chlorophyll and phycocyanin were also determined using a Turner Designs Aquafluor® fluorometer at all stations and depths. Plankton composition (examination via light microscopy) and active chlorophyll-*a* (Strickland and Parsons 1972) were determined from the 3 depths at the vertical station.

Microscopy was conducted on 45 mL samples decanted from the 3 discrete samples collected from the deepest location of the lake. Following centrifugation at 3000 g for 5 min, 42 mL of supernatant was discarded and the bottom pellet resuspended. Five drops (0.185 mL) were transferred to a microscope slide and a cover slip placed over the volume. Organisms in 5 fields were enumerated and recorded.

Results

Peroxide Concentrations

Ambient peroxide levels were low on 12/3 prior to lake treatment with GreenCleanPro® (Figs. 4 and 5). Initial peroxide present was likely produced from normal oxidation of lake organic matter via ultraviolet radiation producing reactive oxygen species. Following the addition of H_2O_2, peroxide concentrations increased to 3 mg/L and rapidly declined to initial, pre-treatment levels shortly thereafter, reflecting the short half-life of hydrogen peroxide in natural waters.

Water Transparency

Secchi disc depths dramatically increased following peroxide dispersal in the lake, indicating substantial reduction in suspended particles (algae, cyanobacteria) and colored dissolved organic matter. The pre-treatment secchi depth approximated 0.73 m (2.4 ft), but following peroxide additions, secchi depth increased to 0.92 - 1.2 m (3.1 - 4 ft) until late in the week following treatment. The increased light penetration would be expected if cells were lysed by the strong oxidizer, peroxide.

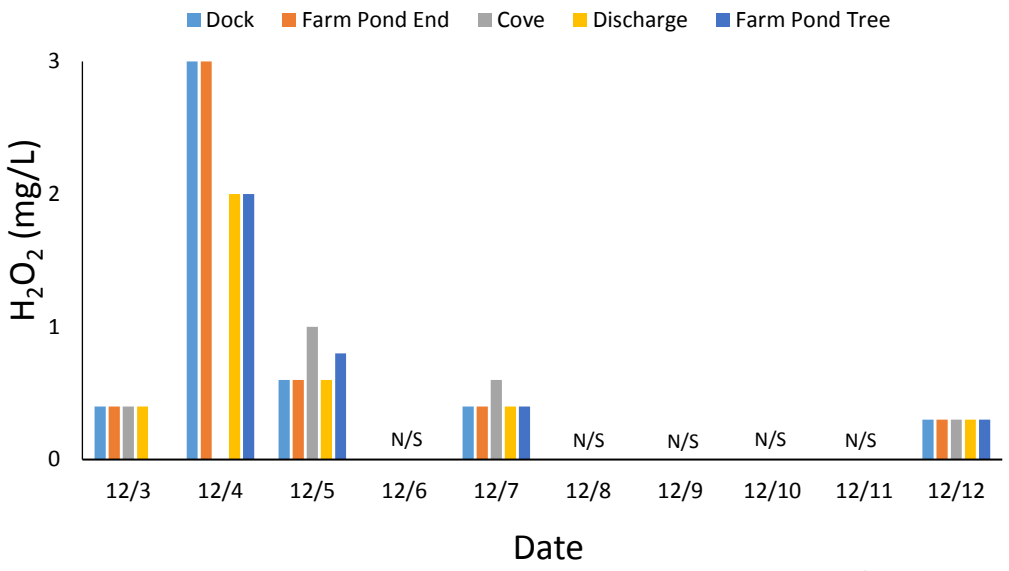


Figure 4. Surface concentration of hydrogen peroxide at 5 stations throughout LAL. N/S indicates dates Not Sampled.

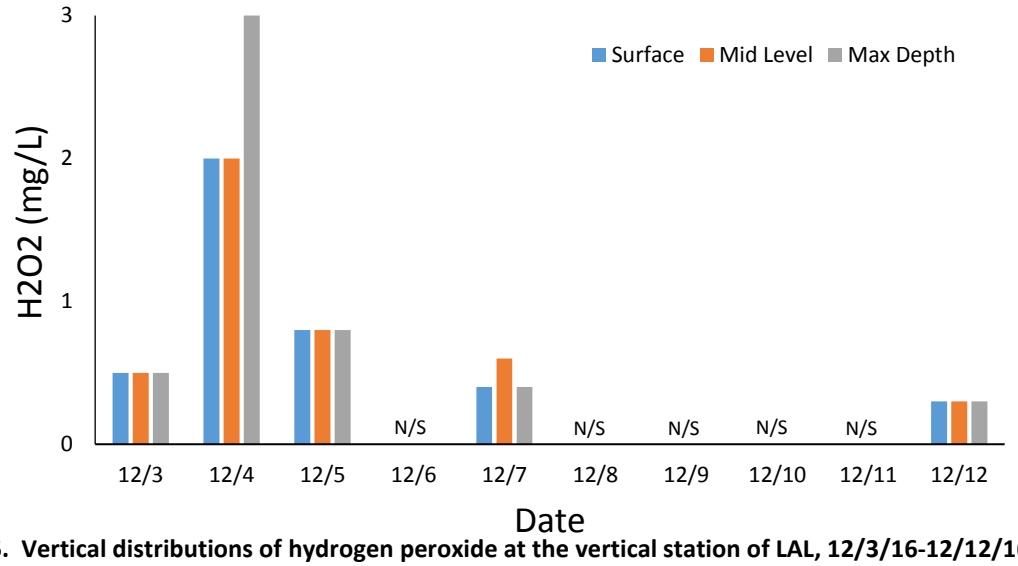


Figure 5. Vertical distributions of hydrogen peroxide at the vertical station of LAL, 12/3/16-12/12/16. N/S indicates dates Not Sampled.

Phytoplankton (Cyanobacteria and non-cyanobacteria)

Over the entire period (pre-to-post treatment), the total number of phytoplankton and cyanobacteria remained relatively constant over time (Fig. 6). A slight reduction is apparent 24 h after the hydrogen peroxide dispersal, but abundances recovered and stabilized. However, the ratio of filamentous cyanobacteria to overall algal species declined following treatment (Fig. 7), suggesting that the H_2O_2 specifically reduced filamentous cyanobacteria. The apparent constant abundances noted in Figure 1 suggest other taxa increased to compensate for the lower cyanobacteria levels, detected as a 2-3 fold increase in the colonial flagellate *Synura* sp.

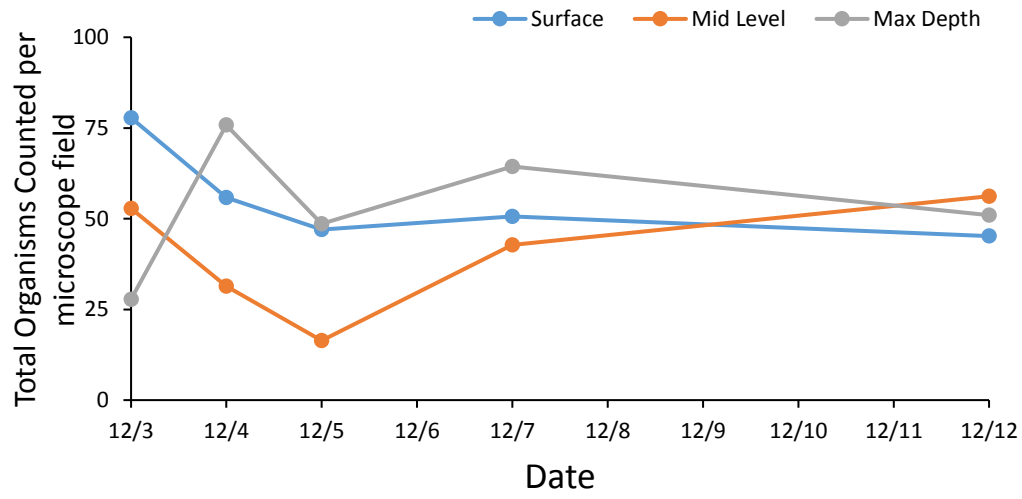


Figure 6. Contributions of cyanobacteria and non-cyanobacteria to total phytoplankton abundances at 3 depths of the vertical station in LAL (based on abundances/5 fields). Each filament is counted as a single organism.

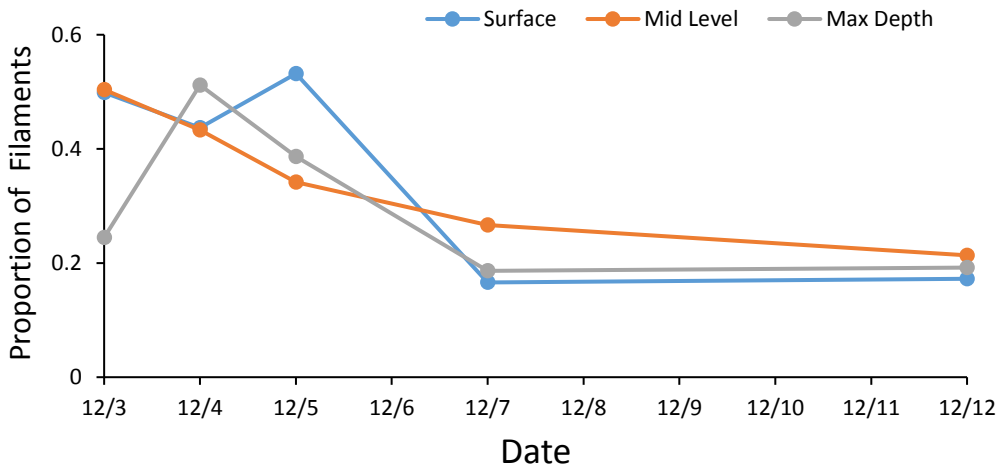


Figure 7. Percentages of cyanobacteria filaments at the 3 depths sampled at the LAL vertical station (based on abundances/5 fields).

Absolute densities of filaments for the study period are shown in Figure 8. Highest abundances were noted immediately prior to treatment, at 1780 filaments/mL. Densities declined 4-5 fold 3-8 d after treatment (385 and 358 filaments/mL, respectively) indicating the selective loss of the cyanobacteria to peroxide.

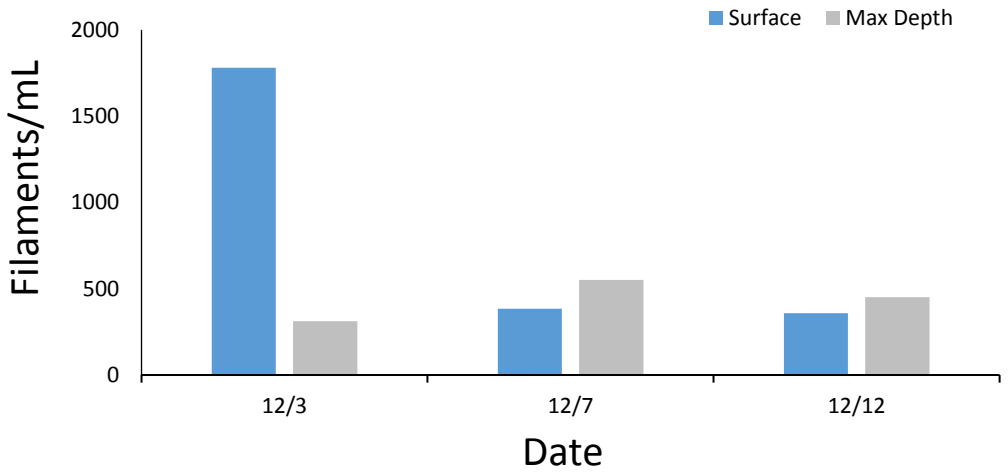
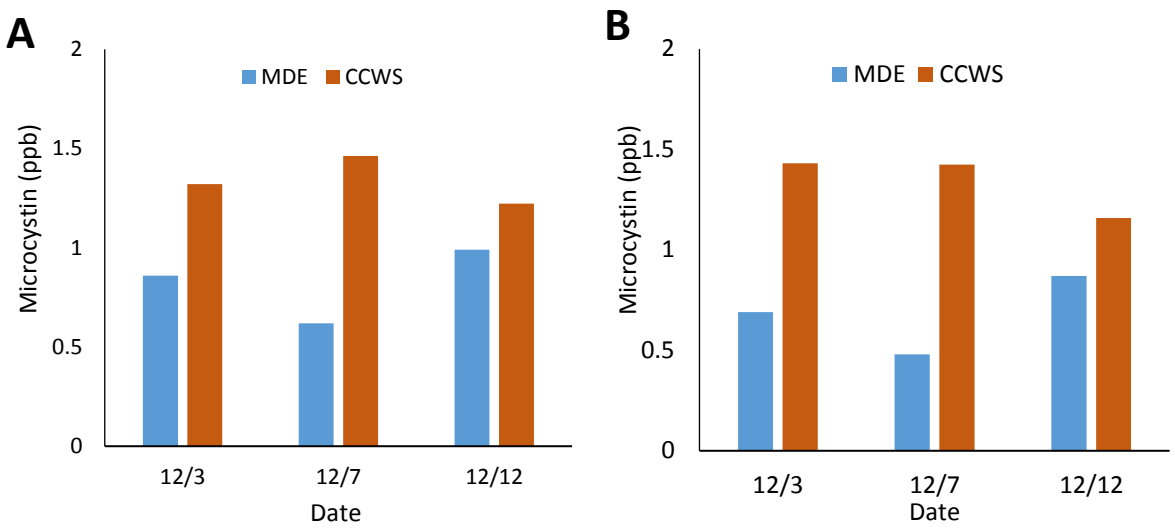


Figure 8. Absolute cyanobacteria filament abundances pre- (12/3) and post- (12/7, 12/12) treatment in LAL.

Toxin Concentrations

Microcystin concentrations were estimated by two laboratories, those of the Maryland Department of the Environment which provides microcystin analyses for state water bodies and the CCWS which is establishing its own toxin testing capability. Low and nearly constant microcystin concentrations (0.4-1.5 ppb) were noted throughout the study period, pre-treatment to days after peroxide additions (Fig. 9). This was not unexpected as no cyanobacteria bloom was present prior to treating the lake, and hence only minimal levels would be found.



Figures 9. Microcystin concentrations noted in surface (A) and bottom (B) samples from the LAL vertical station prior to and 3-8 days after peroxide treatment.

Discussion and Conclusions

The addition of GreenCleanPro® to LAL was efficacious. Hydrogen peroxide concentrations increased to a maximum of 3 mg/L and reduced cyanobacteria densities. Three days post-peroxide treatment, total abundance of cyanobacteria filaments at the surface decreased 4-5 fold; this rapid cell loss resulted in an increase in water column transparency. These results suggest that low peroxide concentrations can effectively target cyanobacteria species, consistent with observations made by Matthijs et al. (2012) in Dutch mitigation projects. In LAL, non-cyanobacteria increased 3 and 8 d after treatment, primarily the colonial flagellate *Synura* sp., yielding ambient chlorophyll-*a* concentrations >100 µg/L (data not shown), indicating low peroxide levels do not impair eukaryotic populations, again similar to conclusions of Matthijs et al. (2012, 2016). Further, although not quantified, crustacean zooplankton were abundant and actively swimming in LAL samples collected on 12/5 and 12/7, mimicking observations by the Dutch group in their systems with low peroxide levels.

Microcystin levels were not affected by the peroxide treatment, remaining low and constant pre- and post-treatment. This could reflect low filament densities and intracellular toxin levels and hence, decreases in filament abundances might have only resulted in minimal microcystin levels that could easily be oxidized by the short-term increase in peroxide.

In conclusion, although promising, these short-term results indicating reductions in cyanobacteria filaments following peroxide treatment warrant some caution. Filamentous cyanobacteria are still present in the lake which could serve as a 'seed' population and a resurgence in growth this winter may be observed if suitable growing conditions occur. Cold

water temperatures and low light levels provide an opportunity for seed populations of cyanobacteria to proliferate, while other non-cyanobacteria species will be limited. Monthly LAL sampling will continue to document long-term effects of the peroxide treatment, i.e., whether the early December peroxide dispersal was sufficient to limit subsequent growth of the toxin-producing *P. rubescens*.

Acknowledgements

The project was possible through the actions and participation of many people. The authors thank LLA staff for providing a sampling boat on the lake as well as scheduling lake discharge to accommodate the timing of peroxide addition and natural peroxide decay rates in the lake. The LLA's E. Roberts was instrumental in coordinating lake access, peroxide purchase, and field application and hence, his assistance is deeply appreciated. Hood College staff C. Hudson and S. Simonson was also important in completing the project while students (B. Fragata, A. Kozlosky, A. Strock, G. Troutman) and H. Zinnert (Chesapeake Conservation Corps) assisted in lake monitoring from June to November. G. Dimitoglou, P. O'Connor, and R. Smith conducted the bathymetric mapping of LAL. Finally, MD Department of the Environment staff (C. Poukish, P. Brady) were critical to toxin analyses and their help has been important and on-going.

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