Assessing cyanobacterial toxins produced from harmful algal communities in the Hudson River watershed

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ABSTRACT:

With an increase in cyanobacteria observed in tributaries of the Hudson River in recent years, it is vital to determine the levels of toxins produced by *Microcystis aeruginosa*, as well as other cyanobacteria. To help assess the toxin levels of the cyanobacteria in the Hudson River watershed, fifteen water samples were analyzed. In these locations, high levels of phosphorous and nitrogen, as well as warm water temperatures, were observed over the summer and fall of 2019, factors that all provide an ideal environment for cyanobacterial growth. Microcystin levels were quantified via an ADDA Elisa test and the relative abundance of cyanobacteria in cultures enriched from eachr sample was determined using fluorometry. Results provided an ability to assess the level of toxicity of the various cyanobacteria and the level of threat created for human and other animal communities in the Hudson River watershed.

INTRODUCTION:

Background:

Cyanobacteria are the most frequent causes of harmful algal blooms (HABs) in freshwater habitats and typically thrive in warm, nutrient-rich waters (*EPA, 2014*). Although cyanobacterial blooms have occurred for billions of years, in recent years, studies have shown that as a result of rising CO_2 levels, the frequency, intensity, and duration of cyanobacterial blooms in aquatic ecosystems across the globe has significantly increased (*Huisman et al. 2018*). In 2012 in New York State, there were 51 reported cyanoHABs, as compared to 183 recorded blooms in NYS in 2019 (*Department of Environmental Conservation, 2019*).

Certain types of cyanobacteria produce toxins. Although not all cyanobacteria are harmful, certain kinds, specifically *Microcystis aeruginosa*, produce dangerous toxins. These toxins are extremely harmful to the ecosystems; humans, animals, and other aquatic organisms. Particularly, pets and livestock are the most suspectable to microcystin, the toxin produced by *Microcystis aeruginosa*.

Objectives:

•Determine whether cyanobacteria growing in surface waters of the Hudson Valley are potentially toxic, i.e., produce unsafe microcystin levels

•See if there is a relationship between an estimator of cyanobacterial abundance (BG-chlorophyll) and microcystin level.

METHODS:

1) Water samples collected April 2019 to November 2019 from fifteen different locations in the Hudson River watershed and stored at approximately 4 ^{0}C until analysis
2) January-February 2020: Cyanobacteria were enriched by placing in BG-11 medium (*University of Texas, 2009*) for 4-6 weeks in 150-mL culture flasks under a grow light on 16:8 light:dark cycle
3) Blue-green (BG) chlorophyll concentrations measured by FluoroProbe III (bbeMoldaenke, GmBH)
4) Total microcystin concentrations measured using ADDA Elisa method (citation)
5) Comparisons made between microcystin levels and toxicity standards

RESULTS:

Toxicity Quantification Standards:

There is no universal accepted threshold level for microcystin in freshwater. The following standards were used for analysis:

1) EPA: Microcystin levels greater than 0.3 ppb are considered toxic for infants and preschool children, compared to 1.6 ppb for school aged children and adults

2) Minnesota State Health Department: 0.1 ppb for all individuals

3) The World Health Organization (WHO) microcystin standards: low risk (< 10 ppb), moderate risk (10-20 ppb), high risk (20-2,000 ppb), and very high risk (> 2,000 ppb**)**

*NYS does not have its own unique standards, but instead uses the EPA guidelines

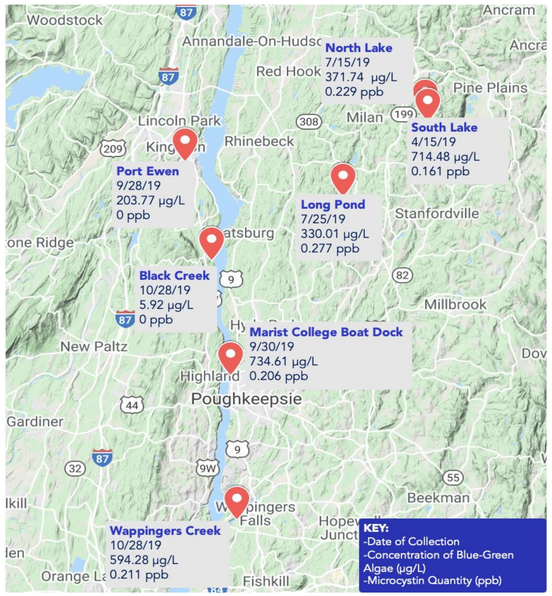

Figure 1: *Illustrates the date of collection, amount of cyanobacteria, and microcystin concentration per sample location. The physical location of each sample is as follows: North Lake (Wilcox Park, Stanfordville, NY), South Lake (Wilcox Park, Stanfordville, NY), Port Ewen (Port Ewen, NY), Long Pond (Clinton, NY), Black Creek (Highland, NY), Marist College Boat Dock (Poughkeepsie, NY), Wappingers Creek (Wappingers, NY)*

Sample Location	Microcystin Level (ppb)	EPA	Minnesota State Health Department	World Health Organization (WHO)
Port Ewen	0	below	below	low risk
Black Creek	0	below	below	low risk
South Lake	0.161	below	above	low risk
North Lake	0.229	below	above	low risk
Marist College Boat House	0.206	below	above	low risk
Wappingers Creek	0.211	below	above	low risk
Long Pond	0.277	below	above	low risk

Table 1*: Establishes if the microcystin levels falls above or below each standard*

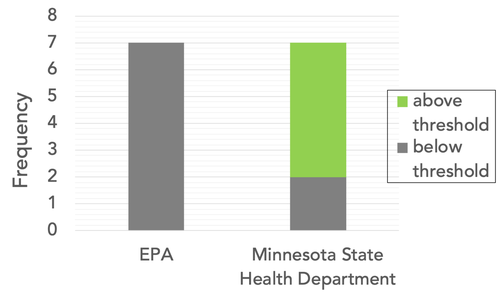

Figure 2: *Depicts the frequency of samples that fall above and below the standard values. Each of the seven samples is classified as ''low risk'' by the WHO*

DISCUSSION:

•In areas where hotspots had been observed by the DEC in previous summers, microcystin was detected (Wappingers Creek, North Lake, and Long Pond). This is logical, as microcystin is often found in cyanobacterial bloom locations. This may be why limited microcystin was found in locations were blooms were absent.

•No samples were considered toxic via WHO or EPA standards. However, there is a moderate risk for infants and small children in two locations using the Minnesota State Health Organization microcystin levels. Based on this, there is low risk for microcystin exposure in all locations for older children and adults, but some risk for infants and toddlers during recreational water-based activities.

•It is possible that high concentrations of blue-green algae may have resulted from exposure to growth lights for 4-6 weeks following sample collection. More research is needed to determine if any significant growth occurred during this incubation period or if the growth occurred before sample collection.

FUTURE WORK:

- Obtain a larger array of sample locations from the Hudson River watershed, particularly focusing on the Hudson River and its tributaries
- Gather water samples on a biweekly or monthly basis at each site so that a systemic progression of microcystin levels and blue green algae concentration per location can be obtained

CITATIONS:

"BG-11 Medium Recipe." Directions , University of Texas, Mar. 2009, web.biosci.utexas.edu/utex/Media%20PDF/bg-11-medium.pdf.

Chapra, S. C., Boehlert, B., Fant, C., Bierman, V. J., Henderson, J., Mills, D., Mas, D. M. L., Rennels, L., Jantarasami, L., Martinich, J., Strzepek, K. M., & Paerl, H. W. (2017). Climate Change Impacts on Harmful Algal Blooms in U.S. Freshwaters: A Screening-Level Assessment [Research-article]. Environmental Science and Technology, 51(16), 8933–8943. https://doi.org/10.1021/acs.est.7b01498

Department of Environmental Conservation. (2019). Harmful Algal Blooms (HABs) Archive Page. https://www.dec.ny.gov/chemical/83332.html

Department of Environmental Conservation. (2018). Harmful Algal Blooms (HABS) Program Guide. http://www.dec.ny.gov/docs/water_pdf/habsprogramguide.pdf

Environmental Protection Agency. (2014). Cyanobacteria and Cyanotoxins: Information for Drinking Water Systems. https://www.epa.gov/sites/production/files/2014-08/documents/cyanobacteria_factsheet.pdf.

Huisman, J., Codd, G. A., Paerl, H.W., Ibelings, B. W., Verspagen, B. W., & Visser, P. M. (2018). Cyanobacterial Blooms. Nature Reviews Microbiology, 16, 471-483.

World Health Organization. (2003). Cyanobacterial toxins: Microcystin-LR in Drinking-water- Background document for development of WHO Guidelines for Drinking-water Quality. Environmental Health, 2, 1–14.