Drinking Water as Route of Exposure to Microcystins in Great Lakes Communities

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Overview

Microcystis blooms are prevalent in western Lake Erie, at times present in high biomass with high toxin concentrations. During the past 5 years, there have been significantly high concentrations of *Microcystis* in western Lake Erie and very often cell densities are high around the Erie Islands. This is of concern because western Lake Erie is a source of drinking water for many communities and may also be a source of algal toxins in the water supply. Of particular concern are many of the smaller communities that might not have extensive treatment of their water supplies and thus be more susceptible to toxins making it through to the finished drinking water. While there are state regulatory standards for factors like turbidity and fecal coliforms, there are currently no regulations for algal toxins and therefore these are not generally measured. We propose a study to measure microcystin concentrations at the intakes and finished drinking water of 2 locations in western Lake Erie (Kelley's Island and South Bass Island). We have been in contact with the operator at each location and they have agreed to help us with the sampling and will send samples to GLERL for further processing. This study will tell us whether water treatment plants are effective in removing microcystins from the drinking water in these small communities and whether there is a risk of chronic exposure. We will also use the newly developed HAB Bulletin to identify when *Microcystis* blooms are likely to be present at the water intakes for these island communities and utilize the opportunity to further develop the Bulletin into a format that is useful to small water treatment operators, which are one of the target communities.

Algal bloom west of Bass Islands in Lake Erie taken August 11, 2009. Photo by J. Lekki, NASA Glenn Research Center.

Objective

Increase number of regional coastal and marine ecosystems delineated with approved indicators of ecological health and socioeconomic benefits that are monitored and understood.

Proposed Work

Sample at water intakes and finished drinking water weekly

Both Kelley's Island and South Bass Island take drinking water directly from Lake Erie, with intakes in less than 5m of water, 150-250m from the shoreline. This water is treated by clarification, sand filtration, granular activated carbon filtration and chlorination and then sent to the taps of about 2/3 of the permanent residences of Kelley's Island and in the village of Put-In-Bay on South Bass Island (Plumley 2008). We have a unique opportunity to sample drinking water intakes, in process and finished water at 2 water treatment plants in western Lake Erie. Affiliates of GLERL who live on Kelley's Island and South Bass Island and who run the municipal water treatment on the islands have agreed to collect additional samples at their water intakes, at locations within the treatment process and of the finished drinking water for this project. These water samples are already collected regularly as part of the monitoring process for drinking water supplies, but are not tested for microcystins. They will freeze the samples for microcystin analysis and will also collect preserved samples for later phytoplankton analysis. These samples will be sent to GLERL on a biweekly basis for analysis. They have also offered to share other data that they collect on a regular basis such as temperature and turbidity.

At GLERL we will measure intra- and extracellular microcystin concentrations using the ELISA assay as well as count *Microcystis* cells and other potential microcystin producers such as *Planktothrix*, *Anabaena* and *Anabaenopsis*. For the finished drinking water, we will filter large

volumes of water (1-5L) onto SPE columns (Oasis SPE columns, Waters) because we expect that toxin concentrations in finished water will be at a low concentration. When there is a particularly dense bloom in western Lake Erie, we will also send samples to Greg Boyer's lab (SUNY-ESF) for analysis of the other cyanobacterial toxins (anatoxin-a and cylindrospermopsin). We will compare toxin concentrations from raw to finished water to determine the efficiency in the water treatment process in removing algal toxins from drinking water.

Use this community as target for HAB bulletin.

This project will also benefit from the newly developed HAB Bulletin (see project reports for CY08 Dyble-05 and CY08 Fahnenstiel-04), which shows the current distribution and projected movement of *Microcystis* blooms in western and central Erie. This is accomplished using satellite imagery processed by (NOAA-NOS-Silver Spring) and the projected movement of that bloom using Coast Water projections and particle tracking models. Field testing in the summer 2008 showed that these models did a good job of predicting *Microcystis* bloom movement in western and central Erie. We will monitor western Lake Erie for *Microcystis* blooms and increase sampling at the Kelley's and South Bass Island water intakes during times in which the bloom in close by. Small water treatment operators are also one of the target audiences for the HAB bulletin, so we will use this opportunity develop the bulletin into a format that is useful for this part of the user community

Put in Bay, Ohio, South Bass Island. July 2009.

Scientific Rationale

The recent increases in cyanobacterial HABs in the Great Lakes has caused significant concern for human and ecosystem health due to the production of toxins by bloom species. In the Great Lakes, *Microcystis* dominates the cyanobacterial bloom community and produces the hepatotoxin microcystin (Brittain et al. 2000, Carmichael 1994, 1997, Vanderploeg et al. 2001). Preliminary studies have documented the presence of microcystins in the Great Lakes, at times exceeding the recommended limit of 1 µg L^{-1} of microcystin established by the World Health Organization for drinking water supplies (Brittain et al. 2000, Vanderploeg et al. 2001). The increase in large *Microcystis* blooms in recent years has caused considerable concern due to the dependence on these waters as a resource and the health risks attributable to microcystins.

There has only been one human death in the US possibly related to recreational exposure to microcystins, though there are multiple cases of gastrointestinal distress, skin irritation and nausea. Recent reports (Backer et al. 2008) have indicated that microcystins can be aerosolized, making recreational activities such as boating and jet-skiing a higher risk of exposure. Microcystins may act as tumor promoters and there is increasing evidence that these compounds may be more harmful through long term chronic exposure, such as low doses in drinking water, rather than short term acute exposure (Carmichael 1997). This chronic toxicity is of significant concern to communities that are consuming drinking water with cyanotoxins in small doses over a lifetime.

Communities like those living on the Erie islands (South Bass, Kelley's) are of particular concern due to their use of Lake Erie surface water for their drinking water source. These are small populations (750-1500 year round residents) that do not have the revenue to support the degree of treatment and monitoring that would be found in larger municipalities. While there are state regulated standards for many potential contaminants such as fecal coliforms, turbidity, some inorganic compounds (i.e. arsenic, cyanide, mercury), and PCBs, there are no state or federal regulations for algal toxins in the Great Lakes region. Some other countries (such as Australia, New Zealand, Brazil, Canada) and one US state (California) have adopted a drinking water standard for microcystin-LR (Burch 2008). For the rest of the US, cyanotoxins (including microcystin, anatoxin and cylindrospermopsin) are currently on the US EPA's Candidate Contaminant List, under consideration for regulation. One factor holding up the approval of cyanotoxins for regulation is the lack of robust monitoring and analytical protocols. Therefore, while communities like the Erie Islands currently do not need to monitor and treat for cyanotoxins, there likely will come a time when they will have to. This project can contribute to assessing the need for cyanotoxin monitoring within the Great Lakes and may be applicable to other freshwater systems.

Governmental/Societal Relevance

Harmful algal blooms are of great importance to NOAA, the scientific community and the public due their potentially significant detrimental impact on ecosystem and human health. In light of this, mandates for their study have come from both the legislature and the scientific community. The widespread presence of microcystin concentrations above the WHO recommended limit of 1 µg L^{-1} in western Lake Erie stresses that detection of toxic *Microcystis* blooms and

understanding the mechanisms stimulating toxin production are highly relevant to both the Great Lakes community and to GLERL. The impact of algal toxins on human health is directly related to the work of our Center of Excellence for Great Lakes and Human Health and has a significant societal impact for local communities that rely on the Great Lakes for clean water for drinking and recreation. The proposed research will directly address whether algal toxins could impact human health in the communities of the Lake Erie Islands and have broader implications for other communities using the Great Lakes as a drinking water source.

Relevance to Ecosystem Forecasting

This project has direct links to forecasting the effects of toxic *Microcystis* blooms in the lower Great Lakes. A prototype model for forecasting *Microcystis* blooms using satellite imagery and hydrodynamics modeling has been developed for western Lake Erie and resulted in series of 'HAB bulletins' put out in late summer 2008. This project will both provide data to validate this forecasting model as well as identify its utility for a targeted user group, local water utility managers.

References

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