Public Testimony
Addressing Issues for Remediation of Lake Water Quality Using Aeration

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Short Bio. Wayne Carmichael is a retired (2007) Professor of Biological Sciences and Professor Emeritus from Wright State University, Dayton, Ohio. He received his B.Sc. In Botany/Zoology from Oregon State University-1969; and an M.Sc-1972 and Ph.D.-1974, in limnology, aquatic microbiology and pharmacology/toxicology from the University of Alberta, Edmonton, Alberta. His professional career was spent on primary research of cyanobacteria (blue-green algae) freshwater harmful algae blooms (HABs) and their toxins. Projects as a Professor Emeritus focus on management and mitigation of harmful cyanobacteria in municipal and recreational water supplies. This includes serving on national and international HAB committees, organization of and participation in workshops and symposia plus advising on HAB issues for local, state, national and international agencies and groups.

Background to water quality remediation issues. In the geological sense, lakes, reservoirs, and rivers are all temporary features of the landscape. Over thousands of years, lake basins change in size and depth as a result of climate, geology and biological processes. Lake aging or eutrophication, occurs primarily as a result of an increase in nutrients, in biological activity (productivity) and in sediments and organic matter from the watershed that fill in the water basin. This progression goes from nutrient poor (oligotrophy) to nutrient rich (eutrophy). It is now accepted that eutrophication from human activities are a significant factor in this aging process. So much so that the term hypereutrophy (extreme eutrophy) has become synonymous with human activities. Hypereutrophy leads to decreased lake depth (sediment accumulation), increased aquatic plants and a shift in the phytoplankton (algae) from beneficial (green and diatom algae) to harmful algae (cyanobacteria or blue-green algae). Cyanobacteria waterblooms have a wide range of social, economic and environmental impacts, including: aesthetic, taste and odor, deoxygenation of the water column from their decomposition, altered water chemistry, detrimental changes in the food web and acute lethal poisoning to wild and domestic animals, aquatic organisms and humans.

Addressing these issues now requires human intervention. The approaches used need to be holistic in order to be successful both in the short and long term.

Management and Mitigation Methods. Currently there are no U.S. federal guidelines, water quality criteria and standards, or regulations concerning the management of harmful algal blooms in drinking water under the Safe Drinking Water Act (SDWA) or in ambient waters under the Clean Water Act (CWA).
However, lake and reservoir management tools have been used, many short term, to prevent or minimize blooms.

These are:
1) Physical controls
•Manipulation of the intake location or depth, aerators, and mechanical mixers.
2) Biological controls
•Manipulation of the lake ecology to favor cyanobacteria grazers (top-down) and increased competition for nutrients (bottom-up).
3) Chemical controls
•Phosphorus treatments (e.g. lime, aluminum sulfate, lanthanum and ferric chloride). Used to both bind nutrients and flocculate cells. Clay particles (these are primarily used to trap cells and pull them below the photic zone).
•Algaecides (e.g., copper-sulfate, hydrogen peroxide).
4) Bioaugmentation (treatments to improve and/or replace 1-3).

**Overlying these methods is an understanding that management of the entire watershed is a long term goal for maintaining clean and safe water quality.

Note: While these methods have all been used in the past, current environmental awareness dictates that some should not or by law cannot be used. For example applying algaecides during a heavy bloom of toxin-producing species will cause the cells to rupture and release the cyanotoxins. The released cyanotoxins are soluble and move into the water treatment plant or recreational area creating problems for their removal and an increased risk of contact with humans and animals.

The task, for the water management team, is to decide which of these management and mitigation methods, especially newer ones, should be used, and by law can be used, given the individual characteristics of the water body in question.

Aeration as a remediation tool for water quality. The VT DEC document (Jan 2019) describes their argument for the usefulness of aeration (page 5, benefits) the main types (page 4) and mechanisms for its application (page 5, paragraph 3). This document concludes (page 31) by stating:

"**Aeration as an in-lake management tool has the potential to improve water quality, but it is important that it be applied correctly to meet clearly articulated water quality management goals and that the systems are designed appropriately in the context of the physical characteristics of a specific waterbody and its watershed. Aeration installations that cannot meet these criteria are likely to be unsuccessful and may potentially cause additional harm to water quality or the lake environment."**

I argue that there are newer methods, that involve air/water flow, that are successful. Moreover I do not agree that there is no support for air flow methods that lead to reduction of accumulated organic matter (muck) on a lake's bottom (page 5, paragraph 4). There are methods using air/water flow, complimented with bioaugmentation that will reduce and remove lake sediments. Such reduction increases water volume, moves nutrients in food webs that are beneficial, allows competition by beneficial algae to outcompete harmful cyanobacteria and reduces sediments that would otherwise encourage growth of aquatic plants.

Summary recommendations

1) **There are more recent methods that use air/water flow plus bioaugmentation that will meet the 7 criteria, permitting future aeration projects, as given on page 31 of the VT DEC (Jan 2019) document.**
2) **Long term and even some short term management of cyanobacteria HABs can be accomplished by a holistic approach that includes newer applications of air/water flow and bioaugmentation.**
3) **Eutrophication is a whole lake process. It is multi-faceted, with numerous factors that can drive the process. It is also a dynamic process, with interaction and feedback between these various causative factors.**
4) **Attempts to manage eutrophication that are focused on just one or two factors, and/or are not implemented on a whole lake basis are ineffective.**
5) **One of the end results of failure to reverse eutrophication will be reduced water quality leading to cyanoHAB dominance. This is evidenced by significant examples such as Lake Erie and Lake Tai in China. Failure to mitigate eutrophication resulted in the Toledo situation in 2014. Similar fates will most likely occur in Lake St Catherine and Lake Carmi.**

Reference:
1) Aeration as a Lake Management Tool and its Use in Vermont. A Review of the Lake Management Literature. Vermont Department of Environmental Conservation (VT DEC). January 2019, 35 pages.

Wayne Carmichael thanks the House Natural Resources Committee and the Senate Committee on Natural Resources and Energy for the opportunity to provide input.

Note: I am unable to be at these hearings since I am in Europe participating in the 11th International Conference on Toxic Cyanobacteria. I have written this letter to support the testimony to be given by Mr. David Emmons, President Lake Saint Catherine Conservation Fund, Inc.

Respectfully submitted Wayne Carmichael, May 1, 2019