DWQI Treatment Subcommittee Cyanotoxins Update Public Meeting: 5/25/2023

DWQI Treatment Subcommittee

Presented by: Oleg Kostin

Wanaque Reservoir, April 2017

DWQI Treatment Subcommittee

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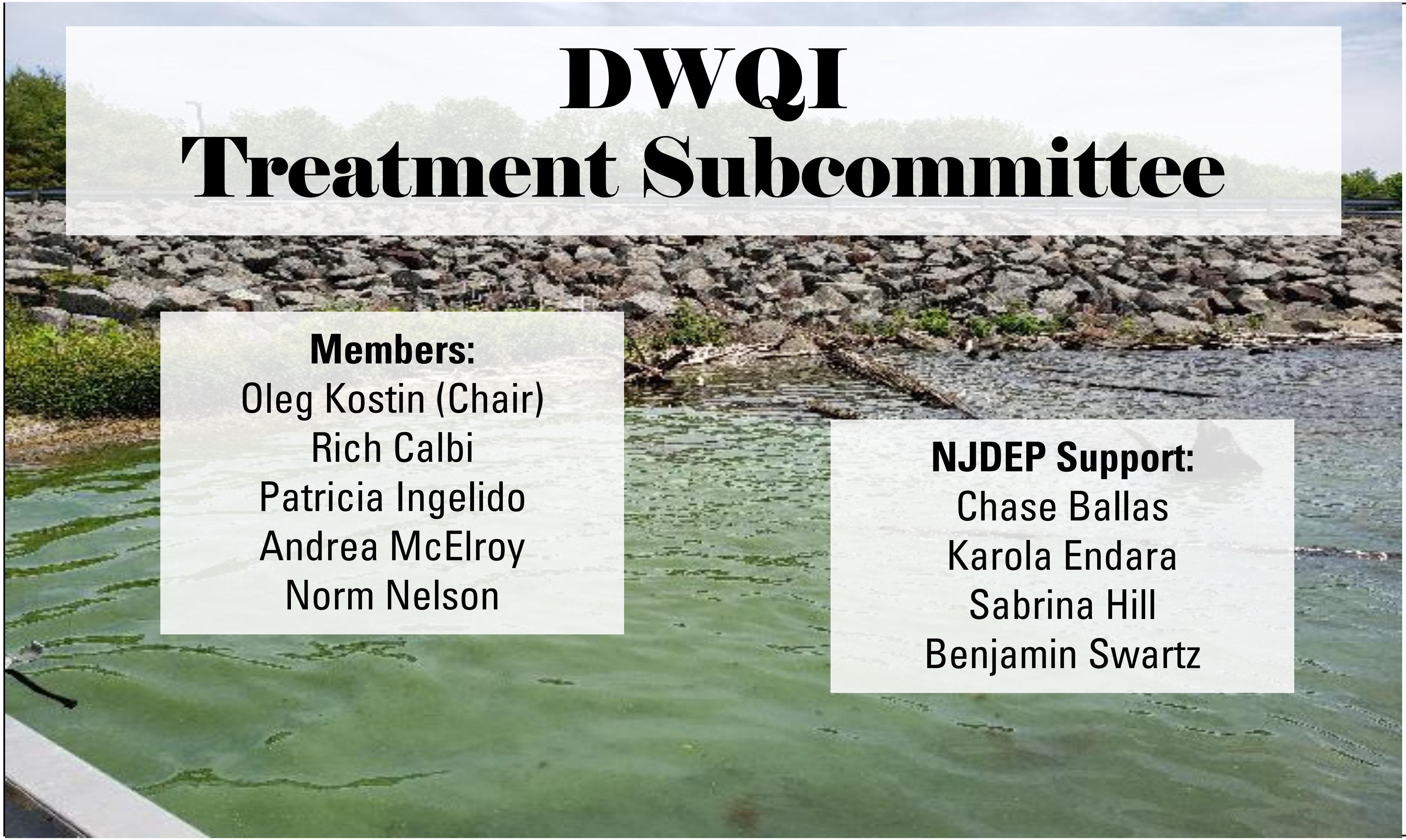


Manasquan Reservoir, June 2021

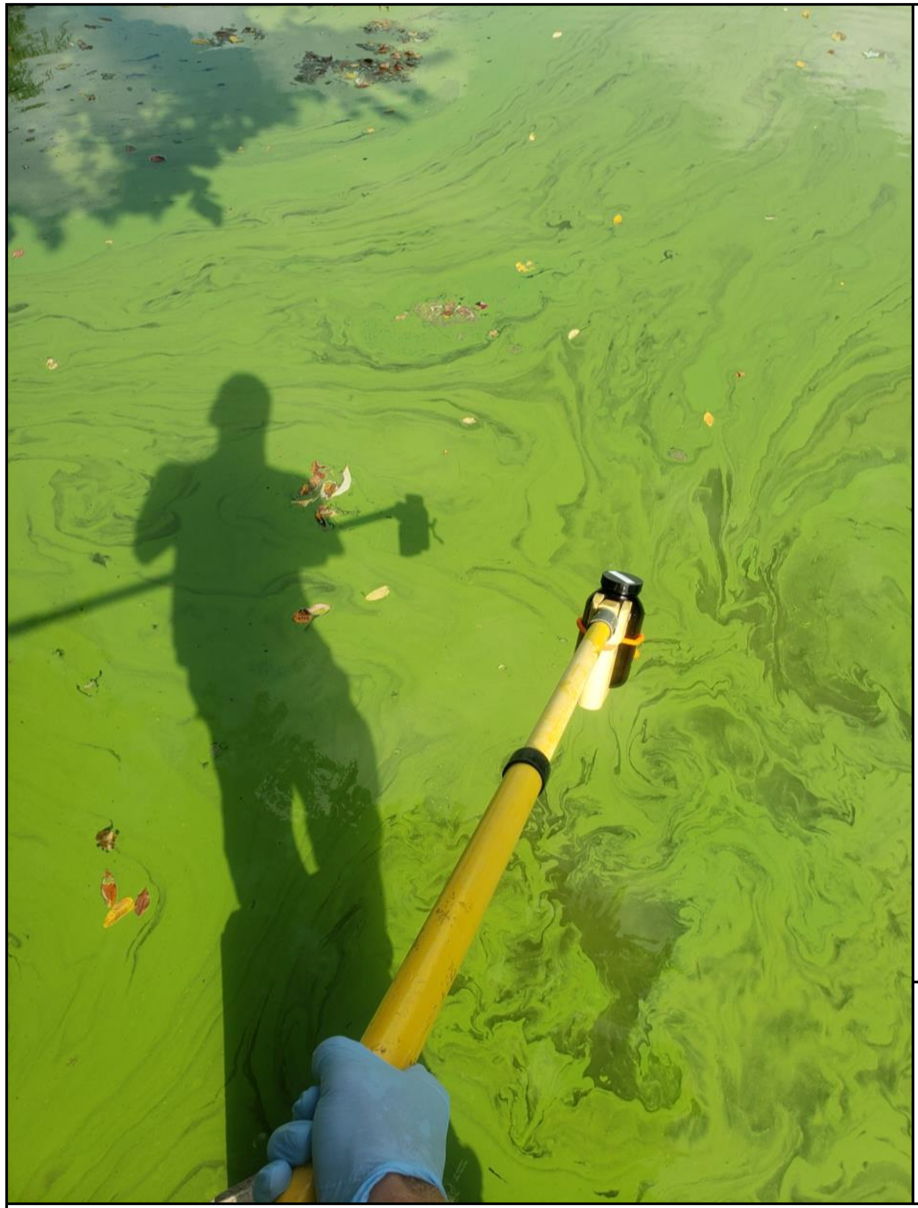
Objectives of the Treatment Subcommittee

To evaluate best available treatment technologies and/or methods for the removal of hazardous contaminants from drinking water

Purpose of this presentation:

1. Update on the progress on identifying treatment technologies and methods relating to the removal of cyanotoxins in drinking water.
2. Outline next steps in completing treatment recommendation on cyanotoxins for DWQI.

Treatment for the Removal of Cyanotoxins in Drinking Water

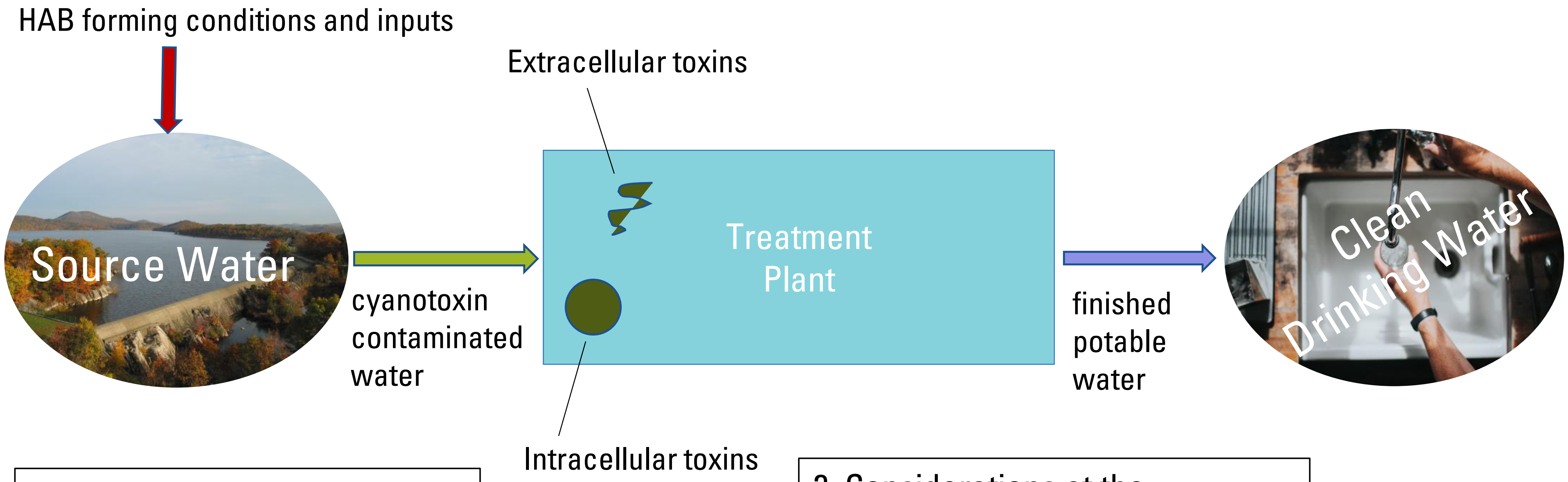


Lake Ceva at The College of New Jersey, September 2019

Information Gathering

Literature Review	Data Collection
• Identified widely-accepted and well-performing strategies for the removal of cyanotoxins • Reviewed performance of strategies at different scales and at different points in the treatment process	• Reached out to other states with cyanotoxin management strategies • Contacted in-state and out-of-state drinking water systems conducting treatment for cyanotoxins

Considering Cyanotoxin Management



1. Considerations at the Source Water. Strategies include monitoring growth, preventing blooms, & treatment.

2. Considerations at the Treatment Plant. These include a multibarrier approach to address both extracellular and intracellular cyanotoxins.

Considering Treatment at the Source Water

Mercer County Lake, August 2022

Monitoring

Environmental Risk Factors	*Strategies*
• Higher temperatures • Prolonged, intensified thermal stratification • Anoxic conditions • High Total Phosphorus • History of HABs	• Proxies: Turbidity, pH, dissolved oxygen • Early warning: Phycocyanin or Chlorophyll-a readings • Bloom outbreak: Open water, depth-integrated sampling • Toxin assessment: Mass Spectrometry or ELISA kits

Prevention

Source System Analysis	*Preventative Treatments*

• Deep or shallow?
  • Stratification: intensity and timing?
• Internal or external nutrient inputs?
• Eutrophic state seasonal or perennial?
• Acidic or alkaline?
	• Nutrient Reduction
	• Hydrological Modification
	  • Mechanical Mixing
	  • Hypolimnetic Withdrawal
	  • Aeration
	• Biological Control
	  • Piscivore/Zooplankton Stocking
	  • Macrophyte Establishment

Treatments

Phosphorus Inactivators	*Cell Flocculants*

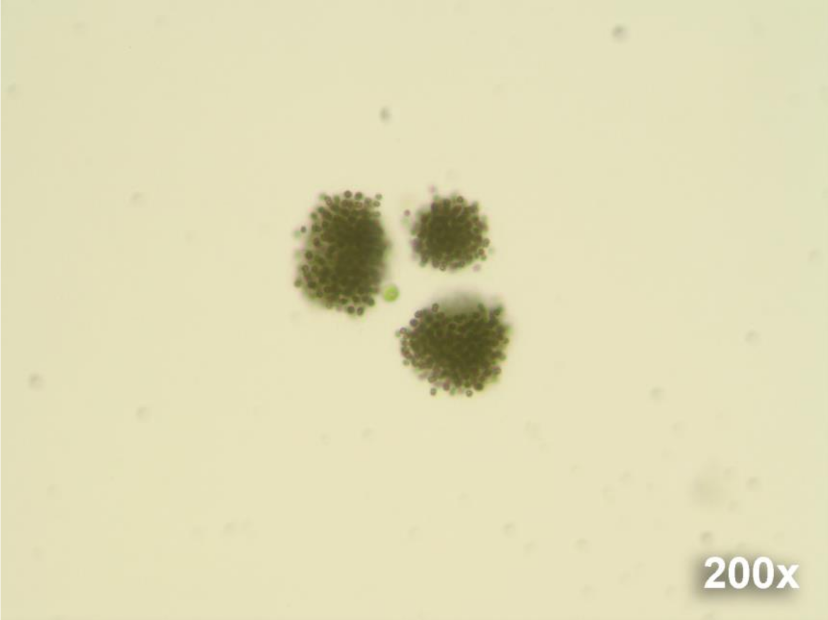
• Aluminum-based
  • "Alum," aluminum sulfate
  • Polyaluminum Chloride
• Iron Salts
• LMB, aka "Phoslock"
	• Aluminum-based
	  • Drawback: environmental persistence
	• Chitosan
	  • Drawback: cell lysis

These are pH dependent

Treatments

Algaecides	*Additional Options*

• Hydrogen Peroxide Preferred
• Copper-based
  • Problems with long-term use
• Emerging Algaecides:
  • Algacidal Bacteria & Fungi
  • Barley Straw, other natural products
	• Sonication
	• Physical Control
	  • Booms and Curtains, Bubble Curtains
	  • Flushing



Considering Treatment within the Treatment Plant

When a HAB is determined to be present in the source water and enters the treatment plant.

Cyanotoxin Form

Intracellular Cyanotoxins	*Extracellular Cyanotoxins*
• Cyanotoxin is produced and stored in the cell cytoplasm • Majority of toxins are produced during blooms • Easier to treat since the toxin is contained in the cyanobacterial cell	• Cyanotoxin is released into the environment due to cell lysis (i.e., bursting) • More difficult to treat since the toxin is free-moving in the water matrix

Treatment of Intracellular Cyanotoxins

Pretreatment/ Oxidation

- Cease if possible
- Potassium Permanganate - safe below 3 mg/L if necessary for other treatment objectives

Coagulation / Flocculation

- Alum, ferric chloride, polyaluminum chloride - all effective
- Jar test to optimize dose
- Enhance with ballasted flocculation using microsand, magnetic powder

Treatment of Intracellular Cyanotoxins

Sedimentation

- Dissolved Air Flotation best
- Cells can survive in sludge and supernatant – remove sludge frequently and suspend recycling of residuals if possible
- Toxins can accumulate even as cell counts remain low

Filtration

- Membrane filtration effective
- Conventional filters effective, but run times should decrease
- Extremely high cell counts and small species can lead to breakthrough in rare cases

Treatment of Extracellular – Physical Removal

Activated Carbon

- GAC more widely used than PAC
- 90% effective yield at treating all cyanotoxins
- Co-treatment of other contaminants

Membranes

- Micro-, nano-, ultra- filtration, reverse osmosis
- More difficult to use at large-scale
- Significant variability:
  - Cell lysis
  - High energy demands
  - Biofilm formation

Treatment of Extracellular – Biological Degradation

Biofiltration

- Addition of biological media (microorganisms) to sand beds

Bioactivated Carbon

- Addition of biological media to activated carbon

Variables

- pH
- Temperature
- Metal / organic matter
- Cell molitity
- Micro-bacterial dosage

Treatment of Extracellular – Chemical Degradation

Oxidation

- Treatment of both organic and inorganics
- Often already in place for pre-treatment/disinfection

Advanced Oxidation Processes

- Ultraviolet light (UV) and H_2O_2 create non-toxic intermediates when treating microystin-LR

Variables

- Non-selective
- Chain reactions unpredictable
- No one oxidant treats all cyanotoxins
- Optimal UV and H_2O_2 determination (AOP)

Toxin Analyzer

Next Steps by the Treatment Subcommittee

Summary of Research

Cyanotoxins require unique evaluation and planning in order to treat successfully, as a single treatment technology does not work in all cases.

Source water and treatment plant dynamics need to be considered in order to properly monitor and treat.

The existence of both intracellular and extracellular cyanotoxins need special considerations.

Additional considerations include existing treatment, the ability to address more than one contaminant, and waste disposal.

Multi-barrier approach to treatment needed in order to prevent cyanotoxins in finished potable drinking water.

For Future Work

1. Complete case studies of treatment at system scale
2. Obtain quantitative data on success of plant treatment
3. Make draft recommendation

Millstone River at RT 518, July 2022