

Title:	PROCESS FOR MANAGING MICROCYSTIN DETECTIONS IN RAW AND FINISHED WATER SAMPLES FOR PUBLIC SURFACE WATER SYSTEMS
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Purpose: To establish a process between the Department of Environmental Conservation (DEC), Department of Health (VDH), Vermont Agricultural and Environmental Laboratory (VAEL), and public drinking water suppliers with surface water intakes for managing detections of toxins from cyanobacteria, specifically microcystin in raw and finished water samples. Microcystin is not regulated by USEPA, but considering potential health risks, monitoring is warranted.

Keyword(s): harmful algal blooms, cyanobacteria (also known as blue-green algae), cyanotoxins, microcystin, source water monitoring, unregulated contaminants, public notice requirements

I. General Policies and Procedures

Toxins Addressed by this Practice. Throughout this Practice, "microcystin" refers to Microcystin-LR (CAS:101043--2) and is reported as microcystin-LR equivalents. Results are reported as micrograms per liter ($\mu\text{g/L}$). For more information on the health effects of cyanotoxin, see: http://healthvermont.gov/enviro/bg_algae/bgalgae.aspx.

Background

While Lake Champlain is primarily a recreational lake, it also serves a drinking water source for 22 public water systems in Vermont. The increase of cyanobacteria blooms in Lake Champlain and health risks associated with ingestion, have been of growing concern to public water systems relying on surface water as a source of drinking water. During the summer of 2007, the Drinking Water and Groundwater Protection Division (DWGPD) drafted the initial "PROCESS FOR MANAGING MICROCYSTIN DETECTIONS IN RAW AND FINISHED WATER SAMPLES FOR PUBLIC SURFACE WATER SYSTEMS"-protocol. The protocol addressed finished water detections for anatoxin and microcystin levels exceeding $0.5 \mu\text{g/L}$ for systems that voluntarily chose to sample. The 2009-version of the protocol addressed finished water detections for anatoxin or microcystin levels equal to or greater than $0.5 \mu\text{g/L}$. In 2015, USEPA established health advisories for microcystin ($0.3 \mu\text{g/L}$ for bottle-fed infants and pre-school children and $1.6 \mu\text{g/L}$ for school-age children and adults) and cylindrospermopsin ($0.7 \mu\text{g/L}$ for bottle-fed infants and small children and $3.0 \mu\text{g/L}$ for school-age children and adults), and VDH followed with new VT health advisories, applicable to all populations, for microcystin ($0.16 \mu\text{g/L}$) and cylindrospermopsin ($0.5 \mu\text{g/L}$).

As a result, the cyanotoxin monitoring program was initiated in the same year for the 22 Lake Champlain-sourced public water systems. Weekly sampling included both microcystin and cylindrospermopsin. In 2016, only microcystin was analyzed due to funding restrictions; however, in 2017 the program included both cyanotoxins. From 2018 until 2021 only microcystin was analyzed.

Funding issues and no confirmed detections for cylindrospermopsin was the motivation to end cylindrospermopsin testing. For the cyanotoxin monitoring season 2022, microcystin will be analyzed. Any testing beyond microcystin, will be outside the cyanotoxin monitoring program.

Water Supplier Initiated Target Monitoring

Although there are currently no rules regarding cyanotoxin monitoring in Vermont, it is the policy of the DWGPD to encourage source water monitoring throughout the summer and fall, and to facilitate appropriate public notification and operational actions, if cyanotoxins are detected in finished water at concentrations at or above health advisory levels established by VDH.

Raw and finished water analyses for microcystin may be advised when changes to source water quality associated with cyanobacterial blooms are noted by the operator during daily visual inspections. Common changes associated with microcystin include pH increases, shortened filter run times, increased chlorine demand, increased turbidity, increased disinfection byproduct (DBP) formation, or altered taste and odor. If changes are observed, the water system should coordinate with the DWGPD to determine if cyanotoxin testing is necessary at that time. The DWGPD Cyanobacteria Coordinator can be reached at 802-585-4893 or 802-828-1535 (main line) during normal work hours.

If a water system collects and submits raw and finished water for cyanotoxin analysis outside of the weekly sampling due to a visual cyanobacterial bloom or other changes to source water quality, DWGPD encourages all systems to submit the results to the DWGPD Cyanobacteria Coordinator.

The DEC Watershed Management Division, in cooperation with VDH and the Lake Champlain Committee, conducts surface water sampling of Lake Champlain and other selected lakes under the umbrella of a lake-wide cyanobacteria monitoring program. Public surface water systems receive lake-wide data published in DEC Watershed Management Division email alerts. The VDH [Cyanobacteria Tracker](#), an interactive map, is searchable by lake region and town.

Routine Cyanobacteria Monitoring by Drinking Water Systems

Public water systems that use Lake Champlain as their water sources are encouraged to participate in weekly sampling of raw (source) and finished (treated) water analyses for one of the toxins produced by certain cyanobacteria, microcystin, during the sampling season.

The DWGPD, in conjunction with VAEL, will ensure test kits are available for participating drinking water systems. Water systems will collect and properly store the kits until courier pick up of the weekly raw and finished water samples for microcystin analyses with VAEL. The sampling season will be defined and adjusted by the DEC and VDH but has historically started during the week of July Fourth and continued for 12 weeks. Both in 2020 and 2021, the sampling season started the second week in July because of limited VDH lab capacity due to COVID-19. For the 2022 monitoring season, testing will commence the second week in July due to issues with starting right after the July Fourth holiday.

VAEL will report all raw and finished water test results for microcystin to the DWGPD. The Cyanobacteria Coordinator will review the test results upon receipt. VAEL will send them to the participating systems via email. In addition, the Cyanobacteria Coordinator will send results initially to VDH, and then to participating systems and other parties via weekly blast email and post on the DWGPD website: <http://www.vermontdrinkingwater.org>.

I. Procedures for Initial Raw Water and Confirmed Raw Water Detections

For microcystin level equal to or greater than 0.16 µg/L (Without finished water detection)

Initial Raw Water Detections - Notification of Personnel

Upon microcystin detection at or above 0.16 µg/L in the raw water only, VAEL will notify the DWGPD Cyanobacteria Coordinator, and the coordinator will notify the Director, Drinking Water Program Manager, and Engineering and Water Resources Section Manager by email. The Cyanobacteria Coordinator will notify VDH via email.

A site visit to the water treatment plant by DWGPD staff will be scheduled within five (5) business days of the detection, and system specific treatment efficacy will be evaluated based on parameters including pH, temperature, contact time (CT) according to [Cyanotoxin Calculation](#).

Immediate Resampling (confirmation samples)

Upon notification from VAEL of initial detection and consultation with appropriate DWGPD staff, the Cyanobacteria Coordinator will directly contact the PWS Administrative Contact via phone and email and notify the PWS Certified Operator about the result and that a confirmation raw water sample and finished water sample must be taken immediately (unless results were received on a Friday, then confirmation sampling is required the following Monday). The Cyanobacteria Coordinator will contact the courier service via phone to pick up the confirmation samples at the water system. The Cyanobacteria Coordinator will notify the VAEL Biology Division Supervisor via phone (802-585-4441) and email (john.jaworski@vermont.gov), that confirmation samples have been requested. The Cyanobacteria Coordinator will also send an email to the system/authorized representative, with a copy to the designated operator, documenting the request for a confirmation raw sample and finished water sample. No further action will be required of the PWS until the confirmation raw water and finished water sample analyses are completed.

Increase to Daily Monitoring

If the confirmation raw water sample validates the presence of microcystin level equal to or greater than 0.16 µg/L, the system will be provided testing kits to begin daily monitoring of both raw and finished water. The Cyanobacteria Coordinator will call and email the water system, copying VAEL and VDH, stating the requested monitoring.

Per agreement with VAEL, the lab will analyze confirmation samples same day they arrive (Monday-Friday, assuming it is within reasonable opening hours).

Per consultation with VDH, detections in the raw water without detection in finished water will not warrant an emergency opening of the lab after opening-hours, and hence VAEL will not be expected to stay open on weekends. The confirmation sampling will not be requested during weekends but will resume the following Monday.

Cessation of Daily Monitoring

Monitoring may be discontinued when two consecutive raw and finished water daily samples confirm that microcystin is no longer detectable at or above the health advisory, unless otherwise advised by the DWGPD or the Microcystin treatment efficacy evaluation shows that the system can treat the microcystin to order(s) of magnitude below the Health Advisory level.

II. Procedures for Initial Finished Water and Confirmed Finished Water Detections

For microcystin levels equal to or greater than 0.16 µg/L

Initial Finished Water Detections - Notification of Personnel

VAEL will notify either the DWGPD Cyanobacteria Coordinator (802-585-4893, heather.campbell@vermont.gov), Director (802-585-4900, bryan.redmond@vermont.gov), Drinking Water Program Manager (802-498-8981, ben.montross@vermont.gov), or Engineering and Water Resources Section Manager (802-522-8709, sille.larsen@vermont.gov) by phone and email. The Cyanobacteria coordinator will alert VDH by emailing Bridget.Obrien@vermont.gov, Sarah.Vose@vermont.gov, BloomAlert@vermont.gov. If the microcystin detection is in the finished water, and it is impossible to obtain the confirmation sample, DWGPD will require the water system to distribute public notice informing customers not to drink their water ("Do Not Drink"). If the public water system can obtain the confirmation sample, DWGPD will wait on the confirmation sample. If confirmation sampling is occurring during the weekend and/or state holiday, the Director, Drinking Water Program Manager, or Engineering and Water Resources Section Manager will be on call and available to receive results from VAEL.

A site visit to the water treatment plant by the DWGPD staff will be scheduled as soon as possible, and the "Treatment Protocol for Water Systems Detecting Cyanotoxins," dated 6-12-2015 (attached), will be followed.

Immediate Resampling (confirmation samples)

Upon notification from VAEL of initial detection and consultation with appropriate DWGPD staff, the Cyanobacteria Coordinator will directly contact the PWS Administrative Contact via phone and email and notify the PWS Designated Operator that a confirmation raw water sample and finished water sample must be taken immediately. The Cyanobacteria Coordinator will notify VAEL via phone and email that confirmation samples have been requested. The Cyanobacteria Coordinator will also send an email to the system/authorized representative, with a copy to the designated operator, documenting the request for a confirmation raw sample and finished water sample. No further action will be required of the PWS until the confirmation raw water sample and finished water sample analyses are completed, except in circumstances when DWGPD and VDH agree that the results from the initial finished water confirmation samples warrant immediate action (follow Do Not Drink policy – to be published by DWGPD) to protect public health. Such circumstances include:

- 1) Lack of opportunity to collect immediate confirmation sample
- 2) Significant changes to water chemistry (turbidity, pH chlorine residual) reported by the water system operator combined with initial finished water result exceeding microcystin health advisory level.

Per agreement with VAEL, the lab will analyze confirmation samples during weekends in the case of microcystin detections in the finished water. Confirmation samples will be expected from the water samples daily delivered directly to VAEL for analysis.

Increase to Daily Monitoring

If the confirmation finished water sample validates the presence of microcystin level equal to or greater than 0.16 µg/L, the system will be provided testing kits to begin daily monitoring. The DWGPD Cyanobacteria Coordinator will call and email the water system, copying VAEL and VDH, stating the requested monitoring.

Cessation of Daily Monitoring

Monitoring may be discontinued when the confirmed microcystin is no longer equal to or greater than the health advisory in results from two consecutive raw and finished water daily samples,

unless otherwise advised by the Cyanobacteria Coordinator.

Public Notice

As soon as possible, but not more than 24 hours after becoming aware of the confirmation sample results in excess of the health advisory, the water system shall provide a Do Not Drink notice (see Appendix for template) that meets the requirements of Section 10.2.23 of the Vermont Water Supply Rule and comports with Section C of the DWGPD Do-Not-Drink Policy (to be published 2022) to every affected consumer. All correspondence between the DWGPD and public water systems regarding case-specific public notification requirements shall be copied to the VDH State Toxicologist and Senior Toxicological and Radiological Analyst.

Consumer Confidence Report. For all community water systems, the DWGPD requires that all confirmed finished water microcystin detection be referenced in the annual Consumer Confidence Report.

Operational Response: The water system will notify DWGPD at 802-585-4893 (Cyanobacteria Coordinator) or 802-828-1535 (main line) when the emergency response plan (ERP) is activated.

Protection of Public Health and Welfare. Water systems with cyanotoxin concentrations chronically exceeding health advisories may, at the discretion of the Secretary in accordance with Subchapter 21-6 (Health Advisories) and Subchapter 21-1 (Authority and Purpose) of the Water Supply Rule, be required to provide treatment or to modify the drinking water system infrastructure in order to protect public health or welfare.

Approved by:

Date: August 19, 2022

Director, Drinking Water and Groundwater Protection Division

Prepared by: The Drinking Water and Groundwater Protection Division, in consultation with Vermont Department of Health-Environmental Health Division, and the Lake Champlain Coalition of Municipal Water Suppliers.

Revision/ Review Date	Reason for Revision
1/23/2009	First version expired June 15, 2008
6/30/2015	Second version expired June 1. 2022
8/19/2022	Overall changes to the process

This Practice and related environmental information are available electronically via the internet. For information visit us through the Vermont Homepage at <http://www.vermont.gov> or visit DWGPD directly at

<http://www.drinkingwater.vt.gov>

Drinking Water and Groundwater Protection Division

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To: The Record

From: Ray Solomon

Subject: Treatment Protocol for Water Systems Detecting Cyanotoxins

Date: 6-12-2015

This memo will describe a water treatment action plan that can be used by any Vermont water system that detects cyanotoxins in either raw or finished water. Currently, the plan will apply to the surface water systems that draw water from Lake Champlain since they will be the only treatment plants actually testing for these toxins in 2015.

Voluntary weekly testing for cyanotoxins (microcystins and cylindrospermopsin) will commence in July at these systems' surface water treatment plants. Of the twenty-two systems that qualify, twenty have, thus far, agreed to test. These plants employ three different types of filtration. Eighteen utilize **rapid sand filtration**. One uses **slow sand filtration** and three use **1 micron absolute cartridge filtration**. All systems use chlorination for primary disinfection and all but one- use **chlorination** for secondary disinfection. Champlain Water District uses **monochloramination**. Because the overall treatments are similar, the plan will discuss modifications that may be necessary for each type of filtration and disinfection. It will not describe, in detail, the specifics and peculiarities of each individual treatment plant and how these factors might influence treatment modifications. These specifics will, of course, come into play if cyanotoxins are detected.

There are some general treatment principles that are well documented and generally agreed upon by drinking water treatment professionals. Taking these into account, the treatment modifications recommended in this plan are based on the following assumptions:

1. All three types of filtration, when working properly, are effective at removing intact algal cells. Only slow sand filtration is effective in removing dissolved toxins.
2. Avoiding algal cell lysis is important since dissolved cyanotoxin removal cannot be achieved by either rapid sand or cartridge filtration.
3. Chlorine will oxidize cylindrospermopsin and microcystins. Increasing CT (chlorine concentration in milligrams per liter multiplied by contact time in minutes) before the first customer will increase the rate of oxidation of these two toxins. Lower pH and higher temperature will enhance this effect. A CT table, similar to the table used to evaluate giardia cyst inactivation by disinfection, has been developed for microcystin and can serve as a guideline for increasing the chlorine dose.
4. Chlorine is not effective in oxidizing anatoxin-a. Permanganate is effective. The required permanganate dose, however, is not clear.
5. Cell lysing may be accelerated by pre-oxidation (oxidation before filtration). Pre-oxidants currently used in Vermont are either permanganate or chlorine.
6. Cell lysing may increase with longer detention times in filters and sedimentation basins.
7. Recycling backwash supernatant may increase toxin concentration in the raw water. (No surface water treatment plants in Vermont are currently doing this).
8. Effective treatments for cyanotoxins include ozonation, powdered activated carbon (PAC) and granular activated carbon (GAC). Of the Lake Champlain treatment plants, only Burlington has PAC capability, and it

is almost never used. No plant currently uses ozone or GAC. Grand Isle Consolidated will be installing GAC filtration for DBP precursor control shortly.

TREATMENT PROTOCOLS

If a cyanotoxin is detected and confirmed, at any level, **in a raw water sample**, but not in the finished water, the following actions will take place:

1. A site visit to the water treatment plant by the staff of the Vermont Drinking Water and Ground Water Protection Division (DWGWPD) will be scheduled within five (5) business days of the detection.
2. Pre-oxidation, coagulation, filtration, disinfection, and all other relevant treatment processes will be reviewed to ensure effective treatment. Depending on the concentration of cyanotoxin in the raw water, modifications may be necessary. These modifications are elaborated in the following section, dealing with detection of toxin in the finished water.
3. Routine cyanotoxin monitoring would be increased, if necessary, to a frequency to be determined by the Department of Health and DWGWPD.

If a cyanotoxin is detected and confirmed, at any level, **in finished water**, the following actions will take place:

1. A site visit to the water treatment plant by the staff of DWGWPD will be scheduled as soon as possible.
2. **Pre-oxidation** will be minimized, or entirely halted in order to reduce cyanobacteria cell lysis before filtration. Taking this step must be weighed against the benefits of pre-oxidation, which include zebra mussel control, taste and odor control and enhanced turbidity reduction. At minimum, the temporary suspension of pre-oxidation will most likely be recommended, unless there is a compelling need to continue it.
3. **For rapid sand filtration plants**, coagulant type and dose will be reviewed to ensure optimum turbidity removal through the filters. Parameters used for evaluation will be turbidity, pH and UVA. Procedures may include jar tests, column tests and full plant dose response tests. Filtration rate will be ascertained, and the rate may be lowered, if practical, to minimize breakthrough of coagulated material. Backwash procedure will be reviewed to make sure that no turbidity breakthrough through the filters occurs before backwash, backwash rate is sufficient to fluidize the bed, backwash time is sufficient to clean the bed, time between backwash is minimized to reduce lysing of intact algal cells retained by the filters and filter to waste time, after backwashing is adequate to minimize turbidity spikes.
4. **For slow sand filtration plants**, filter rate will be ascertained and minimized to the greatest extent possible. This will enhance algal cell removal. Retention time of algal cells in the filter bed is much longer than in rapid sand filters. Cell lysing may be an issue in the filter bed. On the other hand, biological treatment, which commonly occurs in a slow sand filter bed may degrade dissolved toxins. Premature filter scraping (the most common method of cleaning slow sand filters) will disrupt the biological mat and result in the filter being taken offline until a new mature mat develops. We may need to test for the level of both dissolved and intracellular toxin before and after filtration (but before chlorination) in order to determine whether the filter should be cleaned.
5. **For 1-micron absolute cartridge filtration systems**, filter rate will be measured and reduced to the maximum extent possible. This should enhance algal cell removal. Headloss through the membrane will be measured to insure there are no breaks in the membrane. As in the case of slow sand filters, retention of material on the filter is much longer than is the case for rapid sand filters. The filter cartridges are not

backwashed, but simply replaced when headloss becomes too great. Testing for dissolved and intracellular toxins may be necessary to document if this is a problem. If a problem is suspected, filter cartridges should be replaced and a round of testing done to evaluate the effect. In any case, cartridges may be replaced to ensure the structural integrity of the membrane.

6. **Post filtration primary disinfection with chlorine** will be assessed with enhanced oxidation of toxins in mind. Chlorine residual entering the distribution system is usually a balancing act. There must be sufficient residual to meet CT requirements of the SWTR and to maintain a detectable residual at the far ends of the distribution system. On the other hand, residual should be minimized to lower the formation of disinfection byproducts, over time, in the distribution system. Assuming that cyanotoxin contamination of the finished water is a temporary issue, chlorine residual will be raised to a level deemed appropriate by DWGWPD and the plant operator. A quantitative test may be done to ascertain the level needed to sufficiently lower the toxin level in finished water. This would be a bench test that exposed filtered water to progressively higher CT levels. At specific increments of CT, samples would be analyzed for the presence of the detected cyanotoxin. Test results would be used to set the optimum level of CT.
7. **Frequency of raw and filtered water sampling** for the detected cyanotoxin will be increased to daily monitoring until there are two successive days of negative results in the finished water. At this point monitoring can be decreased to a frequency determined by the Department of Health and the DWGWPD.

The evaluation and modification of treatment plant processes that have been listed can be instituted rapidly with little additional cost. If more extensive modifications or a new treatment is necessary, a much more extensive plan would be needed. Whether ozone, PAC, GAC, intake relocation or other capital-intensive treatments might be required is an unnecessary speculation at this point. The summer's worth of data should give us enough information allowing us to decide how much individual attention is needed at each of the water treatment plants.

DRINKING WATER WARNING

[Enter Water System Name]

Water is Contaminated with the Cyanotoxin
Microcystin:

DO NOT DRINK THE WATER

Toxins from cyanobacteria were found in our treated water supply. A sample collected on [Enter Date] shows the cyanotoxin: Microcystin at [Enter Level] micrograms per liter ($\mu\text{g/L}$). The Vermont DEC Drinking Water and Groundwater Protection Division **strongly recommends** that you do not drink the water a Microcystin level at or above **0.16 $\mu\text{g/L}$** .

The Vermont Agency of Natural Resources and Department of Health recommend that users consider taking the following precautions:

- **DO NOT DRINK THE WATER.** Alternative water without elevated levels of the cyanotoxin: Microcystin listed in this public notice should be used for drinking, making infant formula or food, making ice, brushing teeth, and preparing food. Pets and animals should not drink the water.
- **DO NOT BOIL THE WATER.** Boiling the water will not destroy toxins.
- Adults and older children may use the water for bathing, washing hands, washing dishes and doing laundry. Special attention may be needed when bathing children to prevent swallowing. The water may be used for flushing toilets.
- Consuming water containing cyanotoxins may result in skin irritation and abdominal pain/muscle pain and gastrointestinal distress.
- If you are experiencing adverse health effects due to cyanotoxins, contact your health care provider.

What happened? What is being done?

[Enter Surface Water Source], which is a source of drinking water for the [Enter Water System] is experiencing a cyanobacterial bloom near the intake that serves the water system. Some algal blooms produce toxins that may pose a risk to human and animal health. Additional monitoring of your drinking water is being conducted, and you will be notified when the situation has been resolved. The water system is [Describe what is being done]. We are working closely with [Insert Partners] to minimize any potential harm.

For more information, please contact [Enter Contact Person] at [Enter Contact Phone]. Additional information about cyanobacteria can be found at: http://healthvermont.gov/enviro/bg_algae/bgalgae.aspx

For questions regarding the health effects of cyanotoxins, contact the Vermont Department of Health at 1-800-439-8550. You may also contact the Drinking Water and Groundwater Protection Division at 802- 828-1535.

Please share this information with all who drink this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools and businesses). You can do this by posting this notice in a public place or distributing by hand.

This information is being sent to you by [Enter Water System Name Here]. WSID Number: [Enter WSID Number Here]. Date Distributed: [Enter Date Here]