American Water Works Association

2015 Bloom Season Observed Levels and Associated Impacts

(and other free tools/resources from AWWA)

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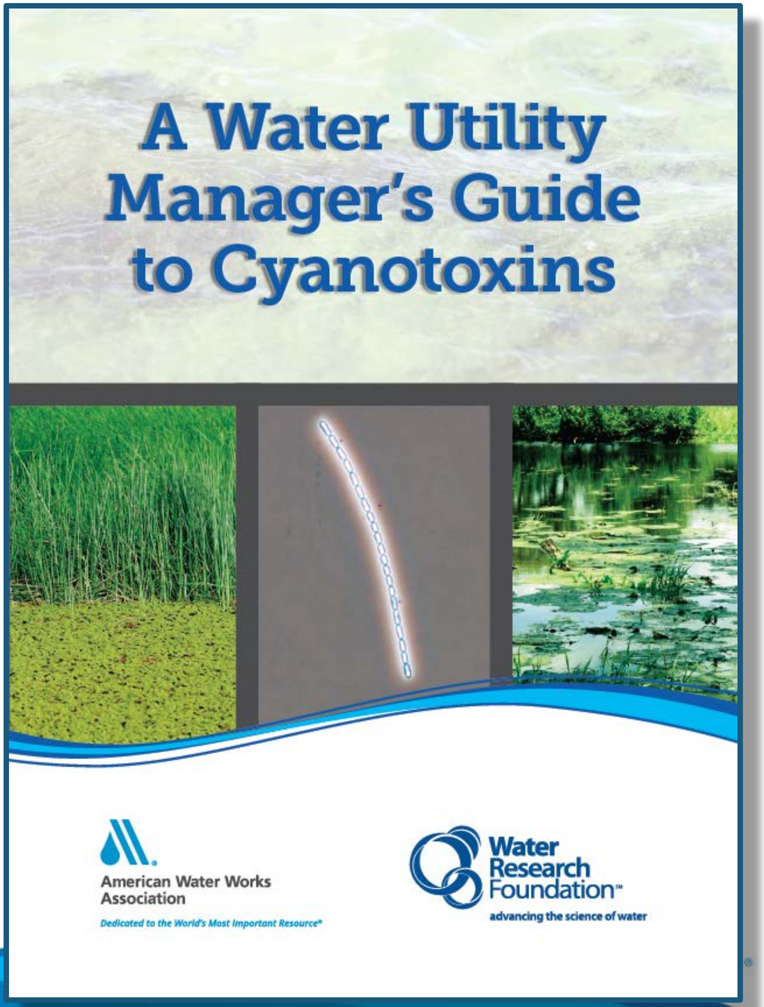
Opening Thoughts

- We need to learn more about cyanobacteria and cyanotoxins
- Utility managers must integrate managing cyanotoxins into existing utility practice
  - Source water protection and water supply strategies,
  - Treatment protocols,
  - Communication plans, and
  - Emergency response strategies

Cyanotoxins are an important concern, hence AWWA and WaterRF developing the Manager's Guide and many other resources.

AWWA/WRF Utility Manager’s Guide

1. What are cyanotoxins?
2. When might cyanotoxins be a concern for a water system?
3. How are cyanotoxins detected?
4. What can a water system do to respond?
5. Where are there knowledge gaps?



Example Resource: Self Assessment

Step 1: How prepared is my system for potential cyanotoxin events?

Asking the following questions can give a water utility a better idea of whether the utility should be preparing itself for possible cyanotoxin problems. This brief assessment considers three categories: 1) source water monitoring; 2) source water quality; and 3) cyanobacteria present during the treatment process. This tool is applicable only for water utilities using water from surface water bodies.

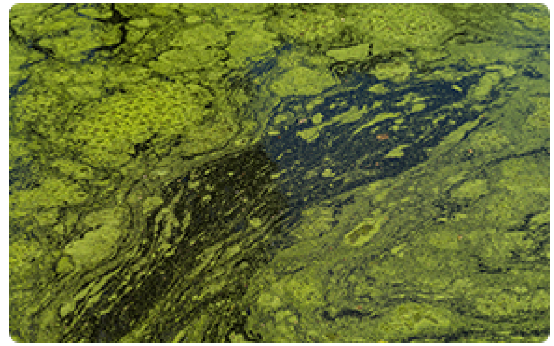
	High Concern	Medium Concern	Low Concern	Very Low Concern
Source Water Monitoring				
Does the utility have a source water monitoring program in place?	Doesn't monitor source water before treatment	Conducts some tests on source water (e.g., turbidity, total organic carbon) as it enters treatment plant	Monitors source water monthly (e.g., chlorophyll *a*, algae counts) at different depths and locations	Has a comprehensive source water monitoring program, sampling at least weekly at different depths, locations
Does the source water quality monitoring program evaluate changes to the water over the year?	No	No	Yes, tracks monthly water quality trends (e.g., to help determine which source(s) to use)	Yes, tracks trends at least weekly of all monitored parameters
Does the utility track changes by comparing water quality data from year to year?	No	No	Yes, seasonal or annual averages are tracked and compared	Yes, charts are created with monthly data for at least the last five years
Source Water Quality and Aesthetics				
Does the source water have algae growth?	Yes, there are blooms and copper sulfate is added regularly	Yes, but treatment adjustments are not necessary in response	Minor algae growth, but no visually obvious blooms	Very minimal, if any, growth

Download the Utility Manager's Guide and many other resources on the AWWA Cyanotoxins Resource Community.

1. AWWA.org
2. Click "resources and tools"
3. Choose "Cyanotoxins"

You do not need to be an AWWA member – this is available to everyone!

Cyanotoxins
RESOURCE COMMUNITY



Cyanotoxins

This AWWA Resource Community is intended to keep the water industry ***in the know*** about tools, issues and developments related to cyanotoxins. If you have any questions or updates to share, please submit them to AWWA.

SUBMIT DEVELOPMENTS

NEW! AWWA Cyanotoxin TESTING & TREATMENT Resources

These guides to cyanotoxins will familiarize water utility managers with the causes and issues concerning cyanobacteria and cyanotoxins, and it provides basic management strategies and guidance for finding other sources on the topic.

- **Water Utility Managers Guide To Cyanotoxins** (PDF)
- **Cyanotoxin Oxidation Calculator** (XLS)
- **Testing Protocols for Site-Specific Oxidation Assessments** (PDF)
- **Testing Protocols for Site-Specific Powered Activated Carbon Assessments** (PDF)
- **Powder Activated Carbon Calculator for Site-Specific Assessments** (xlsx)

Students

If you're pursuing a degree in this field, take a look at the wide range of scholarships available from AWWA and our partners.

Full list of scholarships

UPCOMING WEBINAR: What We Know about Cyanotoxins

This webinar will help participants comprehend the US Environmental Protection Agency's Cyanotoxins health advisory levels and know the AWWA/Water Research Foundation resources that are available to help utilities

US Environmental Protection Agency

USEPA has issued health advisories for two cyanotoxins:

Retrospective 2015 Study

- Funded by AWWA’s Water Industry Technical Action Fund
- Conducted by EE&T, Inc. and Corona Environmental Consulting
- Final report and possible publications in progress and will be publicly available

State approaches to USEPA HAs

States	Action on HA?	Monitoring required?	Intend to collect data?	Written guidance complete, or in development?
OH, RI	**Yes**	**Yes**	**Yes**	**Yes**
MD	**Yes**	No	**Yes**	**Yes**
AL, CO, CT, IL, KS, MA, ME, NH, OR, VT	No	No	**Yes**	**Yes**
SC	**Yes**	No	**Yes**	No
CA, WI	No	No	No	**Yes**
AR, IA, UT	No	No	**Yes**	No
AK, AZ, DE, FL, HI, MN, MT, NC, NM, NV, OK, PA	No	No	No	No
GA, ID, IN, KY, LA, MI, MS, NE, ND, SD, TN, VA, WA, WV	No algal toxin expert was reached after several attempts			
MO, NJ, NY, TX, WY	Currently reviewing or developing their approach to addressing cyanotoxins in drinking water (no current data for this study)			

Publicly available occurrence data

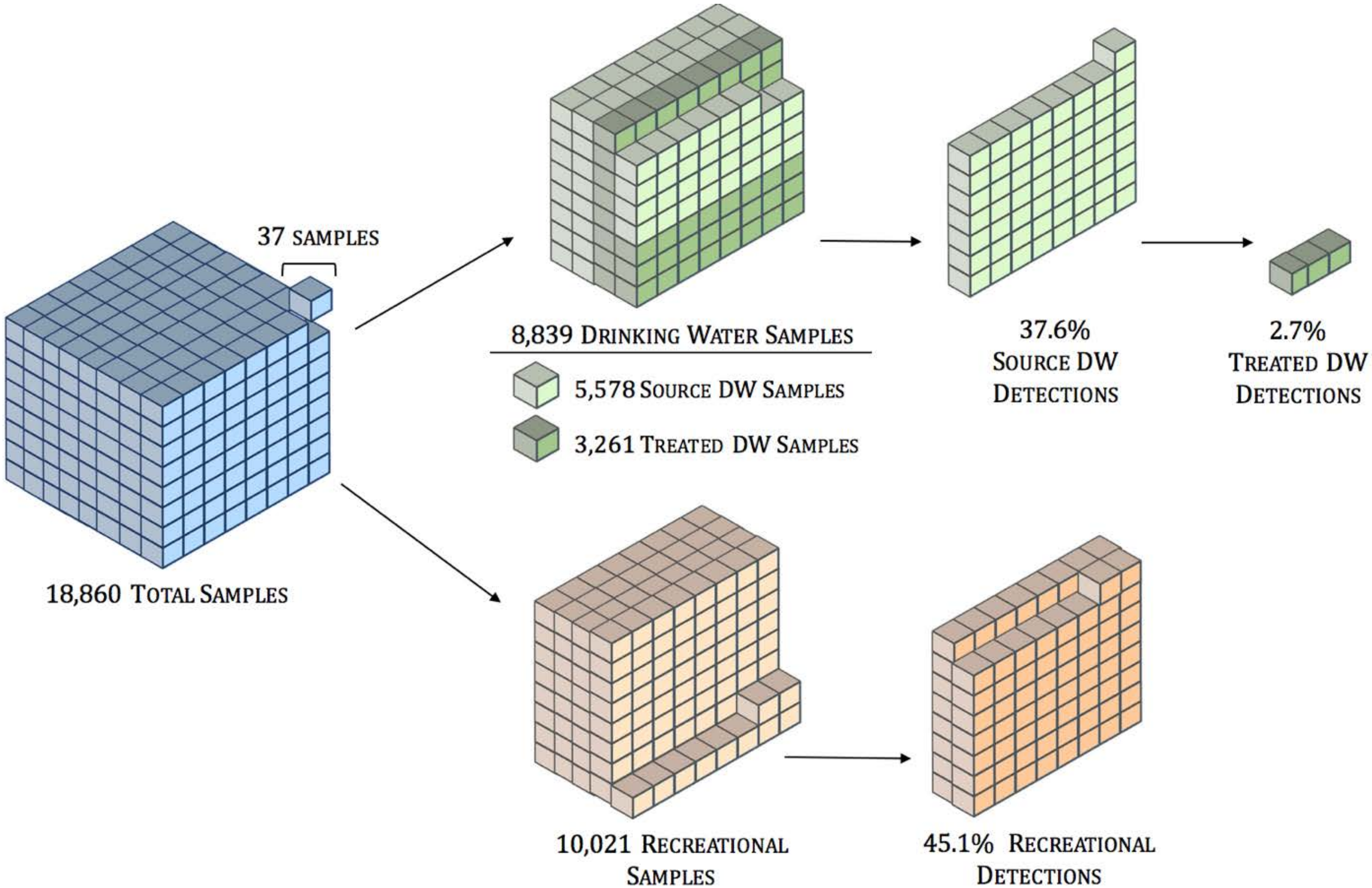
State	Recreational samples	Source Drinking Water samples	Treated Drinking Water samples	Total samples	Years included
MN	671	0	0	671	2006-2007, 2012
OH	2,741	**4,869**	**2,678**	10,301	2010-2015
OR	0	129	27	156	2011, 2015
VT	3	532	532	1,067	2015
WV	0	48	24	72	2015
WA	6,593	0	0	6,593	2000, 2007-2015

Most (but not all) samples are for microcystins. Most states do not report the analytical method used.

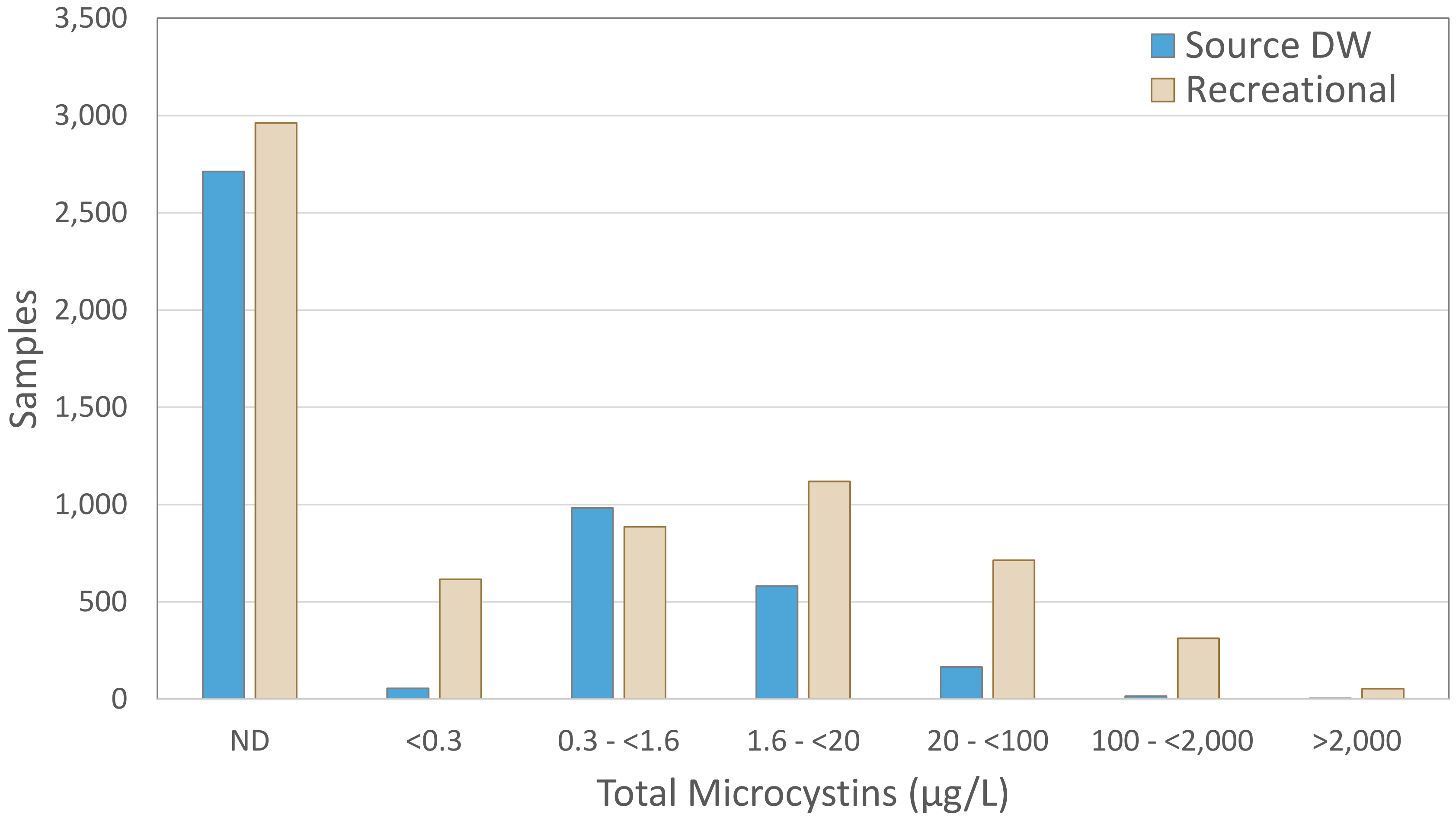
Occurrence Data - 2015 Only

State	Recreational		Source Drinking Water		Treated Drinking Water	
	Samples	Detections	Samples	Detections	Samples	Detections
MN	0	0	0	0	0	0
OH	905	303	**2,619**	**964**	**1,197**	**60**
OR	0	0	24	24	0	0
VT	0	0	**491**	**3**	**491**	**0**
WV	0	0	4	29	24	0
WA	1,360	477	0	0	0	0

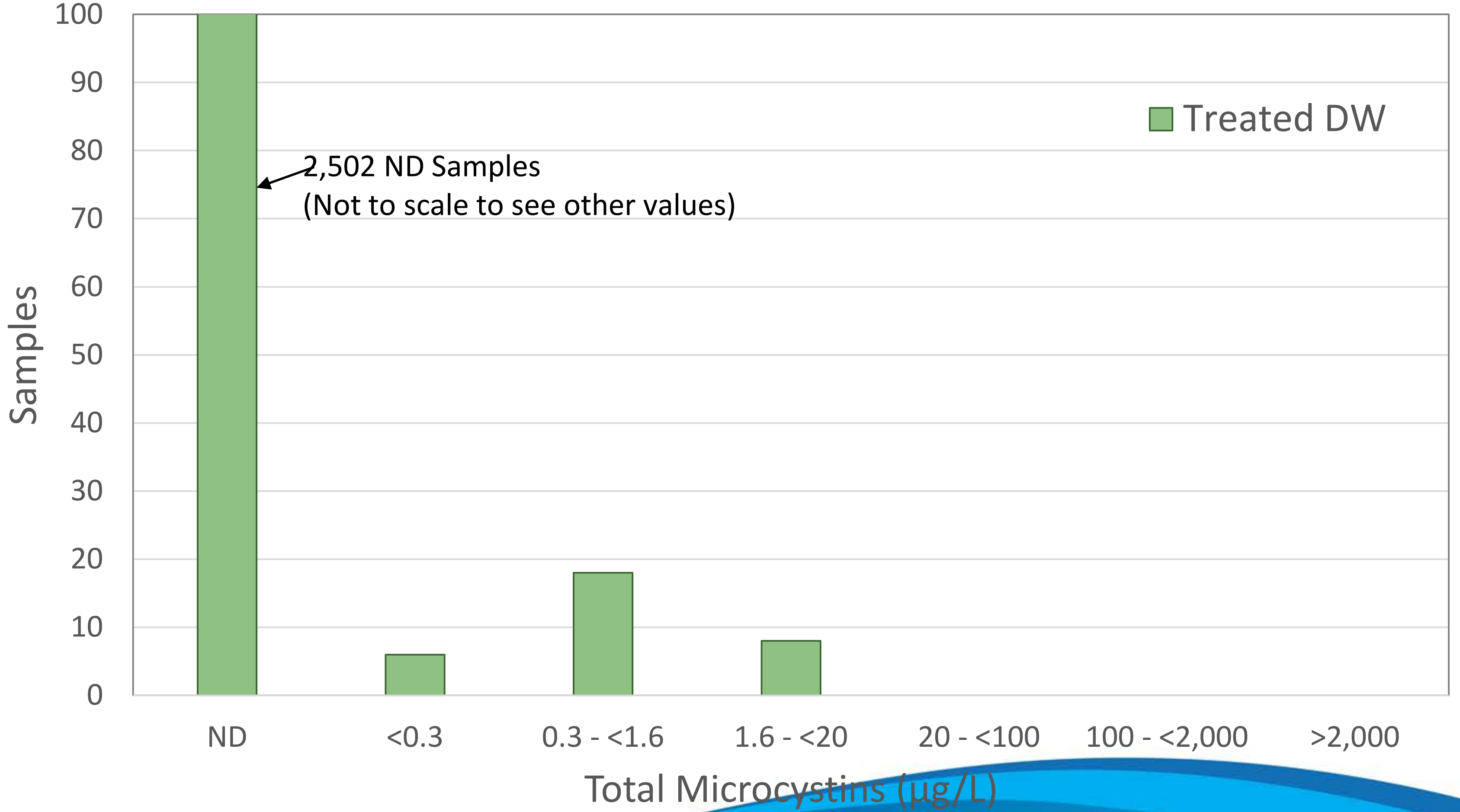
Data set breakdown



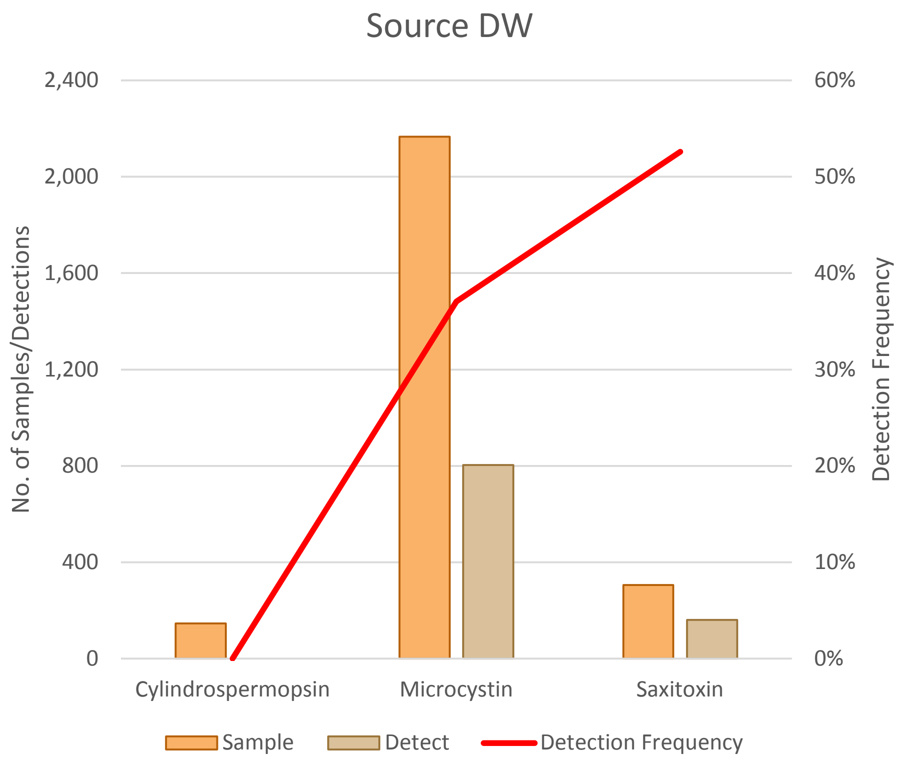
Source and Recreational Water Samples (microcystins)

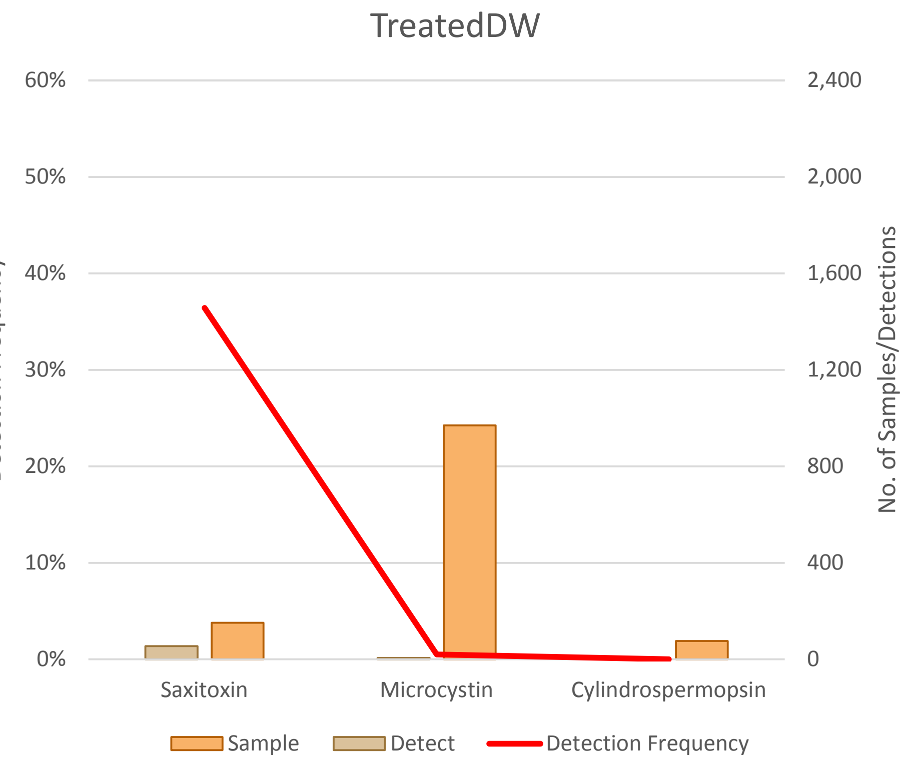


Treated Drinking Water Samples (microcystins)



2015 Ohio Data





No treated DW *microcystin* detections in 2015 were confirmed via follow up sampling – all were single detections, followed by non-detects

Utility interviews

Using

16 of 44 utilities contacted provided information:

- 12 in OH, 2 in OR, 1 in KY, 1 in TX
- Asked about monitoring and responses to source water detections

Monitoring Strategies and Detections

	Monitored		Source DW Detections	
	No. of Systems	% of Systems	No. of Systems	% of Systems
Microcystins	16	100%	14	88%
Cylindrospermopsin	8	50%	2	13%
Anatoxin-a	3	19%	1	6%
Saxitoxin	6	38%	0	0%

Analytical Methods Used

Method	No. of PWSs Utilizing	Reported Detection Level			
		Microcystins (µg/L)	Cylindrosper-mopsin (µg/L)	Anatoxin-a (µg/L)	Saxitoxins (µg/L)
ELISA	12	0.3	0.05	0.05	0.022
ELISA + LC/MS/MS	2	0.3	0.05	0.05	N/A
LC/MS/MS	1	0.1	0.05	0.02	N/A
HPLC-PDA	1	0.2	0.2	0.2	N/A

Utility Responses / Actions

Utility	Modified Operations for Cyanotoxin Removal	Treatment/Practice for Cyanotoxin Removal				
		Adsorption	Oxidation	Shut Down Intake	Modify Pre-filter Oxidation	Eliminate Recycle of Liquid Residuals
A	**Yes**	**Yes**	**Yes**	No	**Yes**	No
B	**Yes**	No	**Yes**	No	**Yes**	No
C	No	**Yes**	**Yes**	No	No	No
D	**Yes**	**Yes**	**Yes**	No	**Yes**	No
E	**Yes**	**Yes**	**Yes**	No	**Yes**	No
F	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**
G	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**
H	**Yes**	No	**Yes**	No	**Yes**	**Yes**
I	**Yes**	**Yes**	**Yes**	No	**Yes**	No
J	**Yes**	No	**Yes**	No	**Yes**	No
K	**Yes**	**Yes**	No	**Yes**	No	**Yes**
L	No	No	No	No	No	No
M	**Yes**	**Yes**	**Yes**	No	**Yes**	No
N	**Yes**	**Yes**	No	No	No	No
O	**Yes**	**Yes**	No	**Yes**	**Yes**	No
P	No	**Yes**	No	No	No	No

Additional Tool- CyanoTOX:

Cover & Caveats
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Hazen
American Water Works Association
UtahStateUniversity

Hazen-Adams
CyanoTOX (Ver. 1.0)

Hazen-Adams CyanoTOX
(Cyanotoxin Tool for Oxidation Kinetics)

This document was prepared by Ben Stanford, Elisa Arevalo, Allison Reinert, and Erik Rosenfeldt of Hazen and Sawyer, and Craig Adams of Utah State University. This document has been reviewed by the AWWA CCL / Potential Contaminant Technical Advisory Workgroup (TAW), with special thanks to Keith Cartnick, David Cornwell, Elsie Kitcher, Issam Najm, Bob Raczko, Rick Sakaji, Steve Via, and Erik Wert for extensive review and comments.

Caveats and Disclaimers

The purpose of this tool is to provide water utilities with a means to assess how changes in their existing treatment (e.g., pH, oxidant dose, contact time) will influence the degradation of specific cyanotoxins or groups of cyanotoxins. This is an evaluation tool, NOT a compliance tool, as such it is critical that the reader fully understand the following caveats.

CyanoTOX – Selected Inputs:

STEP 1. Select the cyanotoxin of interest from the dropdown list

Cyanotoxin Type: Microcystin-LR (MC-LR)

STEP 2. Input the following system parameters

pH (between 6-9): 6.8

Temperature (between 10-30°C): 20

STEP 3. Input the initial cyanotoxin concentration

Cyanotoxin Initial Concentration (µg/L): 50

(If not known, enter an assumed value for the scenario)

STEP 4. Select your target option from the dropdown list

Target. Options: 1) Input target cyanotoxin conc.

Target cyanotoxin concentration (µg/L): 0.3

STEP 5. Select the oxidant of interest from the dropdown list

Oxidant Type: Free Chlorine

STEP 6. Go to your chosen calculator version: CT based or Dose-decay based (tabs in blue)

- Anatoxin-a
- Cylindrospermopsin
- Microcystin-LR
- Microcystin-Mix:

Compound	Percent (if "Mix" used)
MC-LR	5.00
MC-RR	20.00
MC-YR	50.00
MC-LA	10.00
MC-LY	5.00
MC-LF	10.00

CyanoTOX – Example Kinetics (Microcystins with Free Chlorine)

	Free chlorine							
	MC-LR	MC-RR	MC-YR	MC-LA	MC-LY	MC-LF	MC-Mix	Reference/Note
pH (6-9)	6.8							
Temp (10-30 C)	20.0							
pK HOCl/OCl-	7.59							
α HOCl	0.86							
α OCl^-	0.14							
Ea (J/mol)	20100							Acero et al. (2005) for MC-LR value
k"(HOCl) (20C)	1.16E+02							Acero et al. (2005) for MC-LR value
k"(OCl-) (20C)	6.78E+00							Acero et al. (2005) for MC-LR value
keff MC-i/MC-LR	Unity	101%	108%	100%	100%	100%		Acero et al. (2005) for relative rate of MC-RR and -YR, versus MC-LR.
keff (L/mol s) (20C)	1.01E+02	1.02E+02	1.09E+02	1.01E+02	1.01E+02	1.01E+02		$k''_{eff} = k''_{HOCL}\,\alpha_{HOCl} + k''_{OCl}\,(1-\alpha_{OCl})$
keff (L/mol s) (X °C)	1.01E+02	1.02E+02	1.09E+02	1.01E+02	1.01E+02	1.01E+02	1.05E+02	Used in calculations.

- Origins of calculations are clearly indicated and are traceable back to literature demonstrating them
- Kinetics for free chlorine, permangantate, ozone, monochloramine, chlorine dioxide are all available for microcystins, cylindrospermopsin, and anatoxin-a

CyanoTOX Example Results

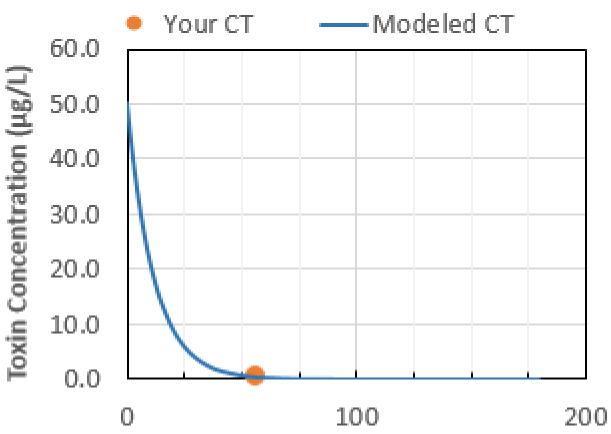

Figure 1a
Microcystin-LR (MC-LR) concentration with Free Chlorine exposure versus Effective CT

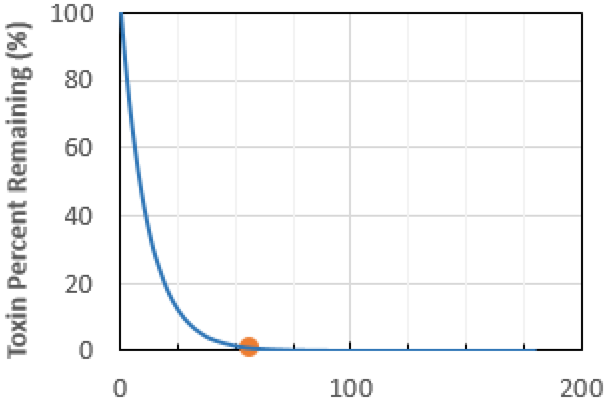

Figure 1b
Microcystin-LR (MC-LR) percent remaining with Free Chlorine exposure versus Effective CT

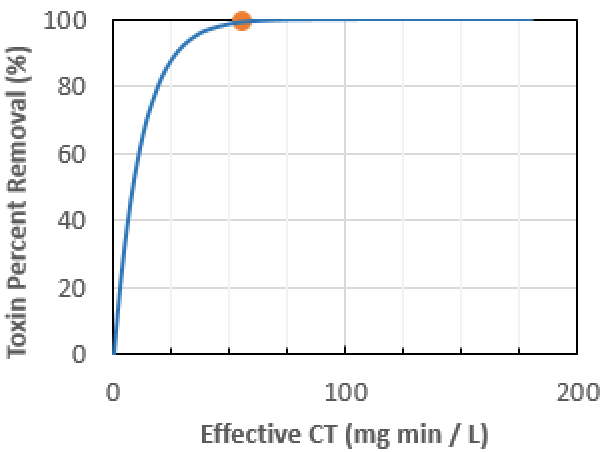

Figure 1c
Microcystin-LR (MC-LR) percent removal with Free Chlorine exposure versus Effective CT

KEY RESULTS:

Final MC-LR Concentration (µg/L)	0.4
MC-LR Remaining (%)	0.8
MC-LR Removal (%)	99.2
CT value of your system (mg-min/L)	56.2
Max influent toxin conc. to achieve target (µg/L)	35.9
Effective CT to achieve target (mg-min/L)	60.1

Additional tools

- Testing protocols for site-specific assessments
  - Oxidation assessments
  - Powdered activated carbon with calculator
- More to come!
  - More detailed treatment information
- Check out the Cyanotoxins resource community at AWWA.org under “Resources and Tools” and the Water Research Foundation’s resources.

Questions?

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Feel free to contact for questions or slides