

SDWA Program Tools to Address HAB-Related Risks to Drinking Water

CyanoSymposium 2023 Tom Waters, PE EPA Office of Water Office of Ground Water and Drinking Water

Overview

• EPA resources to support state, tribal, and water system management of HABs and related cyanotoxins for SDWA purposes



Prevention – health advisories, regulations

<u>Objective</u>: Prevent HABs in source water from impacting finished drinking water and minimize public health impacts

- Federal Health Advisories published in 2015 for total microcystins, cylindrospermopsin in finished drinking water
 - Total Microcystins: 0.3 μ g/L for vulnerable people; 1.6 μ g/L for all persons.
 - Cylindrospermopsin: 0.7 μ g/L for vulnerable people; 3 μ g/L for all persons
- UCMR4 monitoring (2018-2020) for 10 cyanotoxins (total MC, MC-LA, MC-LF, MC-LR, MC-LY, MC-RR, MC-YR, nodularin, anatoxin-a, cylindrospermopsin)
- States such as Oregon and Ohio have enacted monitoring and response regulations

Prevention – EPA publications and tools

• <u>Cyanotoxin Management Plan Template and</u> <u>Example Plans</u>

Cyanotoxin Management Tools for Public Water
 Systems

• Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water

Prevention – WTP evaluation

- Water treatment plant evaluation: <u>Harmful Algal Bloom</u> <u>Comprehensive Performance Evaluation Protocol</u>
 - Support primacy agency and PWS managers, staff and operators
 - Evaluate WTPs for optimized cyanotoxin removal performance during a potential HAB in source water
 - Evaluate results and identify a prioritized list of factors that could limit WTP performance during a HAB
 - Help direct resources to process control optimization, as well as potential administrative, financial, managerial, design and O&M limitations
 - Understand limitations and address them prior to a HAB impacting source water

Prevention – vulnerability analysis

- Conducted water system vulnerability analysis project in Wyoming
 - Study objective: understand WY drinking water system vulnerability to cyanotoxin breakthrough
 - <u>Water system information and performance data</u> → EPA Region 8 (directly implements DW program in WY)
 - <u>Source water vulnerability to HABs</u> collaborated with Wyoming DEQ (recreational HAB data)
 - Result: spreadsheet-based risk analysis and prioritization of WY water system vulnerability to HABs (EPA Region 8 has DW primacy in WY)
- Expanding WY work for national scale (OW & ORD partnership)

Prevention – WTP source vulnerability



Prevention – WTP vulnerability to intracellular cyanotoxin breakthrough



Prevention – WTP vulnerability to extracellular cyanotoxin breakthrough



Prevention – WTP vulnerability – additional risk factors



Monitoring

- <u>Objective</u>: monitor source water and treatment processes regularly to establish a baseline and to understand when treatment adjustments may be needed to optimize during a source water HAB
 - See Dr. Paul's slides 8-18 same CWA monitoring and forecasting concepts can be applied for monitoring drinking source water





Monitoring – summary of known approaches

Visual observation

- Bottle test
- Stick test

Cyanobacteria biomass indicators

Turbidity, particle counts
Pigments: chlorophyll-a, phycocyanin

Molecular methods

- DOC
- UV254
- Color

qPCR

Other indicators

- pH, temperature
- Taste & odor
- Secchi depth
- Decreased filter run times
- Increased chemical usage/needs
- Difficulty maintaining secondary disinfectant residual or meeting turbidity goals

Analytical methods

- ELISA
 - Strip/tube tests
 - Immunoassay
 - Automated CAAS
- LC-MS/MS



Monitoring – methods

- <u>EPA Method 546</u>: Determination of **Total Microcystins and Nodularins** in Drinking Water and Ambient Water by Adda Enzyme-Linked Immunosorbent Assay (**Adda-ELISA**)
- <u>EPA Method 544</u>: Determination of Microcystins and Nodularin in Drinking Water by Solid Phase Extraction and Liquid Chromatagraphy/Tandem Mass Spectrometry (LC/MS/MS): LA, LF, LR, LY, RR, YR, NOD
- <u>EPA Method 545</u>: Determination of Cylindrospermopsin and Anatoxin-a in Drinking Water by Liquid Chromatography Electrospray Ionization Tandem Mass Spectrometry (LC/ESI-MS/MS)

Monitoring / Forecasting – qPCR

Water Research 170 (2020) 115262



Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

Use of qPCR and RT-qPCR for monitoring variations of microcystin producers and as an early warning system to predict toxin production in an Ohio inland lake



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Forecasting

- See slide 18 of Dr. Paul's talk (previously)
- Using satellite imagery (CyAN) for drinking water applications:
 - SDWIS, UCMR4 data sources



Forecast support

Harmful Algae 84 (2019) 75-83



Combining national and state data improves predictions of microcystin concentration

ABSTRACT

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ARTICLE INFO

Keywords: Cyanotoxin Microcystin Chlorophyll Cyanobacteria Bayesian network

Data collected from lakes at national (regional) scales and state (lo regarding relationships between environmental factors and biological of data can potentially yield more precise and accurate understandin can include many measures, cover large spatial areas, and span broad characteristics, analyses of these data can yield accurate estimates or acteristics. However, the number of samples in a national data set tha specific to waterbodies within a smaller region, like a single state, is I provide intensive sampling of lakes within a smaller area, but these dat may only include a subset of relevant measurements. Here, a Baye presents the causal linkages between observations of chlorophyll *a* con microcystin concentration. This network model was fit to national *c* observations of chlorophyll *a* and microcystin collected from lakes in national network model improved the accuracy of predictions of mic to a model based only on lowa data.





Forecast support

F1000Research

F1000Research 2016, 5:151 Last updated: 25 DEC 2016

Check for updates

RESEARCH ARTICLE

REVISED Associations between chlorophyll *a* and various microcystin health advisory concentrations [version 2; referees: 1 approved, 2 approved with reservations]

Jeffrey W. Hollister, Betty J. Kreakie

Office of Research and Development, National Health and Environmental Effects Research Laboratory, Atlantic Ecology Division, US Environmental Protection Agency, Narragansett, RI, USA

V2 First published: 09 Feb 2016, 5:151 (doi: 10.12688/f1000research.7955.1) Latest published: 13 Jun 2016, 5:151 (doi: 10.12688/f1000research.7955.2)

Abstract

Cyanobacteria harmful algal blooms (cHABs) are associated with a wide range of adverse health effects that stem mostly from the presence of cyanotoxins. To help protect against these impacts, several health advisory levels have been set for some toxins. In particular, one of the more common toxins, microcystin, has several advisory levels set for drinking water and recreational use. However, compared to other water quality measures, field measurements of microcystin are not commonly available due to cost and advanced understanding required to interpret results. Addressing these issues will take time and resources. Thus, there is utility in finding indicators of microcystin that are already widely available, can be estimated guickly and in situ, and used as a first defense against high levels of microcystin. Chlorophyll a is commonly measured, can be estimated in situ, and has been shown to be positively associated with microcystin. In this paper, we use this association to provide estimates of chlorophyll a concentrations that are indicative of a higher probability of exceeding select health advisory concentrations for microcystin. Using the 2007 National Lakes Assessment and a conditional probability approach, we identify chlorophyll a concentrations that are more likely than not to be associated with an exceedance of a microcystin health advisory level. We look at the recent US EPA health advisories for drinking water as well as the World Health Organization levels for drinking water and recreational use and identify a range of chlorophyll a thresholds. A 50% chance of exceeding one of the specific advisory microcystin concentrations of 0.3, 1, 1.6, and 2 µg/L is associated with chlorophyll a concentration thresholds of 23, 68, 84, and 104 µg/L, respectively. When managing for these various microcystin levels, exceeding these reported chlorophyll a concentrations should be a trigger for further testing and possible management action.

Open Peer Review

Referee Status: ? ? 🗸

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	1	2	3			
REVISED			~			
version 2						
published 13 Jun 2016			÷			
version 1	?	?	~			
published 09 Feb 2016	report	report	report			
1 Alan E. V	Vilson, Aub	um Univer	sity USA			
2 Jason W. Marion, Eastern Kentucky						
University	USA					
3 Zofia E T	aranu, Uni	versité de l	Nontréal			
Canada						
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Figure 1. Conditional probability plots showing association between the probability of exceeding various microcystin-LR (MLR) health advisory Levels. A.) Plot for USEPA Child (0.3 µg/L). B.) Plot for WHO Drinking (1 µg/L). C.) Plot for USEPA Adult (1.6 µg/L). D.) Plot for WHO Recreational (2 µg/L).

Table 2. Chlorophyll a concentrations that are associated with a 50% probability of exceeding a microcystin health advisory concentration.

Cond. Probability	USEPA Child (0.3 µg/L)	WHO Drink (1 µg/L)	USEPA Adult (1.6 µg/L)	WHO Recreational (2 µg/L)
0.1	0.07	0.07	0.07	1
0.2	0.07	4	12	17
0.3	3	17	32	45
0.4	11	37	68	77
0.5	23	68	84	104
0.6	39	97	115	185
0.7	66	126	871	871
0.8	116	271	871	871
0.9	170	516	871	871

Response – EPA online publications/tools

• Cyanotoxin Management Plan Template and Example Plans

Cyanotoxin Management Tools for Public Water Systems

Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water

Response

• U.S. EPA Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water





Response – public communication tools

- U.S. EPA Drinking Water Cyanotoxin Risk Communication Toolbox
- U.S. EPA Water Contamination Response Resources



- repies collected on (dates) show (cy). Agency's loyanotox
- WHAT SHOULD I DO?
- us me sop water. 9 sources of water) should be used for densing, making infant formula, making ice and prepa **Note heads:** counting the weath west first desired? Operatoristics and tricing increases the basis years. The first matter first interesting, building, weaking hands, weaking divises, flushing bakes, desired, and a so inferent and second ministerio under the price of an adverted to a underward and a price interest and an adverted in a underward and a price interest and a second ministerio under the price of an adverted to a underward and a price interesting of the second ministerio under a second ministerio under the price of an adverted to a underward and adverted in a underward and a second ministerio under a second ministerio underward and adverted to a underward and adverted in a underward and adverted ministerio underward and adverted in a underward adverted in a underward adverted in adve Do Not Drink the tap water. ing, washing hands, washing dialvas, hushing tolates, deaning and let the age of six should be supervised while bathing and during o Do foot Boll the tap water. Bolling the water will not destroy oyand
- ocidental ingestion of water.
- noj uz loceni ekceeding tra nazimal dimeng ekzer Healch Aansones can pa 19 locularija uper klomach, vomilnij and dierbea as wel as liver erd koney 19 die dierbea name) at levels exceeding the national drinking wa
- vius adverse treatm enects including upper sourced, versing and addat attention if you or tamity members are experiencing litres. to advense headtr entects of (cyanotoxin name) at the detected tweets indice incurons of water. Context a veterinarian if entreats shore signs of lineas. Se instant membran security in water, vonsion a contraction is extended water regime to termin We have membran of your administration experienced adverte coardisate-related treatm effects, statute con-termine function.
- In Department) to report the liness.
- health and emergent. en uposted advisory unien: the (organization) levels are test than or equal to the randomal greater this Do Not Drink Advisory is into annour if there are any changes to the consistence of this Do WHAT IS BEING DONE?
- to reduce [cy.



DRINKING WATER ADVISORY - EVERYONE

FOR IMMEDIATE RELEASE Media Contact: [insert name, title, telephone and fax number of spokesperson]

IWATER SYSTEMI ISSUES A ICYANOTOXIN NAMEI DO NOT DRINK ADVISORY

LOCATION [Month Date, Year] - Officials from [local/state agency] have issued a Do Not Drink and Do Not Boil drinking water advisory for [area affected] until further notice. [Cyanotoxin name], a toxin produced by cyanobacteria (formerly known as blue-green algae), was recently detected in the tap water at [levels and/or ranges] on [dates]. This exceeds the U.S. Environmental Protection Agency's national Health Advisory levels of [level]. Therefore, residents in the affected areas should not drink the water

SOCIAL MEDIA

wering, bathing, washing hands, washing dishes, flushing toilor

water in [location] until further notice. For me

as soon as possible: (list actions)

DRINKING WATER ADVISORY - EVERYONE

"Drinking water advisory! Do Not Drink tap water in [location]. For more inform

rarily avoid drinking tap w

water advisory! Cyanotoxins were detected in @ccation/is tar Ag water advisory! Cyanotoxins were detected in [ocation]'s tap water exceeding the relatin Advisories. Therefore, residents in the affected areas should not drink the water.

Everyone may use tap water for showevers, batting, washing hands, washing dishes, tushing diving bandhy. However, infants and young children under the tags of six should be supervise risking when the water-related articulae to consume ancidental investion of water.

you at riski of experiencing adverse health effects of cyanoloxins. Possible adverse health effects include upset isonach, vomiting and diarnos as well as liver and kishey damage. Seek medical attention if you or your family exembers are experiencing ittees.

Do Not Drink the tap water, (Alternative sources of water) should be used for dir unusion in and management found and have management

Do Not Boil the tap water. Boiling the tap water will not dear

ooing aunary, nowever, imans and young cristen under the ag during other tap water-related activities to prevent accidental ing

name) will be taking the following actions to reduce or

wins can be harmful to animals. Consider alternative water sour

Linnking water containing cyanicolos at revos exceedan you at tisk of experiencing adverse health effects of cyan

yone may use tap water for show

Residents in [location] should not drink their tap water. For

FACEBOOK

if animals show signs of illness

[City, State 00000 (www.URL.com) Drinking water advisory! Residents in [location] should not drink their tap water. For m
 website Inter

Officials are working closely with local and state public health and/or emergency response agencies to address and resolve the situation. [System name] is working quickly to reduce [cyanotoxin name] levels in tap water by taking the following actions: [list actions such as adjusting treatment, changing source...].

linsert quote here from a local official!

Individuals who drink water containing [cyanotoxin name] at levels exceeding the national drinking water Health Adviso are at risk of various adverse health effects of [cyanotoxin name]. Possible adverse health effects include upset stoma vomiting and diarrhea as well as liver and kidney damage. Seek medical attention if you or family members are experiencing illness. If you, your family members or your animals have experienced adverse cyanotoxin-related health effects, please contact (State or local Health Department) to report the illness,

[System name] recommends consumers use [atternative sources of water] for drinking, making infant formula, makir and preparing food and beverages and to use precautions against accidental ingestion of tap water until further not ot boil the tap water, as boiling water does not remove cyanotoxins and may increase toxin levels.

ervone may use tap water for showering, bathing, washing hands, washing dishes, flushing toilets, cleaning and indry. However, infants and young children under the age of six should be supervised while bathing and during water-related activities to prevent accidental ingestion of tap water.

rt quote here from a local official

em name] will post an updated advisory when: the [oyanotoxin] levels are less than or equal to the U.S. onmental Protection Agency's national Health Advisories, the Do Not Drink Advisory is lifted and/or if there es to the conditions of the Do Not Drink Advisory.

e with concerns about this event is encouraged to contact Iname of person1 at [contact information] an wing website for relevant information: [link to warning]

Response – state outreach

- Drinking water HAB workshops conducted as part of AWOP in R10 (Oregon, remote) and R6 (Des Moines, IA)
- Operator and technical assistance provider training for Idaho DEQ



Response – technical assistance



Response – technical assistance



Luis Rodriguez Retweeted

EVENADA DE LOS

Embajada EEUU en ES 📀 @USE... · 20h Seguimos ayudando a #ElSalvador a buscar soluciones integrales para garantizar la calidad del agua. Tom Waters, de @EPA, estuvo en la planta potabilizadora Las Pavas de @ANDASV para conocer la situación y dar asesoría técnica según las mejores prácticas de EE.UU. #SocioConfiable

Embajada EEUU en ES 🤣 @USE... 🛛 20h

Después de la ayuda inmediata en la reciente crisis, Tom Waters, experto de la Agencia de Protección Ambiental de EEUU (@EPA), está en El Salvador. El experto se reunió con @FredckBenitez de @ANDASV y @LRodriguez_SV, comisionado presidencial de proyectos estratégicos del país. @LRodriguez_SV

Gracias al apoyo de nuestro principal aliado estratégico Estados Unidos y la gestión de @USEmbassySV, el #PlanNacionalDeAgua tendrá los resultados que esperamos y nuestra población tendra acceso al servicio de agua del que por mucho tiempo estuvieron limitados. @EPA

Control – online documents

- Water Treatment Optimization for <u>Cyanotoxins</u>
 - Supports PWS in developing monitoring and treatment optimization approaches
 - Proactive approaches for sampling/monitoring to help PWS anticipate treatment needs and remove cyanotoxins from DW.



Control - AWOP

- <u>Area-Wide Optimization</u> <u>Program</u>
 - Provides tools and approaches to meet water quality optimization goals
 - Increased, sustainable public health protection
 - Compliance assistance through optimization
 - Teaches problem-solving skills to improve operations without costly capital improvements





Thanks!

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