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Cyanobacteria and Drinking Water:

Occurrence, risks, management and knowledge gaps for public health.

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NCCEH Environmental Health Seminar Series
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Current work

- Drinking water evidence review
  - Overview of cyanoblooms
  - Occurrence in Canada
  - Drinking water and health effects
  - Effectiveness of treatment
  - Approaches to management of risks
  - Knowledge and practice gaps for PH

Lake Erie, July 2015

Blue-green algae confirmed as cause of dogs' sudden deaths in Fredericton

Despite finding, provincial officials say water is still safe for swimming and other recreation

Elizabeth Fraser, Nathalie Sturgeon · CBC News ·
Posted: Aug 03, 2018 12:46 PM AT | Last Updated: August 7, 2018

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Toronto

'My family is traumatized': Man whose dog died blames blue-green algae in Lake Ontario

10-year-old Belgian Malinois died less than two days after swimming at beach in Whitby

Ryan Patrick Jones · CBC News · Posted: Aug 31, 2018 6:00 AM ET | Last Updated: August 31, 2018

Toxic algae near Kamloops possibly linked to cattle deaths, sick dogs

THE CANADIAN PRESS Updated: September 7, 2017

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News

Algae kills dialysis patients in Brazil

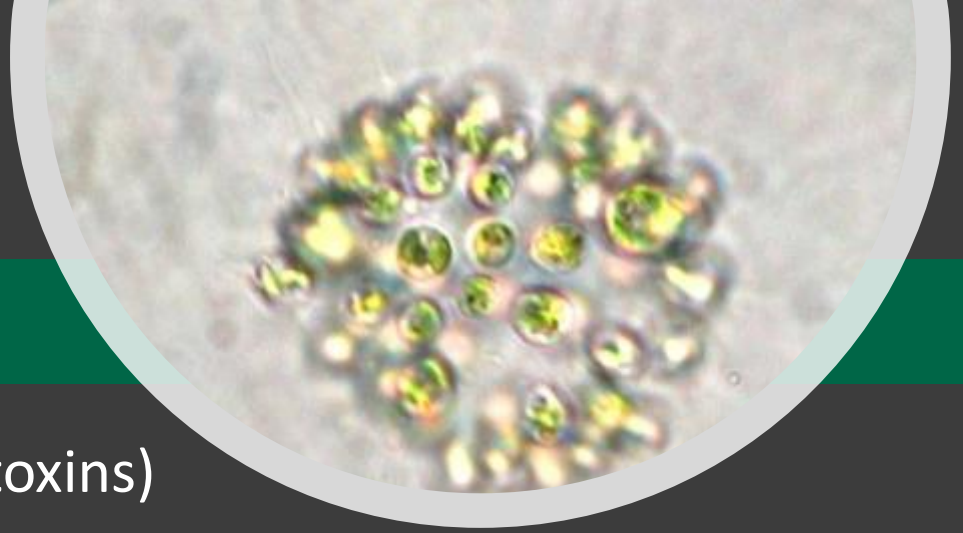
BMJ 1996 ; 312 doi: https://doi.org/10.1136/bmj.312.7040.1183b (Published 11 May 1996)
Cite this as: *BMJ* 1996;312:1183

Article | Related content | Metrics | Responses

Thirty eight patients undergoing dialysis at a renal diseases institute in Brazil have died of acute
result of contamination of the water used for haemodialysis. The cause of the deaths, which all c
20 February and 19 April, was a mystery initially. But the state secretary of health has reported th
for haemodialysis at the institute was contaminated with the toxin microcystin-LR, produced by

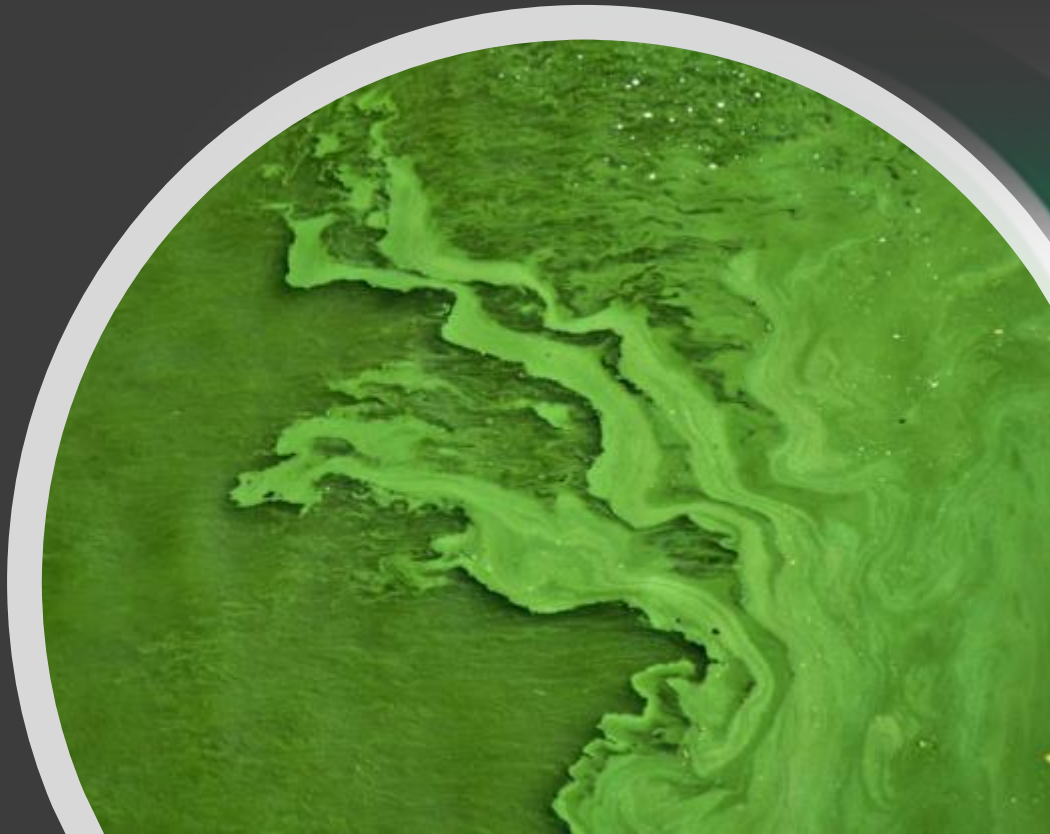
Tatiana Portela, a spokeswoman for the secretary of health, said that the possibility that algae w
deaths was first raised by the ecobiologist Dr Sandra Oliveira e Azevedo of the Federal University
Dr Oliviera e Azevedo collected samples from the water used for dialysis and also from the carbo
dialysis machines at the Institute of Renal Diseases in Caruaru, in the north eastern state of Pern
Preliminary tests showed the presence of the algae and the toxin. Additional samples from the w
from the liver and blood of patients who had died, were sent to the Wright State University, Ohio

Cyanotoxins



- 2000 species of cyanobacteria (~5% produce toxins)
- Between 25-75% of cyanoblooms may contain toxins/toxin producing bacteria
- Cyanotoxins (> 100 principle toxins and variants)

Hepatotoxins	Neurotoxins
• Microcystins (MC) • Cylindrospermopsins • Nodularin	• Anatoxins • Saxitoxins • BMAA



Drinking Water Guidelines (µg/L)

	Microcystins	Cylindrospermopsins	Saxitoxins	Anatoxin-a
Health Canada MAC	**0.4 (infant formula)** **1.5**	**-**	**-**	**3.7 (Quebec)**
US E.P.A. DWHA*	0.3 (children < 6y) 1.6	0.7 (children < 6y) 3.0	-	20 (Ohio) 3 (Oregon)
Australia DW Guidelines	1.3	1 (health alert value)	3 (health alert value)	-
New Zealand Provisional MAC	1.0	1	3	6
WHO	1.0	-	-	-
Brazil	1.0	15 (guideline value)	3 (guideline value)	-
CZ, FI, FR, SP	1.0	-	-	-

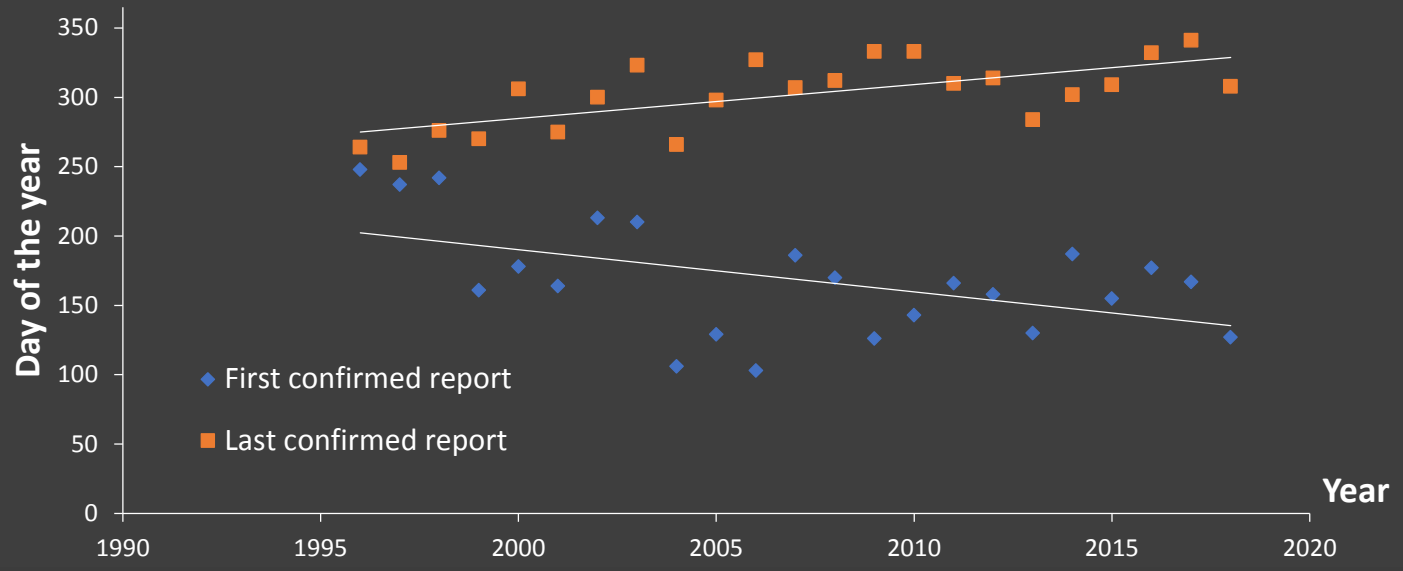
** Variation of limits applied by state*

Occurrence in Canada

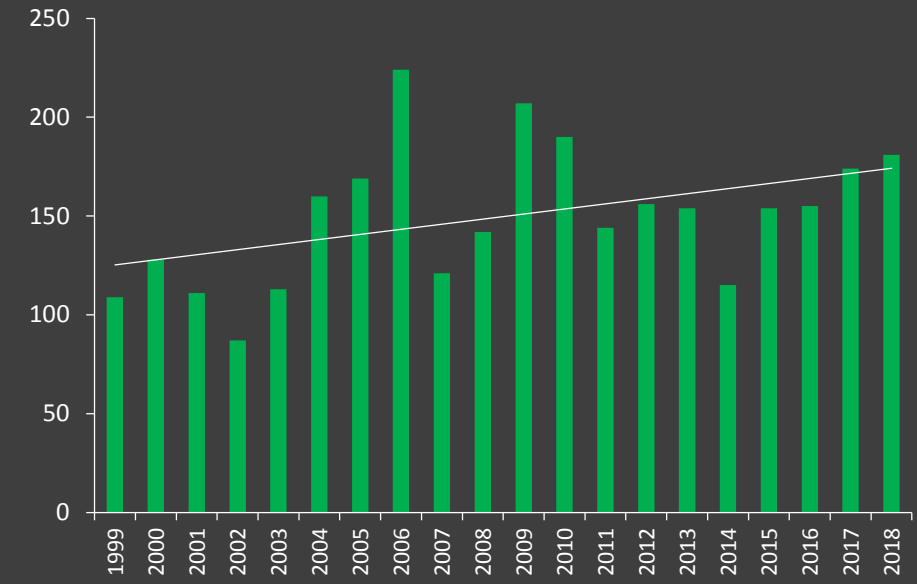
- Bloom season is typically Jun-Nov
- ~150 reports of affected lakes & reservoirs in 2018

Confirmed reports of algal blooms by day of the year 1996-2018

(Environmental Monitoring and Reporting Branch, Ontario Ministry of the Environment)



Length of bloom season, Ontario (days)



Affected DW sources

- Surface water more at risk than groundwater (lakes/reservoirs)
- Affected drinking water source waters in all provinces except for PEI (groundwater only)
- A source water issue in 4-5% of drinking water treatment plants *(Giddings et al. 2012)*

Evidence of health effects from drinking water

- Acute poisoning events
  - Canada - 0 from drinking water
    - Study of 267 families in Quebec – some evidence of increase in mild symptoms where DW supplied by affected lake. *(Levesque et al. 2014)*
  - Globally - 27 drinking water, 3 haemodialysis (1800-2010) *(Wood, 2016)*

- Chronic illness - less well studied
  - Canada – No evidence of chronic effects, but limited study
  - Globally
    - China – Three Gorges Reservoir/Liver damage in children; Elsewhere, link to cancers
    - Ohio - Evidence of MC carcinogenicity but inadequate data on long-term effects from DW

Challenges to identifying cases

- Non-specific symptoms
- Health provider may not be looking for cyanobacterial illness
- No diagnostic tools
- No formal reporting mechanism

- Unknown exposure levels
- Drinking water user may be unaware of affected supply
- Monitoring may be sporadic, data on historic levels not available
- Unregulated small and private supplies unlikely to test for MC

Effectiveness of drinking water treatment

- Municipal treatment plants
  - 88% of Canadian households
  - Multi-barrier approach
  - Majority have never exceeded the MAC for MCs in treated water
  - But exceedances occasionally occur

  e.g. 31 DNC notifications in Quebec 2006-2012

- Key risks
  - Blooms near intake
  - Pre-treatments that kill cells (release toxins)
  - Inadequate monitoring (varies by utility)
  - Lack of system maintenance (filters)

Small and private treatment systems

- 12% of Canadian households not supplied by municipal supply
- e.g. small communities, rural homes and businesses and seasonal properties located on affected waterbodies
- Disinfection only or no treatment systems most at risk
- Advice during a bloom is usually to seek alternative source
- Key challenges
  - Toxins may be present when bloom not visible
  - Length of advisory – till bloom clears or whole season?
  - Lack of simple monitoring/detection tools
  - Lack of suitable treatment technologies

Managing the risk

- Range of approaches across Canada
- Typically
  - Assess the situation
  - Plan for response
  - Monitor
  - Advisories/risk communication
  - Mitigation/Treatment

Assessing the situation

Challenges

- Who is responsible?
  - MoE
  - Utilities for DW sources
  - Health authorities?
- Which waterbodies are vulnerable?
- Who will monitor, and who will respond if there is an issue?

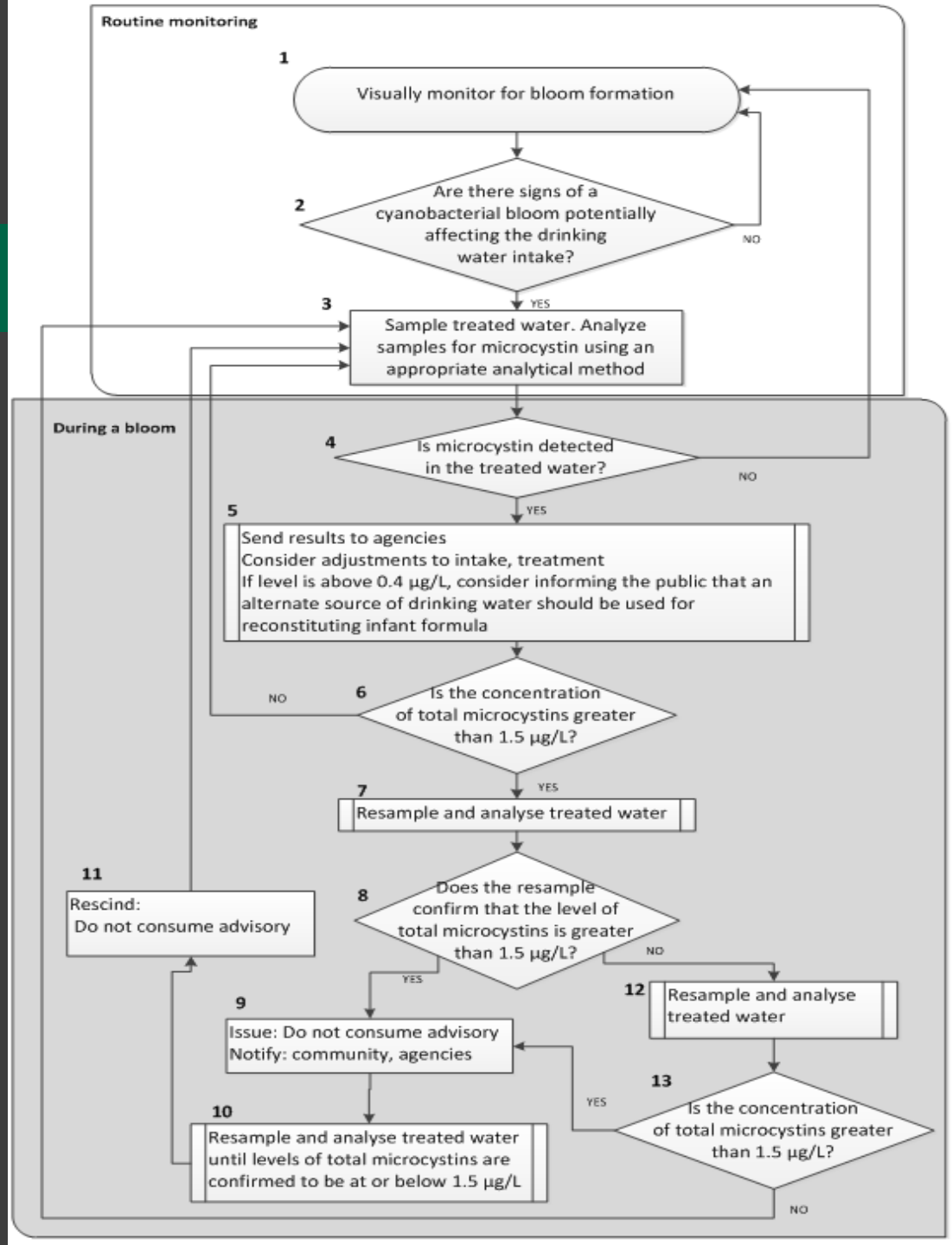
e.g. Alberta – Drinking Water Safety Plans - incorporating consideration of cyanobacteria.

Planning for response

Challenges

- Multiple agencies involved (who leads?)
- Preparing communication plan
  - For whom? (public, EPH, utility operators etc.)
  - What message? (DNC, adjust treatment, etc.)
- Actions at various alert levels
  - Treatment actions, avoidance, advisory
- Most follow Health Canada's flowchart, but some have developed own

e.g. BC decision protocols for Rec/DW



Monitoring

Challenges

- Who is responsible?
  - MoE for recreational water bodies (usually)
  - Utilities for raw/treated DW
  - **SDWS/PWS?**
- Where to monitor/how often/what to measure?
  - Monitoring tools
    - Field tools - Quick but low resolution
    - Lab tests - Accurate but costly and time consuming
    - Real time monitoring
- Need for rapid, cost-effective and accurate field monitoring tools; standard methods, data access

Waterways confirmed to have blue-green algae in the Sudbury and district area

2018

Affected waterway	Area	Date
Clearwater Lake	Sudbury	July 12, 2018
Ramsey Lake	Sudbury	August 9, 2018
Lake Nepahwin	Sudbury	August 16, 2018
Lake Nipissing	Su	
Red Deer Lake	Su	
Lake Kagawong	Ma	
McCharles Lake	Su	
Kakakiwaganda Lake	Su	

- Summary of all waterways (2
- Map of waterways with confi

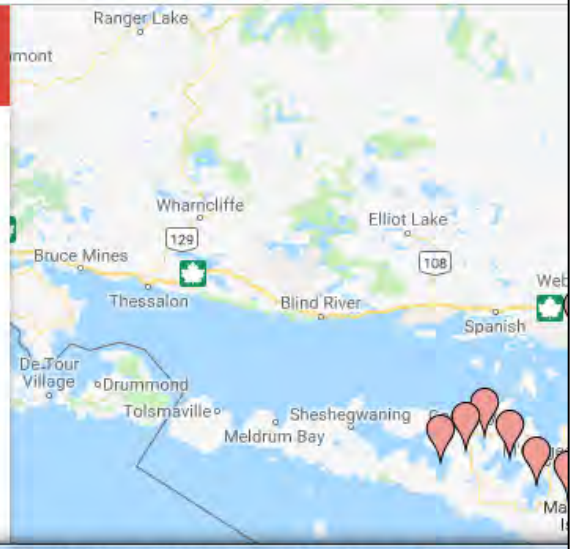
What are blue-gree

Blue-green algae, technically kn
organisms that are naturally pre
present in low numbers. Blue-g
shallow, undisturbed surface w
they can form blooms that disc

McCharles Lake

name
McCharles Lake

description
Blue-green algae identified in October 2008, October 2011, September 2015, November 2016, and September 2018.



Blue-Green_Algae_Identified_From_2006_To_Present_Compliant-1 - Microsoft Excel

File Home Insert Page Layout Formulas Data Review View Acrobat Table Tools Design

B26 Kakakiwaganda Lake

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Area	Waterways	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006
2	Sudbury	Bethel Lake								September					
3		Clearwater Lake	July	September											
4		Ella Lake						February							
5		Grant Lake											November		
6		Hanmer Lake				November									
7		Hannah Lake			July								October		
8		Little Panache Lake				October	August								June
9		Long Lake			November		October	October	June	June			November		
10		Makada Lake				November			November						
11		McCharles Lake	September		November	September		September		October			October		
12		McFarlane Lake		November		June				July			October, November		
13		Middle Lake								August					
14		Nepahwin	August	September	August, November	September									
15		Panache Lake - North East			September	July									
16		Ramsey Lake	August	July	July	July	July	August, October	August	July	August		September		
17		Red Deer Lake	August			July, October									
18		Richard Lake				July									
19		St. Charles Lake		July											
20		Vermillion River								October					
21		Whitson Lake		June		June									
22		Wanapitei Lake		September	July										

BG Algae EN BG Algae FR

AEPHIN

Cyanobacterial Blooms in Alberta Recreational Waters

Home About Contact

Distribution of Sample Results

Select Year

Cell Count (cells/mL)

13 Reported

Microcystins (µg/L)

13 Reported

mcyE Gene (copy/mL)

0 Reported

Visual Evidence

13 Reported

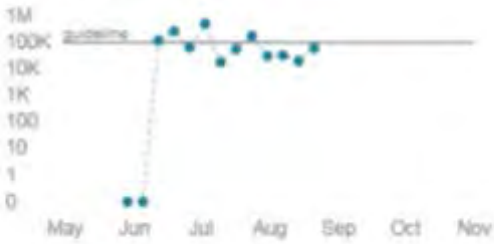
Samples by Beach - 2018

Order by Geography | Lake Name | Number Of Tests | Cell Count | Microcystins | mcyE | **Visual Evidence** reset

Pigeon Lake - 2018

Grandview Beach

Cell Count cells/mL



Microcystins µg/L

Advising the public

Challenges

- When to issue and when to rescind?
- Seasonal or event based?
- Different messaging for different groups?
- Getting the message out – what is most effective?
  - Signage
  - Door knocking/letters
  - Social media
  - Provincial websites
- Most advisories are for recreational use.
- Risk communication for DW - usually DNC, Do Not Boil – what about other uses?

Mitigation/Treatment

Challenges

- Reactive vs. Proactive
- Prevention
  - Diffuse and Point Source Pollution (multiple agencies involved)
- Risk communication
  - Engaged residents and communities (messaging?)
- Treatment
  - Nutrient reduction, Aeration, Biological controls, Algaecides, (risks?)
- DW Treatment systems
  - SOPs for utilities, Additional treatment for SDWS/PWS?

Summary of key knowledge and practice gaps identified

- Need for better access to current and historical monitoring data, and link to health data
- Need for more data on effects of chronic exposure (levels, toxins)
- Research gaps on mechanisms and level of toxicity (toxins and mixtures)
- Lack of universal indicators and standard methods of sampling and analysis
- Lack of rapid and reliable field tests affecting timely detection and quantification of risk
- Uncertainty over exposure in SDWS and PWS
- Uncertainty over best practical advice for SDWS and PWS
- Lack of SOPs for water treatment plant operators for various levels of risk
- Coordination of multiple stakeholders could benefit from local champions and organizational leadership

National cyanobacteria in drinking water – knowledge exchange forum/group

- Quarterly forum/discussion session
- Share ideas and information, common issues

- Seeking your feedback….
  - Do you think it is needed?
  - What types of activities?

  e.g
    - Sharing good practice
    - Developing SOPs
    - Improve coordination
    - Develop knowledge of local champions

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Thank you for listening

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Selected Key References

- Giddings M, Aranda-Rodriguez R, Yasvinski G, Watson S, Zurawell R. Canada: cyanobacterial toxins: drinking and recreational water quality guidelines. In: Chorus I, editor. Current approaches to cyanotoxin risk assessment, risk management and regulations in different countries: Federal Environment Agency (Umweltbundesamt); 2012. p. 29-39. Available from: http://www.umweltbundesamt.de/en/publikationen/current-approaches-to-cyanotoxin-risk-assessment-0.
- Carmichael WW, Boyer GL. Health impacts from cyanobacteria harmful algae blooms: implications for the North American Great Lakes. Harmful Algae. 2016 Apr;54:194-212. Available from: https://doi.org/10.1016/j.hal.2016.02.002.
- Giddings M, Aranda-Rodriguez R, Yasvinski G, Watson S, Zurawell R. Canada: cyanobacterial toxins: drinking and recreational water quality guidelines. In: Chorus I, editor. Current approaches to cyanotoxin risk assessment, risk management and regulations in different countries. Germany: Federal Environment Agency (Umweltbundesamt); 2012. p. 29-39. Available from: http://www.umweltbundesamt.de/en/publikationen/current-approaches-to-cyanotoxin-risk-assessment-0
- Levesque B, Gervais MC, Chevalier P, Gauvin D, Anassour-Laouan-Sidi E, Gingras S, et al. Prospective study of acute health effects in relation to exposure to cyanobacteria. Sci Total Environ. 2014 Jan 01;466-467:397-403. Available from: https://doi.org/10.1016/j.scitotenv.2013.07.045
- Paterson AM, Rühland KM, Anstey CV, Smol JP. Climate as a driver of increasing algal production in Lake of the Woods, Ontario, Canada. Lakes Reservoir Manage. 2017 2017/10/02;33(4):403-14. Available from: https://doi.org/10.1080/10402381.2017.1379574.
- Pick FR. Blooming algae: a Canadian perspective on the rise of toxic cyanobacteria. Can J Fish Aquat Sci. 2016 Jul;73(7):1149-58. Available from: http://www.nrcresearchpress.com/doi/abs/10.1139/cjfas-2015-0470#.WLnCAG_yu70.
- Wood R. Acute animal and human poisonings from cyanotoxin exposure - a review of the literature. Environ Int. 2016 May;91:276-82. Available from: https://doi.org/10.1016/j.envint.2016.02.026

Images and Screenshots

- CBC.ca. '*My family is traumatized': Man whose dog died blames blue-green algae in Lake Ontario*. Aug. 31, 2018. Available at: https://www.cbc.ca/news/canada/toronto/whitby-man-dog-dies-lake-ontario-1.4805858
- Vancouver Sun. *Toxic algae near Kamloops possibly linked to cattle deaths, sick dogs*. Sept. 7, 2017. Available at: https://vancouversun.com/news/local-news/toxic-algae-near-kamloops-possibly-linked-to-cattle-deaths-sick-dogs
- CBC.ca. *Blue-green algae confirmed as cause of dogs' sudden deaths in Fredericton.* Aug. 3, 2018. Available at: https://www.cbc.ca/news/canada/new-brunswick/blue-green-algae-1.4773088
- Governing.com. *Toxins in Tap Water Prompt State of Emergency for Oregon Counties.* June 1, 2018. Available at: http://www.governing.com/topics/transportation-infrastructure/tns-salem-oregon-water.html
- Reuters. Toxin leaves 500,000 in northwest Ohio without drinking water. Aug. 2, 2014. Available at: https://www.reuters.com/article/us-usa-water-ohio/toxin-leaves-500000-in-northwest-ohio-without-drinking-water-idUSKBN0G20L120140802
- WPTV . Algae cleanup underway in Martin County. Aug 27. 2018. Available at:
- WPTVhttps://www.wptv.com/news/region-martin-county/algae-cleanup-underway
- Public Health Sudbury and District. 2018. *Blue-green algae and affected waterways.* Available at: https://www.phsd.ca/health-topics-programs/water/blue-green-algae-cyanobacteria
- Manitoba Government. 2018. Beach Monitoring Information. Available at: https://www.gov.mb.ca/waterstewardship/quality/beach_table.html
- Alberta Health. Cyanobacterial Blooms in Alberta Recreational Waters. 2018. Available at: http://aephin.alberta.ca/cyano/?sortState=visualEvidence&sizeBy=ppi&selectedBeachId=48&colorBy=ppi&ppi=null&mcyE=null&cellCount=null&year=2018&visualEvidence=null.