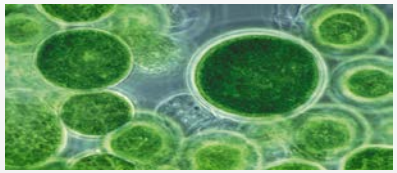
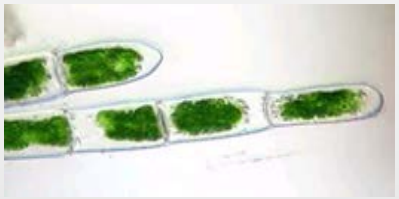
Microcystin-LR and Harmful Algal Blooms





Julia Dady
MDH Health Risk Assessment Unit
CEC Advisory Forum
February 13, 2013

nvaders

turning Americas lakes into toxic pools.

PICS: Wisconsin • District of Columbia • Lincoln Memorial • Ohio

ABC News Video

abc NEWS

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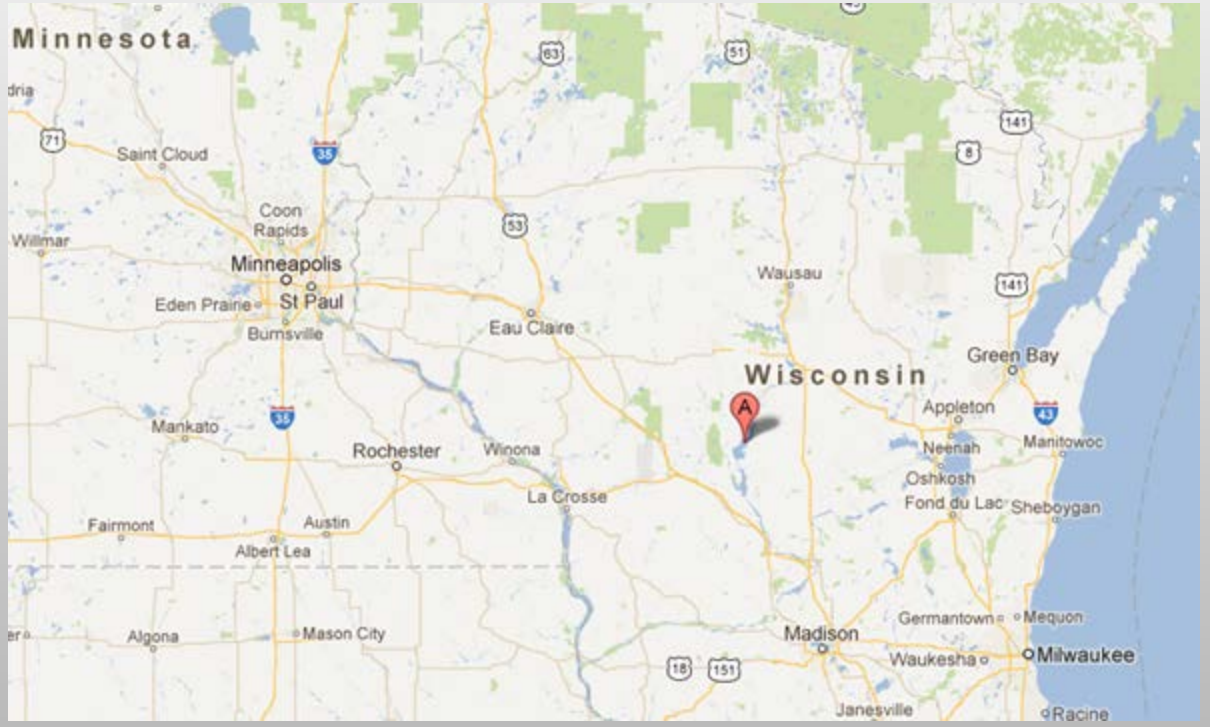
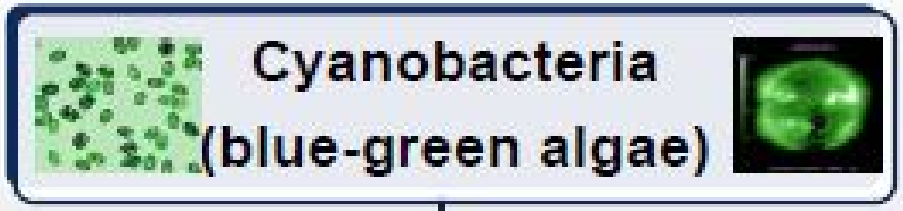
Lake Invaders 9/30/12

http://abcnews.go.com/WNT/video/algae-lakes-toxic-swimming-blooms-us-17362157





Cyanotoxins

Nodularin

Anatoxins

Cylindrospermopsin

Saxitoxin

Microcystins

Many other toxins

Over 80 variants

Microcystin-LR

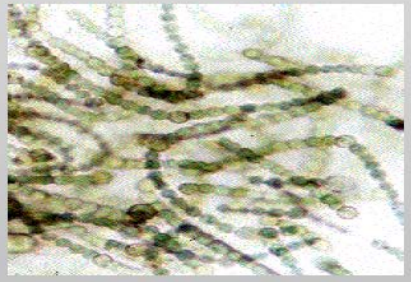
Microcystin-LR – A Contaminant of Emerging Concern

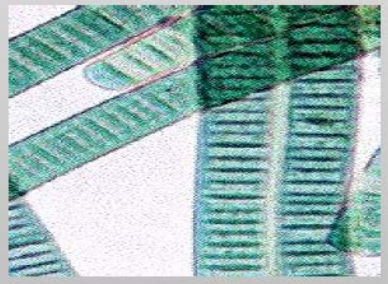
Nominated to CEC program by MPCA in 2011

- Microcystins identified by MPCA as primary cyanotoxin in MN lakes
- Ranked by MDH as high priority for guidance development based on toxicity and exposure factors

Microcystin-LR - MDH Drinking Water Guidance –

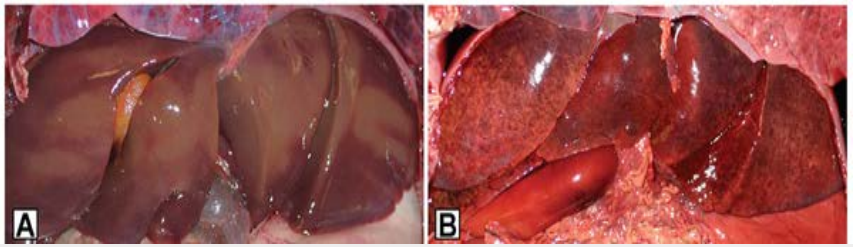
- Health-Based Value (HBV) = 0.04 µg/L
- Guidance posted on MDH website – Sept. 2012





Microcystin-LR – Adverse Health Effects

- Potent liver toxicant



Miller et al. 2010. PLoS ONE 5(9): e12576. doi:10.1371/journal.pone.0012576

- Irritant – skin, eyes, stomach

- Possible male reproductive toxicity?

Needs further study…

Microcystin-LR and Cancer

- Possibly carcinogenic to humans (IARC Group 2B) – Liver, Colon

- Tumor promotor -

Example

Aflatoxins:
Tumor Initiator

+

Microcystin:
Tumor Promotor

=

Liver Cancer

9

Why a Concern for Minnesota?

- **Ambient and Recreational Water Quality –**
  - Fish kills, dog, bird and livestock deaths throughout the world, including several dog deaths in MN
  - Human illness and deaths are also reported globally, but no algal-related human deaths known in MN



  - Citizens are encouraged to report blooms to MPCA and call MDH with health questions or to report health effects.

CLEAN WATER LAND & LEGACY AMENDMENT

10

Why a Concern for Minnesota?

- **Drinking water quality**
  The basis for HBV

- **Lakes & Rivers**: provide drinking water for many cities

Fairmont MN, Budd Lake
Citizen contact MDH about algae toxins & drinking water concerns -summer 2012

They've filtered the stink out of each drink
St. Paul's tap water has better taste and smell

By Jason Hoppin
jhoppin@pioneerpress.com

Article Last Updated: 04/14/2008 06:08:31

- **Groundwater:** shallow residential wells near lakeshores

CLEAN WATER LAND & LEGACY AMENDMENT

Severe Algal Bloom in 2007 – Little Rock Lake

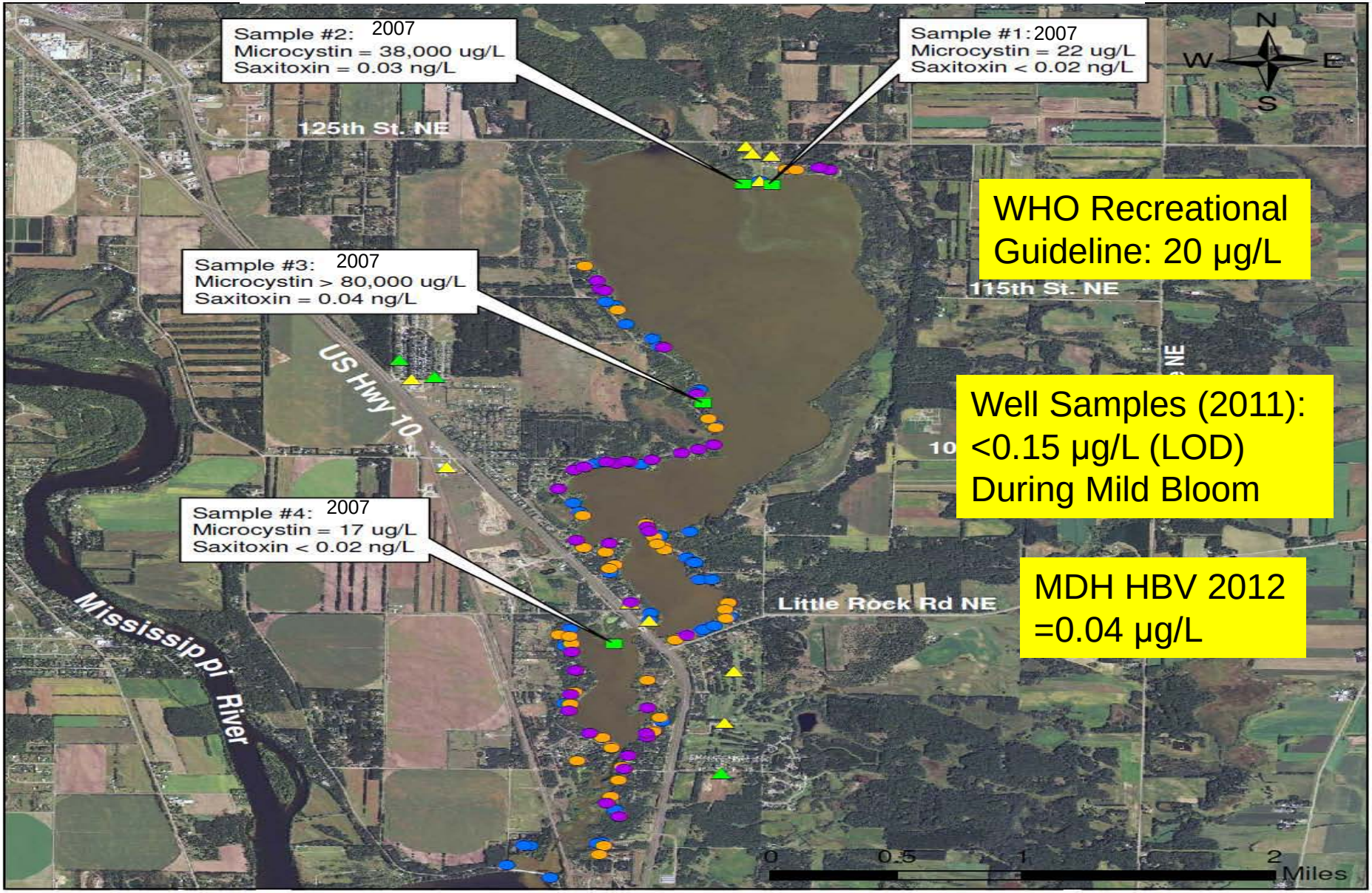


Figure 1: Wells and Water Samples, Little Rock Lake

Detection

- Detection Limits
  - HBV (0.04 µg/L) is below LOD (0.1 µg/L) for standard ELISA method
  - More sensitive methods exist–but expensive and costly special equipment (LC/MS/MS) – may not be feasible for routine screening
  - Recent finding - A new "Enhanced" ELISA method – sensitivity @ 0.04 ug/L – need to explore further….

LOD = Limit of Detection

Drinking Water Guidance Values: MDH & WHO Comparison

Short-term and Subchronic:

MDH (0.04 ug/L)
WHO (n/a)

Chronic:

MDH (0.04 ug/L) **25 x lower!**
WHO (1 ug/L)

Primary Differences:

- MDH applies multi-duration assessment
- MDH used Infant Water Intake Rates
  -to protect bottle-fed infants

WHO = World Health Organization

Algal Blooms and Climate Change

- Conditions favoring algal blooms
  - longer growing seasons, increased water temps, altered rainfall patterns impacting fertilizer run-off
- Increasing frequency, size, and duration
  http://www.cop.noaa.gov/stressors/extremeevents/hab/current/CC_habs.aspx
- Distribution patterns of algal species – new toxins?
  -e.g. *Cylindrospermopsis* not native to WI – A tropical/subtropical organism, recently found in several Midwestern states
- Recent Impacts Noted Locally - Wisconsin DNR
  "Unsightly multi-colored algal blooms appeared earlier than usual on lakes across Wisconsin in the summer of 2012… temperature records were set throughout the state. The unseasonably warm weather changed the trajectories of many natural communities."
  http://www.wisconsinacademy.org/magazine/algal-blooms-wisconsin

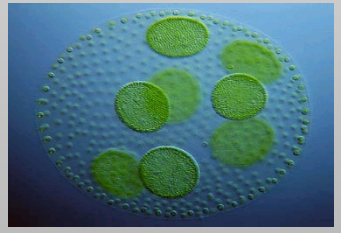
Making an Impact

- **What levels of microcystin are harmful?**
  - MDH HBV much lower than WHO guideline
- **What levels of microcystin can be measured?**
  - HBV much lower than analytical LODs for common methods
  - Spurring investigation of new analytical methods
- **What are current exposures and risks in Minnesota?**
  - Communications with stakeholders
  - Pilot surveillance project for a few lakes with public water intakes

Making an Impact

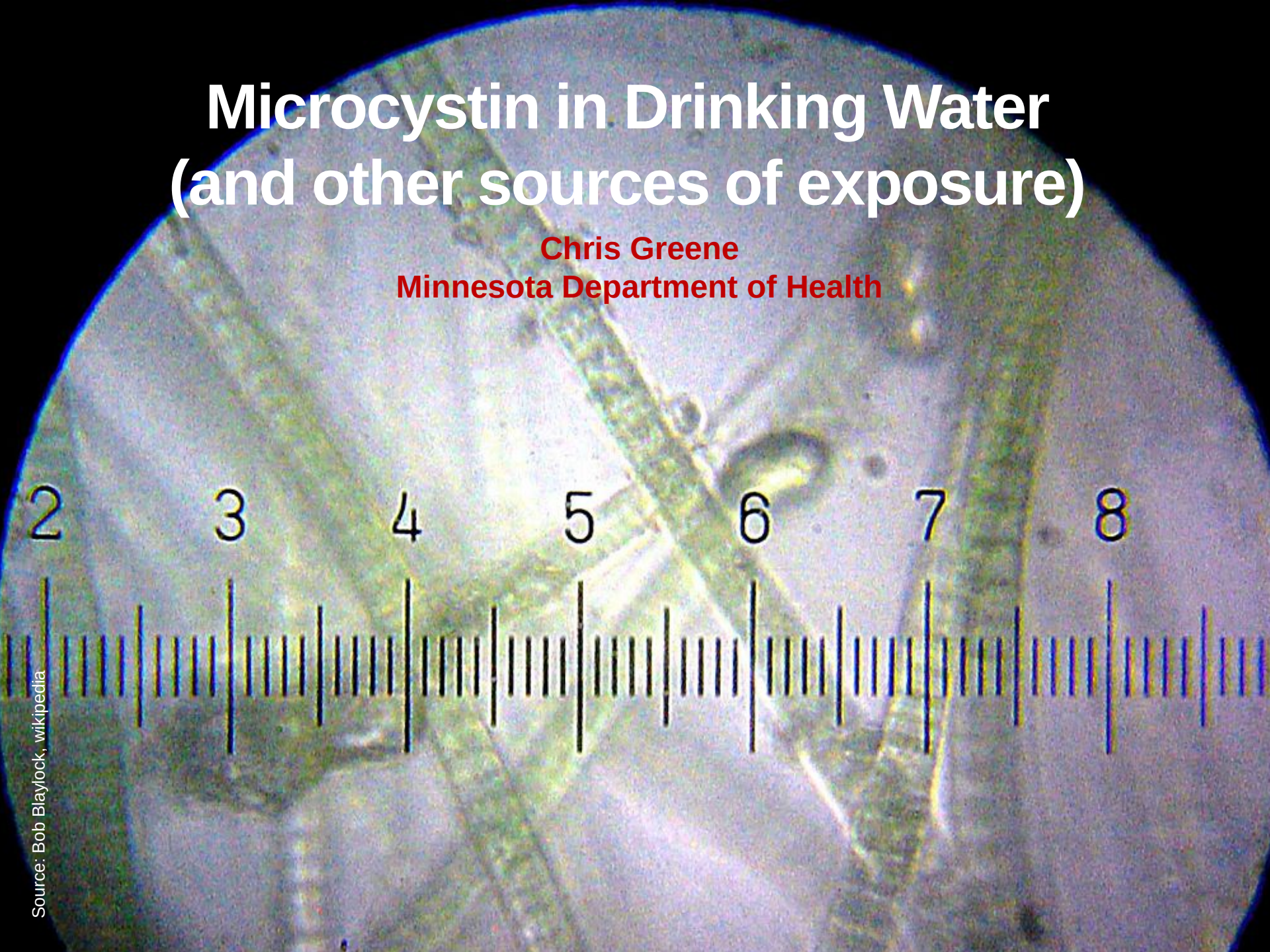
- **Who will continue to research exposure and mitigation?**
  - MDH, MPCA, MDA, and DNR communications around the issue
  - National interest in MDH activities (CDC, USGS, EPA & other States)

- **What emerging concerns need to be followed?**
  - Concerns about climate change and potential for growing health impact
  - Continued evaluation of surface and ground water
  - Continued efforts to develop sensitive laboratory detection methods
  - Awareness of additional toxins to monitor and evaluate



Microcystin in Drinking Water (and other sources of exposure)

Chris Greene
Minnesota Department of Health



Source: Bob Blaylock, wikipedia

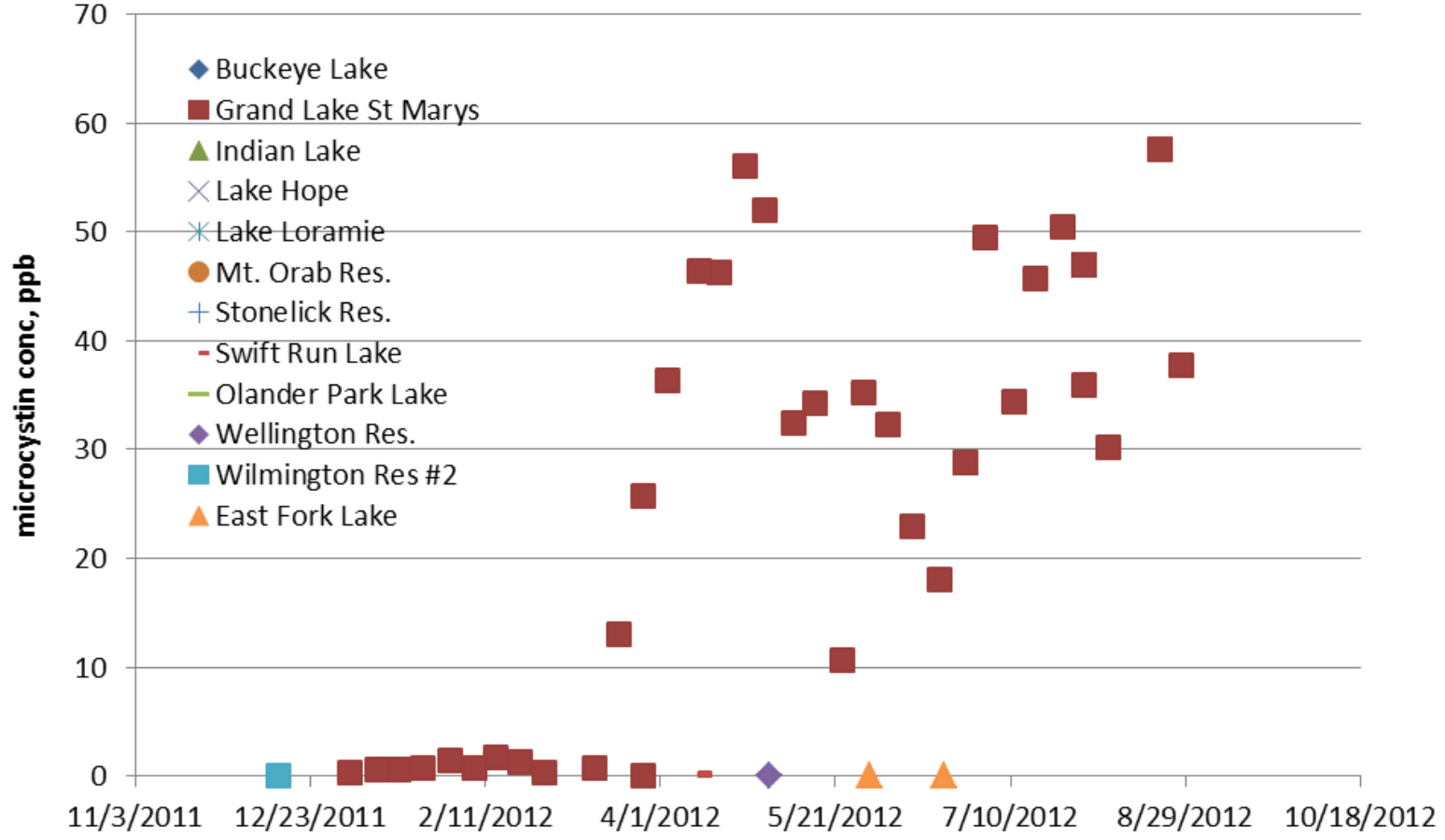
Exposure to Microcystin

- Can people be exposed to microcystin through drinking water?
  - Measurement of microcystin in lakes used as drinking water sources (both inside and outside of Minnesota)
  - Measurement of microcystin in treated drinking water
  - Technical issues in ensuring safe water
- How else are people exposed to microcystin?
  - Dietary supplements
  - Recreational activities

Microcystin in Inland Ohio Lakes, 2012
(PWS and Reservoir Intakes only)

source of data: http://wwwapp.epa.ohio.gov/dsw/hab/toxin_monitoring.php

Note: nondetects are plotted as zero concentration



Source Water vs. Drinking Water (Ohio)

- 2011: 119 finished drinking water samples
- 2012: 39 finished drinking water samples
- No microcystin detections (RL=0.15 or 0.30 ppb)
- Compare to MDH HBV of 0.04 ppb
  - Potential use of enhanced ELISA method?

Microcystin in Minnesota Drinking Water

- Budd Lake (water supply for Fairmont)
  - 2008: surface water concentrations 133 and 134 ug/L
  - Concentration at intake: <0.16 and 0.4 ug/L
- Little Rock Lake
  - 2007 algal bloom: 38,000 - >80,000 ug/L
  - Potential exposure from shallow drinking water wells close to shore

Fall 2012 sampling by DWP

- **Lake Kabetogama:** transient non-community, historical complaints about algal blooms
- **Mankato:** Shallow wells near lakeshore
- **Eveleth,Fergus Falls, Fairmont:** North/South geographical spread
- **Saint Paul:** "test" of city's GAC filters, expected removal of MC from raw water

Fall 2012 sampling

Site	Influent ug/L	Effluent ug/L
Lake Kabetogama	0.21/0.22	ND/ND
Mankato	ND/ND	ND/ND
Eveleth	ND/ND	ND/ND
Fergus Falls	ND/0.16	ND/ND
Fairmont	0.83/0.54	ND/ND
Saint Paul	ND (three plant samples)	

ND = not detected
(RL = 0.15 ug/L)

Drinking Water Observations and Responses

- Microcystin contamination is episodic in nature
  - Hard to sample entre peak
- Contamination appears to be more prevalent in the south (temperature and land use influences)
  - Stewardship and public awareness
- Concentrations can vary substantially within a lake, both horizontally and vertically
  - Carefully select location of drinking water intakes and sampling points
- Treatment seems to be effective
  - Keep plant operators informed
- Reporting limits are typically higher than MDH health-based guidance value
  - Improved methods are under development

Recreational Exposure

Source: Wadewilliams, wikipedia

Recreational Exposure to Microcystin

- Backer et al. (2010) took water and air samples from two recreational California lakes affected by algal blooms, and one unaffected control lake.
- Blood samples, nasal swabs, and personal air space from 81 volunteers on bloom lakes, 7 on control lake.
- Bloom lakes exceeded 10 ug/L for an extended time (July-Sept.) and some samples exceeded 1000 ug/L total microcystins. Control lakes had no detectable microcystin.

Recreational Exposure to Microcystin

- Blood: No detections in any sample (MDL = 1 ug/L).
- Nasal swabs: Before exposure, mean of 0.2 ng ± 0.1 ng; after exposure, 0.6 ng ± 0.8 ng. (Statistically significant) No difference between pre and post in control group.
- Air: At each lake, 3 mid-lake and 3 shore samples. Only one sample had detectable microcystin (0.052 ng/m3, at shore).
- Personal Air: 44 samples ranged from nondetect (0.1 ng/m3) to 0.4 ng/m3. Concentrations did not correlate with concentrations of BGA cells or microcystin in water.

Recreational Exposure to Microcystin

- Inhalation and incidental ingestion are possible routes of exposure
- Skin irritation can occur from contact with microcystin, but it does not penetrate the skin easily
- Exposure can best be reduced by informing the public of risks, and avoiding contact with water during active blooms

Microcystin in Dietary Supplements

Microcystin in Dietary Supplements

- Blue-Green Algae (BGA) supplements: for health, well-being, relief from what ails you
- 1 million consumers in U.S. and Canada
- Marketed to both adults and children as a "natural product"
- Can contain high levels of microcystin, especially when harvested from natural lakes

Microcystin in Dietary Supplements

- Oregon health standard of 1 ug/g Microcystin is often exceeded
- Studies in 2001, 2005, 2008, 2011 found more than half of samples exceed 0.5 ug/g, and some detections as high as 25 ug/g
- At 1 ug/g, just 1 gram of BGA supplements will hit the toxicological reference dose for a 70 kg adult
- *"Take two or three [411-mg] capsules with a meal three times a day."* That's three and a half grams.
- MDH recommends that users of these products "use caution and consult a doctor."

Questions/Discussion

http://earthobservatory.nasa.gov/IOTD/view.php?id=76127

Landsat image created for NASA's Earth Observatory by Jesse Allen and Robert Simmon, using data provided courtesy of the United States Geological Survey. MODIS Rapid Response imagery provided courtesy of Jeff Schamltz. Caption by Holli Riebeek.

Julia Dady
Phone: 651-201-4956
Julia.dady@state.mn.us

Chris Greene
Phone: 651-201-4914
Christopher.greene@state.mn.us

Useful links -

MDH – Microcystin-LR in Drinking Water

http://www.health.state.mn.us/divs/eh/risk/guidance/gw/mclrinfo.pdf

MDH – Little Rock Lake

http://www.health.state.mn.us/divs/eh/hazardous/sites/benton/littlerocklake/index.html

MPCA – Blue-green Algae and Harmful Algal Blooms

http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/lakes/lake-water-quality/blue-green-algae-and-harmful-algal-blooms.html?menuid=&redirect=1&expandable=1

MPCA – National Lakes Assessment Project report:
http://www.pca.state.mn.us/index.php/view-document.html?gid=6231