Blue-green Algal Toxins in Minnesota Lakes

Harmful Algal Bloom Workshops 2008

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Outline

- Brief history on MN algal toxin issues;
- Overview 3 studies that examine blue-green algal toxins in MN – focus on microcystin (MC);
- Overview of findings
- Recommendations based on studies to date;
Accounts of algal toxicity in MN go back to 1800’s on livestock.

Increasing concern and reports worldwide.

Three dog deaths in 2004 (Fish and Benton) prompted further work on this issue.

2005 MPCA joined MDNR, MDH, and the Minnesota Veterinary Medicine Association (MVMA) to form the Minnesota Blue-green Algal Toxicity Workgroup.

2006 study conducted to examine MC in several eutrophic lakes in two south central MN counties.

2007
- Five confirmed dog deaths
- Very high MC results (>80,000 µg/l)
- National Lake Assessment assessed MC in 50 randomly-selected lakes;
- MC monitored in 35 southern MN lakes;
Questions addressed in the 2006 study

- What is the range in MC in eutrophic / hypereutrophic MN Lakes
- Is there a significant difference in near-shore MC as compared to mid-lake?
- Is there seasonality to MC concentrations?
- What limnological and physical factors appear to be associated with high MC?
- How can these findings be used to communicate risk to lake users?
2006 South-Central MN Study

• 12 eutrophic – hyperutrophic lakes

• Sampled six times May-Sept.;

• Mid-lake “pelagic” site – full water chemistry

• Near-shore (bloom hunting) site, typically downwind or distinctly higher algal concentration;
Methods

- Surface grab samples were taken monthly.
- MC samples underwent triple freezing, cell lysis procedure.
- MC analysis was done at MDH:
  - ELISA (Enzyme-Linked ImmunoSorbent assay)
  - Method detection limit (MDL) 0.15 µg/L.
  - The analysis tests for total MC.
Standards or guidelines

- **No MN standards**
- **World Health Organization (WHO) Risk Categories** *(used as reference in our study)*
  - $<1 \mu$g/L (ppb) very low (below drinking water guideline),
  - 1-10 $\mu$g/L Low,
  - 10-20 $\mu$g/L Moderate,
  - 20-2000 $\mu$g/L High
  - $>2000 \mu$g/L Very high

Guidelines for safe recreational water environments *(WHO, 2003).*
71 Pelagic samples
56 nearshore samples
142 Total samples
8 ND's

MC Distribution by Site and Risk Category

MC ppb distribution within WHO risk categories in ppb

0.075-1 >1-10 >10-20 20-2000 >2000
Low Risk Low Risk Moderate High Risk Very High Risk

Near shore Sites
Pelagic Sites

Near shore Site Cumulative %
Pelagic Site Cumulative %

Near shore Sites
Pelagic Sites

Cumulative
Near-shore: Scum vs. no Scum

MC µg/L Range and WHO risk categories

- Low Risk
- Moderate
- High Risk
- Very High Risk

Frequency

Cumulative

0.075-1
>1-10
10-20
20-2000
>2000

Bloom site w/ scum
Bloom site w/o scum
Cumulative % w/ scum
Cumulative % w/o scum
Pelagic Sites

Near Shore Sites

Mid summer High Chl-a But Low MC

Mean 64 Median 47.5

Mean 95 Median 65.1
Percent occurrence of MC risk levels relative to algal bloom intensity

MC versus bloom intensity. Based on 109 pairs of MC & chl-a data

Chl-a Range (ppb) or Bloom Intensity

% MC occurrence

Low

Moderate

High

10 or less

>10-20

>20-30

30-60

>60

>2000

>20-2000

>10-20

>1-10

.075-1
Spearman Rank Correlations for MC and Select Variables:

Sig. pos (+): pH, chl-a attributed to MC producers & chl-a/TSV

Sig. neg (-): alkalinity, conductivity, Secchi
Conclusions from the 2006 Study

- Likelihood of encountering measurable MC at pelagic site?
  - 94% MC results were above mdl at all sites (n=79)

- How do they compare to WHO guideline levels?
  - 25% of the results were above the WHO low risk category

- Do MC conc. differ between near-shore and pelagic sites?
  - Significantly different distributions
  - 40% of mid-lake were less than 1 µg/L vs. 23% of near-shore
  - Greater occurrence of high risk levels at near-shore
  - The likelihood of a moderate to high risk MC at a near-shore with a scum is 25%
Is there seasonality to MC levels in these lakes?
- No distinct seasonal trend evident;

As bloom intensity increases is there a greater likelihood of encountering high MC values?
- Yes, as chl-a exceeded 30 µg/L (severe nuisance bloom levels) risk of high MC increased to ~ 15%; in contrast at lower bloom levels all MC was in the low risk category.

What limnological factors appear to be associated with high MC?
- + association with: pH, TSV and chl-a of MC producers
- - association with: alkalinity, Cond. and Secchi

How can these findings be used to communicate risk to lake users?
- Highest risk MC is most often associated with severe nuisance blooms that result in low transparency (0.5 m or less), high pH (9.0 or more), and that occur most frequently in downwind near shore areas;
Algal Toxin studies: 2007

- NLAP study with mid-lake & near-shore MC measures for 50 lakes;
- 35 lakes in SW MN included Saxitoxin as well as MC;
- Responding to reports of severe blue-green blooms, dog deaths and related concerns – as early as June;
NLAP Methods

Collection
- Index site for EPA & MPCA
- Random near-shore site

Analysis
- Cells were lysed
- Analyzed with ELISA for total MC
- MDH Lab for PCA
- USGS Lawrence KS for EPA samples
- 10 of EPA samples will be scanned
- MDL 0.15 µg/L.
NLAP: Geographic Distribution of MC

Highest MC concentration:
Upper Sakatah 44 ug/L
NLAP MC distributions for mid-lake & near-shore

Drinking Water Guideline

# of samples

Proportion per Bar

MC µg/L

Frequency

Index_site

Mean = 5.0479
Std. Dev. = 1.24963
N = 32

Frequency

J_site

Mean = 2.5102
Std. Dev. = 7.20461
N = 39
NLAP MC Study Conclusions

- Stratified random MC results were lower than previous targeted studies (MC max 44 ppb)
- Somewhat of a geographic trend in MC distribution
- Index and Nearshore results were similar (when lakes and sites are selected randomly)
Responding to Public Concerns

The chart shows the concentration levels of a particular contaminant in different locations, with the Y-axis representing concentration in μg/L. The locations are categorized into three groups: Low, High, and Very High.

- **Benton Crystal Erie** exhibit Very High concentrations in 2004 and 2005.
- **Goose Rock** shows High concentrations in 2004 and Very High in 2005.
- **Como** has Low concentrations across the years.
- **Osakis** displays Low concentrations in 2005.
- **Wallmark Crystal** shows High concentrations in 2004 and Very High in 2005.
- **Wallmark FOUNTAIN** has Very High concentrations in 2006.
- **LONE TREE Crystal** exhibits High concentrations in 2006.
- **LITTLE OUT Bald Eagle** displays Low concentrations in 2006.
- **LITTLE ROCK PELTIER Circle** shows Low concentrations across the years.

The years 2004, 2005, 2006, and 2007 are indicated at the bottom of the chart.
Summary

- 2006 study supplied useful information relative to the range, seasonality and association of MC and other factors in eutrophic MN lakes. [http://www.pca.state.mn.us/water/lake.html](http://www.pca.state.mn.us/water/lake.html)

- 2007 stratified-random study exhibited lower MC (relative to other studies); however it demonstrated that MC is present at measurable concentrations in a wide range of lakes in MN; (posted at: [http://www.pca.state.mn.us/water/nlap.html](http://www.pca.state.mn.us/water/nlap.html))

- Incident response sampling often results in high MC levels;

- Based on these studies - Current recommendation to avoid contact with blue-green algal blooms is sound; further, blooms that yield very low transparency (< 0.5 m), high pH (>9.0), and distinct surface scums are highly likely to have high MC concentrations.