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;
MN History With Algal Toxins

- Accounts of algal toxicity in MN go back to 1800’s on live stock
- Increasing concern and reports world wide
- 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 µg/L (ppb) very low (below drinking water guideline),
  - 1-10 µg/L Low,
  - 10-20 µg/L Moderate,
  - 20-2000 µg/L High
  - >2000 µg/L Very high

Pelagic samples: 56
Nearshore samples: 71
Total samples: 142

MC Distribution by Site and Risk Category:

- Low Risk:
  - 0.075-1: 11
  - >1-10: 25
  - >10-20: 5
- Moderate Risk:
  - >10-20: 6
- High Risk:
  - 20-2000: 8
- Very High Risk:
  - >2000: 2

MC ppb distribution within WHO risk categories in ppb:

- Near shore Sites
- Pelagic Sites
- Near shore Site Cumulative %
- Pelagic Site Cumulative %
Near-shore: Scum vs. no Scum

- **Frequency**
  - 0.075-1
  - >1-10
  - 10-20
  - 20-2000
  - >2000

- **Cumulative %**
  - Bloom site w/ scum
  - Bloom site w/o scum
  - Cumulative % w/ scum
  - Cumulative % w/o scum

**MC µg/L Range and WHO risk categories**
- Low Risk
- Moderate
- High Risk
- Very High Risk
Percent occurrence of MC risk levels relative to algal bloom intensity

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

- Low
- Moderate
- High

Chl-a Range (ppb) or Bloom Intensity:

- 10 or less
- >10-20
- >20-30
- 30-60
- >60

% MC occurrence

Legend:

- >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%
Continued

• 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 μg/L
NLAP MC distributions for mid-lake & near-shore

Drinking Water Guideline

# of samples

MC µg/L

Proportion per Bar

Frequency

Index_site

Frequency

J_site

Mean = 0.079
Std. Dev. = 1.096
N = 32

Mean = 2.312
Std. Dev. = 7.066
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

Very High
High
Low

2004 05 2006 2007
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.