Algal Toxins in Iowa’s Water

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Cyanobacteria a.k.a. “Blue-Green” Algae

A quick primer...

- 1 Billion years and going strong
- Photosynthetic bacteria
  - Can produce green, blue, red, or brown pigments
- Found in fresh and salt water
- Many can fix nitrogen (not all)
- Resting spores
- Mobile - regulate buoyancy
- Can harvest nutrients from sediments
- Toxins with >100 variants
How Toxic are Cyanotoxins?

- **Acute Toxicity**
  - Cytotoxic
  - Dermatoxic
  - Hepatotoxic
  - Neurotoxic

- **Chronic Toxicity**
  - Carcinogen
  - Tumor promoter
  - Mutagen
  - Teratogen
  - Embryolethality
  - Neurodegenerative disease

![Diagram showing acute and chronic toxicity of various cyanotoxins](slide)
Impacts of Cyanotoxins and Harmful Algal Blooms

- Human and Animal Health Risks
- Hypoxia and Fish Kills
- Water Treatment Costs
- Lake Aesthetics - Clarity & Smell
- Quality of Life
  - Recreational Opportunities
  - Property Values
  - Tax Revenues
  - Employment
Harmful Algal Blooms are a Nationwide Issue

Graham and others, 2016, USGS OFR 2016-1174
http://dx.doi.org/10.3133/ofr20161174
Cyanotoxins Are Detected in All Types of Waterbodies Throughout the Nation

Graham and others, 2016, USGS OFR 2016-1174
http://dx.doi.org/10.3133/ofr20161174
In 1944, an *Anabaena* bloom in a lake in the Okoboji chain of lakes in Iowa was blown onshore and caused fatal poisoning of pigs and at least one dog that drank from the lake\(^1\)

Backer et al, Toxins 2013, 5, 1597-1628; doi:10.3390/toxins5091597

“Storm Lake in Iowa experienced dramatic bloom events in 1952: associated with *Anabaena flos-aquae* blooms were estimated deaths of 5-7,000 gulls, 560 ducks, 400 coots, 200 pheasants, 50 squirrels, 18 muskrats, 15 dogs, 4 cats, 2 hogs, 2 hawks, 1 skunk, 1 mink, plus “numerous” songbirds.”


Blue-green algae being studied for impact on cattle
May be cause of some cattle deaths

Blue-green algae, also known as cyanobacteria, are microorganisms with photosynthesizing ability which grow in water bodies.

An increase in case submissions for algae identification has been hypothesized to be related to drought conditions that existed across the Midwestern U.S. during the past two years. In one such example, 30 out of 50 cows died shortly after consuming pond water in central Iowa. A blood chemistry evaluation of a surviving cow revealed some indications of temporary liver damage, and the pond water revealed significant numbers of Microcystis (toxic to the liver) cyanobacteria.

However, we are also observing an increase in a new emerging invasive species of tropical cyanobacteria known as Cylindrospermopsis which produce potent systemic toxins known as cylindrospermopsins. Their impact on Iowa livestock is yet to be determined.

The majority of blue-green algal intoxications are caused by microcystins. Cattle can be affected by drinking water containing toxins or intact blue-green algal cells.

In small lakes or large ponds of water, wind effect tends to concentrate the blooms on one side of the water body. Cattle are usually poisoned when they drink from the windward side of these stagnant water bodies where the blue-green algae accumulate.

However, toxic blue-green algae also will grow in stagnant small puddles of water and accumulation occurs on forms if left to the elements. Cattle can become poisoned if they drink from such puddles.

Symptoms of cyanobacterial poisoning include lethargy, incoordination, ataxia, tremors, convulsions, loss of appetite, constipation or diarrhea, retinal lesions and tearing of the eyes, urination, diarrhea, dehydration, tremors, incoordination and convulsions. Affected animals die of respiratory paralysis. There are no gross or histological lesions in animals that have died of anatoxin intoxication. Death comes quickly, usually in a matter of minutes to hours and may occur in the vicinity of the contaminated water body.
History of Bloom Monitoring

Carter Lake, IA - June 2004

Big Creek State Park, June 2005
Sampling Protocol

Sampling Design
- Focus on beaches
  - Weekly samples
  - Total microcystin
  - Composite and Discrete (scum) samples
- Designed as survey with rapid turnaround
  - Allows for public health decisions to be made
  - 20 μg/L total microcystin threshold level established
- Samples collected Monday/Tuesday
  - Results usually available Thursday afternoon
Iowa Advisory Policy (2016)

Three-tiered advisory policy:
Based on results from both composite and discrete samples
- **Stage 1** (no algal toxin-related advisories)
- **Stage 2** (advisory) - sample result exceeds 20 µg/L total microcystins
- **Stage 3** (closure) - toxin result > 2000 µg/L; reported health case(s).
Public Notification

- General information signs
- Park staff notified
  - Post advisory signs
- Iowa Department of Public Health HAN
- IDNR Beach Monitoring website
- Beach Monitoring Hotline
- Press releases
Advisory Summary in Iowa (2006-2016)
Number of Lakes with Advisories (2006-2016)
Microcystin Advisories (2006-2015)

Beaches
Number of Samples Exceeding 20 µg/L
- 0 - 1
- 2 - 3
- 4 - 6
- 7 - 12
- 13 - 27
Illness Surveillance

- The Iowa Department of Public Health (IDPH) is responsible for tracking illness in humans attributed to microcystin poisoning
- Reporting of suspected cases of microcystin poisoning required of health care providers
- The IDPH works cooperatively with local health care partners in this tracking process
  - Local county environmental health
  - Local network of health care providers
Four of 2011 cases were at a triathlon
Complaint Type (2011-2016)
Solutions?
Cyanobacterial Harmful Blooms (CyanoHABs): Symptomatic of human and climatic alteration of aquatic environments

Urban, agricultural and industrial expansion

Increasing nutrient (Nitrogen & Phosphorus) inputs

Water use and hydrologic modification play key roles

Climate (change) plays a key interactive role

Blooms are intensifying and spreading
An increasing number of studies finding that BOTH nitrogen and phosphorus reductions are needed

“Bioavailability of both N and P during the summer plays a key role in sustaining cyanobacterial blooms.”

Nutrient Goals

National Lake Assessment (1,2)
• Total Nitrogen 1100 ug/L
• Total Phosphorus 87 ug/L

Region 7 (3) Lake Benchmarks
• Total Nitrogen 700 ug/L
• Total Phosphorus 35 ug/L

Nutrient Goals

Iowa DNR Lake Monitoring Program (138 lakes)
• Median Nitrate 1900 ug/L
• Median Total Phosphorus 78.3 ug/L

A long way to go.....
North Raccoon River near Sac City (Sac Co.)

Year

Nitrate+
Nitrite-N (mg/L)
0
5
10
15
20
25
30
Health Information
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Questions?

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Rock Creek Lake August 18, 2006