



Microcystin concentrations following treatments of harmful algal blooms

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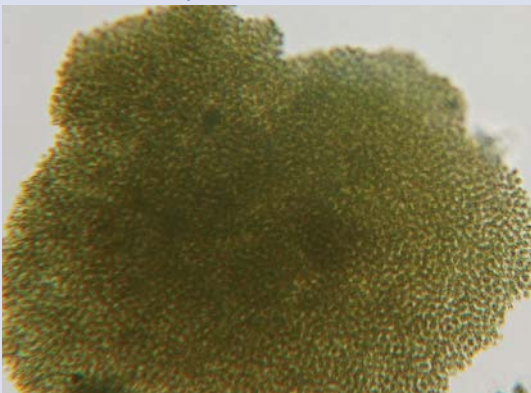
The Question:

Should the fear of “releasing” *microcystin* deter an algaecide application?

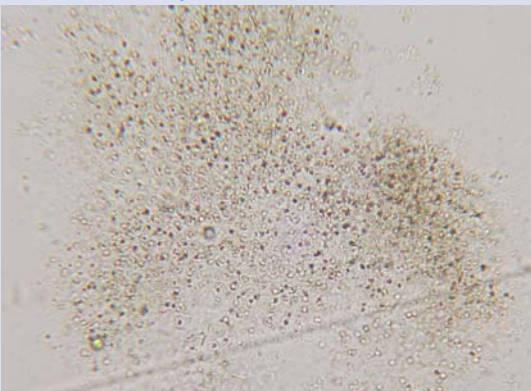
LEAKY CELL HYPOTHESIS

The hypothesis: Many cyanobacteria contain *microcystin* internally and upon treatment with algaecides cells are lysed and release *microcystin* into the water, consequently posing increased threats to organisms.

Microcystis Pre-treatment



Microcystis Post-treatment



The rebuttal:

- If the source of the toxin is controlled (i.e. cyanobacteria) no more toxin can be produced.
- Treatments do not have to lyse the cell for cell death to occur.
- The “no action” decision often results in increased toxin and consequent risk.

Anabaena Pre-treatment



Anabaena Post-treatment



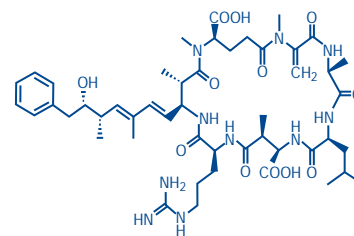
Microcystin producing cyanobacterial genera:

<i>Microcystis</i>	<i>Nostoc</i>
<i>Anabaena</i>	<i>Hapalosiphon</i>
<i>Oscillatoria</i>	<i>Anabaenopsis</i>
<i>Planktothrix</i>	

- World Health Organization drinking water guideline of 1 µg/L total *microcystin*.
- Total *microcystin* includes both intracellular (inside algal cells) and extracellular (in the water).

MICROCYSTIN

- Hepatotoxic Cyclic Peptide Toxin
- Potentially toxic to fish, invertebrates, and mammals at low concentrations ($\leq 8 \mu\text{g/L}$)
- Many Forms: LA, LL, AR, YA, RR, LR
- Widespread
- Water Soluble
- Chemically Stable

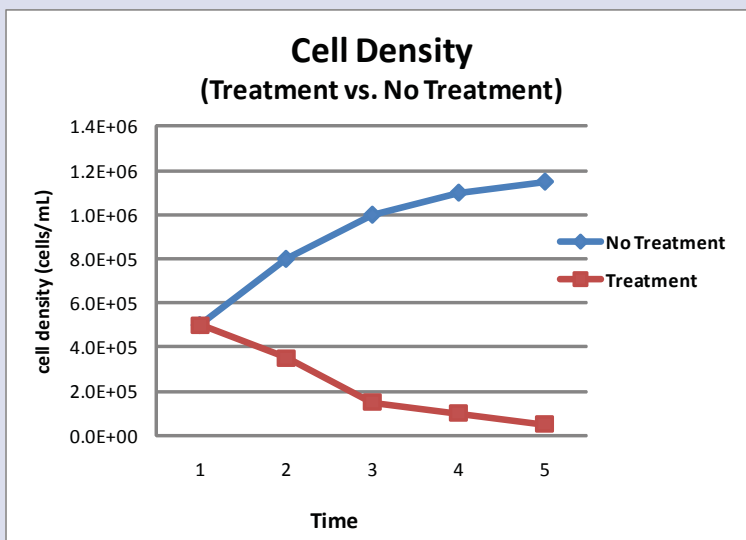
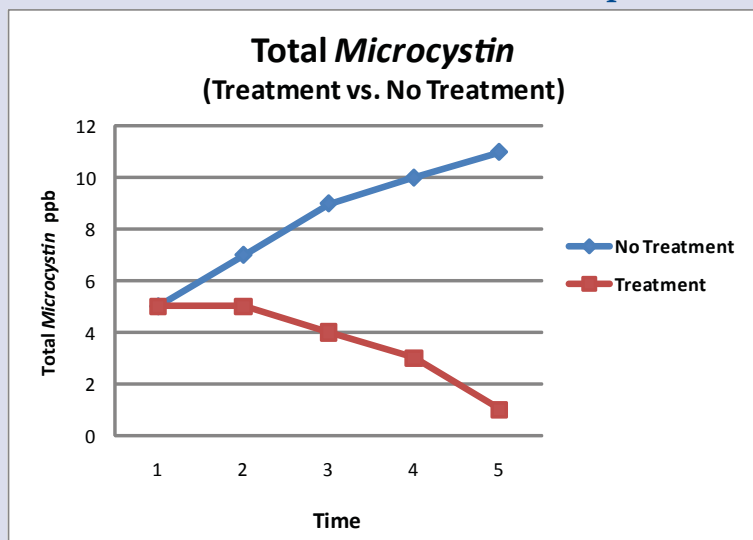


Potential Sources of Leaky Cell Hypothesis (Were treatments legal for surface waters?)

Reference	Algae Studied	Treatments	Microcystin Released?
Kenefick et al. 1993	<i>Microcystis</i> concentrated from Coal Lake (density unspecified)	CuSO ₄ : higher than field treatments (concentration unspecified)	Aqueous <i>microcystin</i> measured, not total
Jones and Orr 1994	<i>Microcystis aeruginosa</i> dense bloom in Australia (density unspecified; total <i>microcystin</i> : 1300-1800 µg/L)	Coptrol: spot sprayed (concentration unspecified algae in reservoir controlling 2 - 3 days)	<i>Microcystin</i> released and subsequently degraded
Peterson et al. 1995	<i>Aphanizomenon flos-aquae</i> laboratory culture medium (2.5 x 10 ⁵ cells/mL)	FeCl ₃ /AlSO ₄ (25 mg/L), CuSO ₄ (0.125 - 0.5 mg Cu/L), KMnO ₄ (0 - 2 mg/L), H ₂ O ₂ (≤ 10 mg/L), CaOH (0 - 100 mg/L)	Membrane damage, dissolved organic carbon and geosmin released
Daly et al. 2007	<i>Microcystis aeruginosa</i> laboratory culture (3 x 10 ⁵ to 1.1 x 10 ⁶ cell/mL)	Chlorine (8 - 20 mg/L)	Chlorine (≥ 12 mg/L) cells lysed released toxin; chlorine can degrade <i>microcystin</i>
Touchette et al. 2008	<i>Anabaena</i> and <i>Microcystis</i> laboratory microcosms (density unspecified)	CuSO ₄ and PAK-27 (SCP) at ≤ 5 times label rate)	At high treatments released 1.8 and 1.3 µg/L, respectively

Is “doing nothing” (not treating) avoiding or decreasing risk?

- The leaky cell hypothesis may be mute (risk is due to total *microcystin*, not just released fraction).
- If no treatment is implemented, total *microcystin* is likely to increase.
- If treatment is implemented, both cell density and total *microcystin* are likely to decline.
- Subsequent release of *microcystin* would be curtailed due to the lack of cells for production.
- Below is an illustration of this concept from measurements taken on a Wisconsin lake.



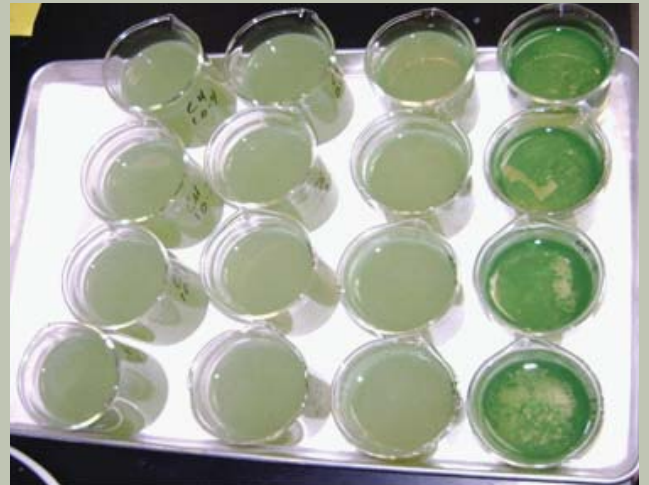
Responses of Harmful Algal Blooms to Algaecide Exposures:

Objectives:

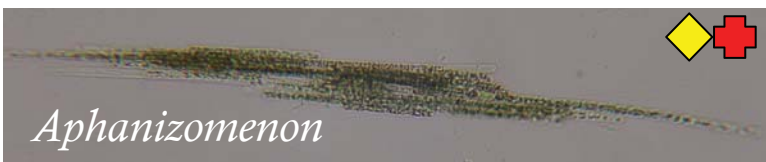
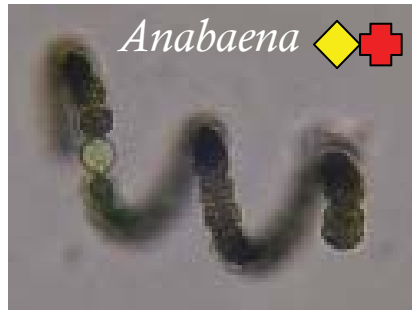
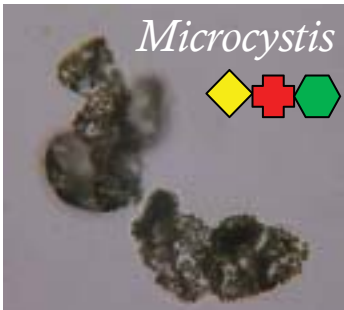
1. Acquire field samples of toxin producing cyanobacteria blooms.
2. Measure responses to algaecide exposures (Chlorophyll *a*, Cell Densities, Total *Microcystin*).
3. Based on responses, recommend an effective algaecide treatment.

The Algal Challenge Test (ACT)

- Samples of site waters and algae were collected
- Laboratory toxicity tests with US EPA registered algaecides
- Measured responses of target algae to treatments (Chlorophyll *a*, Cell Densities, Total *Microcystin*)
- Identified an effective treatment that complies with water resource usages and restrictions at the site



Samples:



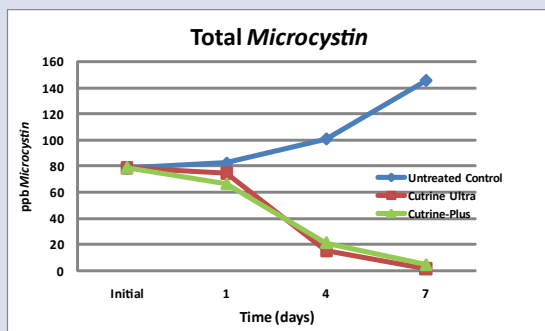
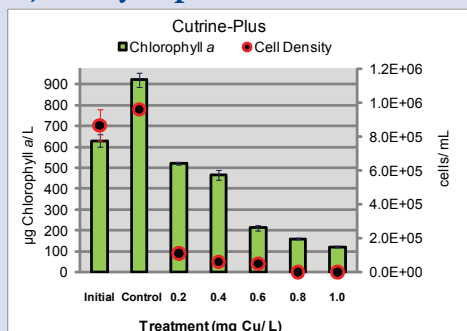
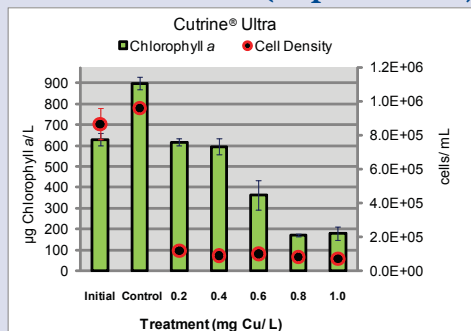
3 *microcystin* producing cyanobacteria blooms were sampled and tested



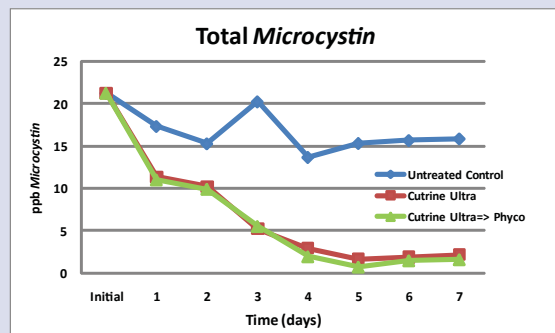
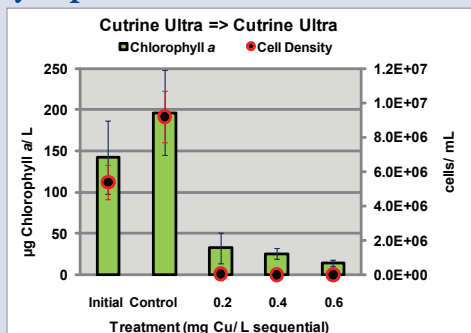
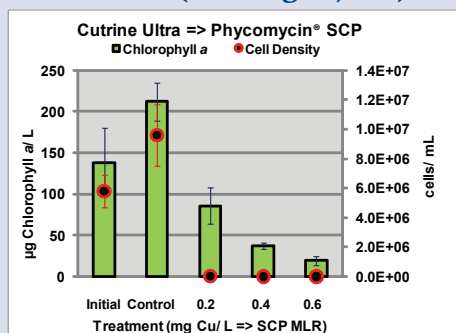
Sites	pH	DO mg/L	Conductivity $\mu\text{S/cm}$	Temperature $^{\circ}\text{C}$	Alkalinity mg/L as CaCO_3	Hardness mg/L as CaCO_3
Candlewick Lake (Poplar Grove, IL) ◆	8.62	9.50	317	23.1	126	144
Mona Lake (Muskegon, MI) +	8.46	8.61	588	22.2	104	155
Lake Sylvan (South Vienna, OH) ◆	9.09	9.10	323	21.4	154	180

Results of Laboratory Algaecide Treatments:

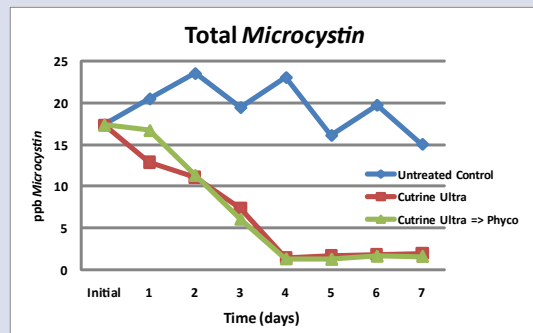
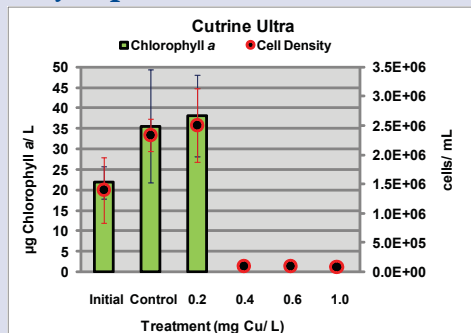
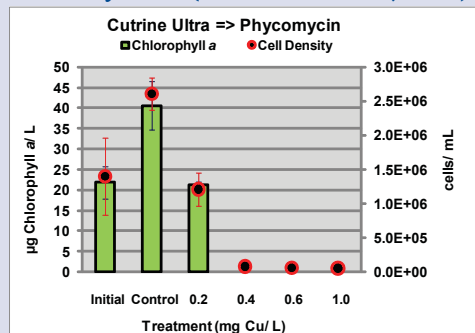
Candlewick Lake (Poplar Grove, IL): 7 day exposure



Mona Lake (Muskegon, MI): 7 day exposure



Lake Sylvan (South Vienna, OH): 7 day exposure



Conclusions:

- Cutrine Ultra controlled *Microcystis* in samples from all sites without increasing total *microcystin*.
- Even if toxin was released, total *microcystin* did not increase with an effective treatment.
- Risks are not avoided by taking “no action”; however, an algaecide should be applied before algal densities and *microcystin* production poses risks.
- Leaky Cell Hypothesis is based on unrealistic treatments, flawed consideration of risks, and not supported by results from typical, surface water treatments.

References

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