Microcystin concentrations following treatments of harmful algal blooms

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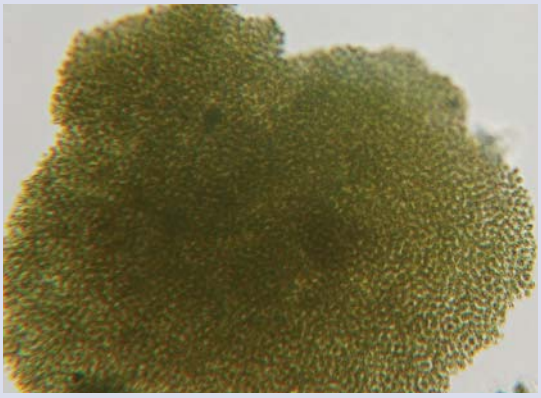
The Question:

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

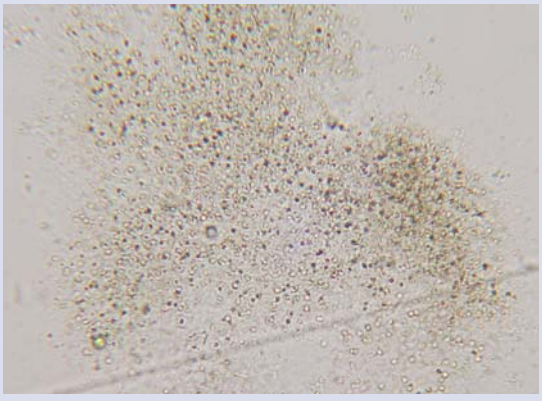
LEAKY CELL HYPOTHESIS

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

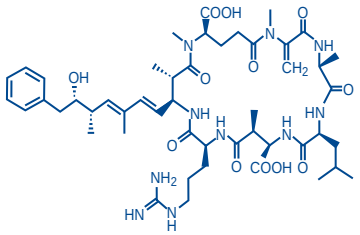
Microcystin producing cyanobacterial genera:

Microcystis	*Nostoc*
Anabaena	*Hapalosiphon*
Oscillatoria	*Anabaenopsis*
Planktothrix	

- 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 (≤8 µg/L)
- Many Forms: LA, LL, AR, YA, RR, LR
- Widespread
- Water Soluble
- Chemically Stable

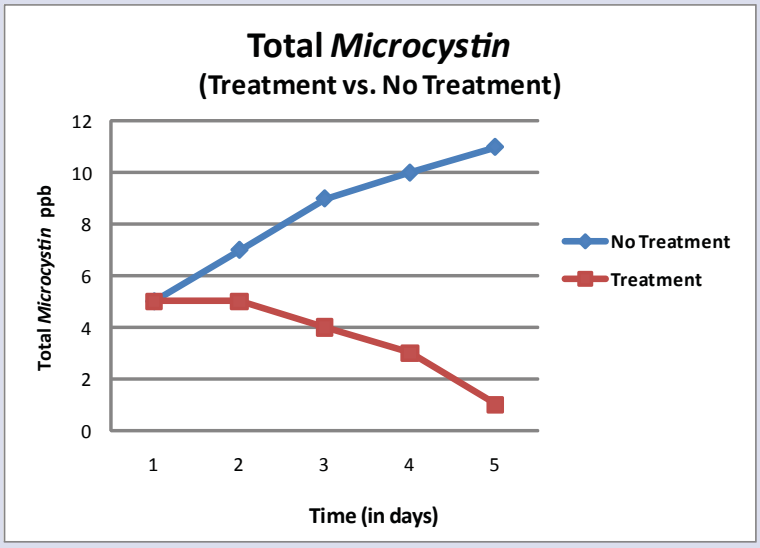


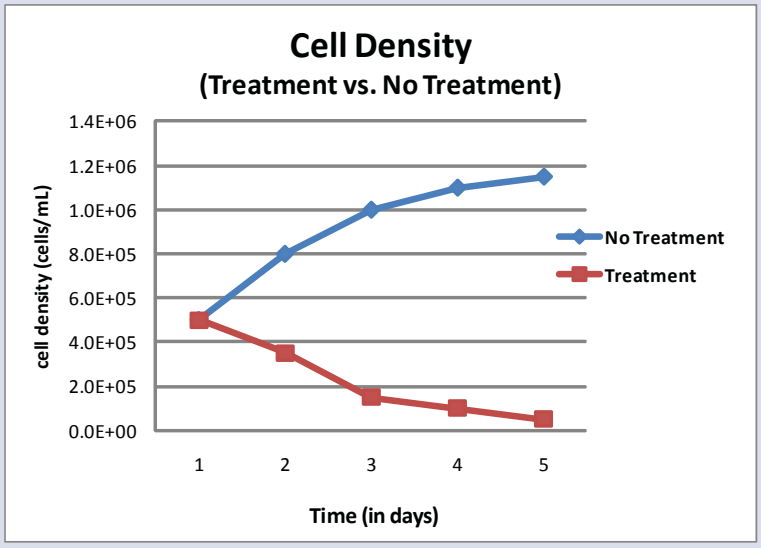
Potential Sources of Leaky Cell Hypothesis (Were treatments legal for surface waters?)

Reference	Algae Studied	Treatments	*Microcystin* Released?
Kenefick et al. 1993	*Microcystis* concentrated from Coal Lake (density unspecified)	$CuSO_4$: higher than field treatments (concentration unspecified)	Aqueous *microcystin* measured, not total
Jones and Orr 1994	*Microcystis aeruginosa* dense bloom in Australia (density unspecified; total *microcystin*: 1300-1800 µg/L	Coptrol: spot sprayed (concentration unspecified algae in reservoir controlling 2 - 3 days)	*Microcystin* released and subsequently degraded
Peterson et al. 1995	*Aphanizomenon flos-aquae* laboratory culture medium (2.5 x 10^5 cells/mL)	FeCl3/AlSO4 (25 mg/L), CuSO4 (0.125 - 0.5 mg Cu/L), KMnO4 (0 - 2 mg/L), H2O2 (≤10 mg/L), CaOH (0 - 100 mg/L)	Membrane damage, dissolved organic carbon and geosmin released
Daly et al. 2007	*Microcystis aeruginosa* 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 *microcystin*
Touchette et al. 2008	*Anabaena* and *Microcystis* laboratory microcosms (density unspecified)	CuSO4 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.





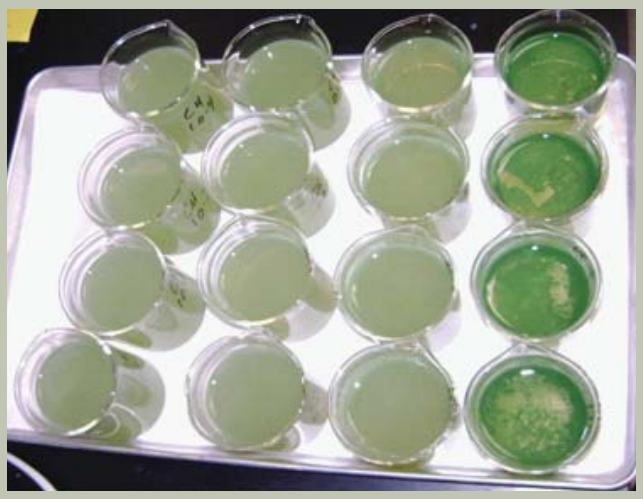
Responses of Harmful Algal Blooms to Algaecide Exposures:

Objectives:

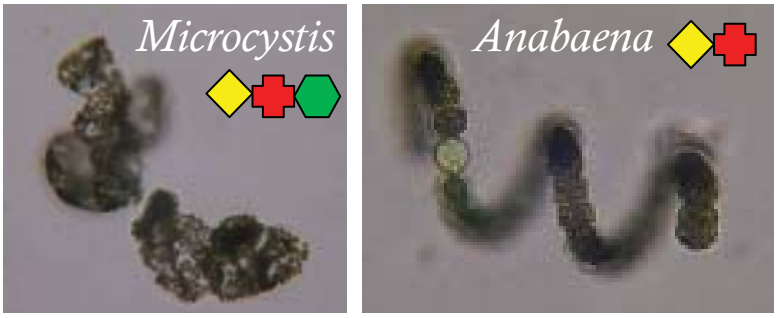
1. Acquire field samples of toxin producing cyanobacteria blooms.
2. Measure responses to algaecide exposures (Chlorophyll *a*, Cell Densities, Total *Microcystin*).
3. Based on responses, recommend an effective algaecide treatment.

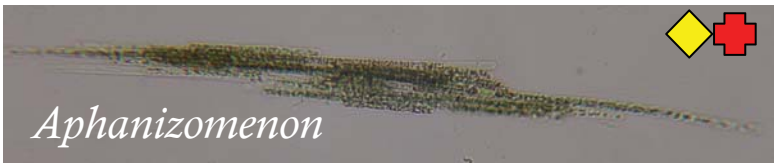
The Algal Challenge Test (ACT)

- 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:



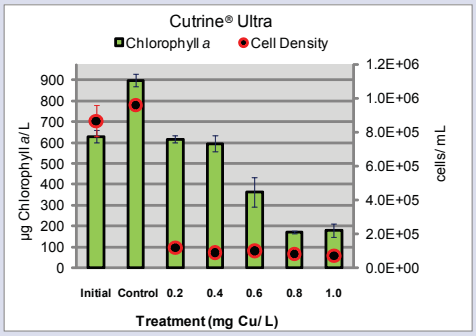


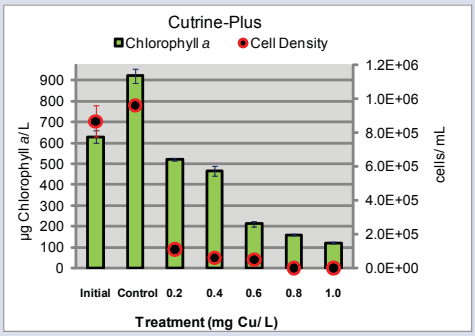
3 *microcystin* producing cyanobacteria blooms were sampled and tested

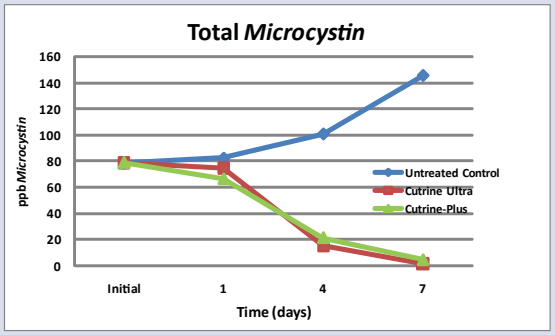
Sites	pH	DO mg/L	Conductivity µS/cm	Temperature °C	Alkalinity mg/L as $CaCO_3$	Hardness mg/L as $CaCO_3$
Illinois Reservior (210 Acres)	8.62	9.50	317	23.1	126	144
Michigan Lake (700 Acres)	8.46	8.61	588	22.2	104	155
Ohio Reservior (35 Acres)	9.09	9.10	323	21.4	154	180

Results of Laboratory Algaecide Treatments:

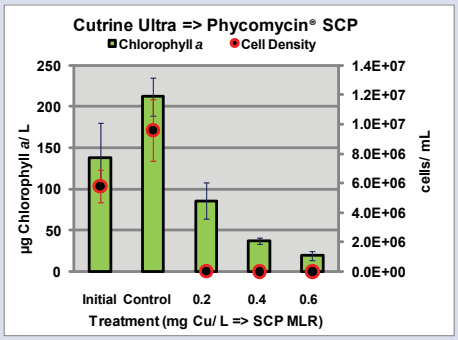
Illinois Reservoir (210 Acres): 7 day exposure

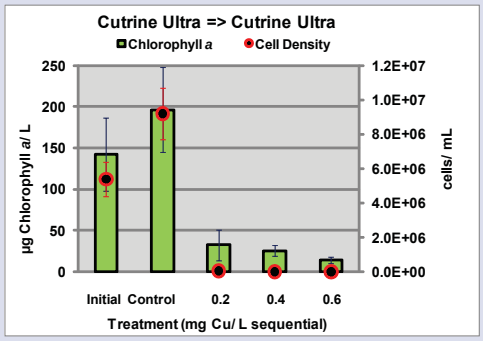


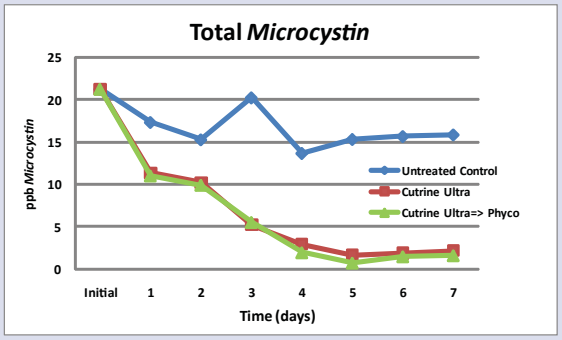




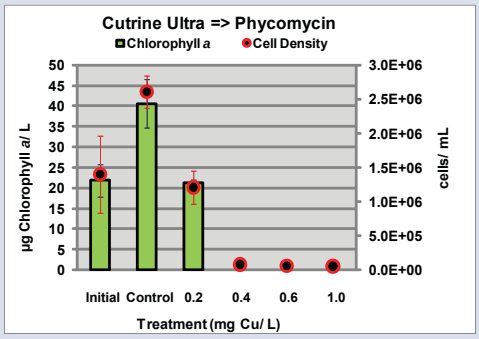
Michigan Lake (700 Acres): 7 day exposure

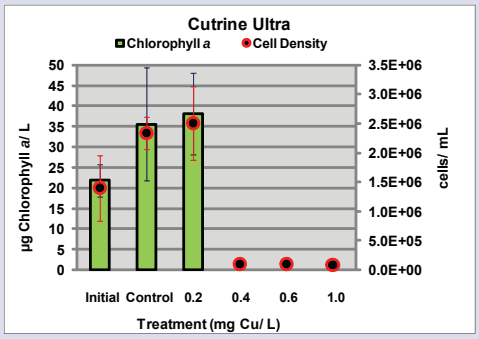


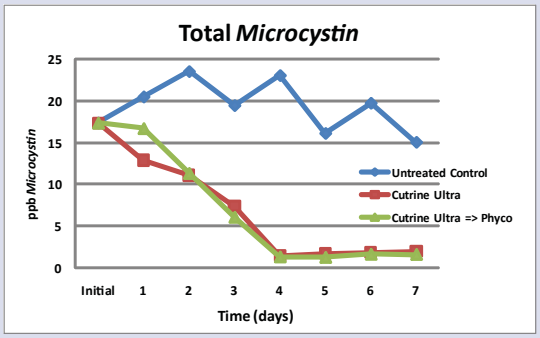




Ohio Reservoir (35 Acres): 7 day exposure







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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