Two Occurrence Studies of Cyanobacterial Toxins in Source and Finished Drinking Waters

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Introduction

- Cyanotoxins may occur in drinking water at levels that cause adverse health effects.
- Examples:
  - Palm Island, Australia- 150 people sick
  - Sewickley, PA- thousands sick
- National occurrence information needed on cyanotoxins in drinking water to determine risk.
- Some drinking water cyanotoxin surveys conducted. Will discuss 2 studies
  - 1996- 1997 AWWARF survey- Carmichael
  - 2005 survey of 5 vulnerable sites- Westrick

AWWARF Carmichael Survey

- Described in “Assessment of Blue-Green Algal Toxins in Raw and Finished Drinking Water” AWWARF, 2001
- 24 utilities from all 10 EPA regions, 3 Canadian Provinces
- 2 years
  - Samples collected 2/month at some utilities; Only during algal blooms (>2000 cells/mL) at others. Usually April to October
- Microcystins analyzed

AWWARF Samples

- 4 samples taken per utility at each sample time
  - Bloom in source water body
  - Inlet to the treatment system
  - Inlet to the plant
  - Plant outlet (finished water)

- Some but not all samples separated into water and cells
  - Water- 500 mL of filtered water
  - Filters- fiberglass filter with filtered cells

Sample Analyses

- Microcystin analyses
  - Samples split and analyzed by Wright St. Univ., and Univ. of Wisconsin
  - Concentrated by C18 Bond Elute Cartridges
  - ELISA
    - Detects all microcystins including nontoxic variants
  - Protein Phosphatase Inhibition Assay (PPIA)
    - Detects toxicity of microcystin
- Detection limit ELISA and PPIA: 0.002 ppb
- 677 water samples analyzed

% of Samples at 3 Concentrations of Microcystin (ELISA) at each Sample Location

	Bloom	Intake	Plant Influent	Finished Water
Total Number of Samples Analyzed	127	152	181	204
% Microcystin Not Detected	19%	12%	14%	34%
% < 1 ppb of Microcystin	74%	84%	82%	65%
% ≥ 1 ppb of Microcystin	7.1%	4.6%	3.3%	1.0%

Sample with High Microcystin in Finished Drinking Water

Sample Site	Microcystin ELISA ppb
Intake	1200
Plant Influent	8.1
Finished Water	7.8

% of Samples at 3 Concentrations of Microcystin (PPIA) at each Sample Location

	Bloom	Intake	Plant Influent	Finished Water
Total Number of Samples Analyzed	119	147	172	197
% Microcystin Not Detected	70%	63%	64%	78%
% < 1 ppb of Microcystin	29%	35%	35%	21%
% ≥ 1 ppb of Microcystin	1.7%	2.0%	1.2%	1.0%

Relation of Microcystin to Taste and Odor

- 243 samples tested for 4 taste and odor compounds
- 181 samples had taste or odor compounds
- 148 samples had detectable microcystin
  - 148/181 or 82% of samples with taste or odor also contained microcystin

Westrick Survey

- Conducted by Judy Westrick and collaborators, Lake Superior State University, funded by OGWDW, TSC
- 2005
- 5 vulnerable utilities sampled
  - California
  - Oklahoma
  - Texas
  - Vermont
  - Florida

Samples and Analyses

- Weekly samples for 12 weeks May to August 2005
- Raw intake water, finished water
- Microcystin, cylindrospermopsin, anatoxin-a
  - Microcystin- ELISA; 0.05 ppb detection limit
  - Microcystins (4 congeners), cylindrospermopsin, anatoxin-a- HPLC/PDA, 0.25 ppb detection limit
- Algal counts, identifications
  - Genera known to produce microcystin, cylindrospermopsin, anatoxin-a
  - Algal units (aggregations of cells) counted

Numbers of Potential Toxin-Producing Algae and Removal by Treatment

Site	Range of algal unit density/ mL	Range of log10 removal by drinking water treatment
	Algal units/mL	
California	113- 350,000	1.5- >5.5
Oklahoma	143- 1500	1.6- >3.4
Vermont	< 1- 190	up to 2.3
Texas	50- 9400	>1.7- >4.0
Florida reservoir	17- 1500	
Florida river	85- 4300	1.6- 3.8

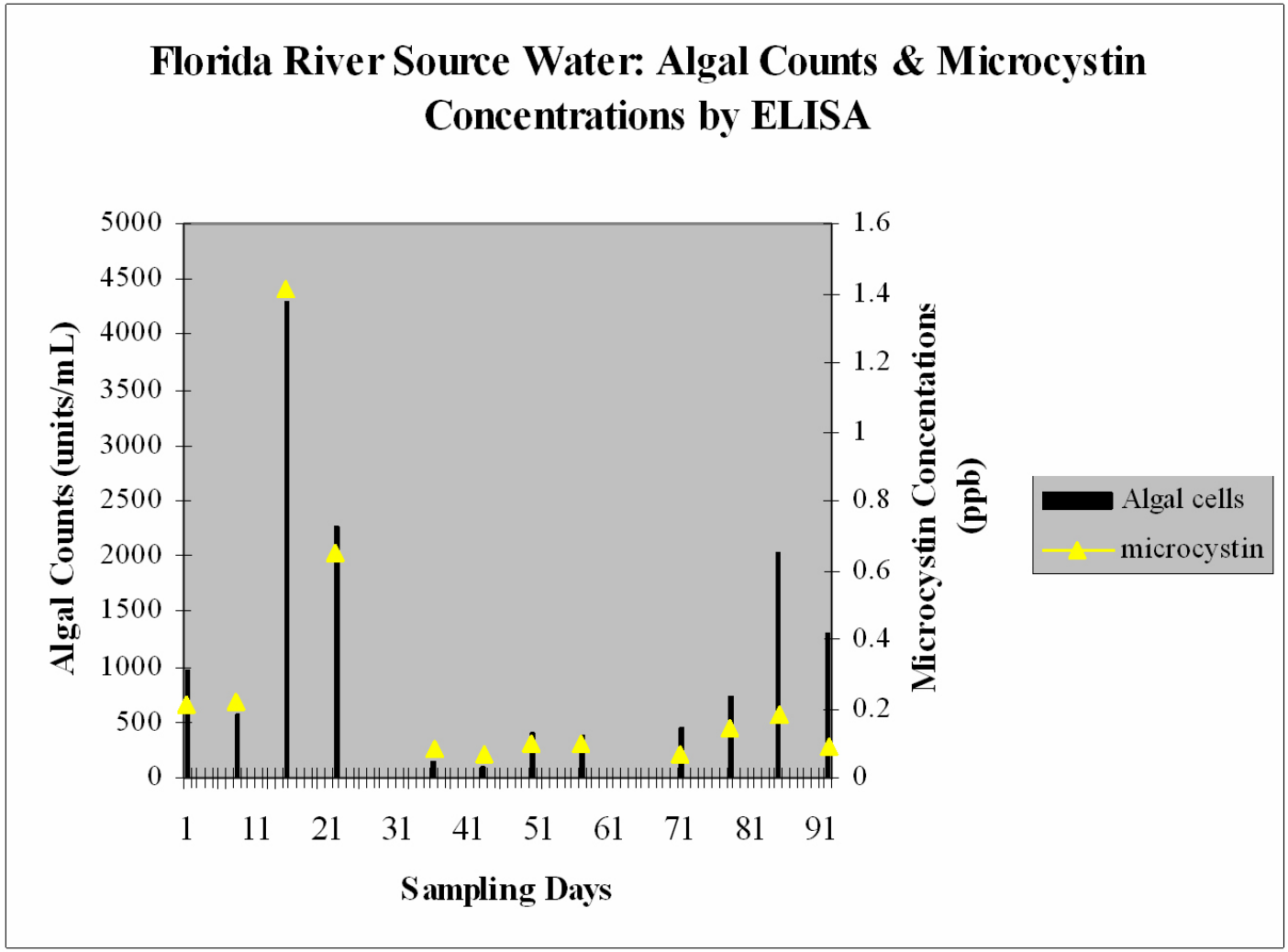
Microcysin ELISA Analyses of Samples from 5 Utilities

- Microcystin detected by ELISA in 38/56 raw water samples (68%)
  - All microcystin detections (except 1) from 0.06-0.17 ppb
  - 1 Florida river sample had 1.41 ppb microcystin
- Microcystin not detected in any finished water sample by ELISA

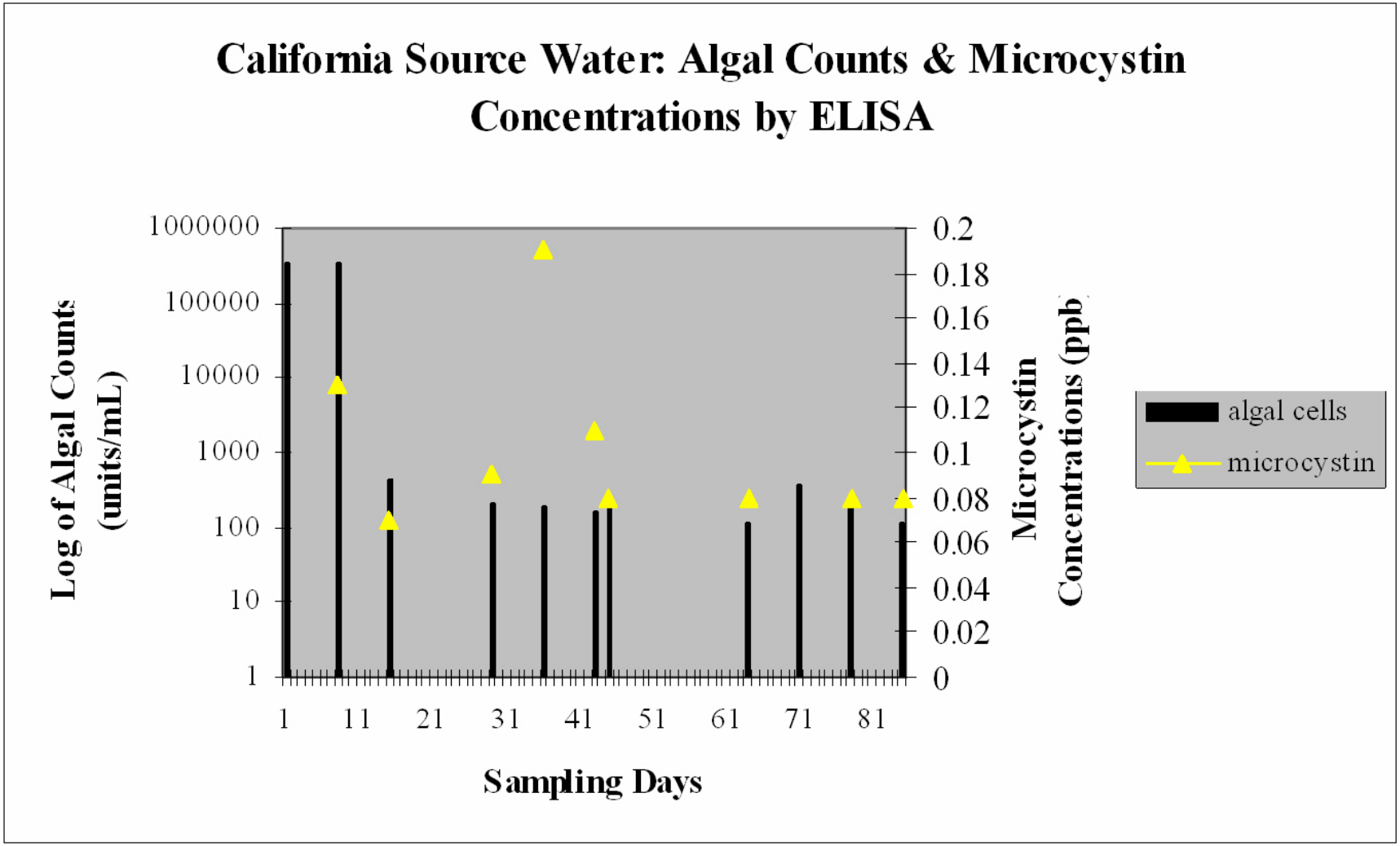
HPLC Analyses of Microcystin, Cylindrospermopsin and Anatoxin-a

- Microcystin detected in 2/66 raw water samples by HPLC
  - 0.79 ppb microcystin LR in 1 California sample
  - 0.90 ppb microcystin LW in 1 Oklahoma sample
- Cylindrospermopsin detected in 1/66 samples
  - 0.41 ppb cylindrospermopsin in 1 Oklahoma sample
- Anatoxin-a not detected
- No finished water detections of microcystin, cylindropermopsin, or anatoxin-a

Relation of algal Counts to Microcystin in Florida River Raw Water Samples



Relation of Cell Counts to Microcystin in California Raw Water Samples



Conclusions AWWARF Study

- ELISA analyses: Most raw and finished water samples had detectable microcystin at < 1ppb;
  - 1% of finished water samples ≥ 1ppb microcystin
- PPIA analyses: Most raw and finished water samples did not have detectable microcystin
  - 1% of finished water samples ≥ 1ppb microcystin
  - PPIA results suggest most ELISA detections had lower toxicity
- Strong relation of taste and odor to microcystin

Conclusions Westrick Study

- >2000 of toxin-producer algal units/mL in 3 of 5 sites.
- Microcystin was detected in 68% of raw water samples by ELISA at <1ppb; 1 sample >1ppb
- Treatment was effective in removing algal cells and toxins; cyanotoxins not detected in finished water
- Microcystin most common; 1 cylindrospermopsin observation
- Toxin concentration not always related to toxin-producer cell density.
- ELISA and HPLC didn't give same results
- Limited numbers of utilities surveyed.