Freshwater Harmful Algal Bloom (FHAB) Suppression through Solar-Powered Circulation (SPC)

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2010 Land Grant & Sea Grant National Water Conference, Marriott Hilton Head Hotel, February 21-25, 2010

Freshwater Harmful Algal Bloom (FHAB) Suppression with Solar Powered Circulation (SPC)

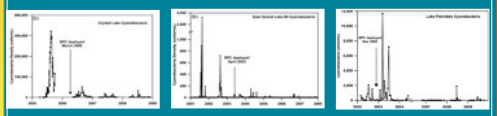
Algaecides such as Copper Sulfate are often used to terminate FHABs

- $CuSO_4$ has multiple adverse impacts
- $CuSo_4$ use is unsustainable, and cyanobacteria are becoming resistant

SPC is an Ecological Approach to FHAB Suppression

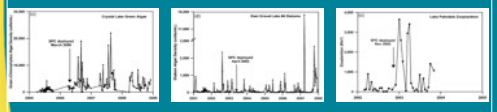
- Promotes Natural Processes
- No Adverse Environmental Impacts
- No Grid Power or Chemicals used

FHAB Suppression in 3 Source Waters



- Crustal Lake – No Algaecides used, Pre-SPC used other Source Water during FHABs
- EGL4 & Lake Palmdale – reduced influent algaecide applications 85-92% during SPC

Promotion of Beneficial Plankton



Reservoir & Treatment Parameters

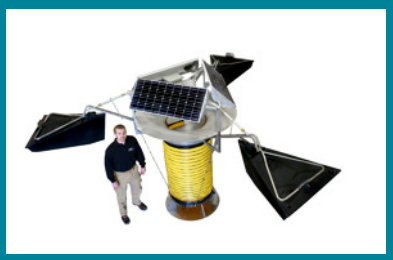
Reservoir data collection and treatment parameters

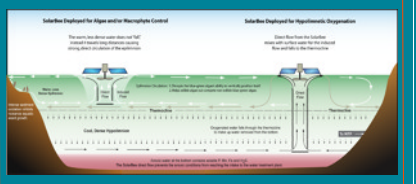
	Crystal Lake	EGL 4	Lake Palmdale
Algaecides used	No	Yes	Yes
Surface area (km²)	0.26	0.07	0.03
Max depth (m)	7.6	10.7	7.6
Mean depth (m)	3.9	7.6	5.5
Water volume (km³)	7.65×10^{-4}	3.53×10^{-3}	4.90×10^{-3}
Water mean residence time (days)	40	270	91
Data collection period	March–December 2005–2008	January–December 2001–2007	January–December 2002–2004
Treatment date	March 2006	April 2003	October 2002
# SPC units	1	1	1
Surface area km²/SPC unit	0.13	0.16	0.15-0.13[a]
Mean intake depth (m)	2.4	6.7–9.7[b]	4.6
Water volume circulated (km³)	6.1×10^{-4}	3.1×10^{-3}–2.9×10^{-3}[c]	4.1×10^{-3}
Water km³ circulated/SPC unit	3.05×10^{-4}	1.04×10^{-3}–7.457×10^{-4}	6.82×10^{-4}–5.85×10^{-4}
SPC circulation rate (km³/day)	5.5×10^{-2}	5.5×10^{-2}	5.5×10^{-2}
Total circulation rate (km³/day)	0.11	0.17	0.11-0.09[a]
Turnover duration (days)[c]	3.6	10.0–12.2[b]	12.4–10.6[a]

[a] A seventh SPC unit was installed in June 2003.
[b] Water intake depths were varied as the reservoir surface elevation and water clarity varied over time.
[c] The duration required for the SPC units to circulate all the water between the surface and mean intake depths one time.

SPC Reduces FHAB Risks Near Term & Sustainably

Solar Powered Circulation (SPC) Technology





Technical Specifications

- FHAB Suppression through Long Distance Circulation of the Epilimnion – Area Circulated per Unit = 0.15 km²/unit (35 acres/unit)
- 3, 80 W Solar Panels & Battery
- High Efficiency Gearless Motor
- 24 hr/day, 7 day/wk Operation
- 0.91 Wide Flexible Intake Hose
- Steel Plate Suspended 0.31 m below Hose causes Radial, Near-Laminar Flow Intake
- 80 RPM; 37,850 L/min Upflow
- Non-turbulent Surface Outflow

Support FHAB Legislation at http://www.FreshwaterHABlegislation.com

The State of U.S. Freshwater Harmful Algal Bloom (FHAB) Assessments, Policy & Legislation

U.S. Occurrence & Toxins

- FHAB Incidence & Duration is Increasing Rapidly Worldwide
- FHAB Toxins are among the Most Potent Known

Compounds and rodent 24 h intraperitoneal LD_{50} (μg/kg).

Cyanotoxins	LD_{50}	EPA priority	Comparison	LD_{50}
Saxitoxins[a]	10	Medium/high	Ricin[e]	22
Anatoxin-a(s)[b]	20	Medium/high	Cobra venom[f]	185
Microcystin-LR[c]	50	Highest	Sarin[g]	218
Anatoxin-a[d]	200	Highest	Curare[f]	500
Cylindrospermopsin[a]	300/180	Highest	Strychnine[f]	2500/980

Draft U.S. EPA Toxicological Reviews

- FHABs & their Toxins are Risks for Human & Animal Health, Aquatic Ecosystem Sustainability & Economies

Cyanotoxin toxicological reviews.

	Exposure duration	Critical study	Critical effect	NOAEL[a] LOAEL[b] mg/kg-d	RfD[c] mg/kg-d	Uncertainty factors[d]	Guideline level mg/kg-d
Microcystin-LR, HR, YR and LA (based on microcystin-LR data)							
RfDs	Acute	–	–	–	–	–	–
	Short Term	Heinze, 1999	Hepatic	5×10^{-3} a	6×10^{-5}	10 × 10 × 10	6×10^{-4}
	Subchronic	Heinze, 1999	Hepatic	5×10^{-3} a	6×10^{-5}	10 × 10 × 10	6×10^{-4}
	Chronic	Ueno et al., 1999	Hepatic	3×10^{-3} a	–	10 × 10 × 10	3×10^{-4}
RfCs	All the above	–	–	–	–	–	–
Cancer	Any	–	–	–	–	–	–
Cylindrospermopsin							
RfDs	Acute	–	–	–	–	–	–
	Short Term	–	–	–	–	–	–
	Subchronic	Humpage and Falconer, 2003	Nephrotic	3×10^{-2} a	3×10^{-2}	10 × 10 × 10	3×10^{-3}
	Chronic	–	–	–	–	–	–
RfCs	All the above	–	–	–	–	–	–
Cancer	Any	–	–	–	–	–	–
Anatoxin-a							
RfDs	Acute	–	–	–	–	–	–
	Short Term	Fawell et al., 1999	Systemic	2.5[e]	–	10 × 10 × 10	3×10^{-3}
	Subchronic	Astrachan and Archer, 1981	Systemic	0.5[e]	–	10 × 10 × 10	5×10^{-4}
	Chronic	–	–	–	–	–	–
RfCs	All the above	–	–	–	–	–	–
Cancer	Any	–	–	–	–	–	–

[a] No observable adverse effect level.
[b] Lowest observable adverse effect level.
[c] Benchmark dose lower confidence limit.
[d] 10 for interspecies variability, 10 for intraspecies variability, 10 for various database deficiencies.

U.S. Federal Policy & Research

- There is NO U.S. POLICY or Research & Control Program for FHABs

U.S. Federal Legislation

- HABHRCA (1998) Established a Research & Control Program for Coastal HABs (NOAA), but not FHABs
- HABHRCA (reauthorization 2010, pending) Authorizes Funding & Mandates the EPA Establish a National FHAB Research & Control Program