Solar Powered Circulation (SPC): An Ecological Approach to Solving Water Quality Problems while Reducing Atmospheric Emissions and Chemical Applications

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Freshwater Harmful Algal Blooms

- 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[f]	22
Anatoxin-a(s)[b]	20	Medium/high	Cobra venom[g]	185
Microcystin-LR[c]	50	Highest	Sarin[h]	218
Anatoxin-a[d]	200	Highest	Curare[i]	500
Cylindrospermopsin[e]	300/180	Highest	Strychnine[j]	2500/980

- FHABs & their Toxins are Risks for Human & Animal Health, Aquatic Ecosystem Sustainability & Economies
- There is NO U.S. POLICY or Research & Control Program for FHABs

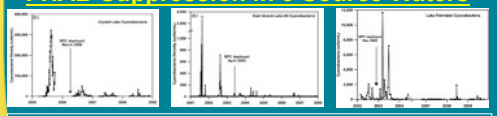
Algaecides such as Copper Sulfate are often used to terminate FHABs

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

SPC is an Ecological Approach to FHAB Suppression

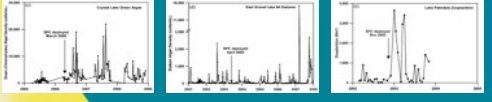
- Promotes Natural Processes
- No Adverse Environmental Impacts
- No Grid Power or Chemicals used

FHAB Suppression in 3 Source Waters



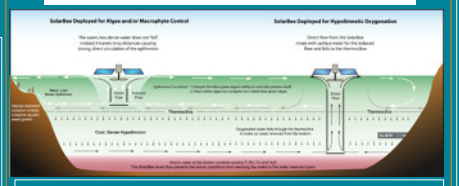
- Crustal Lake – No Algaecides used, Pre-SPC used other Source Water during FHABs
- EGL4 & Lake Palmdale – reduced algaecide applications by 85-92% during SPC

Promotion of Beneficial Plankton



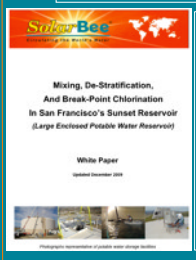
SPC Reduces FHAB Risks Near Term & Sustainably

Solar Powered Circulation (SPC) Technology



- 3, 80 W Solar Panels & Battery
- High Efficiency Brushless Motor
- 24 hr/day, 7 day/wk Operation
- 0.91 Diameter 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
- Long Distance Circulation of Epilimnion; FHAB Suppression over 0.15 km^2/unit Area

Potable Water Storage



San Francisco Public Utility Study

- Storage Reservoir
- 0.05 km^2, 87.3 MG

Destratification & Circulation

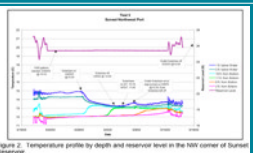
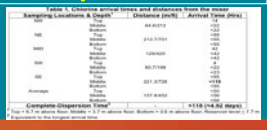


Figure 2. Temperature profile by depth and reservoir level in the NW corner of Sunset Reservoir

Single SPC unit Test
Destratification Rate = 0.85 mpd

Chlorine Dispersion

Complete Dispersion Time ≤ 4.87 d



Wastewater Mixing

The Problem

Oxygenation and mixing are required in many municipal and industrial wastewater treatment plants (WWTPs) to improve processing and shorten treatment durations. WWTPs often use mechanical aerators to both oxygenate and mix wastewater. However, much more aeration is needed to thoroughly mix than oxygenate the wastewater. This imbalance creates an operational inefficiency when excessive aeration horsepower (HP) is used for mixing. Excessive HP usage increases electrical grid-power consumption, greenhouse gas emissions and operational costs.

New Hampshire Department of Environmental Services' Study

Goals

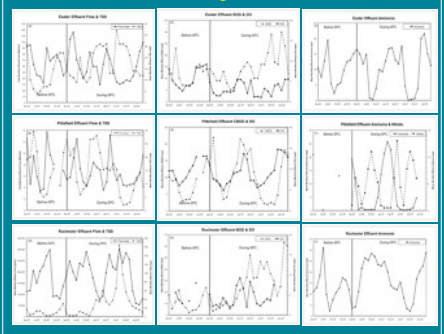
- Assess SPC at 3 WWTPs
- Maintain Effluent Water Quality
- Reduce KWh consumption & costs

Table 1. Study site descriptions, aeration HP, SPC units and kWh usage before & during study

	Total # Lagoons used in study	Total Surface Area (acres)	Total Water Volume (million gallons)	Total Aeration HP in place	# SPC Units Used	Mean kWh/ month Pre-SPC[1]	Mean kWh/ month During-SPC[2]
Exeter[2]	3	28.1	77.4	327.5	6	166,313	91,960
Pittsfield[2]	4	5.2	12.5	78	4	50,043	28,373
Rochester[2]	2	18.3	41.7	140	5	83,400	7,709

[1] kWh is all electrical-grid power used at the plants, including that used for aeration
[2] Partial mix pond system using aeration and mixing in the initial lagoons
[3] Activated sludge system using aeration and mixing in the raw septage and sludge storage lagoons

Water Quality Maintained



- All NPDES Standards Met
- No Malodorous Events
- No Sludge Buildup

Operational Efficiency Improved

Exeter - 45% kWh↓, 3 Yr Payback

Pittsfield – 43% kWh↓, 3.9 Yr Payback

Rochester – 91% kWh↓, 1.5 Yr Paybk.

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