Mitigating Cyanobacteria Blooms in MD Lakes [flushing, barley straw, clay flocculation, peroxide, permanganate, and ultrasound]

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Maryland's Cyanobacteria Blooms

- Blooms of microcystin-producing *Planktothrix rubescens* , *P. agardhii*, and *P. prolifica* in Frederick County
- Benthic cyanobacteria blooms of *P. isothrix* (microcystin) and *Lyngbya* wollei (saxitoxin, cylindrospermopsin, anatoxin) in upper Potomac River
- Surface *Microcystis aeruginosa* scums in Higgins Mill Pond, Sassafras River, Poplar Island, and Lake Williston
  - Produces hepatotoxic microcystin with 1 and 10 ppb as WHO and MD advisory limits
  - 2009 dog mortalities in 24-48 h at Higgins Mill Pond; [microcystin] = 22,000 ppb
  - Summer blooms in Lake Williston in 2009-2011, exceeding WHO levels for recreational use

J. Mullican, DNR

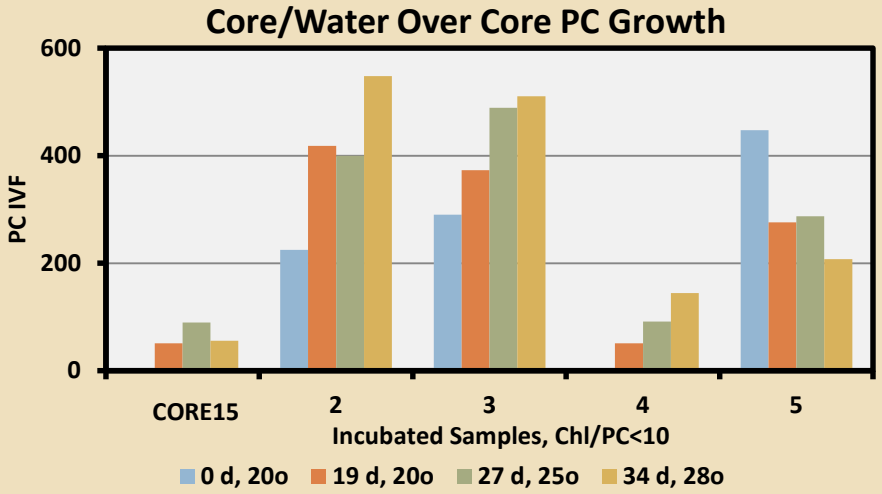
http://aerfupdate.blogspot.com/2014/06/plant-profile-lyngbya.html

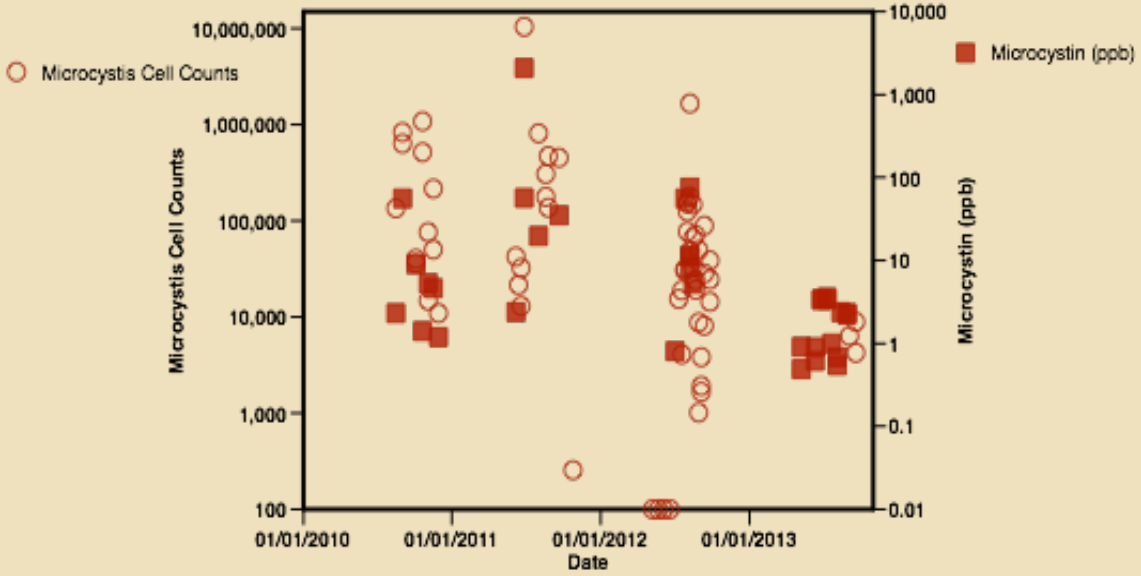
Lake Williston Mitigation

- Drained 80% of the lake in 8 h removing over-wintering *M. aeruginosa* on the sediments + exposing remaining cells to freezing
- Lined the lake and incoming streams with bales of barley straw (*Hordeum vulgare*, 3-5 bales/acre), some with fungal additions (*Trametes versicolor* and *Ceriporiopsis subvermispora*)

Cyanobacteria from Cores & Lake Responses

- Cores from littoral zone of refilled lake May, 2012 incubated under slow increase to summer temps
  - Although phycocyanin increased from initial low levels, **NO** *Microcystis* was observed
- Lake showed marked declines in *Microcystis* and toxin levels
- No blooms, only clear water through 2016





Poplar Island Cyanobacteria

- Poplar Island: 40 mcy for 1140 acres (50:50 uplands: intertidal marsh)
- Cell 6 lagoon (245 acres) has received 9.6 mcy of dredged material since 2011
- Additions can be anoxic, sulfidic black muds with *Clostridium botulinum* and very high NH_4^+ & DIP
- Shallow, high T's, no flow in or out yield toxic *Microcystis*
- Bird mortalities, fauna with microcystin

MD DOT

Poplar Island Mitigation Activity

- Placement of barley straw bales in lagoon in summers 2013-2015
- In 2013, only 1 *M. aeruginosa* maximum so apparently effective
- Not so fast: Large 2014 bloom (>79M cells/mL) with very high microcystin (>28 ppm)
- Partial Explanation?: No winter inflow of dredged material in winter 2013-2014, so no 'capping' or H_2S exposure of 2013 *M. aeruginosa* over-wintering on the bottom of the lagoon. Hence viable 'seed' population emerged during hot summer of 2014

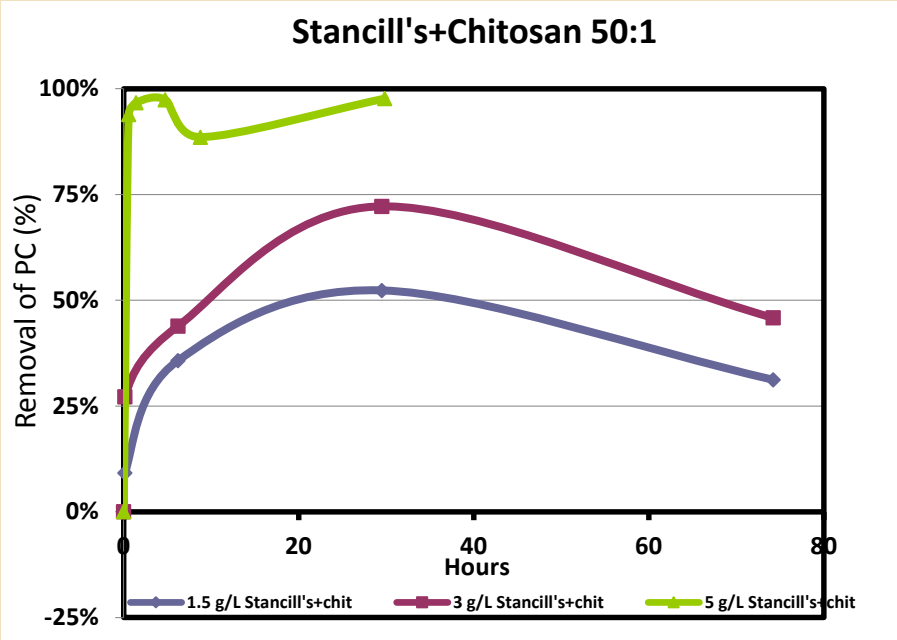
Take home message:

Combination of sediment capping and barely straw offers best option to reduce *Microcystis* blooms in brackish lagoons

Other factors: Salt, DOC

Clay Flocculation

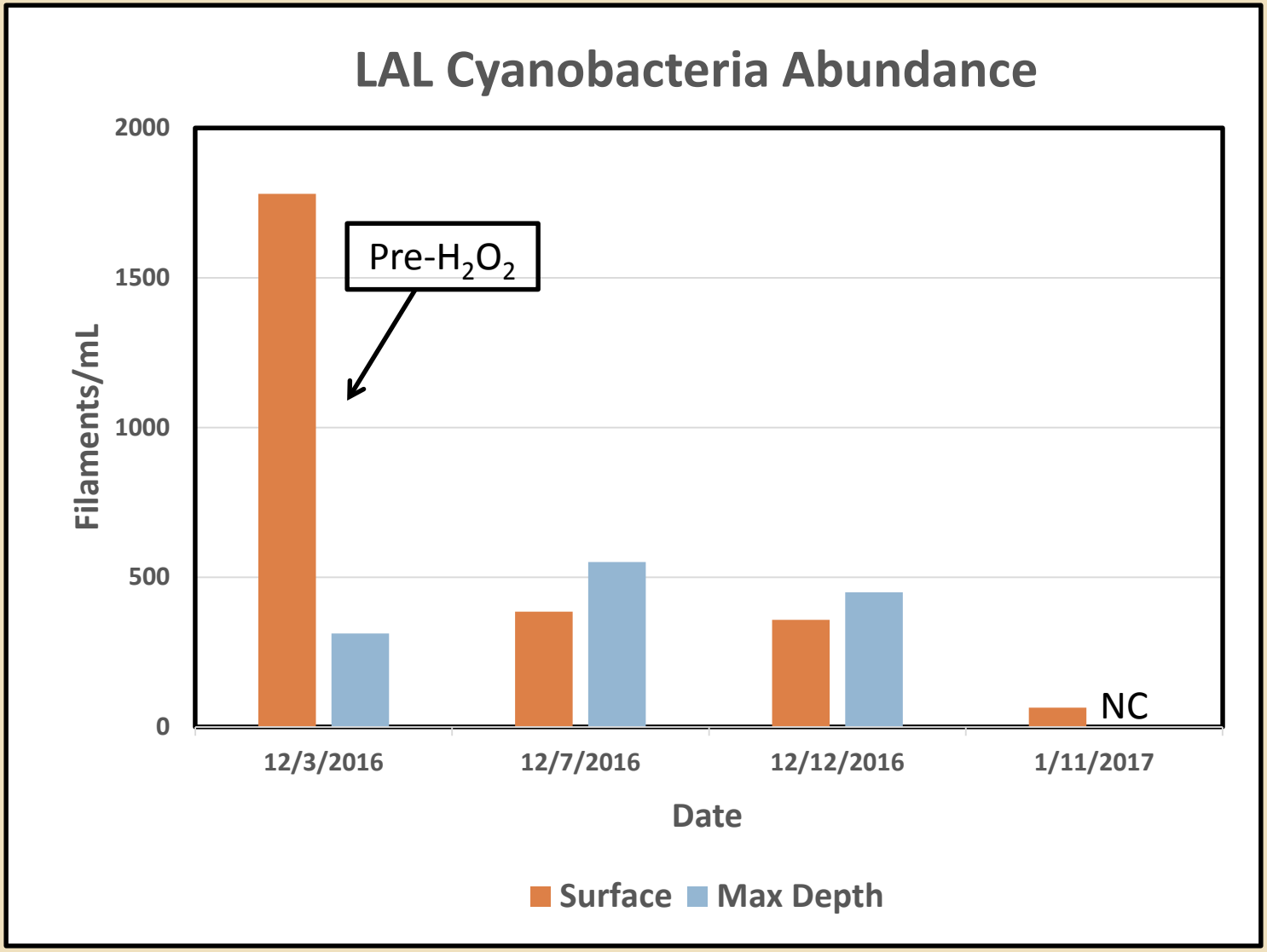
- *M. aeruginosa* in Williston Lake & Higgins Mill Pond
- Additions of acidified kaolin suspensions to mesocosms
- Limited bloom removal at permissible clay additions
- Phoslock®: Stimulation of N flux from underlying sediments
- Storm resuspension likely so repeated applications & $$$?



SEDIMENT + CHITOSAN/L	t_{50} (h)
1.5 g <125 µm SAND + 0.03 g	6.9
3 g 125-250 µm SAND + 0.06 g	2
5 g <125 µm SAND + 0.15 g	0.98
5 g 125-250 µm SAND + 0.15 g	1.15
1.5 g STANCILL'S + 0.03 g	28.19
3 g STANCILL'S + 0.06 g	20.44
5 g STANCILL'S + 0.15 g	0.3
1.14 g STANCILL's + 0.014 g	0.64
All other lower concentrations of sediments with or without chitosan never removed 50% of bloom cyanobacteria	

Peroxide

- Winter 2016 *Planktothrix rubescens* bloom microcystin levels >300 ppb
- Pre-2017 winter addition of Green Clean Pro® (350 lbs/3 acres) yielded ≤3 mgH_2O_2/L
- Surface *P. rubescens* declined to ~20% of initial abundances in 1-3 d, microcystin <1.5 ppb; filaments rare from January-March 2017
- No winter bloom in 2017



Planktothrix filaments/mL before and after peroxide treatment; NC=not collected

Permanganate

- Fountain Rock Quarry pond dominated by *P. prolifica* with microcystin >10 ppb, the WHO and MD thresholds for recreational exposure
- In 2010, County treated pond with $KMnO_4$ at 4 mg/L and microcystin decreased to <1 ppb
- Surface bloom re-appeared in winter 2016 with >20 ppb microcystin

Ultrasound

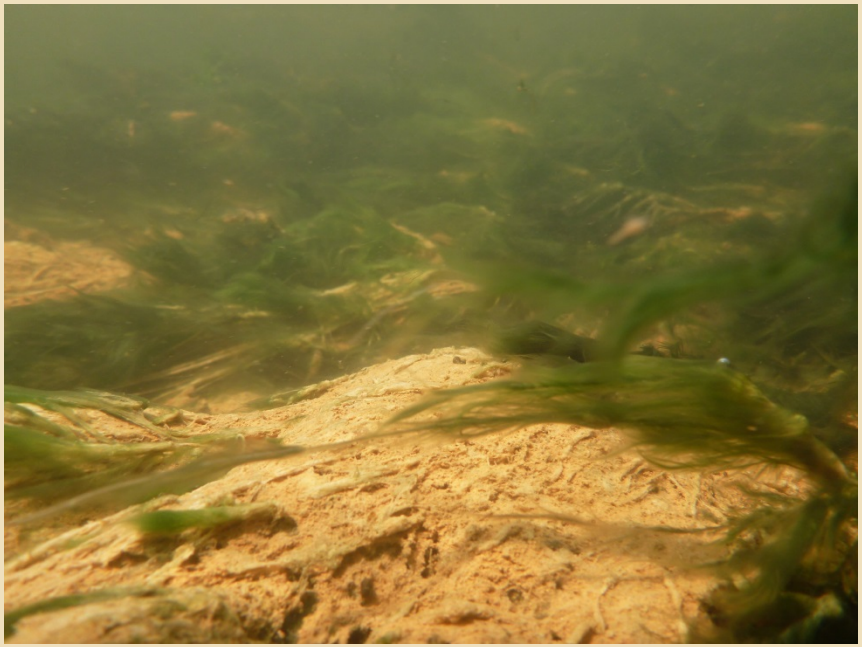
- ‘Algal blooms’ in Rainbow Lake, drinking water reservoir for Emmitsburg, MD
- LG Sonic MPC Buoy® now deployed in the lake; proprietary sensor-driven adjustments to ultrasound frequencies and durations
- Proprietary software so no agreed collaboration between us (monitors) & company

WQ-sensed information leads to automated changes in ultrasound frequencies & durations

https://www.environmental-expert.com/products/lg-sonic-model-mpc-buoy-for-controlling-and-monitoring-algae-221350

Next: Benthic Cyanobacteria in upper Potomac River & tributaries

- *Planktothrix isothrix* (microcystin producer) & *Lyngbya wollei* (STX, anatoxin-a producer) found in >100 km river reach
- Other microcystin-producing taxa in WV tributaries
- For a few 2015 and 2016 samples, no microcystin found in cyanobacteria, yet microcystin found in macroinvertebrates and fish
- Mitigation: Through regulating nutrient loads?



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