Preliminary Assessment of Nutrient Dependency of a Mixed Cyanobacteria Culture

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Presentation Overview

- Introduction
  - What is the problem?
  - Why is it a problem?
  - How to fix the problem
- Research Objectives
- Approach & Methods
- Results
- Future Work

What is the Problem?

- Cyanobacteria-dominated harmful algal blooms (cHABs)
- Adverse affects to aquatic community
  - Depletion oxygen
  - Hypoxia – increasing internal flux
  - Further depletes biodiversity (mass)
- Toxicity (cyanotoxins)
- Public water systems
  - Recreational
  - Drinking water sources

Why is it a problem?

- Driving forces of the frequency and magnitude of cHABs are eutrophication and climate change
- Eutrophication
  - Excess nutrients
  - Inherently drives down biodiversity
- Climate Change
  - Photoautotroph
  - Air-water interface (CO_2)
- Weather

Eutrophication

- Point Source
  - Combined sewer overflow events
  - Weather (climate change)
- Non-point source
  - Weather (climate change)
  - Agriculture and urbanization (sheet flow)
- Internal loading
- Extensive accumulation (i.e. sediment)

How To Fix the Problem?

- Driving forces behind cHABs are elusive
- Short-term
  - Management
  - Treatment train adjustments: cyanobacteria cells, cyanotoxins, T&O compounds
  - *In-situ* management: algaecide treatment
- Long-term
  - Prevention
    - Reducing frequency and magnitude of cHABs
  - Influent nutrient concentration & internal loading
  - Stabilize the eco-system
    - Increased biodiversity

Research Objectives

Overall objective:

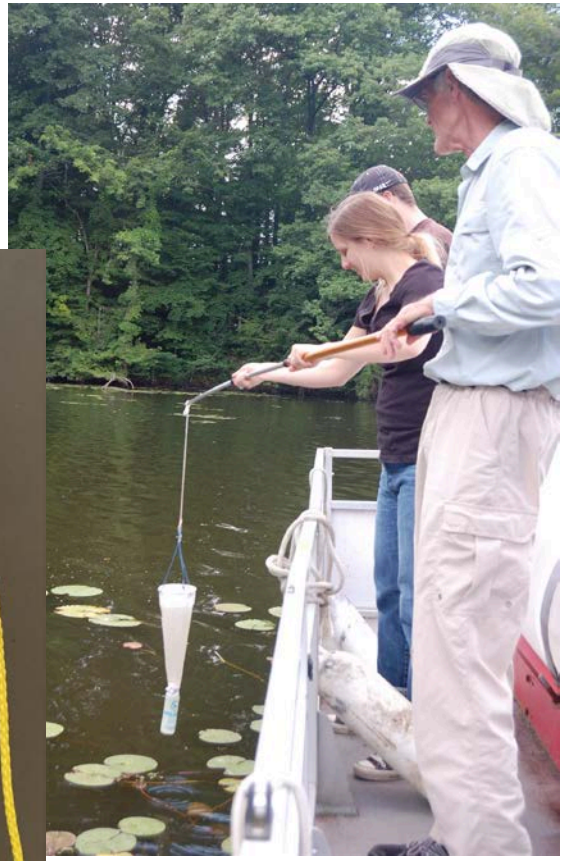
Reduce the amount of cyanobacteria and cyanotoxins that can potentially enter the drinking water treatment plant.

- Long-term management strategy
  - Begin investigating the indigenous cyanobacteria
  - Investigate the relationship to common macronutrients (N and P)
  - C:N:P → 100:10:1

Experimental Methods

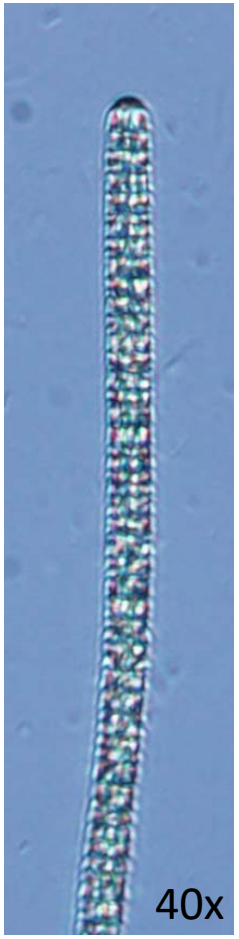
Raw Materials

- Cyanobacteria collected with a plankton net (53 µm mesh)
- Growth chamber
  - 12:12hr light cycle
  - ~100 lumens/ft^2
  - 25°C/20°C
- Raw source water (intake)



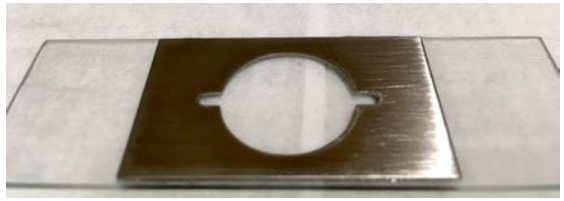
Experimental Methods

- Batch, fully sacrificed reactors (100 mL each)
- Filter-sterilized source water
- Three factors
  - Phosphate (0, 1, 2 mg/L)
  - Nitrate (0, 1, 2 mg/L)
  - Cyanobacteria (present/not present)
    - *Planktothrix sp*. & *Pseudanabaena sp*.
- Blank & 2 controls



Experimental Methods

- Time interval: 0, 3, 7, 14, 21, and 28 days
- Cyanobacteria cell counts
  - Genera based composition of population
  - Palmer-Maloney counting chamber (400x)
- Phosphate & nitrate concentration
  - HACH DR 890 Colorimeter
- Water quality parameters
  - Hannah instrument (HI9829)
  - pH, temp etc.



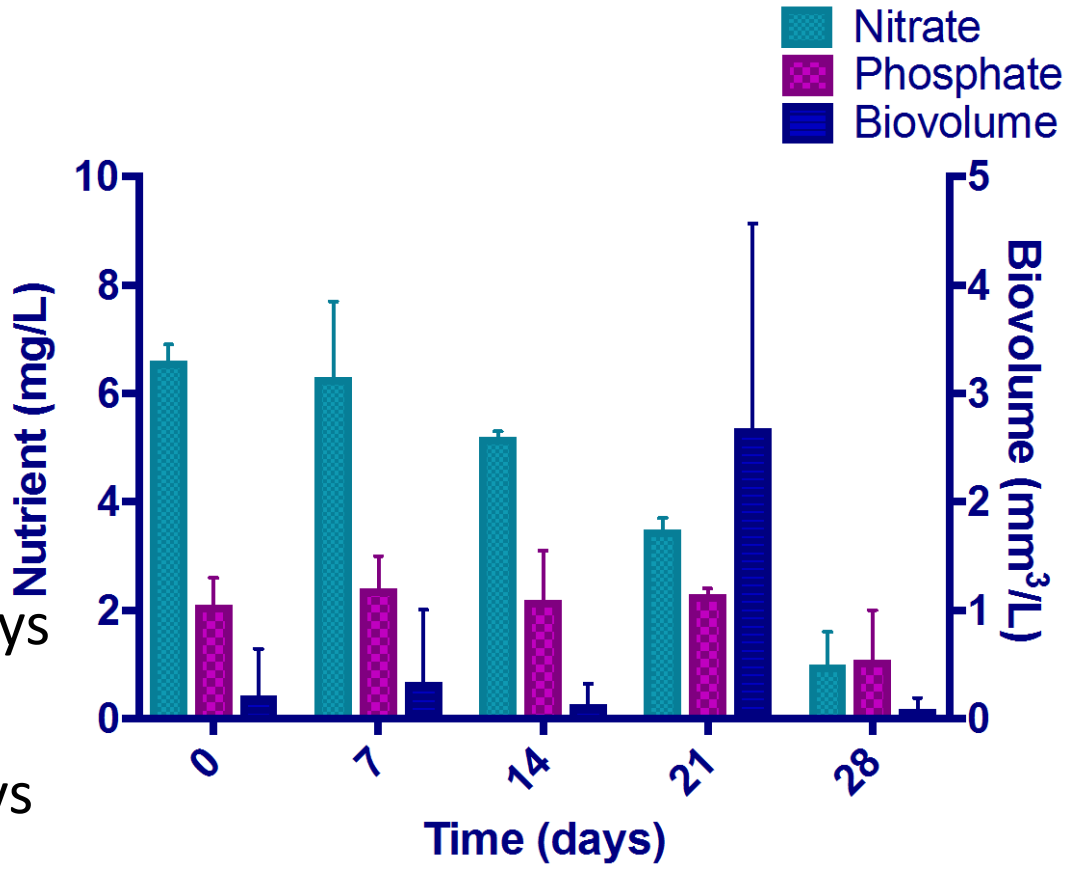
https://www.hach.com

Experimental Conditions

Experiments #	Phosphate (mg/L)	Nitrate (mg/L)
1	2	-
2	1	-
3	-	2
4	-	1

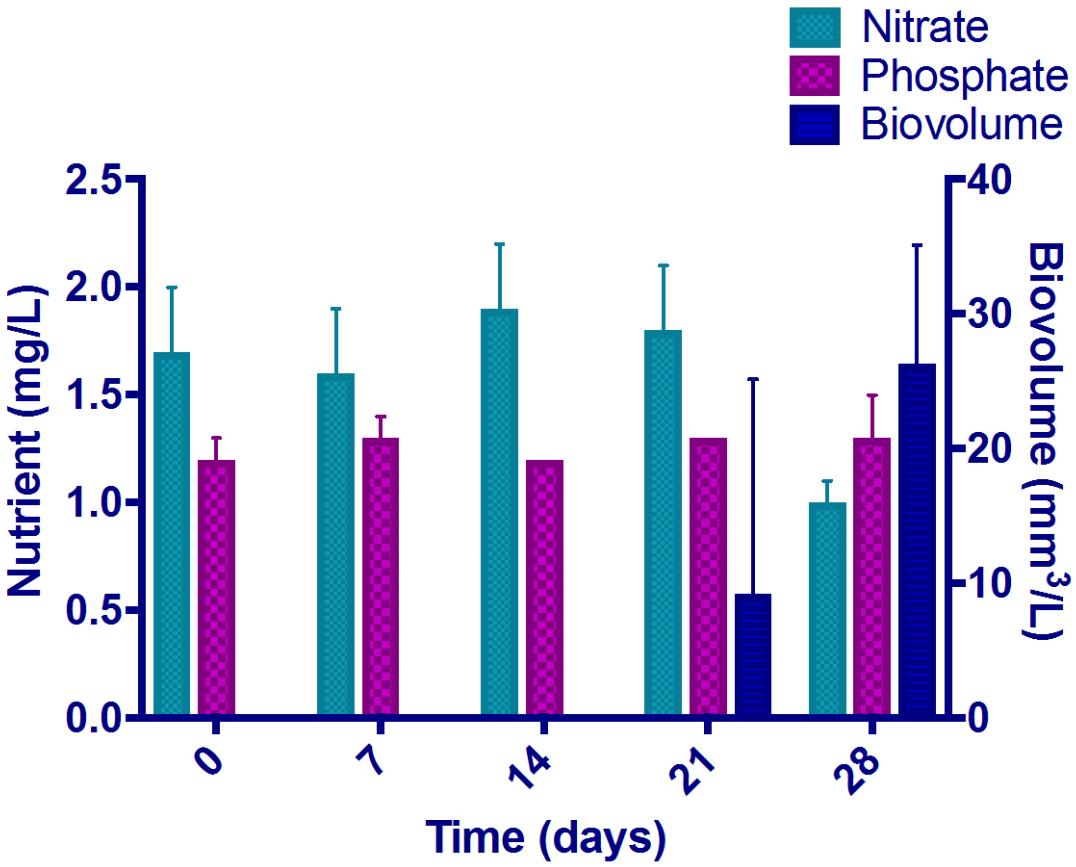
Experiment #1: Results

- Dosed: 2mg/L phosphate
- C:N:P → 100:10:1
- Biovolume
  - No lag
  - Slight increase at 7 days
    - N:P → 3:1
  - Largest yield at 21 days
    - N:P → 2:1



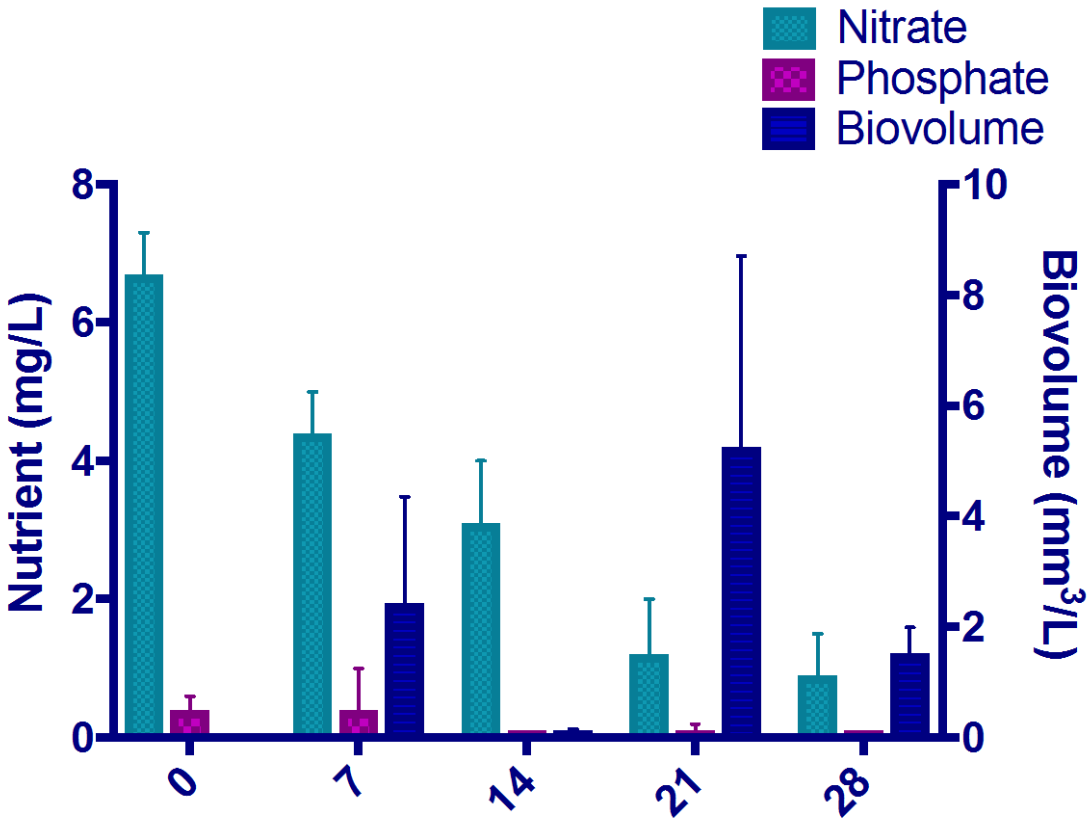
Experiment #2: Results

- Dosed 1 mg/L phosphate
- Biovolume
  - 14 - 21 day Lag
  - Increase at 21 days
    - N:P → 1:1
  - Largest yield at 28 day
    - N:P → 1:1



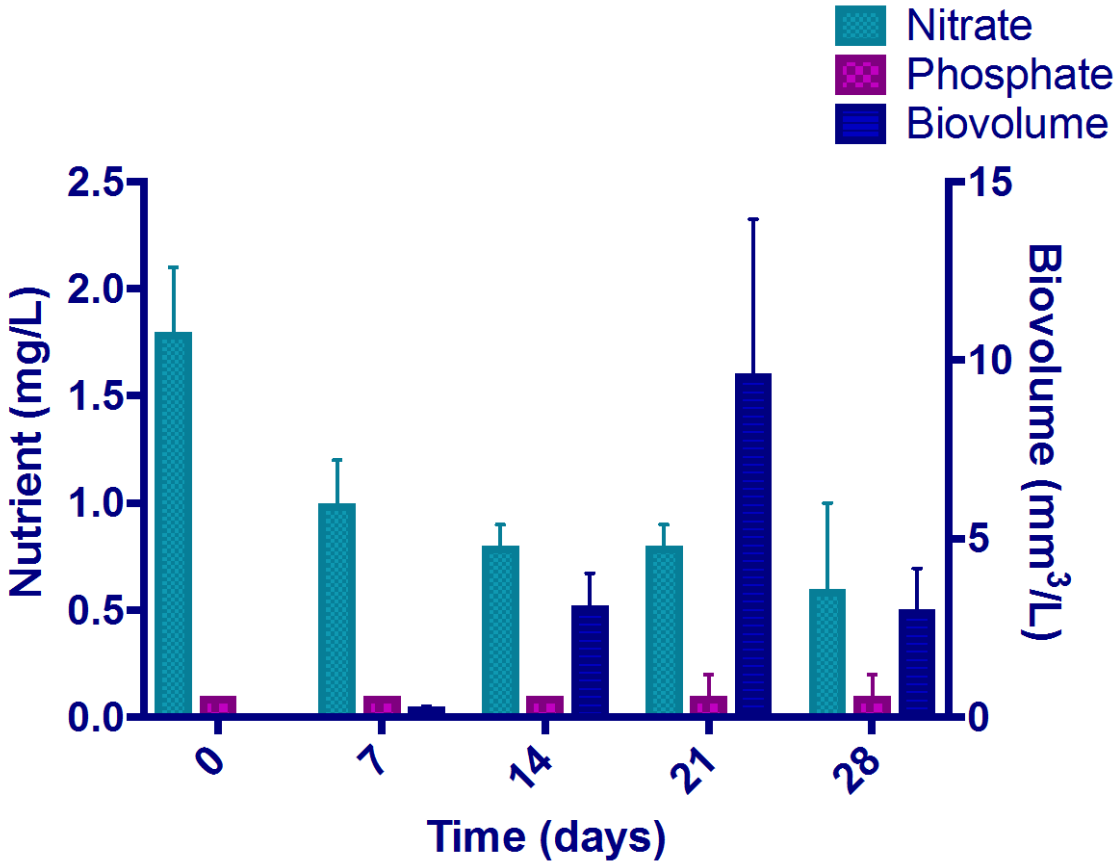
Experiment #3: Results

- Dosed 2 mg/L nitrate
- Biovolume
  - 7 day lag
  - Increase at 7 days
    - N:P → 11:1
  - Largest yield at 21 days
    - N:P → 11:1



Experiment #4: Results

- Dosed 1 mg/L nitrate
- Biovolume
  - 7-14 day lag
  - Slight increase at 14 days
    - N:P → 10:1
  - Largest yield at 21 days
    - N:P → 8:1



Results: Summary

Phosphate Dose:

- 2 mg/L
  - No true lag, largest biovolume at 21 days
- 1 mg/L
  - 21 day lag, largest biovolume at 28 days

Nitrate Dose:

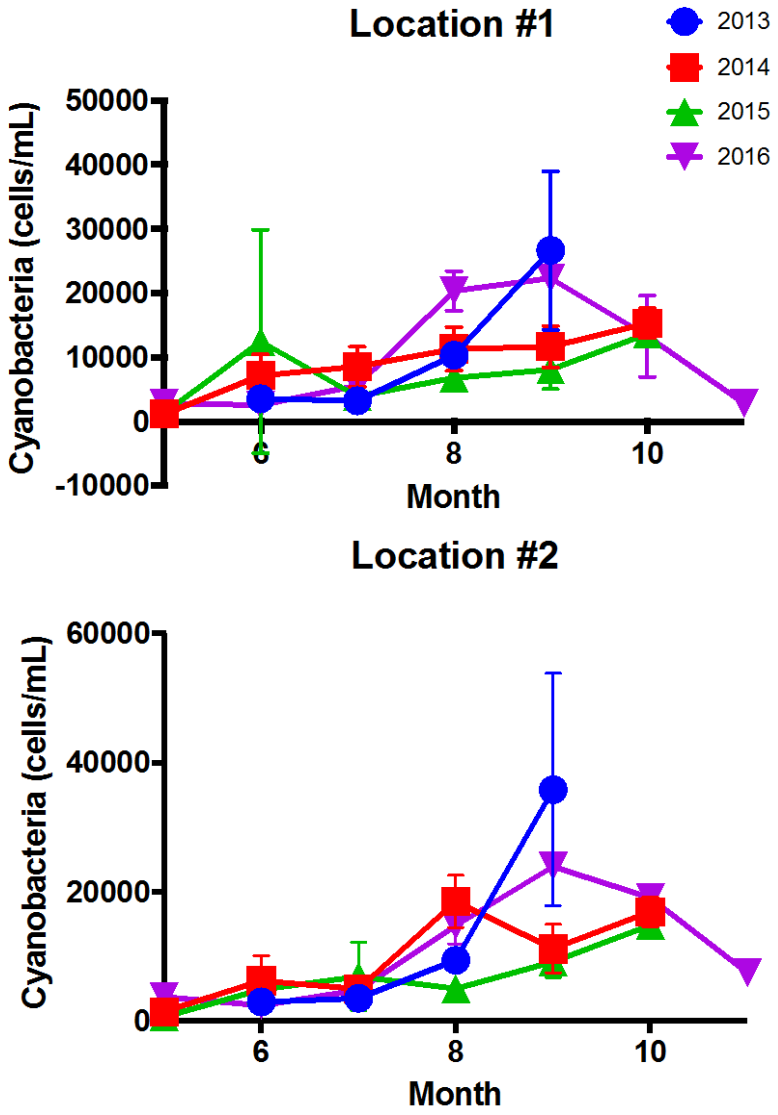
- 2 mg/L
  - 7 day lag, largest biovolume at 21 days
- 1 mg/L
  - 7-14 day lag, largest biovolume at 21 days

Results: Summary

- High nutrient dose → less lag time, less biovolume
- Lower nutrient dose → longer lag time, more biovolume
- Highest to lowest biovolume production
  - 1 mg/L phosphate dose N:P = 1:1
  - 1 mg/L nitrate dose N:P = 8:1
  - 2 mg/L nitrate dose N:P = 11:1*
  - 2 mg/L phosphate dose N:P = 2:1*
- Most nitrate starved yielded the highest biovolume
- *Excess nitrate yielded lower biovolume
- C:N:P → 100:10:1

The Next Step

- Build off of preliminary experiments
- Increase volume to 1.6L
- Instead of fully-sacrificed at each time step, continuous sampling
- Initial population ~30,000 cells/mL



The Next Step

- *Planktothrix sp.* beginning and end of grow season
  - Low-light adapting, temperature
- *Anabaena sp.* throughout season
  - Prefer more light, warmer temperature
- 3 population compositions
  - Non-diazotrophic dominated (>80%)
    - (*Planktothrix sp*.)
  - Diazotrophic dominated
    - (*Anabaena sp*.)
  - 50:50 split

THANK YOU!