Environmental predictors of algal blooms in a freshwater lake in Ontario, Canada

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BACKGROUND

- Climate change and human pollution are contributing to an increase in frequency and severity of algal blooms.
- In freshwater systems, algal blooms negatively impact water quality and ecosystem functioning, which has health, recreational, and economic implications.[1]
- Thus, identification of key environmental predictors of algal blooms is becoming increasingly important.
- Traditional algal bloom prediction methods are aimed at marine environments and rely on time- and labor-intensive methods that are not feasible for scales finer than 30 km^2.[2]
- However, monitoring chlorophyll fluorescence has been suggested as a cost-effective, early warning mechanism for algal blooms in freshwater systems.
- Previous studies have highlighted the importance of other environmental variables, such as temperature, in predicting blooms.[3]

Objectives:

(1) Assess the relationship of chlorophyll a content (proxy for bloom biomass) with chlorophyll fluorescence & multiple environmental conditions.

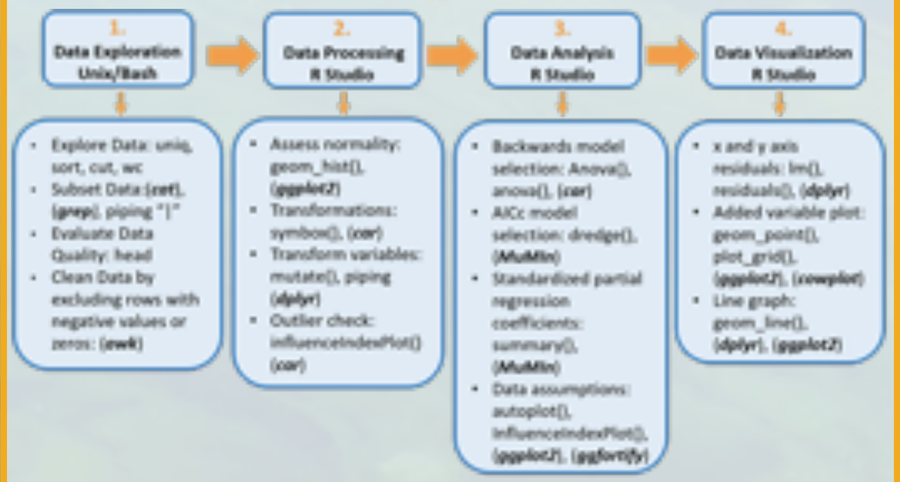
(2) Examine whether the rate of change in chlorophyll fluorescence can be used to predict algal blooms, as indicated by chlorophyll.

METHODS

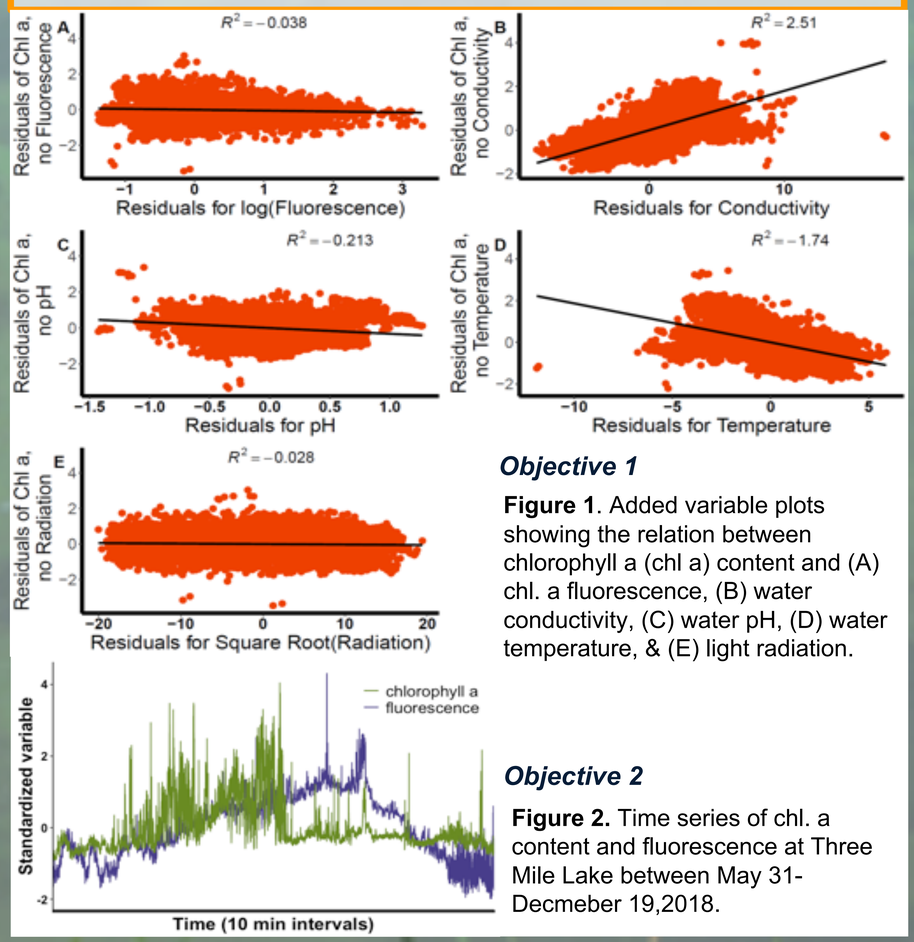
Dataset

- Sampling conducted to create data set occurred at Three Mile Lake in Muskoka, Ontario: a 8.8 km^2 freshwater lake, shoreline perimeter of 31.2 km, surrounded by lakefront cottages
- Contains 10-minute averages of continuously measured environmental variables (25,000 measurements) from May 31 to December 19, 2018
- Subsetted to include the following variables:
  - water temperature (0.1m below surface)
  - conductivity
  - longwave radiation (available sunlight at surface)
  - pH
  - fluorescence (relative chlorophyll fluorescence)
  - chlorophyll a (proxy for algal biomass)

METHODS PIPELINE



RESULTS: BLOOM PREDICTORS



Objective 1

Figure 1. Added variable plots showing the relation between chlorophyll a (chl a) content and (A) chl. a fluorescence, (B) water conductivity, (C) water pH, (D) water temperature, & (E) light radiation.

Objective 2

Figure 2. Time series of chl. a content and fluorescence at Three Mile Lake between May 31-Decmeber 19,2018.

DISCUSSION

Objective 1: Our results indicate that several environmental variables are significantly associated with algal bloom presence at Three Mile Lake. **Water conductivity and temperature were the two most closely related variables to bloom presence**, which is consistent with previous research in freshwater systems. Water temperature in particular has been shown to affect water density and stratification periods in ways that are beneficial to certain species of cyanobacteria[4].

Objective 2: As predicted, chlorophyll a content and fluorescence were associated. However, plotting of these variables on a temporal scale showed that **chlorophyll a content peaks before fluorescence**, which contrasts previous findings that fluorescence peaks first. This suggests that **we cannot use fluorescence as an indicator for blooms**. However, the present study uses total fluorescence, whereas several studies with positive findings use species-specific wavelengths instead of the total value. These studies have also used data collected over multiple years to assess temporal patterns[3]. Thus, the present study may not have a sufficient time scale or appropriate fine-scale measures to discern this relationship.

Implications Despite not finding the predicted temporal relationship between chlorophyll a content and fluorescence, our results provide insight into environmental variables that can act as important predictors for blooms. These insights may aid in establishing a reliable and efficient early warning system for algal blooms in eutrophic freshwater ecosystems.

CONCLUSIONS & NEXT STEPS

- Conductivity & water temperature were most closely related to bloom presence.
- Future research will be needed to clarify the relationship between fluorescence and algal bloom onset.
- To improve understanding of bloom causal mechanisms, future studies may:
  - Monitor community dynamics and rate processes over several years
  - Investigate other key environmental variables (e.g. nutrient concentrations)

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