THE INTERPLAY OF PHOSPHORUS & TEMPERATURE ON ALGAE TOXINS IN LAKE SENECA, NEW YORK

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RESEARCH QUESTION

What do the phosphorus and water temperature levels in Lake Seneca, New York tell us about the presence of toxic algae?

HYPOTHESIS

Elevated levels of phosphorus and increased temperature will exhibit a strong correlation with the occurrence of chlorophyll-a in Lake Seneca, NY.

BACKGROUND

There are certain characteristics that need to be examined when delving into the outcomes of total harmful algae blooms (HABs) in freshwater lakes. Chlorophyll-a has been observed to correlate with the presence of HABs and thus can be used as a reliable indicator. The presence of phosphorus in freshwater lakes has been noted to be a key component of plant life. However, once lakes begin to exhibit an excess amount of phosphorus, they can increase the process of eutrophication. Extreme growth of algae and aquatic plant life may result in a depletion of oxygen as aquatic life can no longer survive. Likewise, temperature is a valued indicator when investigating the presence of algae. An increase in temperature allows algae to flourish in their environment. As temperatures around the world become affected by climate change, it is necessary to delve into a possible change in the presence of HABs in our lakes.

METHODOLOGY

This study focused on Seneca Lake, investigating the relationship between phosphorus levels, water temperature, and chlorophyll-a from 2017-2021.

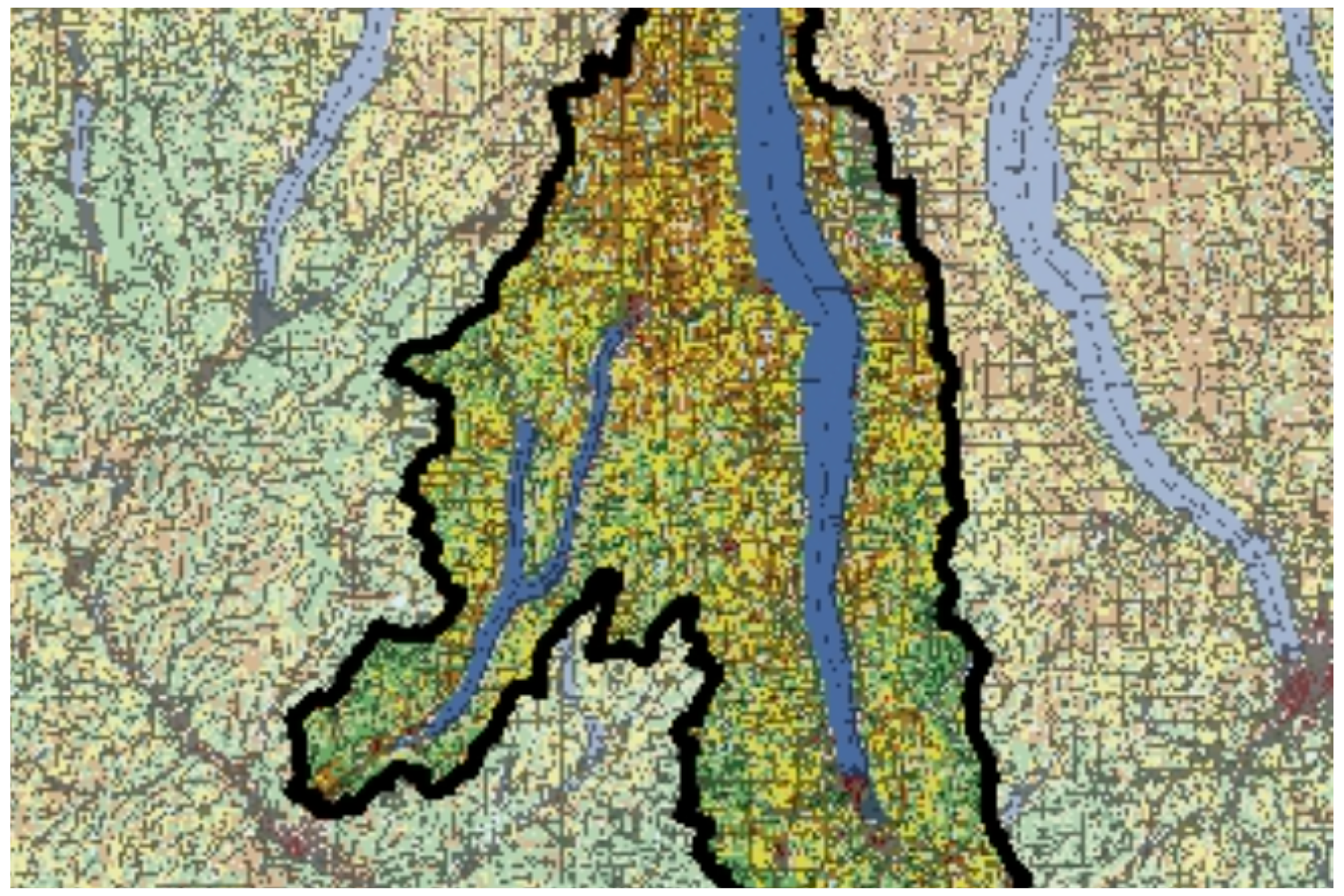
Phosphorus and temperature data was gathered from public government databases. Data sets were organized into tables by year and compared with their respective variables in the same time frame.

Outliers exceeding measurements of 100 were removed from the chlorophyll-a data.

Stacked area graphs for temperature and chlorophyll-a were created for each year.

Stacked area graphs for all years were created to depict the average of each variable in comparison to chlorophyll-a levels

RESULTS



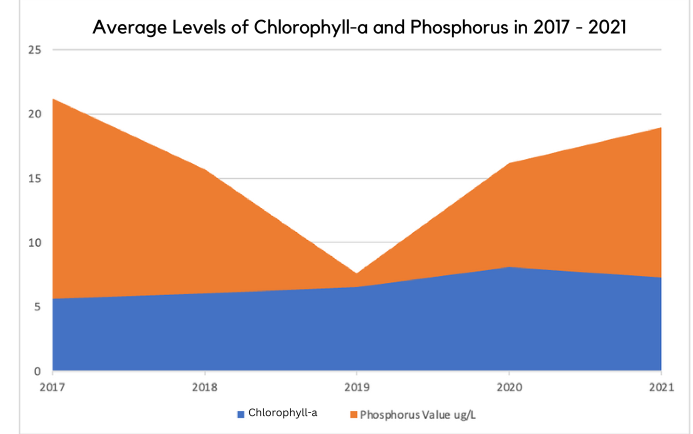


Fig. 1. Stacked area graph of average of chlorophyll-a and phosphorus 2017-2021

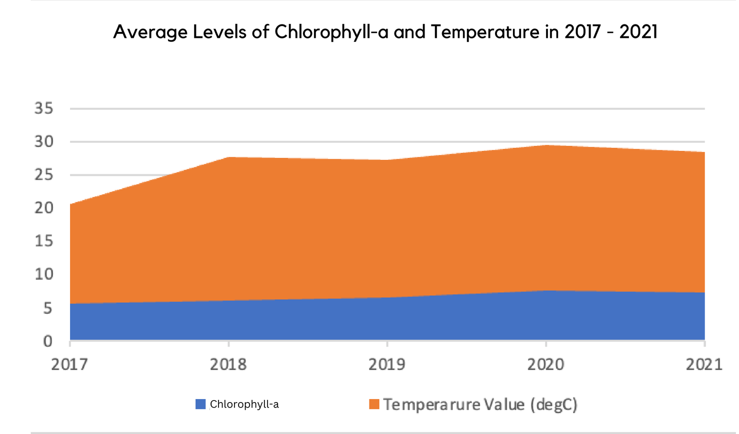


Fig. 7 Stacked area graph of average of chlorophyll-a and temperature 2017-2021

Fig. 1. depicts the average levels of phosphorus from 2017 to 2021 decreasing before 2019 and increasing after 2019. Chlorophyll-a depicts a steady state until a noticeable increase after 2019. It is possible that measures were taken to decrease phosphorus levels before 2019. However, due to the COVID-19 pandemic, these measures were interrupted. As the temperature increased, the trend of chlorophyll-a remained steady throughout. In comparison to phosphorus, temperature does not seem to be the main contributor to chlorophyll-a levels.

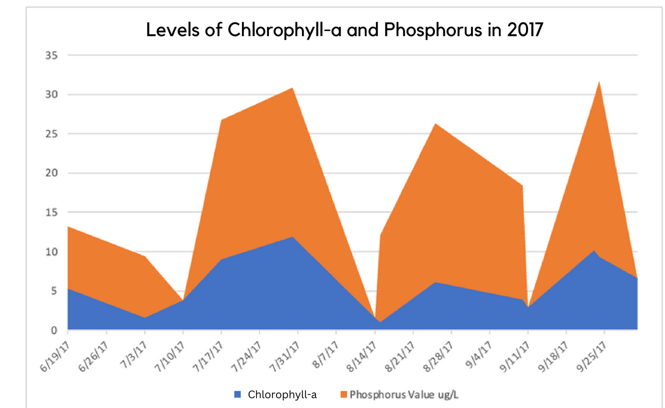


Fig. 2. Stacked area graph of levels of chlorophyll-a and phosphorus 2017

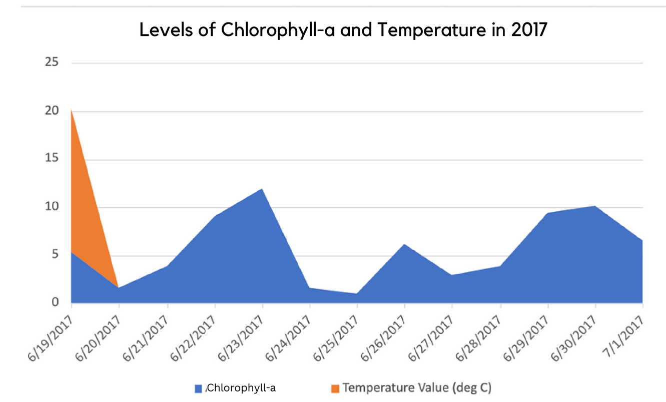


Fig. 3. Stacked area graph of levels of chlorophyll-a and temperature in 2017

2017- Chlorophyll-a decreases and increases similar to phosphorus levels in Fig. 2; each month from June to September depicts a peak in phosphorus and chlorophyll-a. The levels of chlorophyll-a and temperature do not follow a consistent trend in Fig.3.

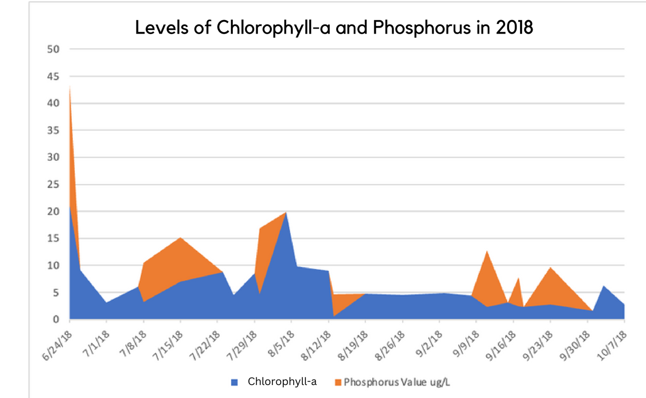


Fig. 4 Stacked area graph of levels of chlorophyll-a and phosphorus 2018

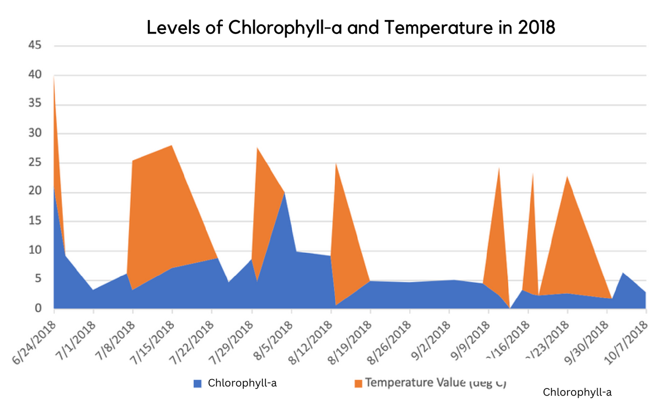


Fig. 5. Stacked area graph of levels of algae and temperature in 2018

2018- Chlorophyll-a increases and decreases similar to phosphorus in Fig. 4. Phosphorus appears to match the levels of chlorophyll-a from mid-July to early September. Chlorophyll-a and temperature do not have a consistent trend that follows one another.

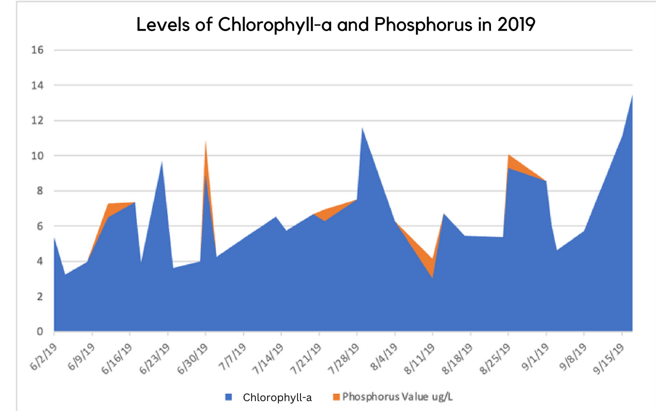


Fig. 6. Stacked area graph of levels of chlorophyll-a and phosphorus 2019

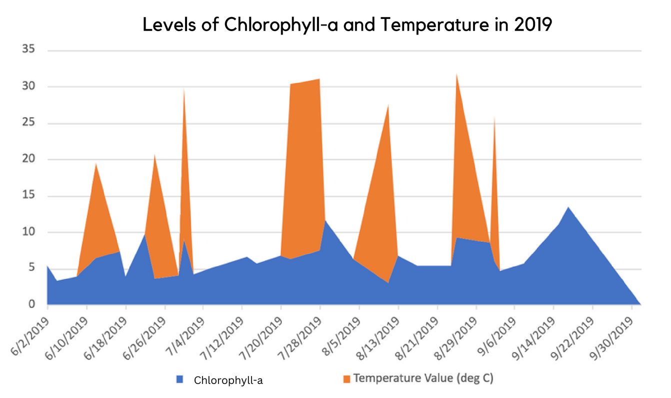


Fig. 7. Stacked area graph of levels of chlorophyll-a and temperature in 2019

2019- Chlorophyll-a in Fig. 6 has a similar trend as phosphorus from June to August; as phosphorus peaks, chlorophyll-a peaks as well. Fig. 7 has similar trends from June to late July. This does not continue after early August.

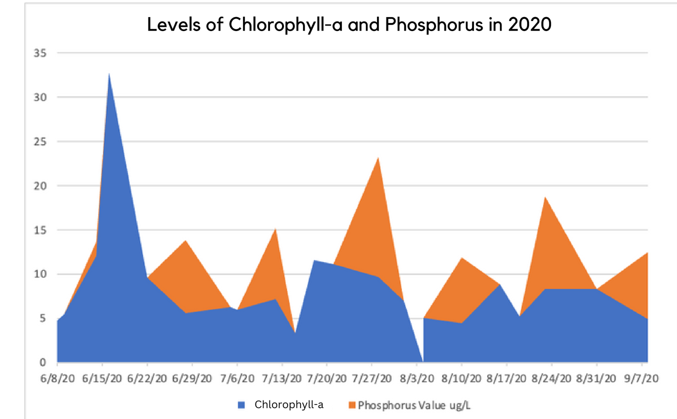


Fig. 8. Stacked area graph of levels of chlorophyll-a and phosphorus 2020

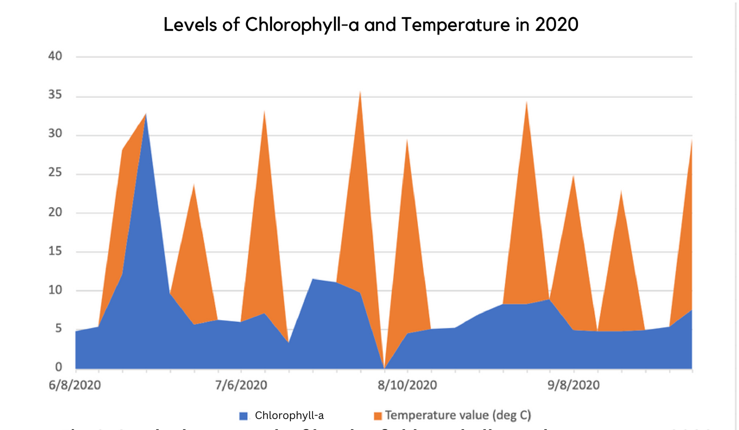


Fig. 9. Stacked area graph of levels of chlorophyll-a and temperature 2020

2020- Chlorophyll-a has a weaker trend with phosphorus. In late June, chlorophyll-a decreases while phosphorus peaks at its highest in early June. In early July, chlorophyll-a doesn't reach phosphorus and the incline is not extreme. In Fig. 9, chlorophyll-a and temperature see a peak in early June. In July and August, chlorophyll-a and temperature increase and decrease at similar times.

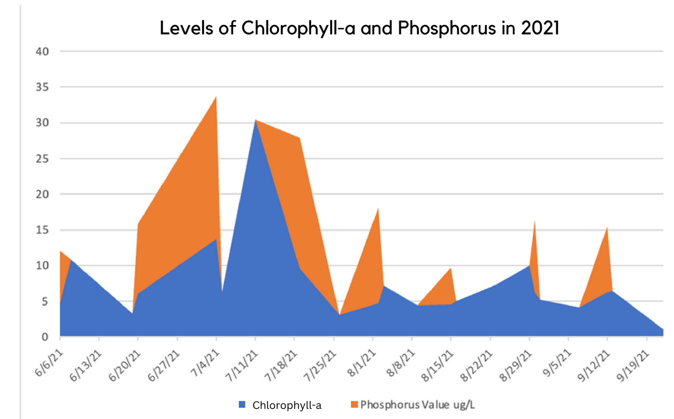


Fig. 10. Stacked area graph of levels of chlorophyll-a and phosphorus 2021

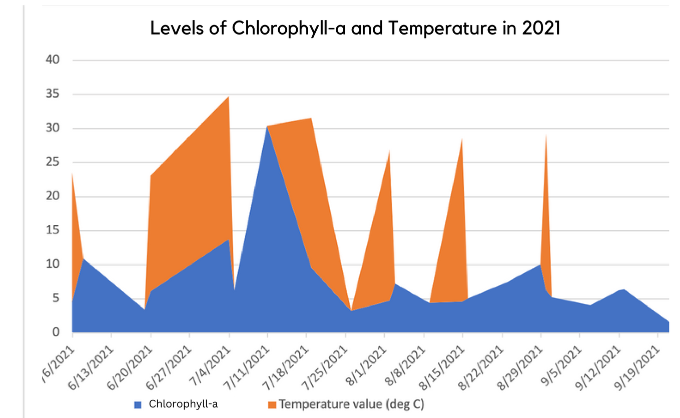


Fig. 11. Stacked area graph of levels of chlorophyll-a and temperature in 2021

2021- Chlorophyll-a has a similar trend as phosphorus in late June to late July and shares a peak in early July. In early August, the rate of increase and decrease of chlorophyll-a is not as extreme. In Fig. 11, temperature and chlorophyll-a increased and decreased from June to late July with a matched peak in mid-July. After early August, chlorophyll-a was steady as temperature continued to reach peaks.

LIMITATIONS

9/8/18	CHLOROPHYLL A	4.409	ug/L
9/11/18	CHLOROPHYLL A	2.302	ug/L
9/13/18	CHLOROPHYLL A	743.6	ug/L
9/15/18	CHLOROPHYLL A	3.157	ug/L

9/15/19	CHLOROPHYLL A	11.106	ug/L
9/17/19	CHLOROPHYLL A	13.483	ug/L
10/2/19	CHLOROPHYLL A	626.1	ug/L
6/8/20	CHLOROPHYLL A	4.776	ug/L

We removed chlorophyll-a values in our data (9/13/18 and 10/2/19) that exceeded the value of the hundred to reduce the chance of outliers. Additionally, due to a lack of reliable data for chlorophyll-a in January, February, March, April, May, November, and December, the use of year-round graphs could not be utilized. Rather than assuming the lack of data could equate to zero findings in levels of chlorophyll-a, it was decided to remove these months from the study.

CONCLUSION

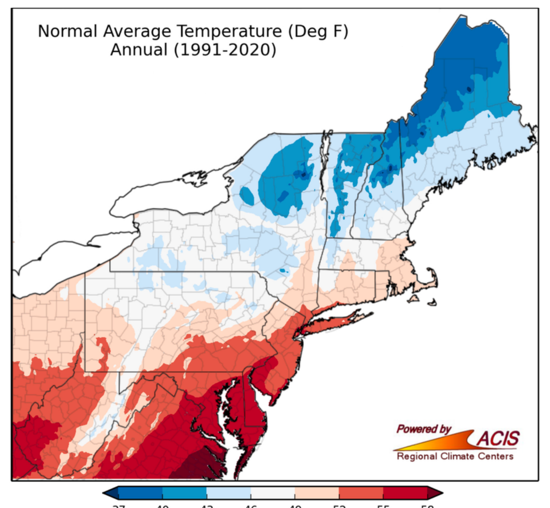
The high levels of phosphorus and algae blooms have been noted in previous studies. However, this study delves into the relationship between levels of phosphorus and temperature to the levels of harmful algae blooms, with chlorophyll-a acting as an indicator of this variable. Our data was successful in showing a correlation between levels of phosphorus and chlorophyll-a in a majority of the studied years.

- Within the years 2017 to 2019, levels of phosphorus and chlorophyll-a followed a similar trend; as phosphorus levels increased, chlorophyll-a levels increased and as phosphorus levels decreased, chlorophyll-a levels decreased. An interruption in this trend occurs between 2019 and 2020. This is indicated in Fig. 1 and Fig. 7. It should be emphasized that this outlier may have been caused by possible phosphorus-decreasing measures which were then interrupted by the COVID-19 pandemic.

Within this study, temperature levels and chlorophyll-a levels did not present trends as strong as our previous variables. However, in the early summer months, it was noted that as temperature levels increased, chlorophyll-a levels also increased.

The results of this study present the average trend in levels of phosphorus and temperature in relationship with algae blooms, using chlorophyll-a as a reliable indicator. Due to the unexpected results in these averages, more has been observed in how these variables have been impacted throughout recent years of societal uncertainty.

FUTURE RESEARCH



The impact of temperature on HAB growth, using chlorophyll-a as its indicator, can be further studied by studying water bodies in various parts of the United States. This data can further analyze the phosphorus and temperature relationship with HABs through freshwater and saltwater sites.

References: Applied Climate Information System (ACIS). (2022, October 13). Map of Northeast U.S. total annual snowfall, averaged over the thirty-year period of 1991-202. Earth at Home. Fact Sheets | UMass Amherst MWWP. (n.d.). Www.umass.edu. https://www.umass.edu/mwwp/resources/factsheets.html Glibert, Patricia M, et al. Florida Bay: Water Quality Status and Trends, Historic and Emerging ..., 2009, www.researchgate.net/profile/Joseph Boyer/publication/284306213_Florida_Bay_water_quality_status_and_trends_historic_and_emerging_algal_bloom_problems/links/57dbe6b408ae5292a3799660/Florida-Bay-water-quality-status-and-trends-historic-and-emerging-algal-bloom-problems.pdf. Gobler, Christopher J., et al. "The Dual Role of Nitrogen Supply in Controlling the Growth and Toxicity of Cyanobacterial Blooms." Harmful Algae, Elsevier, 12 May 2016, www.sciencedirect.com/science/article/pii/S1568988316300269. Gorney, Rebecca M, et al. "Detections of Cyanobacteria Harmful Algal Blooms (CyanoHABs) in New York State, United States (2012–2020)." Lake and Reservoir Management, vol. 39, no. 1, 2 Jan. 2023, pp. 21–36, https://doi.org/10.1080/10402381.2022.2161436. Lung, Wu-Seng, and Hans W. Paerl. "Modeling Blue-Green Algal Blooms in the Lower Neuse River." Water Research, vol. 22, no. 7, July 1988, pp. 895–905, https://doi.org/10.1016/0043-1354(88)90027-9. Sarson, D. (2000, February). Microcystis bloom in Matilda Bay, Swan-Canning Estuary, Western Australia. Oz Coasts.

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