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Abstract

Cyanobacteria are tiny organisms that have existed for billions of years. They are most commonly known for their role in oxidizing the atmosphere over 2 billion years ago which made it possible for the Earth to sustain human life. However, they were identified to be one of the main sources of harmful algal blooms (HABs) in freshwater bodies and a producer of a toxin that can negatively target the skin, liver and brain. There are several techniques that can be used to reduce their populations in water, two of which are aeration and the addition of biochar, a charcoal-like material made from carefully burned organic matter. Aeration introduces air bubbles at the bottom of the tank which makes the body of water less favorable for cyanobacteria by decreasing the pH and nutrient availability as well as disrupting their migration patterns. Alternatively, biochar—which is made from pine wood in this case—works by making the nutrients adhere to its surface in a process known as adsorption. As a result, the nutrients are no longer bioavailable to the cyanobacteria. With this knowledge, eight identical 1L tanks were set up with water taken from Morningside pond, a pond in Harlem, New York with an active cyanobacteria-induced HAB. These tanks were inoculated with a known freshwater strain of cyanobacteria (2973) and allowed to grow under constant light exposure before the respective treatments were applied—two received the aeration treatment, two received a “low” biochar treatment, two received the “high” biochar treatment and two received no treatment. At the end of the experiment, the data was analyzed using Microsoft Excel and the tanks underwent a colorimetry analysis. It was found that dissolved oxygen dropped across the board and aeration worked more rapidly to prevent cyanobacteria colonies from forming while the biochar tanks had fewer nutrients in general. With that being said,

biochar is still a promising approach to mitigate cyanobacterial growth especially because it is cost effective and applicable on larger scales.

Introduction

Cyanobacteria, also called blue-green algae, is commonly found in lakes, ponds, and other stagnant bodies of water. Through the process of eutrophication, runoff from farm fertilizers and sewage can cause colonies of cyanobacteria to grow rapidly. Fertilizers are high in the nutrients nitrogen and phosphate which are used by the cyanobacteria. Excessive cyanobacterial growth, or “harmful algal blooms” are extremely harmful for aquatic ecosystems and cause dead zones where the entire food chain is disrupted. Surface level colonies block sunlight from plants and the cyanobacteria use so much oxygen that fish and other animals can’t survive. Research into preventing and fighting algae blooms is important for keeping the ecosystem healthy. Some bioremediation methods:

- Cyanophage virus that targets cyanobacteria
- Chemical pesticides that kill cyanobacteria
- Biochar
- Aeration

Our experiment focuses on biochar and aeration to find which is more effective in removing cyanobacteria.

Experimental Questions

How effective are the following bioremediation techniques on cyanobacterial colony reduction?
Aeration: bubbler that disrupts the shape of the colonies
Biochar: carbon-based material that binds with phosphorus, making it unusable by the cyanobacteria

Hypothesis

We developed two hypotheses for this experiment:

- If we use a remediation method such as biochar in tanks with cyanobacteria, then there will be a decrease in cyanobacteria colonies, because of the decrease in levels of phosphorus due to the addition of biochar. Biochar is most likely to work as it deprives the cyanobacteria of a vital nutrient, phosphorus, in which it is required to grow and maintain colonies.

- If we aerate tanks that have cyanobacteria, there will be an increase in dissolved oxygen due to the addition of aeration in the tanks. This remediation method will disrupt cyanobacteria by reducing the accessibility of nutrients and their ability to move vertically.

Procedures

There were three major steps in the experiment. They are as follows:

1. Collect samples from Morningside Pond, as seen in the map below
2. Perform water quality tests (ammonia, phosphate, and D.O.)
3. Introduce the three different bioremediation methods: aeration, 5g of biochar and 10g of biochar.



Figure 1: *Left*: aerial view of Morningside pond taken from google maps. It shows the two locations where samples were collected. *Right*: image of the tank setup showing the tanks that were aerated (top), tanks treated with 10g of biochar (right below), the tanks treated with 5g of biochar (bottom right) and control tanks with no treatment (bottom left)

Data

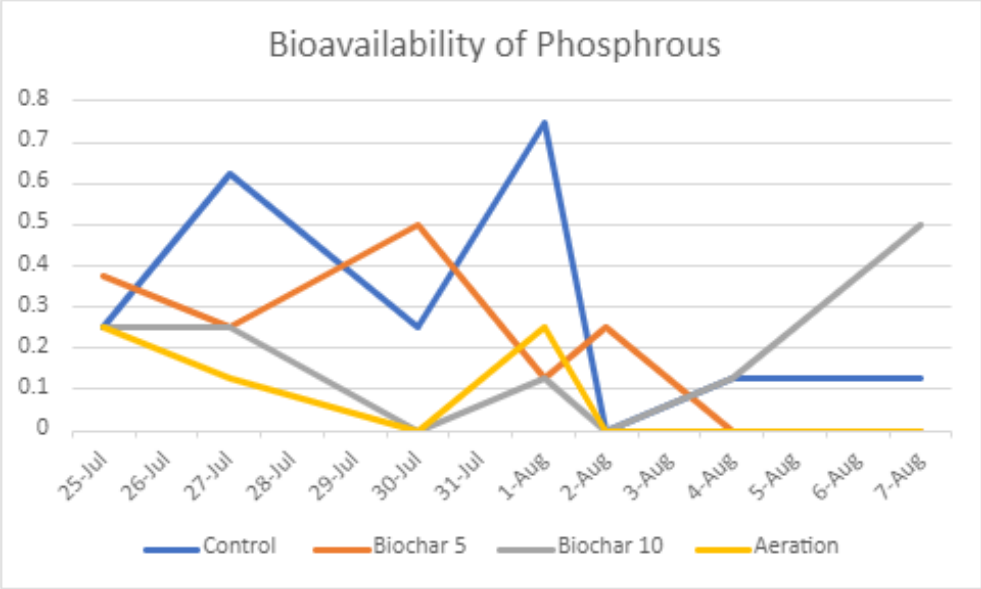

Figure 1: n=8. In the beginning of the water testing quality from 7/25 to 8/1, the control group generally has higher levels of phosphate found in the water. Towards the end of the testing, 8/2 to 8/7 there is a general constant trend upwards with the level of phosphate in the tanks treated with the highest level of biochar treatment, biochar 10. Throughout the period of time tested from 7/25 to 8/7 there is no general and consistent trend available

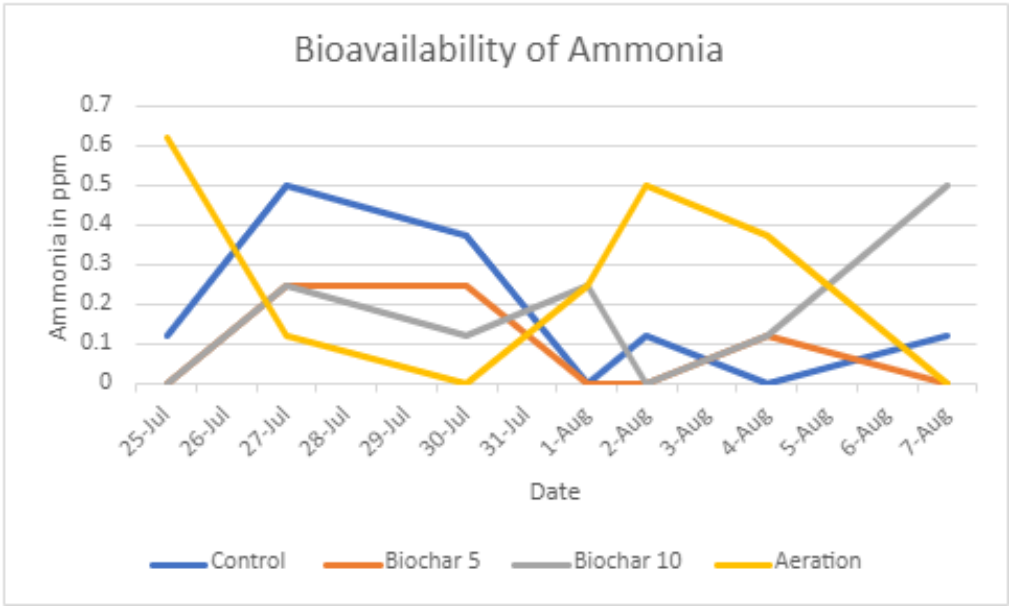

Figure 2: n=8. Throughout the testing of the data, the aerated tanks generally have higher levels of ammonia present in the tanks, but overall the levels of phosphate in the tanks

have no appreciable difference.



Figure 3: Experimental setup (pre-inoculation with freshwater strain of cyanobacteria)

Colorimetry Analysis

How to read colorimetry results:

The control tank does not have any modifications so it represents the standard that the other tanks should be compared to. The reasoning behind the lines being divided into red, green and blue is because those are the components of natural white light. Because of this, every color can be broken down into those colors with white light having equal amounts of all of the colors. As for the colorimetry, this is important because cyanobacteria have reddish and blue pigments as well as chlorophyll—a green pigment used for photosynthesis.

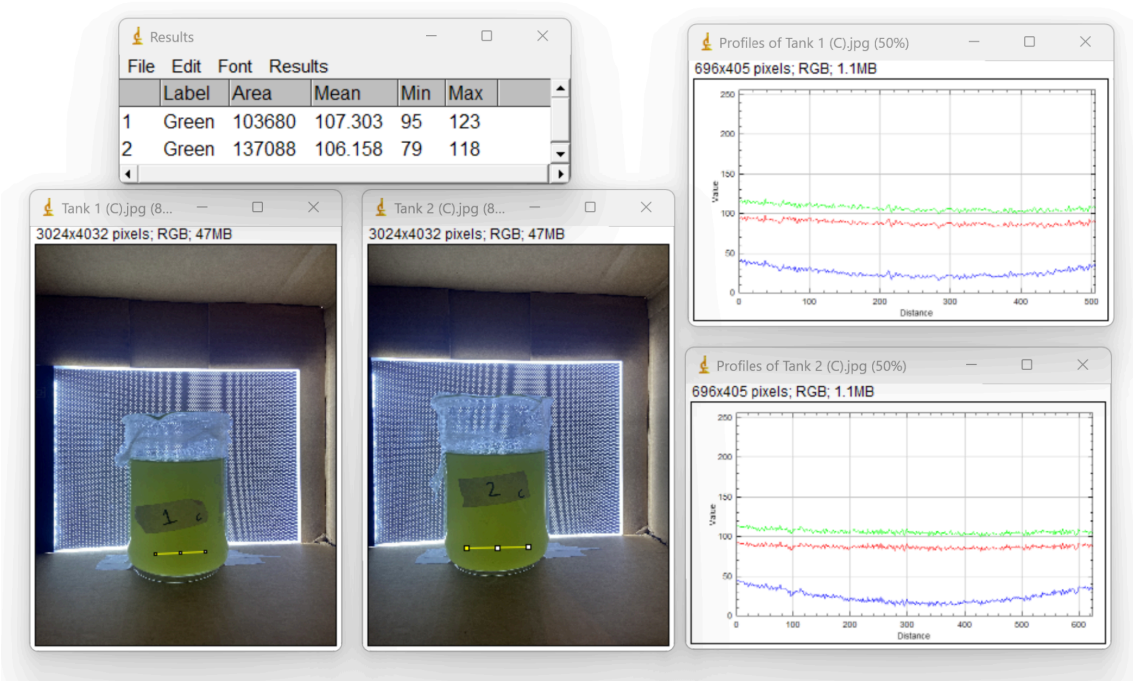

Figure 4: first colorimetry analyses of the control tanks

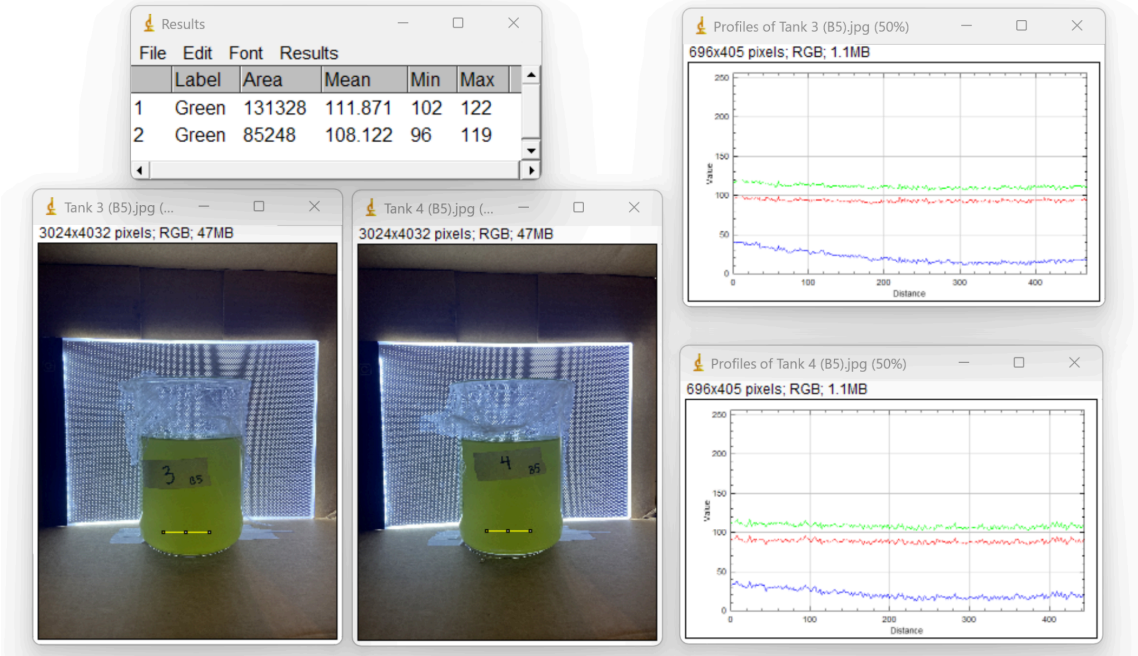

Figure 5: first colorimetry analyses of the low dose biochar tanks

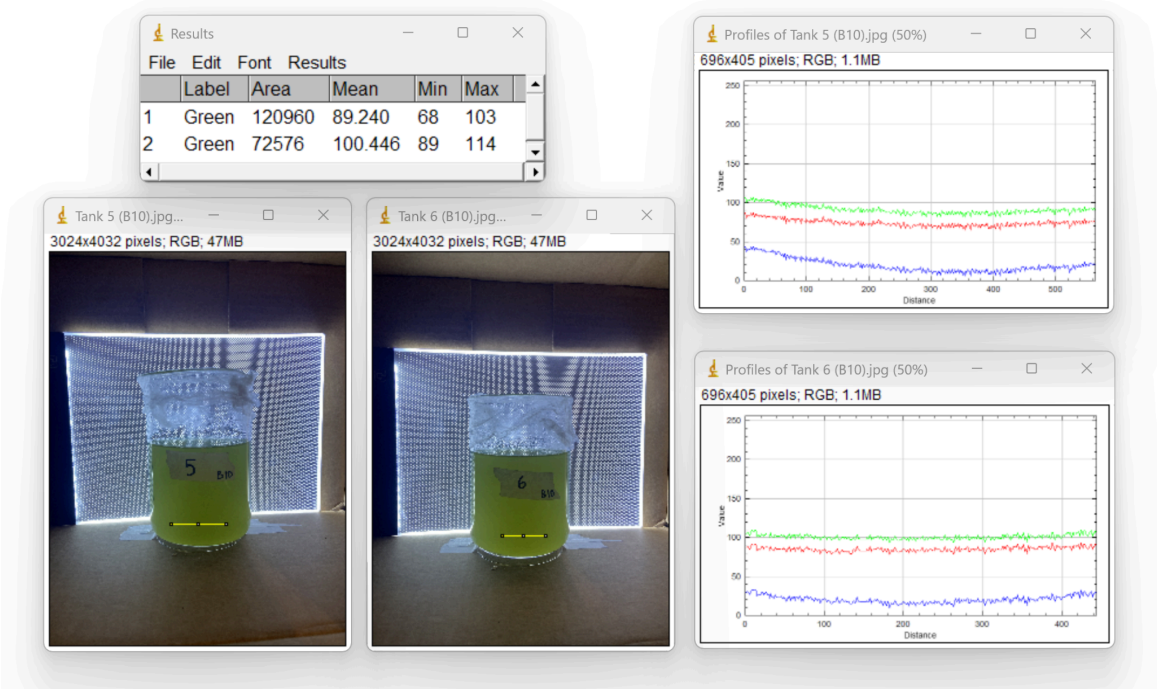

Figure 6: first colorimetry analyses of the high dose biochar tanks

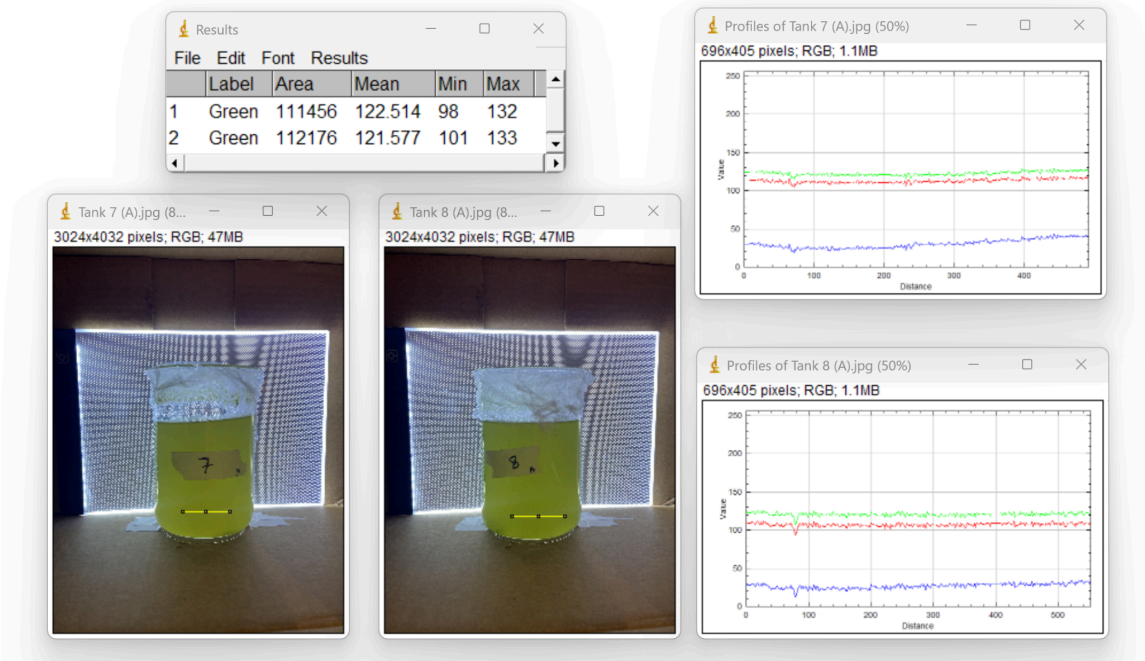

Figure 7: first colorimetry analyses of the aerated tanks

2nd Colorimetry Analysis

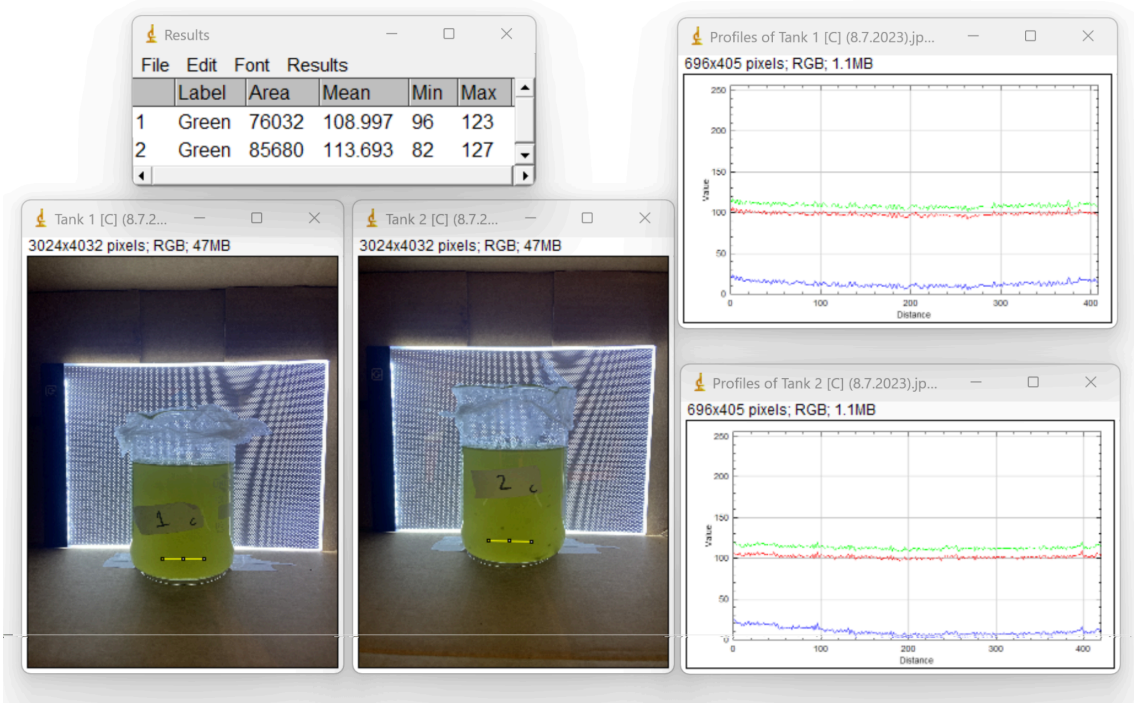

Figure 8: second colorimetry analyses of the control tanks

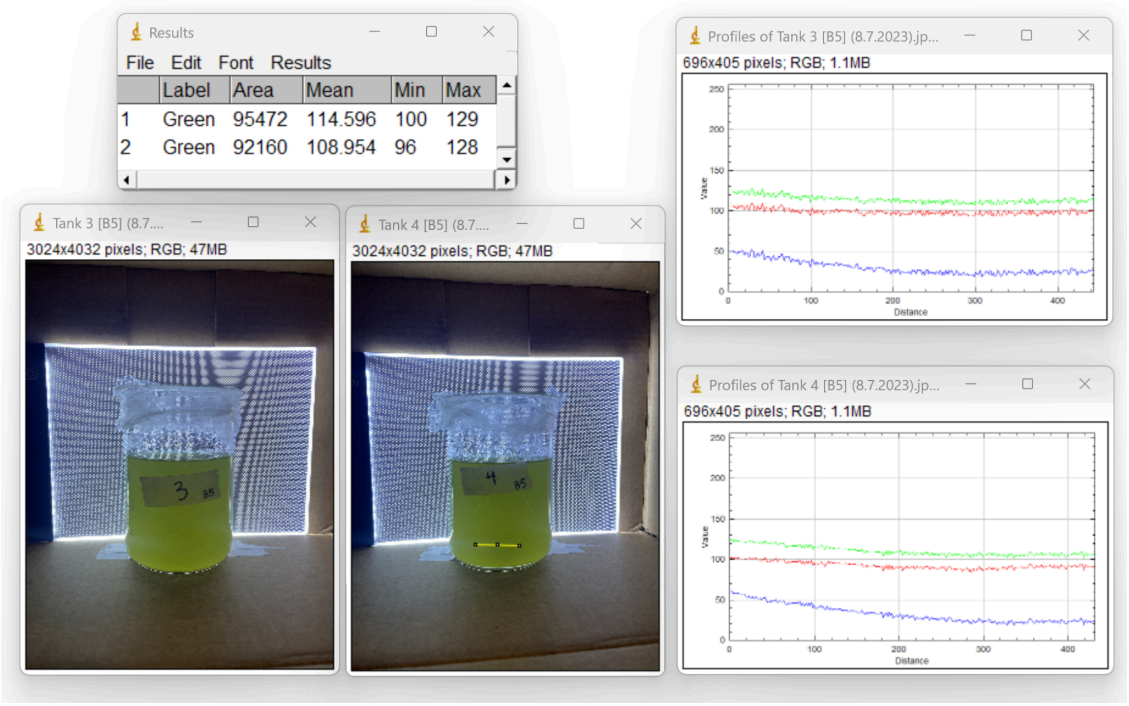

Figure 9: second colorimetry analyses of the low dose biochar tanks

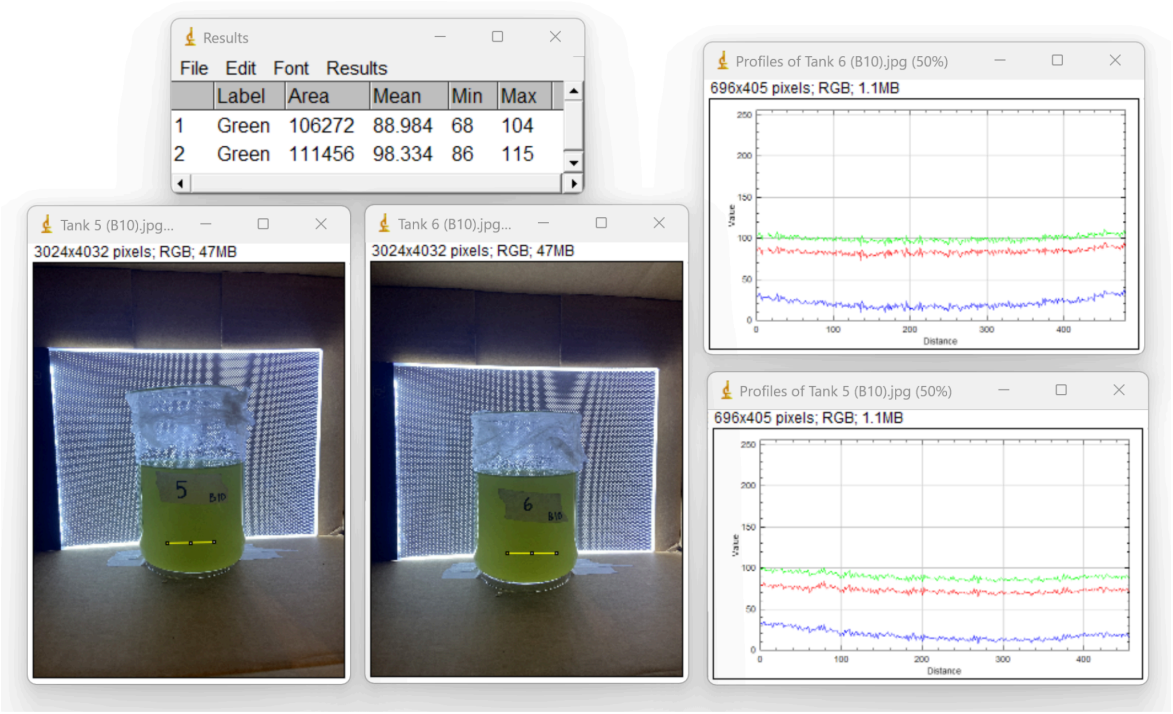

Figure 10: second colorimetry analyses of the high dose biochar tanks

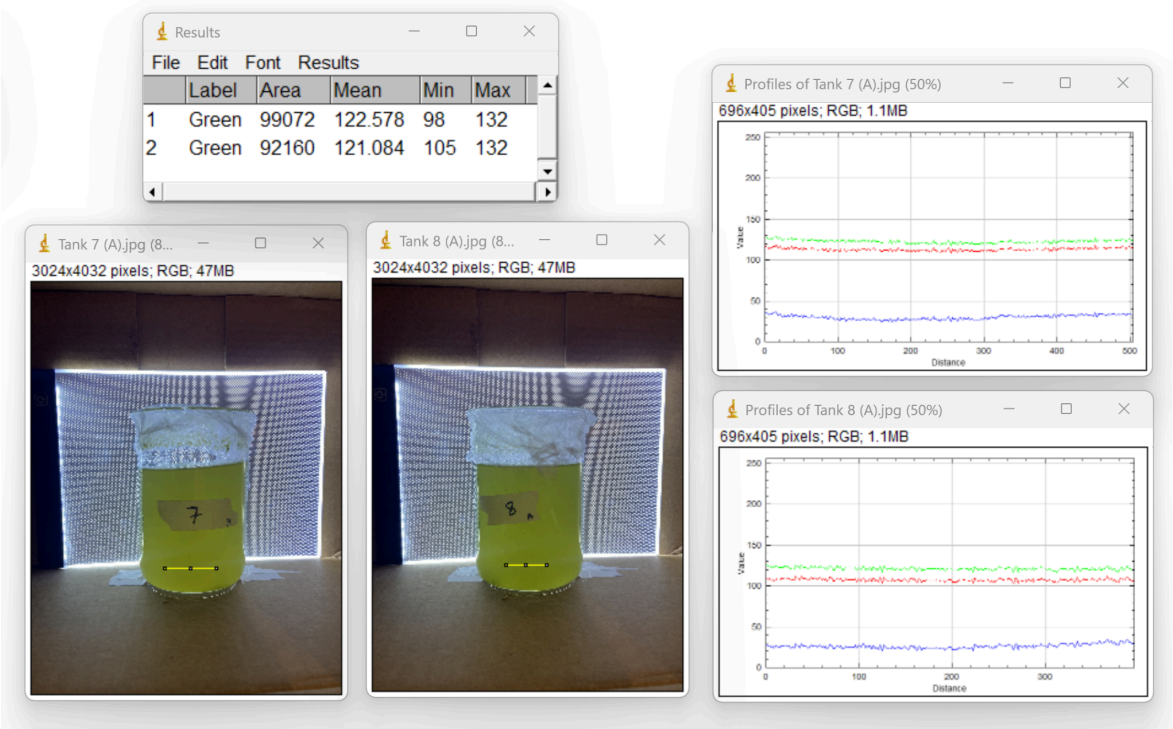

Figure 11: second colorimetry analyses of the aerated tanks

Conclusion

Cyanobacteria remediation methods are important to develop in order to address environmental pollution and develop a sustainable ecosystem. Our use of Biochar and Aeration greatly reduced the number of colonies in our tanks. Upon observation under a microscope, the control group with no bioremediation had more diverse and more populous cyanobacteria than the Biochar group. The Biochar took away the nutrients that were present in the water; therefore there were less colonies compared to the control. When using aeration, cyanobacteria are physically disrupted and prevented from forming colonies. When looking at our results we saw that Phosphate, Ammonia, and Nitrite had all decreased to 0 ppm in the aeration and low biochar conditions. This means our remediation methods are working in reducing the number cyanobacteria colonies in our tanks. However the high biochar causes an increase in Phosphate and Ammonia, this contradicts our hypothesis based on the mechanism of biochar. Maybe this could have been an error in the testing or it is a real effect that should be investigated further. In the future we would like to add cyanophages into bodies of water that are suffering from excessive cyanobacteria growth. These viruses only interact with and disrupt cyanobacteria meaning that other organisms and plant life will not be affected by these viruses. This makes Cyanophages a great alternative for removing these harmful algal blooms. Another thing we want to do is test the water from Central Park, which is another body of water affected by cyanobacteria and compare it to the water from Morningside Park, and use the same remediations to collect data. With cyanobacteria currently posing a threat to our aquatic ecosystem, our present goal is to increase public awareness of this environmental issue.

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Acknowledgements

We would like to thank Tessa Hirschfeld-Stoler, Robert Frawley, Maia Yoshida, Joe Parziale, and Francesca Sodu BioBus for their indispensable assistance and guidance throughout this project.

Glossary

Bioavailable:
a substance that can be taken in by an organism

Bioremediation:
the use of naturally occurring or introduced methods to break down or clean an environment of pollution

Cyanobacteria (blue-green algae):
a phylum of gram-negative, prokaryotic, photosynthetic bacteria that live in all types of water and are not technically classified as algae

Eutrophication:
the process of excess nutrients from runoff or sewage causing heavy plant growth and death of animals from lack of oxygen

Harmful algal bloom (HAB):
excessive growth of algae or cyanobacteria whose toxins harm the aquatic ecosystem where it takes place

Nitrite (NO_2^-):
salts of nitrous acid or compounds containing NO2-

Phosphate (PO_4^{3-}):
important nutrient used for energy and communication within a cell

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Thanks for reading!

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