Investigating the Effectiveness of Flocculants to Mitigate Harmful Algal Blooms (HABs)

Introduction

Over the past few years Lake Erie has seen a significant increase in harmful algal bloom growth over the past few years. Harmful algal blooms are fatal to habitants where a significant number of animals live. The algal blooms can infect many of these animals with diseases that can even lead to death. Algal blooms can also suffocate the water's oxygen supply, making it harder for marine species to breathe. The degradation of gills or the suffocating of aquatic vegetation occurs as oxygen levels drop. Algal blooms have a negative influence on both animals and people as the blooms have the potential to contaminate and poison drinking water. As a result of the toxicity of the water, humans can get diseases which can result in death. Every U.S coast and the Great Lakes contain harmful algal blooms are have experienced them in the past. The lakes that have a frequent occurrence of cyanobacteria blooms are Lake Erie, Green Bay, and Saginaw Bay. According to the National Oceanic and Atmospheric Administration (NOAA), from **2002** to **2015**, the severity of harmful algal blooms in Lake Erie has gone up from around **0.7** to **10.4**. This increase in severity shows that harmful blooms have a significant impact on the wildlife that inhabit Lake Erie. Even though the severity has been reducing since **2015**, in **2020**, the severity level was around **3,** which is still a really high impact on Lake Erie. These findings compelled us to investigate methods to remove harmful algae blooms from large bodies of water.

Problem Statement

How effective are aluminum chloride, ferrous sulfate, and sodium hydroxide at "clumping" and clarifying an algae solution?

Hypothesis

If aluminum chloride is used for algae clarification, then it will yield better mitigation of algal blooms than ferrous sulfate and sodium hydroxide because it can inhibit the growth of the algae.

Variables & Groups

Independent Variable (IV)	Type of flocculant used to mitigate or clump the algae.
Dependent Variables (DV)	The turbidity of the algae solution and chemical flocculants. Turbidity is measured in NTU's.
Control Variables	Temperature when growing the algae culture, amount of flocculant used, amount of algae solution used for each experiment, the algae culture grown for the experimentation (**Chlorella Vulgaris**), and the turbidity tube used to test.
Control Groups	The dirt water in which all the turbidity results are compared to for a comparison between two solutions to get a better idea of turbidity.

Procedure & Materials

EXPERIMENTAL SETUP:

The general setup required: (I) **12** inch turbidity tube, **4** *10* mL test tubes, **4+** pipettes, popsicle sticks to mix the algae solution and flocculant solution, **4** mason jars (**3** for the algae flocculated solution and **1** for the dirt water constant), and algae culture solution (**Chlorella Vulgaris**)

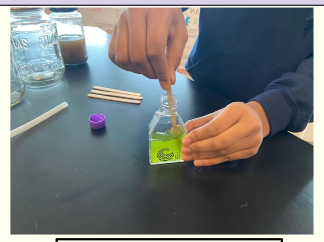
The turbidity tube was placed in a stabilizer clamp for no motion during the test and for accurate results as we have more of a part in getting the correct number because we don't have an electronic turbidity meter where we can get 100% accurate results right away.

The algae solution was used for **4** different tests. **(1)** Testing the turbidity of the algae solution itself **(2)** Testing the turbidity of all **3** flocculated solutions. The solution was divided into **10** mL for each test as we had **40** mL of algae solution in total.

In **3** of the mason jars we added **10** mL of algae solution, while in the fourth mason jar we added **10** mL of dirt water. A few popsicle sticks were used to mix the algae solution as well as the flocculated solution.

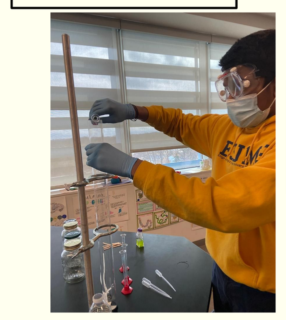
EXPERIMENT PROCEDURE:

- Algae solution was mixed using popsicle sticks.
- Turbidity of **ONLY** the algae solution was tested.
- **10** mL of solution was taken into the test tube using the pipette.
- Solution was poured into the turbidity tube.
- After waiting **1** minute, looking into the solution we couldn't see secchi disk perfectly.
- **9** mL of water was added to the tube using the pipette
- After adding the water, looking into the solution now we could see the secchi disk much clearer than before
- Looking at the lines on the side of the tube, we could see that the turbidity of just the algae solution was **1.3** NTU.
- **10** mL of chemical solution was added to each mason jar with the algae solution.
- After solutions were made, we mixed the solution with popsicle sticks and with the jar.
- Turbidity was tested for each flocculated solution.
- **50** mL of water was added when testing the turbidity of the ferrous sulfate solution. For the other solutions **0** mL of water was added.
- After, turbidity of dirt water was tested. **40** mL of water was added when testing the turbidity.

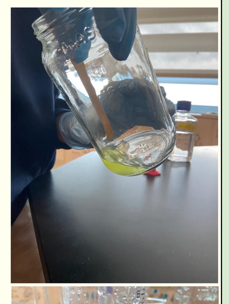


Mixing of the algae solution.

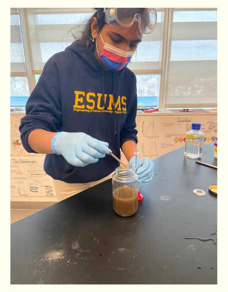
Adding the algae solution to the test tube.



Pouring the algae solution into the turbidity tube.

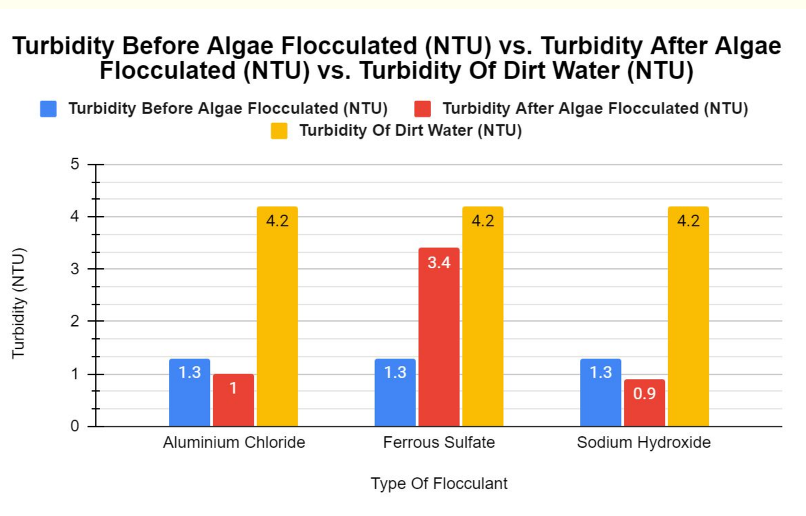


Mixing the solution after adding the chemical to it.

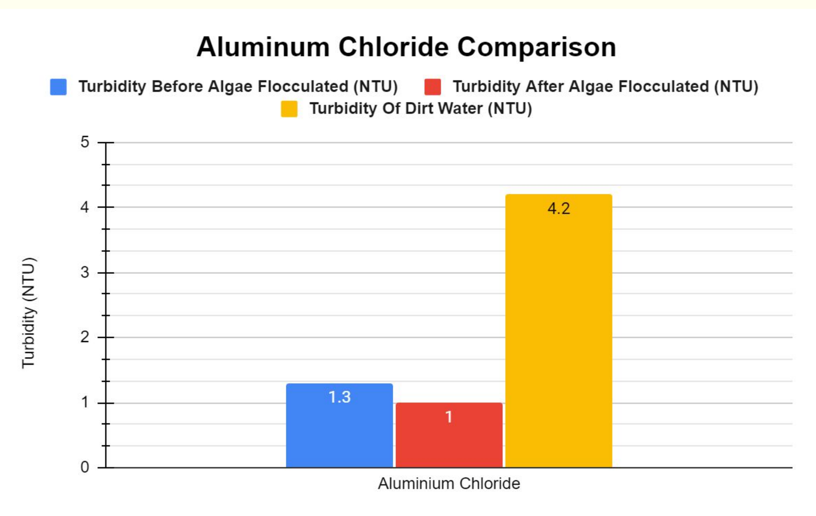


Testing the turbidity of dirt water.

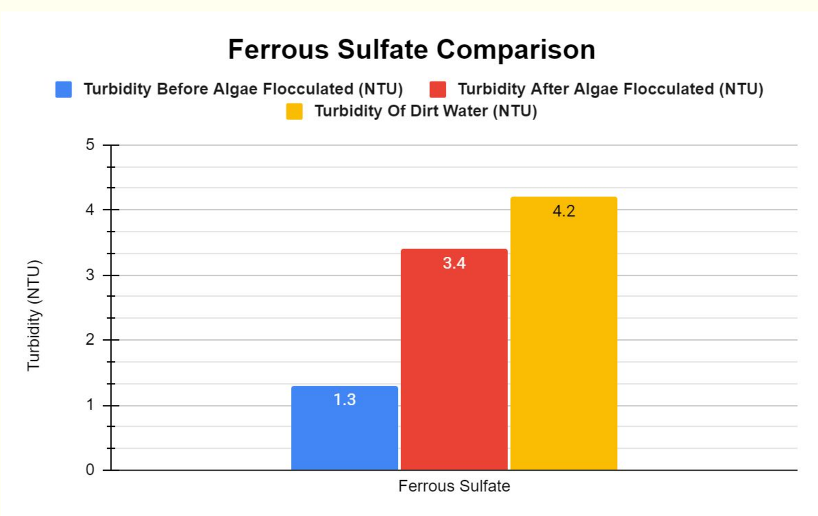
Data & Results



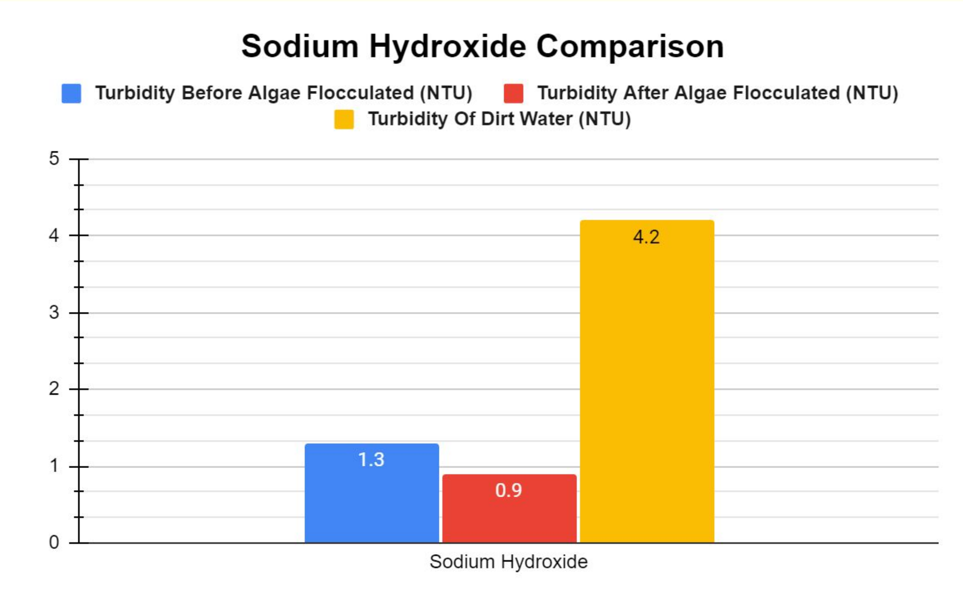
All the chemicals compared to each other show that sodium hydroxide was the most effective. This can be proven further because it is the farthest from reaching the turbidity of the dirt water.



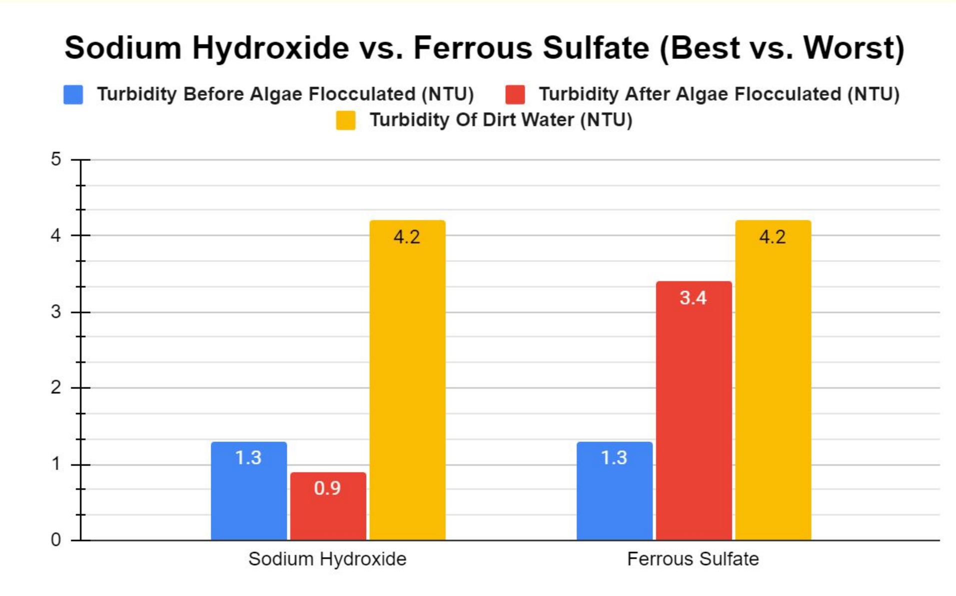
This aluminum chloride comparison shows that it was the second most effective when it came to flocculating the algae. It reduced the turbidity of the algae solution by **0.3** NTU and is the second farthest from reaching the turbidity of the dirt water.



This ferrous sulfate comparison shows that it was the least effective when it came to flocculating the algae. It increased the turbidity by **2.1** NTU and is the closest from reaching the turbidity of the dirt water.



This sodium hydroxide comparison shows that it was the most effective when it came to flocculating the algae. It reduced the turbidity of the algae solution by **0.4** NTU, which is **0.1** more NTU than aluminum chloride when it reduced the turbidity of the algae solution. Compared to the dirt water, it is the farthest from reaching its turbidity.



This ferrous sulfate and sodium hydroxide comparison shows how much more effective sodium hydroxide was in flocculating the algae solution. Comparing both chemicals to the dirt water shows that ferrous sulfate is the closest to reaching the turbidity of the dirt water while the sodium hydroxide is far from it.

Conclusion

Based on this experiment, we can conclude that flocculants can efficiently mitigate algal blooms in water. From our experiment, **2 out of the 3** chemicals we used showed promising results and sufficiently mitigated the algae. The one that didn't work as well as we expected was ferrous sulfate, which is surprising because ferrous sulfate is one of the most used chemicals used for water treatment. We can't say that the water didn't change because it did clump together after the chemical was added, but we did have a higher turbidity level of **3.4** NTU after adding **50** mL of water to the turbidity tube, which indicated that the water wasn't purified because the turbidity of the original algae solution was **1.3** NTU which tells us that the water was not purified, but only deteriorated. Ferrous sulfate was a solid, so the water solution was **8** mL, but we used **5** mL of that water solution. The rest of the chemicals used were liquids, so we used **5** mL for each. Although aluminum chloride is a widely used water treatment chemical, we were shocked to find that sodium hydroxide performed better. Based through our tests, The turbidity of aluminium chloride was **1** NTU, while the turbidity of sodium hydroxide was **0.9** NTU. Based on these findings, we can conclude that sodium hydroxide outperformed aluminium chloride and would be a preferable alternative for algal bloom mitigation. To summarize, aluminium chloride outperformed ferrous sulfate and sodium hydroxide outperformed all three substances. Our results fall within a **2.5** NTU range. The difference between the highest turbidity created by ferrous sulfate and the lowest turbidity caused by sodium hydroxide is seen here.

Discussion / Applications

For our experiment, all procedures were followed to receive the best results possible, but there were downsides, or better ways to run this experiment and better prove its validity. To start, running multiple tests on the turbidity of the algae solution would have resulted in better and more thorough results to compare to. Growing algae was quite difficult for us seeing as how we could only grow in small quantities of **40** mL. This small amount of accessible algae made it hard for us to run multiple tests because the **40** mL was just enough for us to run **1** test for each flocculant and **1** test for the algae solution itself. More thorough testing could have benefited because it would have gave us a confirmation that the results that we get were not just from luck.

To add on, we could have further improved our validity by getting an electronic turbidity meter. The naked eye cannot tell the exact number of turbidity, which means that the results we got were estimates based on the scale on the side of the turbidity tube. An electronic turbidity meter could have told us the exact turbidity without any human error. Having the exact turbidity of the algae solution before and after the flocculation would have resulted in more accurate comparisons between the different flocculated algae solution and also between the dirt water. One more improvement that could have have improved the experiment is by having a better lighting setup. We used a desk lamp that worked perfectly fine, but lacked emitting an even spread of light all over the algae. The algae did grow in the end, but the growing could have been faster if the lighting setup were better.

These results and findings can be used to remove harmful algal blooms from bigger bodies of water. Harmful algal blooms not only affect us humans, but animals as well. These results and findings could be scaled up and help stop the effects of harmful algal blooms on our society.