Topic: How do *Arthrospira platensis* and *Chlorella vulgaris* differ in their carbon dioxide absorption efficiency under controlled photic, thermal, and nutrient conditions?

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2025-2026 Logbook

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Abstract- January 18

The purpose of this experiment was to investigate whether Chlorella vulgaris or Arthrospira platensis absorbs more carbon dioxide dissolved in water when grown under the same environmental conditions. Carbon dioxide absorbed by these two algaes was measured indirectly by monitoring changes in water pH, as higher carbon dioxide levels in water lowers the pH levels of water by forming carbonic acid. In my last science fair project, I investigated how the acidification of oceans due to increased amounts of carbon dioxide is damaging the shells of shelled marine life. I chose this topic because I wanted to find a way to decrease the acidification of oceans, so that marine life could survive in a healthy way.

For the procedure, I took three jars and labelled them A, B and control group. Then I added 800mL of distilled water in each jar and carbonated it by generating carbon dioxide by mixing baking soda and vinegar in a separate bottle and bubbling it through the 800mL distilled water in each jar for a minute. Initial pH of this carbonated water in each jar was noted by using a pH meter. Then, 20mL of Chlorella vulgaris was added to jar A, 20mL of Arthrospira platensis was added to jar B and nothing was added to the control group jar. An equal amount of nutrients (20ml of MiracleGro fertilizer) was added to jar A and jar B.The jars were kept under LED lights

for 7 days and after 7 days pH of all three jars was measured using pH meter.

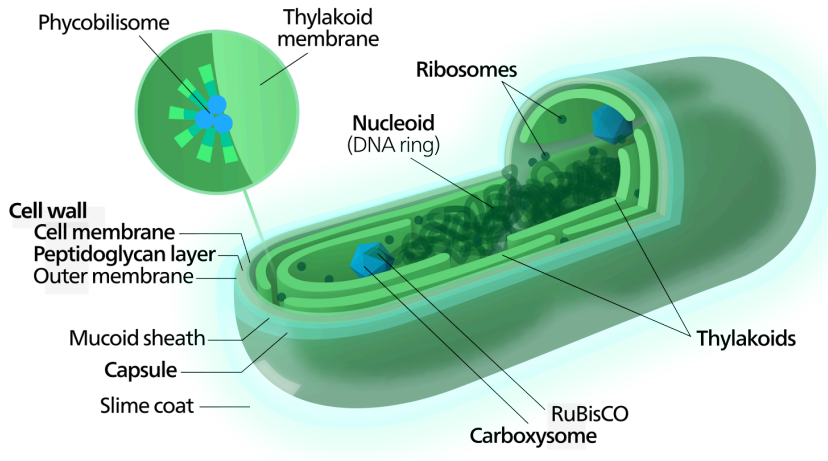
The final results showed that Chlorella vulgaris consistently increased the pH than Arthrospira platensis in all three trials, indicating higher carbon dioxide absorption by it,which supported my hypothesis. This research suggests that Chlorella vulgaris may be a more effective option for reducing carbon dioxide in aquatic environments.

Background Research- October 29, November 10, 11, 20

Arthrospira Platensis

Common Name: Spirulina

Arthrospira Platensis is a filamentous micro-algae that transforms nitrogen into a more usable form. This algae has helical shaped filaments that can help us distinguish this algae from other algae. However, this only exists in culture mediums and liquid environments. Because of this property and the gas filled vacuoles in its cells, this algae is able to float in mats. This algae is a **prokaryote Gram-negative** bacterium that has a cell wall composed of multiple layers. It mainly consists of **peptidoglycan** and **lipopolysaccharide** natures. This algae has many **inclusions**, such as polyphosphate, polyglycan, and cyanophycin granules. This algae thrives in **alkaline** conditions, but it grows best in salt waters with a high pH of 8.5-11, especially when, at tropical elevations, there are high levels of solar radiation. When this algae goes through the process of photosynthesis, the main thing it creates is glycogen, which is a **branched polysaccharide** that consists of multiple linked glucose units and serves as the main energy storage molecule in bacteria, animals, and fungi.



Biochemical composition

- 55-70% protein
- 15-25% polysaccharide
- 6-13% nucleic acids
- 5-6% lipid
- 2.2-4.8% minerals

This algae contains multiple minerals, vitamins, insulin-like proteins and photosynthetic pigments.

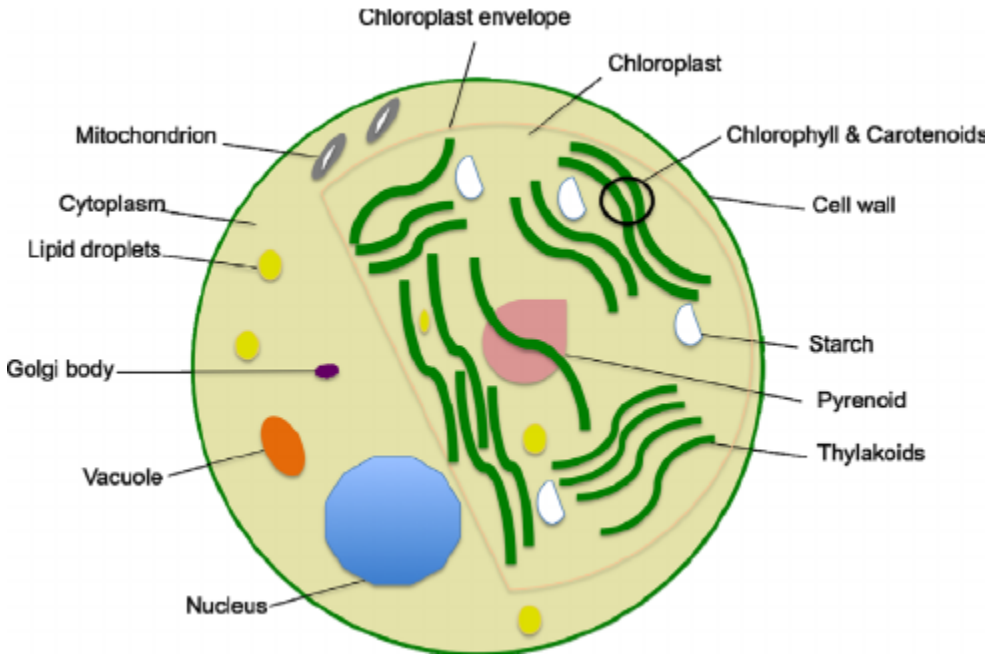
Daily Carbon Dioxide Absorption: According to an article on PubMed, Arthrospira platensis absorbs 0.876-1.051 grams of carbon dioxide per litre per day in preferred conditions.

Health Benefits: Spirulina has many health benefits. For example, it is rich in many nutrients, can reduce swelling or irritation, may protect the body from damage, lower cholesterol and triglyceride levels, reduce blood pressure, and improve muscle endurance and strength.

Chlorella Vulgaris

Common name: Chlorella

This algae is a single cell algae that belongs to the chlorophyta family. This algae is a green microalga that contains large amounts of minerals, vitamins, polysaccharides, protein, dietary fibre, and pigments. Chlorella vulgaris is cultivated in fresh water that has an enzyme-digestible cell wall. It reproduces asexually, through a process called auto sporulation. Auto sporulation is when the parent cell divides into multiple daughter cells internally. This algae is a **spherical unicellular eukaryotic** green algae whose main characteristic is a thick cell wall. This algae is one of the most used microorganisms for waste treatment because its cell wall provides chemical and physical protection and heavy metal resistance. Carbonic anhydrase, one of Chlorella vulgaris's enzymes, is responsible for the algae's uptake of carbon. This causes the formation of HCO_3^-(bicarbonate ion/hydrogen carbonate) and a proton.



Daily Carbon Dioxide Absorption: Chlorella vulgaris (as stated in an article in the website MDPI), in certain conditions, absorbs on average 0.144 L (144 mL) of carbon dioxide per day for 1 L of algae.

Health Benefits: Chlorella vulgaris is very nutritious, helps the body detoxify, can improve our immune system, acts as an antioxidant, and promotes eye health.

Chlorella Vulgaris's Chlorophyll vs Arthrospira Platensis's Chlorophyll

As stated in an article in the website Scholarly Community Encyclopedia, Chlorella vulgaris has 1.16–24.0 mg/g of the pigment chlorophyll. Arthrospira platensis has 3.01-17 mg/g of the pigment chlorophyll. This means that Chlorella vulgaris can have more chlorophyll than Arthrospira platensis, which may allow it to absorb more carbon dioxide.

pH

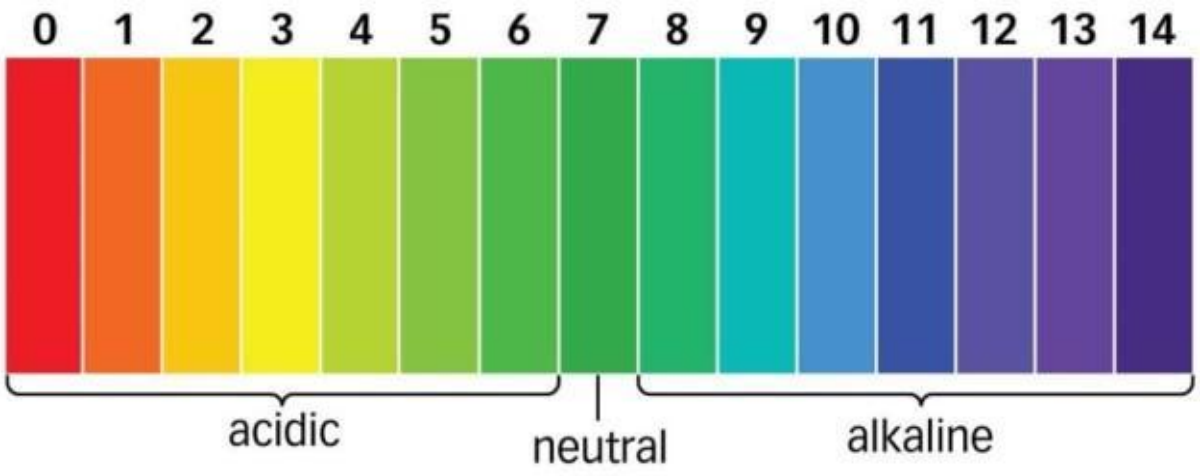
pH is the measurement of a liquid's acidity or basicity. A pH scale is a tool for measuring acids and bases.It has numbers ranging from 0-14. A pH of 7 is considered neutral. Anything below the pH of 7 (6.9 or less) is considered acidic and anything above the pH of 7 (7.1 or more) is considered alkaline (basic).

The more carbon dioxide there is in water, the more acidic the water is. This also means that if there is less carbon dioxide in the water, the water will be more basic.

When carbon dioxide combines with water, it makes carbonic acid. The carbonic acid decreases the pH of water by increasing the amount of hydrogen ions and thus the water becomes acidic.

Arthrospira platensis favour high pH levels of 9-10 for their growth.

Chlorella vulgaris favour a pH of 7.5-8 for their growth.



Climate Change

What is it?

Long term changes in average weather patterns in Earth's global, regional, and local climates is known as climate change.

What causes it?

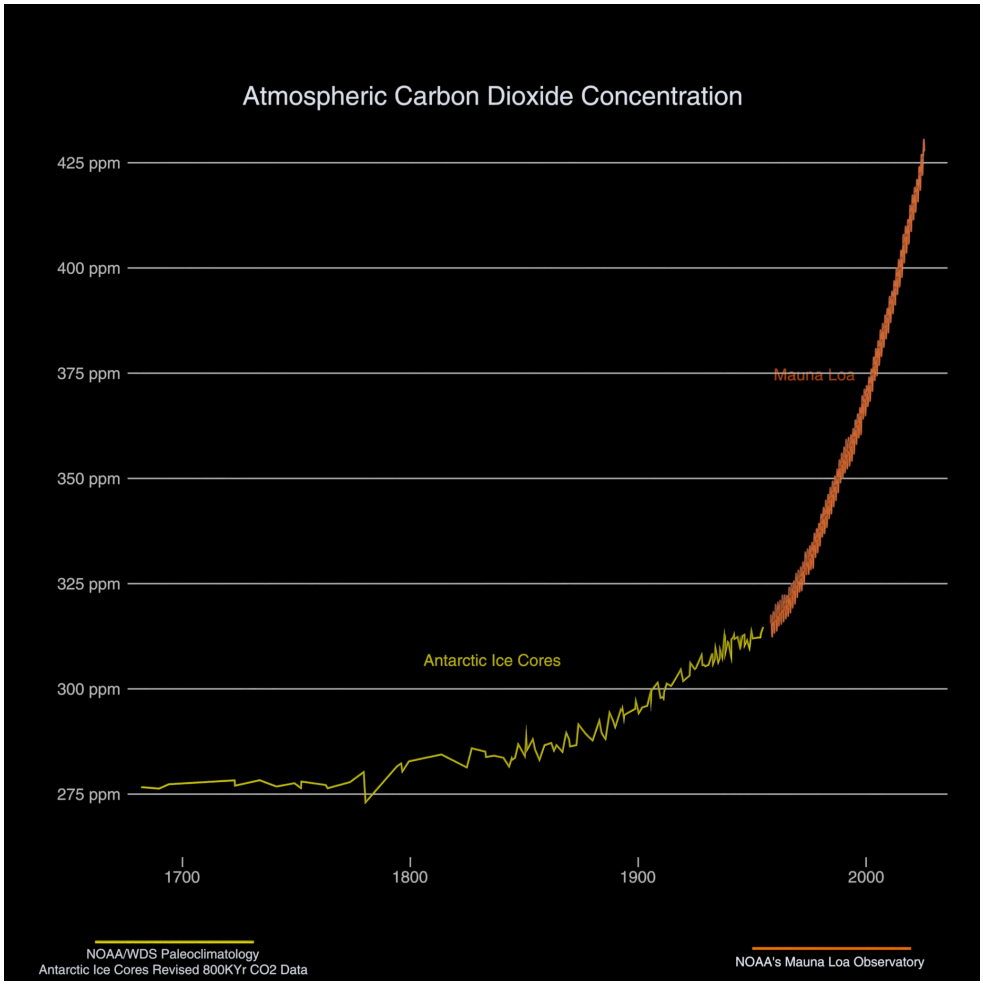
Climate change can be natural because of large volcanic eruptions or alterations in the sun's activity. However, since the 1800s the drastic use of fossil fuels like coal, oil, and gas has been the main cause behind climate change. When the fossil fuels are burned, they produce greenhouse gases which trap the heat coming from the sun, thus raising the temperatures of the Earth. Carbon dioxide and methane are the major greenhouse gases. Fossil fuels are mainly used by humans for transportation, heating the buildings, and energy production. The amount of carbon dioxide in the air also increases when land is cleared by cutting forests for agriculture or other purposes, such as mining. Methane gas is produced by agriculture, oil, and gas operations. Climate change can cause intense drought, water scarcity, severe fires, rising sea levels, flooding, catastrophic storms, and declining biodiversity by killing many natural ecosystems.

Why is it different from global warming?

The terms climate change and global warming are not the same. Climate change refers to a broad range of things happening to Earth's climate, such as rising sea levels and melting glaciers. Global warming is an aspect of climate change because it only refers to the long-term warming of Earth's surface.

Increase of Carbon Dioxide in the Atmosphere

It has been recorded by satellites and ground-based measurements that there has been a sharp increase in the amount of carbon dioxide in our atmosphere over the past few decades. Specifically, after the industrial revolution in the 18th century, there has been more than a 50% increase of carbon dioxide in the atmosphere.



(NASA Website)

Climate Change and the pH of Water Bodies

Due to increased amount of carbon dioxide in the atmosphere from human activities such as burning of fossil fuels, large amounts of carbon dioxide are getting dissolved into Earth's oceans and other water bodies.When carbon dioxide dissolves in water, it reacts with the water to form carbonic acid. Carbonic acid dissociates in water to form hydrogen ions and thus lowers the pH of water and makes it more acidic. As per the report published in Smithsonian National Museum of Natural History, surface water of oceans have become 30% more acidic over the past 200 years due to industrial revolution.

Increased Acidity of Water Bodies and the Impact on Marine Life

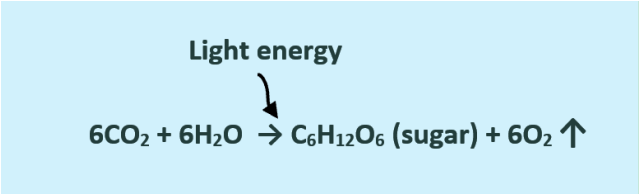
When the water in oceans and other water bodies becomes more acidic, it makes it hard for some marine organisms to thrive and survive. These organisms include shell-building animals such as corals, oyster, clams, sea urchins, and some kind of plankton who depend on carbonate ions to form calcium carbonate shells and skeletons. When the carbon dioxide mixes with water , it forms carbonic acid and this carbonic acid dissociates to form hydrogen ions, which decrease the pH of water. Additionally, these hydrogen ions combine with carbonate ions present in the water to form bicarbonate ions. The carbonate ions are required by the shell building animals to build their shells which are composed of calcium carbonate. The combination of hydrogen ions with carbonate ions reduces the availability of carbonate ions for the shelled marine animals.

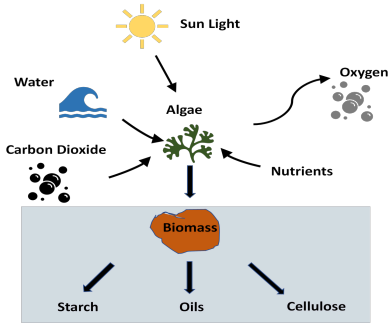
In fact, the United States Environmental Protection Agency has published that increased acidity not only slows down the growth of calcium carbonate structures like shells, but in severe cases, can dissolve structures faster than they are formed. Acidification of oceans also stresses other marine life and they need more energy to grow and maintain healthy body chemistry.

These alterations in water chemistry can disrupt the entire ecosystems, which can in turn impact food webs negatively and reduce biodiversity. The amount of increasing carbon dioxide can be decreased by natural methods like algae photosynthesis.

How Can Algae Be Used to Fight Against Climate Change?

Algae can reduce the amount of carbon dioxide in the air through photosynthesis. Photosynthesis is the process in which plants and some **protists** go through to make their own food. In this process, a plant or protist absorbs carbon dioxide and water, and by using the energy from light and the chlorophyll in it, produces glucose and oxygen, The scientific formula for this process is:





As shown in the above image, algae make their food in the form of biomass by using carbon dioxide, water, and nutrients in the presence of sunlight. So algae can be used to reduce the amount of carbon dioxide from the atmosphere like trees do on land and convert them into useful carbohydrates. Additionally, algae can grow 10 times more rapidly than the **terrestrial** plants

and it can also be grown on non-productive land as well as in the water. The algae photosynthesis also synthesizes useful byproducts such as renewable biofuels, aquaculture feed products, fertilizers, and other “green” products.

Previous Research

One of the studies carried out by Moreira D., Pires, and C.M.J. have shown that microalgae can be effectively used to mitigate carbon dioxide from the atmosphere through photosynthesis. In this process, biofuel is produced as a bioproduct which can be used in many ways. In another research by Silva et al. (2024) has shown that coralline algal beds can be effectively used in removing carbonate ions from the oceans thereby decreasing the acidity of oceans.

Testable Question- October 25

How do *Arthrospira platensis* and *Chlorella vulgaris* differ in their carbon dioxide absorption efficiency under controlled photic, thermal, and nutrient conditions?

Hypothesis- November 11

If *Arthrospira platensis* and *Chlorella vulgaris* are exposed to the same temperature, light, and nutrient conditions, I believe Chlorella vulgaris will absorb more carbon dioxide than Arthrospira platensis because this algae has more chlorophyll than Arthrospira platensis, which causes it to perform more photosynthesis leading to more growth of algae.

Variables- November 11

Independent Variable- The algae present in the container

Dependant- pH of water

Controlled- Amount of baking soda, vinegar, nutrients, water, and the type of algae sample

Uncontrolled- Temperature, light that shines on the cultures when the LED light is off

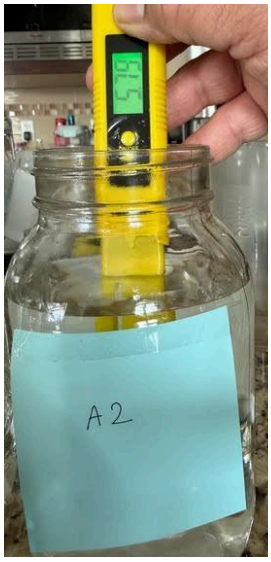
Materials (For Each trail)- November 19

1. 6.6L distilled non-chlorinated water
2. 35g Baking soda
3. 420mL vinegar
4. 60mL of Chlorella vulgaris culture
5. 60mL of Arthrospira platensis culture
6. Measuring cylinder
7. Graduated cylinder
8. Seven 1L glass containers
9. Kitchen Weighing scale
10. A spoon
11. A notebook and pencil
12. 38 NPK (Miracle-Gro 20-20-20) fertilizer
13. Root farm LED grow lights 45W
14. 7 paper straws
15. 1 empty plastic bottle with lid
16. Knife
17. Thermometer
18. Stop watch
19. pH meter

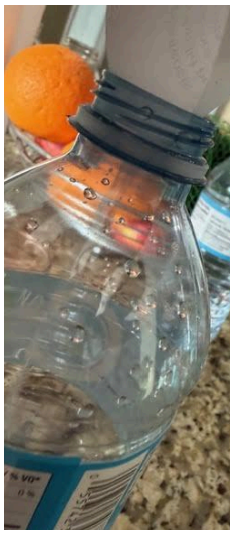
Procedure- January 11th, 2026

1. Take three 1L glass containers and wash them thoroughly to get rid of any impurities and avoid contamination.
2. Dry the containers and label them as jar A, jar B and control group.
3. Measure 800mL of non-chlorinated distilled water at room temperature(20 degrees celsius) and pour it in jar A.
4. Again measure 800mL of non-chlorinated distilled water at room temperature(20 degrees celsius) and pour it in jar B.
5. Again measure 800mL of non-chlorinated distilled water at room temperature(20 degrees celsius) and pour it in a jar labelled control group.
6. Measure the temperature and pH of water in all three jars (jar A, jar B & control group jar). Note it down in your logbook.
7. Take an empty 500mL plastic bottle, clean it, dry it, and make a hole in its lid by using a knife.
8. Measure 5g of baking soda with a weighing scale and pour it in an empty dry plastic bottle.
9. Now take a paper straw and place it in a hole made by a knife in the lid of a plastic bottle.
10. Measure 60mL of vinegar with a measuring cylinder and pour it over the baking soda in a plastic bottle.
11. Immediately close the lid of the plastic bottle to prevent the escape of carbon dioxide produced during this reaction and bubble the carbon dioxide through the water in the control group jar for 1 minute by immersing the end of plastic straw in water.
12. Measure the pH of water by using a pH meter.
13. Repeat steps 7-11 for bubbling carbon dioxide in jar A and jar B.
14. Note the pH of all three jars (A,B & control) in your logbook.
15. Measure 20mL of chlorella vulgaris culture with a graduated measuring cylinder and pour it in jar A.
16. Add 20mL of NPK(Miracle Grow) fertilizer, prepared by dissolving 36g of solid fertilizer in 1 L of distilled water, in jar A.
17. Immediately close the lid to prevent any escape of gases.
18. Measure 20mL of Arthrospira platensis culture with a graduated measuring cylinder and pour it in jar B.
19. Add 20mL of NPK(Miracle Grow) fertilizer, prepared by dissolving 36g of solid fertilizer in 1 L of distilled water, in jar B.
20. Immediately close the lid to prevent any escape of gases.
21. Set up all three jars(A, B & control group) under artificial LED grow lights for 7 days.
22. After 7 days, remove the jars from under the artificial lights and measure the pH of each jar by using the ph meter.
23. Note the final reading of pH in your logbook.
24. Repeat steps 1-23 for the remaining two trials.

Procedure Pictures




B1




CONTROL
GROUP


A1 (CV)


A2


A3


B1
(SP)


B2


B3


HEALTHALGAE
Living Spirulina Culture
(Spirulina platensis)
250 ml


ALGAE
CHLORELLA VULGARIS


CONTROL
GROUP
B2
A2


B1
(SP)
A1 (CV)


A2


A3


B2

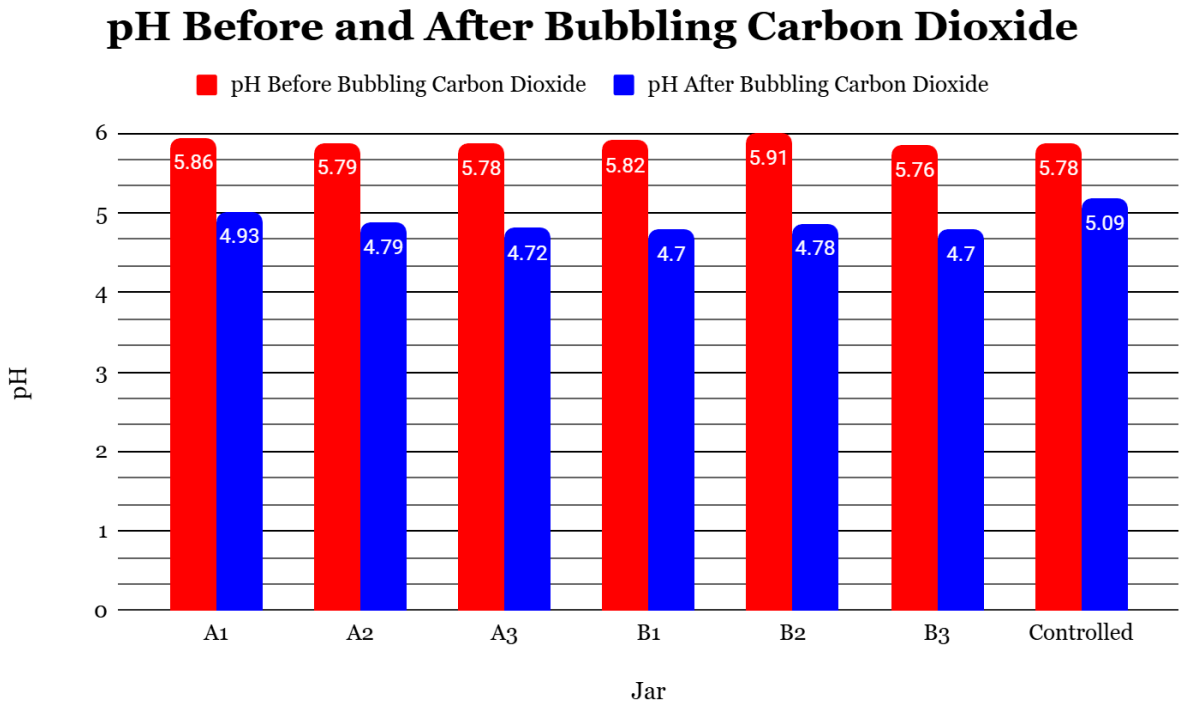

CONTROL
GROUP

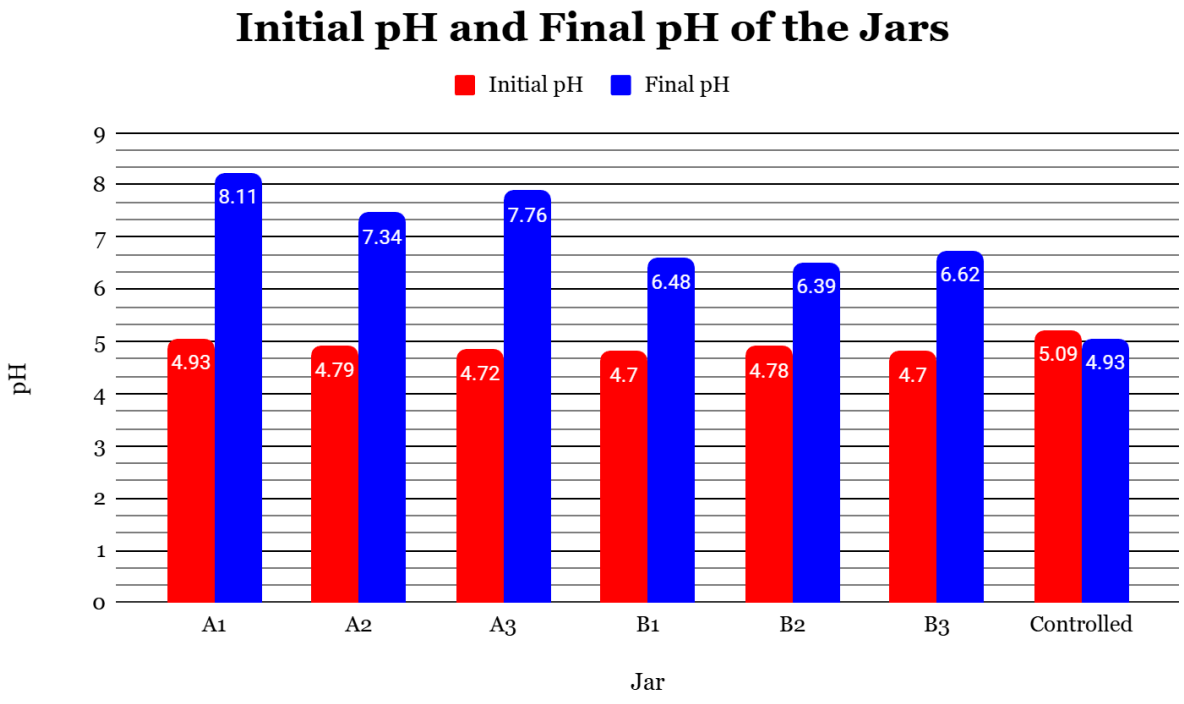
Data

Jar	pH Before Bubbling Carbon Dioxide	pH After Bubbling Carbon Dioxide
A1	5.86	4.93
A2	5.79	4.79
A3	5.78	4.72
B1	5.82	4.70
B2	5.91	4.78
B3	5.76	4.70
Controlled	5.78	5.09

Jar	Initial pH	Final pH
A1	4.93	8.11
A2	4.79	7.34
A3	4.72	7.76
B1	4.70	6.48
B2	4.78	6.39
B3	4.70	6.62
Controlled	5.09	4.93

Observations– Graphs





Results- Jan 14

Quantitative Analysis

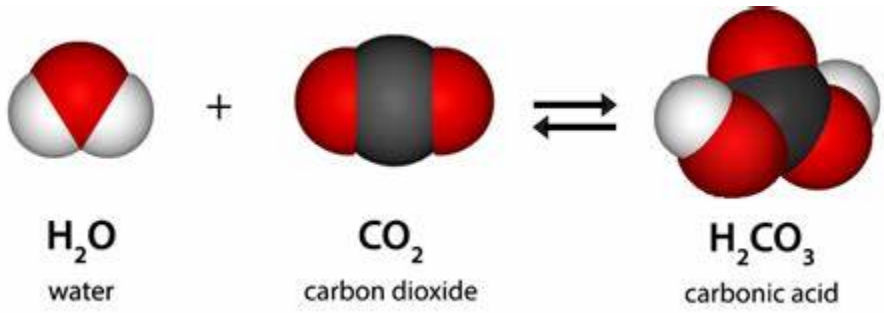
Chlorella vulgaris absorbed more carbon dioxide than *Arthrospira platensis* in all three trials. In trial 1, the pH of the water the *Chlorella vulgaris* was grown on increased by 3.18 and the pH of the water *Arthrospira platensis* was grown in increased by 1.78. In the second trial, the pH of the water *Chlorella vulgaris* was grown in increased by 2.37 while the pH of the water *Arthrospira platensis* was grown in increased by 1.61. In trial 3, the pH of the water the *Chlorella vulgaris* was grown in increased by 3.04 and the pH of the water *Arthrospira platensis* was grown in increased by 1.92. The average pH increased by Chlorella vulgaris in three trials was 2.86 and the average pH increased by Arthrospira platensis was 1.77. However, the pH of water in the control group decreased by 0.16.

Qualitative Analysis

In all the three jars, after 7 days lots of evaporation was seen on the walls and lids of jars. The water in jar A looked much greener than in jar B at the bottom of the jar in all three trials. When the jars were opened after 7 days, I could tell some sort of gas escaped from the sound I heard while opening the jar. In jar B , a very funny smell was coming out of the sample of Arthrospira platensis while adding it to the jar during the start of the experiment.

Conclusion- Jan 14

The objective of this experiment was to determine whether *Chlorella vulgaris* or *Arthrospira platensis* absorbs more carbon dioxide. To test it, I first filled 7 glass jars with 800mL of water. I checked the pH of the water using a pH meter. Then I bubbled carbon dioxide in the water of each jar by mixing 60mL of vinegar with 5g of baking soda in an empty plastic water bottle and transferring the carbon dioxide through a paper straw into the water in jar for one minute.After that, I measured the pH of water in each jar again.When carbon dioxide is bubbled through water, it combines with water to form carbonic acid, thus increasing its acidity and decreasing the pH of water.



I then poured 20mL of Chlorella vulgaris in jar A and 20mL of Spirulina in jar B. I also added 20ml of NPK (Miracle Grow) fertilizer in jar A and jar B to promote algae growth. Then I left the jars undisturbed under the LED lights for 7 days. After 7 days, I measured the final pH of each of the jars.

In all three trials, the jar with *Chlorella vulgaris* in it had the greater increase in pH which occurred due to more absorption of carbon dioxide by it. It proved my hypothesis that when *Chlorella vulgaris* and *Arthrospira platensis* are grown under similar conditions, *Chlorella vulgaris* absorbs more carbon dioxide than *Arthrospira plantenis,* was correct. This happened because *Chlorella vulgaris* has more chlorophyll than *Arthrospira platensis*, which enabled it to perform photosynthesis at a faster rate. In photosynthesis algae produces its own food by using carbon dioxide, water, and nutrients in the presence of sunlight.Cholorophyll, a green pigment in algae, helps to absorb sunlight for photosynthesis. As *Chlorella vulgaris* has more chlorophyll than *Arthrospira platensis*,it means *Chlorella vulgaris* absorbed more carbon dioxide than Arthrospira plantenis and thus performed more photosynthesis. It has resulted in more consumption of carbon dioxide in water in which *Chlorella vulgaris* has grown, in comparison to water in which *Arthrospira platensis* has grown.

Sources of Error

There are many sources of error in my experiment which could have altered or impacted my final results. These are as following:

1. Unequal light exposure: During my experiment the amount of light received by each jar from LED lights could be different which could have affected the rate of photosynthesis and the rate of absorption of carbon dioxide.
2. Different algae concentration: Another factor which could have impacted my results of my experiment is the starting concentration of Chlorella vulgaris and Arthrospirsa platensis. If one type of algae has more algae cells, it could have absorbed more carbon dioxide.
3. Temperature Fluctuations:The rate of photosynthesis depends on temperature. If there was a difference in temperature in different jars due to uneven distribution of heat, it could have affected the enzyme activity and thus carbon dioxide absorption rates.
4. Errors in measurement of pH by pH meter: Sometimes the accurate measurement of pH could have been impacted in my experiment due to inaccurate calibration of pH meter.
5. Sometimes the carbon dioxide could have escaped while opening the jars for measurements of pH and this could have altered the results.
6. I could have done more trials for longer periods of time for more accurate results.

Application

- ➔ My experiment helps us to find out an effective method to remove carbon dioxide from water. The amount of carbon dioxide present in water is increasing day by day due to burning of fossil fuels and pollution. It has resulted in acidification of oceans, due to which shells of mussels, corals and many other aquatic species have been dissolving. It puts the existence of these species in danger as shells of these creatures play an important role in their survival as they provide them protection, shelter and mobility. Chlorella vulgaris can be cultivated to use this excessive carbon dioxide and maintain the healthy pH of water, enabling marine life to survive and grow in a healthy environment.

- ➔ Also, Chlorella vulgaris and Arthrospira platensis are very high in nutrition and can be used as an excellent food source for human consumption.
- ➔ In conclusion, my experiment suggests a sustainable way to reduce the acidity of water bodies on Earth, which is happening due to climate change and also provide a possible food solution for human consumption.

Next Experiments

For my next experiment, I would like to test which type of water (tap, saltwater, or distilled) is the best for algae to grow in. I would also like to test how the pH level of the water affects the growth of the algae.

Glossary

Prokaryote- Single cell organisms

Gram-negative- A bacteria group that has specific, complex cell structures

Peptidoglycan- Surrounds bacteria and is made of amino acids and sugar. Its job is to give the cell structure strength.

Lipopolysaccharide- Found in Gram-negative bacteria and is the outermost layer in the bacteria's double-membrane system. It is made of fat and sugar and its job is to make it harder for chemicals to enter the cell.

Inclusions- Storage bodies that are not living

Alkaline- A base that can dissolve in water

Polysaccharide- The form of natural carbohydrates that occurs the most naturally

Branched polysaccharide- A large, complex sugar molecule

Spherical unicellular eukaryotic- A round single cell that is complex

Protists- Single cell organisms that do not fit into the animal, fungi, and plant kingdoms

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