Photosynthesis Face-Off: Comparing Carbon Dioxide Removal in Algae and Land Plants

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How feasible is it to grow and use algae to reduce carbon dioxide levels in cities?

This research topic focuses mainly on analyzing the impact of algae on the reduction of carbon dioxide levels in the air. The results of this research could provide useful knowledge on how to potentially use algae as an alternative to plants to lower the high CO2 levels in cities.

Introduction

Carbon Dioxide (CO2) is the most abundant greenhouse gas by concentration in our atmosphere, responsible for around 60% of anthropogenic (human-caused) heat retention and global warming (Freedman,2021). Greenhouse gases allow light to pass through and hit the Earth's surface but also traps the heat that results from the light, ultimately furthering global warming and climate change. These issues could cause a myriad of other problems that would be threats to the environment and humans, including exacerbated weather disasters (such as hurricanes) and rising sea levels (Kost,2023). Most of the world's CO2 is generated from cities, with much of it coming from combustion of fossil fuels. In fact, only 25 megacities produce 52% of the world's CO2 (Wei,2021). Thus, targeting cities with solutions meant to eliminate CO2 could be a successful way to lower the overall CO2 concentration in the global atmosphere.

One way to achieve this lies in organisms that perform photosynthesis, primarily plants (including algae). Through this process, plants absorb water, sunlight, and CO2 and turn them into glucose, which is vital for their energy and growth. As a byproduct, they also produce oxygen, which is essential for many organisms. One method that's been implemented is planting trees and other terrestrial plants within cities to reduce CO2 through absorption, with over 80 cities across Europe, Asia, North America in the United Nations Economic Commission for Europe (UNECE) pledging to plant 13 million trees (UNECE,2021). However, some concerns do arise over the way that terrestrial plants grow. Trees, bushes, and other plants may extend their roots over large areas, making it so they're less portable. In addition, trees and bushes take multiple years to fully grow and require the extra usage of space to plot soil for them to use.

However, their exists an alternative in using algae in cities rather than terrestrial plants. The algae can be held within a container, making it more portable and adaptable for use. Additionally, it's been proven that algae is more effective at removing CO2 than terrestrial plants (Gabris,2023).

One way to test this at our school and to gain a better understanding of CO2 within IA is through using the Magnitude.io ExoLab, a device originally used to grow plants in space. It has LED growth lights and reads humidity, light, and most importantly, CO2. Using this device, which a teacher had readily available, could allow for a comparison between algae and terrestrial plants.

Acknowledgements

- Steve Jones
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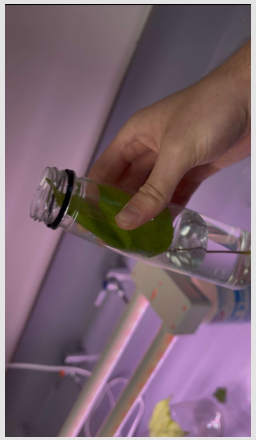
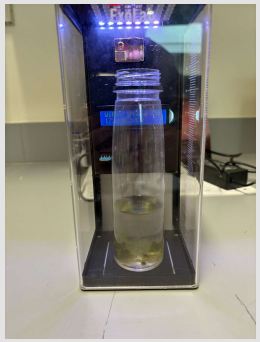
Citations:

- Freedman, B., Lerner, K. L., & Duncan, L. (2021). Global Warming. In K. H. Nemeh & J. L. Longe (Eds.), (6th ed., Vol. 3, pp. 2023-2026).Gale. https://link.gale.com/apps/doc/CX8124401134/SCIC?u=inn_aca&sid=bookmark-SCIC&xid=bbe9b449
- Kost, G. J., Füzéry, A. K., Carataq, L. K. R., Tinsay, S., Zadran, A., & Ybañez, A. P. (2023). Using geographic rescue time contours, point-of-care strategies, and spatial care paths to prepare island communities for global warming, rising oceans, and weather disasters. , (1), 1–22. https://doi.org/10.1186/s12942-023-00359-y
- Wei, T., Wu, J., & Chen, S. (2021). Keeping Track of Greenhouse Gas Emission Reduction Progress and Targets in 167 Cities Worldwide. , . https://doi.org/10.3389/frsc.2021.696381
- Gabris, J.M. (2023). . Law.lclark.edu. https://law.lclark.edu/live/blogs/253-liquid-trees-carbon-capture-and-sequestration-via
- . (2021). Unece.org. https://w3.unece.org/sdg2024/story-11.html

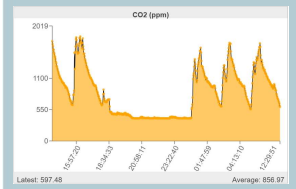
Methodology

1. Set up and configured the Magnitude.io ExoLab, connect it to a phone hotspot, and created and experiment for this on the classroom.magnitude.io website with teacher assistance
    1. Configured the LED grow lights to be on from roughly 11 a.m. to 2 a.m. for 15 hours
    2. Configured the grow lights to be blue, which is a good wavelength to spur photosynthesis in plants
2. Sampled and tested the algae
    1. Collected 1 gram of wet algae (likely of the Rhizoclonium genus) from a teacher's aquarium tank
    2. Placed algae in 100 mL of tap water in a beaker
    3. Transfered contents to a thin bottle
    4. Placed bottle in ExoLab and placed the covers over the ExoLab after letting new air (new CO2) into it, at 4:10 p.m.
    5. Left the bottle in overnight and during the next school day until 4:10 p.m.
    6. Removed the bottle, then began the same process for one other trial
3. Sampled and tested the plant leaf
    1. Plucked a single 1-gram leaf from a plant (likely Liquidambar styraciflua, or sweetgum tree), including the stem
    2. Transferred 100 mL of water from a beaker to the same bottle used for the algae
    3. Placed leaf stem-down into the bottle
    4. Placed bottle in ExoLab and placed the covers over the ExoLab after letting new air (new CO2) into it, at 4:10 p.m.
    5. Left the bottle in overnight and during the next school day until 4:10 p.m.
    6. Removed the bottle, then began the same process for one other trial
4. Obtained dry mass of algae
    1. Collected 1 gram of wet algae
    2. Placed sample in glass beaker
    3. Placed beaker underneath a light, then let the algae dry until all or nearly all moisture was gone
    4. Weighed dry algae on a scale
5. Obtained dry mass of leaf
    1. Collected 1 gram leaf
    2. Placed leaf underneath a light, then let it dry until all or nearly all moisture was gone
    3. Weighed dry leaf on a scale





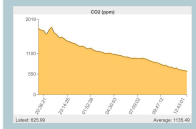
Results



Overall CO2 levels April 16, 4:18 p.m. – April 24, 8:30 a.m.

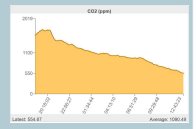
Note: the spikes around and sightly before the 18:34:33 time-mark represent the CO2 levels of Flex Friday, when only a fraction of the normal students come in.

Algae Test Trial 1 (April 17-April 18)
(Approx. 4:00 p.m. – 9:00 a.m.)



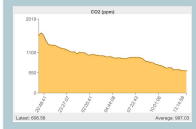
Highest Value: 1801.15 ppm
Lowest Value: 625.98 ppm

Algae Test Trial 2 (April 22-April 23)
(Approx. 4:00 p.m. – 9:00 a.m.



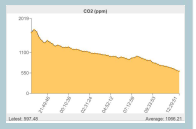
Highest Value: 1721.76 ppm
Lowest Value: 554.67 ppm

Leaf Test Trial 1 (April 21-April 22)
(Approx. 4:00 p.m. – 9:00 a.m.)



Highest Value: 1635.86 ppm
Lowest Value: 606.57 ppm

Leaf Test Trial 2 (April 23-April 24)
(Approx. 4:00 p.m. – 9:00 a.m.)



Highest Value: 1714.21 ppm
Lowest Value: 597.48 ppm

Dry mass of algae: roughly 0.1g

Dry mass of leaf: roughly 0.3g

Average CO2 reduction with algae: 1171.13 ppm

Average CO2 reduction with leaf: 1073.01 ppm

CO2 elimination per gram of dry algae biomass included: 11,711.3 ppm/ dry gram

CO2 elimination per gram of dry leaf biomass included: 3,576.7 ppm/ dry gram

Conclusion/Additional Inquiries

Ultimately, these results support that per dry gram of biomass, algae is stronger than leaves and terrestrial plants at removing CO2 from the air (PPM). Thus, it may be reasonable to invest in algae growth projects within cities to remove CO2 more efficiently and within a shorter timeframe than terrestrial plants due to the rapid growth of algae in the presence of sunlight (or artificial light equivalent), nutrients, and CO2. This research also raises additional information about the sustainability of schools and of IA in particular. This research supports that the presence of students and staff raise the amount of CO2 in the school's air significantly – with human presence, the CO2 (ppm) is around 3 times higher than without people here. However, perhaps more significantly, this research supports that Flex Fridays at IA make the school building significantly more sustainable compared to other school buildings without the Flex Friday system. The maximum amount of CO2 during the day on Flex Friday was around only half of the CO2 present during a regular school day.