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How do some algae make the Earth warmer?

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Abstract

If you have ever visited a lake, a pond, or even the ocean, then you know about algae – both the big ones that wash up on the beach, and the much smaller microalgae. Responsible for the green you see on the water, these tiny organisms are food for small fish. They also photosynthesize. That means they take carbon dioxide out of the atmosphere like plants. And we all know how important that is because of global warming!

Interestingly, some algae also produce nitrous oxide – another greenhouse gas. We wanted to find out which type of algae produces it and how they create it. We tested different types of algae in both light and dark environments, which made us realize that only green algae make nitrous oxide. We also found that they have different ways of doing it based on the amount of light available. Finally, we linked nitrous oxide production by algae to fertilizers. That means there may be a way to reduce the amount of nitrous oxide produced by algae in the future.

Introduction

When you hear the term "**greenhouse gas**," the first gas that comes to mind is probably carbon dioxide (CO_2). While this heat-trapping gas is the main culprit of global warming, there are other greenhouse gases. These gases exist at much lower levels than carbon dioxide, but they are often more able to trap outgoing heat energy from the Earth. Nitrous oxide (N_2O) is one of these stronger greenhouse gases, and scientists are trying to figure out how to reduce its impact on the global climate.

To do so, we must first understand what produces it. For some time, scientists noticed a correlation between algae and nitrous oxide, but they didn't understand how they produced this gas. In this study, we wanted to figure out the link between algae and nitrous oxide. How do algae produce it? Does light affect this process? And is there a way that we can reduce its production?

An algal bloom on a pond's surface.
Photo: EPA

Methods

Experiment 1:

We placed algae into an environment without oxygen. Next, we added nitric oxide, which is a substance that algae convert to nitrous oxide. Then, we used a special type of **mass spectrometer** to measure the amount of nitrous oxide that formed over time. We ran the experiment in the dark and in light to see how things changed. Then we ran the experiment again in an environment with oxygen. Instead of nitric oxide, we added a common fertilizer. Using the fertilizer better simulates what happens naturally.

Experiment 2:

We conducted the same experiment with nine species of algae. These species included green algae, red algae, and **diatoms**. What was different about these algae species besides their color is the type of enzymes they have. An **enzyme** is a substance in an organism that helps a reaction occur. It turns out that there are two types of enzymes that help algae transform nitric oxide into nitrous oxide. Let's call them enzyme F and enzyme C. Two of the green algae species we tested had both types of enzymes. Two other green algae species only had enzyme F. The red algae and diatoms did not have either enzyme. We ran the experiment in both the light and dark and compared the results to Experiment 1.

Results

Experiment 1:

The experiment showed that algae produced nitrous oxide in both the dark and the light. But the rate of this production is faster in the light (Figure 1). Similar results occurred when we used a common fertilizer. The algae transformed the fertilizer into nitric oxide. Then the algae transformed it to nitrous oxide in both the light and dark.

Experiment 2:

We found that all the green algae species produced nitrous oxide. But only the two species that had both enzyme F and enzyme C produced nitrous oxide in both the light and dark. The other two green algae species (that had just enzyme F) only produced nitrous oxide in the light. The red algae and diatoms did not produce nitrous oxide.

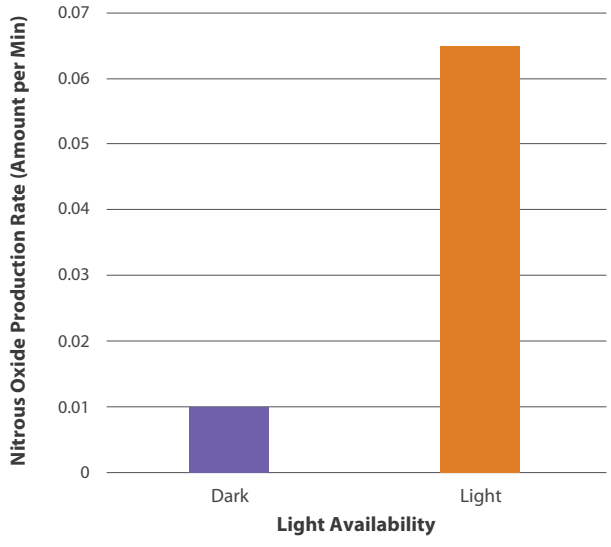

Figure 1:
The rate of nitrous oxide production in algae in a dark and light environment.

In which light availability does algae produce the nitrous oxide at the fastest rate?

Discussion

Our data showed that there are two ways algae make nitrous oxide. Algae used enzyme F in the light but enzyme C in the dark. We know this because the green algae with only enzyme F didn't make nitrous oxide in the dark. But the green algae with both enzymes could make nitrous oxide in both the light and dark. We also learned that algae produced nitrous oxide faster in light than in darkness. That means photosynthesis helps this process.

Our results also proved that only green algae produced nitrous oxide. Since the red algae and diatoms don't have enzymes F and C, we know that algae need them to produce nitrous oxide.

Our experiment using fertilizer showed how human activity can cause algae to produce nitrous oxide. After it rains, **runoff** carries fertilizer from farms and lawns to coastal waters and lakes. Just like in our experiment, the algae in coastal waters will transform it to nitric oxide. Because nitric oxide is toxic, the algae change it to nitrous oxide, which is less harmful. Unfortunately, this gas is harmful in a different way – as a strong greenhouse gas.

Conclusion

Global warming is a real concern. Increasing temperatures are already impacting both our climate and our oceans. We must lower the production of greenhouse gases. Now we know that one solution is to decrease the amount of fertilizer runoff into lakes and the ocean.

You can help reduce the amount of fertilizer runoff from your garden!

- Plant a garden with local plants because they need less fertilizer.
- Apply fertilizer at the right time of year and in the right amount for your plants.
- Avoid applying fertilizer right before storms. This prevents it from washing into the closest body of water (where algae can transform it into nitrous oxide).

Glossary of Key Terms

Diatoms - species of algae that use silica (SiO_2) for their cell walls.

Enzyme - special types of proteins that plant and animal cells make. They help control how quickly chemical reactions happen.

Greenhouse gas - a gas in the atmosphere that traps outgoing heat energy from the Earth. By preventing this energy from radiating into space, the Earth is warmed. The greenhouse gases act like a blanket. When you wrap yourself in a blanket, you warm up because it prevents your heat energy from escaping.

Mass spectrometer - a device used to identify the presence of chemical compounds. A mass spectrometer makes the compounds into an ion by removing electrons. Then they are moved through a magnetic field which exerts a force on them, causing them to move in a more circular path. The path they take depends on their mass. The mass spectrometer uses their path to identify what compound they are. Think about it like this: if you shoot water at a tennis ball flying by, then at a bowling ball, they'll end up in different places because they have different masses.

Runoff - liquid that drains or flows off, as rainwater flows off fields and into nearby streams and rivers.

Check your understanding

1. How do some algae increase the amount of greenhouse gases in the atmosphere?

2. How did we figure out that photosynthesis helps algae transform nitric oxide into nitrous oxide?

3. Why do only green algae produce nitrous oxide?

4. Enzymes play an important role in the production of nitrous oxide. Can you think of other processes that utilize enzymes?

5. The article suggests ways for people with gardens to reduce the impact of fertilizer. However, fertilizer runoff also comes from farms. Research one of the following solutions that farms can use to reduce fertilizer runoff. Describe how this solution works. Then explain if you would recommend it to farmers.

   - Nutrient management
   - Year-round ground cover
   - Field Buffers
   - Wetland protection
   - No-till agriculture

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