Thawing Permafrost in the Arctic: The carbon cycle in water ecosystems and implications for climate change

Adapted from Thawing Permafrost Lessons and Lab Manual, courtesy of Bruce Taterka

Background

When permafrost thaws it releases previously frozen organic matter to participate in the earth's carbon cycle. While some organics may be consumed in place by microorganisms and converted to CO_2 or CH_4, other organics may dissolve into water and become dissolved organic matter ("DOM"). Given that permafrost contains approximately 1.6 billion tons of carbon that could potentially mobilize as DOM as the earth warms, it is important to understand the fate of DOM. After thawing, DOM likely flows in groundwater or surface water, from where it may be consumed by microorganisms, deposited in lake sediments, or carried out to the ocean.

This lab provides an opportunity for students to measure production of CO_2 from surface waters and consider the role of surface waters in the global carbon cycle and climate change. Students will compare rates of production in different types of surface water and identify the physical characteristics that affect production rates.

Materials

- CO_2 sensors
- Floating plastic containers with cutout for CO_2 sensor. This can be made from a pretzel barrel cut in half, or other plastic container. (See photos).
- Natural streams, ponds or pools with varying amounts of DOM.
- Copies of Data Sheets

Procedure

Field Work:

1. Select sampling locations with a variety of "color." Ideally, samples should be collected from a variety of locations including clear flowing streams, stagnant wetlands, slow-moving waters, surface waters in flat areas, hilly areas, sunny locations and shaded locations.
2. Use DI water in a sink or a tub for a control.
3. Each group will select a question to explore with this setup. Some questions might include: "What effect does temperature have on the production of CO_2?", "What effect does turbidity have on the production of CO_2?", or "What effect does proximity to living plants have on the production of CO_2?"
4. At each sample location, have students fill out the Sample Data Sheet. Students should record observations on the physical setting of the location. Photographs should be encouraged.
5. At each location, connect the CO_2 sensor to the floating CO_2 chamber and place it on the surface of the water. Record ppm CO_2 every minute for at least 10 minutes.

Data Analysis

1. Graph CO_2 production curve for each location (see sample, below)
2. (Extension) Calculate delta ppm CO_2 per minute for each location and/or calculate percent change in ppm CO_2 for each location.
3. Have the groups develop a Claim, based on their Evidence, and explain that claim using scientific Reasoning. Questions to explore as they are working on this analysis:
    - Describe any relationship you observed between the physical setting of the sample location and the CO_2 production curve.
    - What is the reason for the relationship you observed?
    - How does this experiment relate to the carbon cycle and climate change?

4. Groups will share their findings with the class. This could be through a poster-sharing session, in-class presentations, or through a class blog.