The Impact of Freeze-Thaw Cycles on CO_2 Emissions and Subsequent Algae Growth

Adeline Niemier

Q1: Research Questions

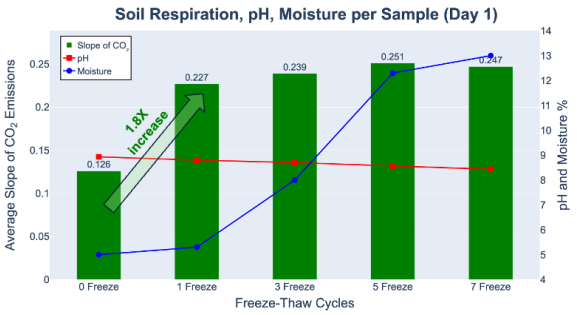
- **One of the biggest unknowns in climate change is the impact of thawing permafrost on the planet**
- Permafrost is soil/rock/organic matter that remains frozen for at least two consecutive years ■ some areas frozen for 1000s of years ■ covers 15% of land area in Northern Hemisphere
- Permafrost contains dead plant & animal matter which is rich with carbon
- Temperatures in the Arctic are warming 2-4 times faster than the global average, causing permafrost to thaw
- To understand how this thawing could impact ecosystems and climate change, a *two-phase project* investigated how freeze-thaw cycles (FTCs):
  - (1) affect soil respiration, CO_2 emissions, moisture levels and pH levels
  - (2) the amount/timing of algae growth

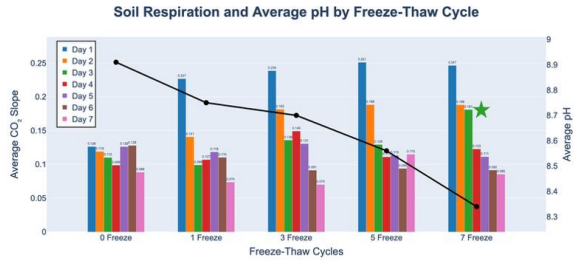
Q2: Project Design

- **Phase 1:** Filled 15, 250 mL bottles with 130 grams of soil from local park
  - Soil samples were exposed to 0,1,3,5,7 freeze–thaw cycles
  - Each day for 7 days: (1) Used sensor to measure CO2 from each bottle over 300 second intervals (2) inserted soil probe to test soil pH and moisture
- **Phase 2:** Create supernatant by mixing 1 cup of soil with 1 L of distilled water; shook for 5 minutes; let settle overnight; decanted water 2 times with coffee filters
  - Supernatant was exposed to 0,1,3,5,7 freeze–thaw cycles
- Filled 50 mL test tubes with 5 mL algae culture, 20 mL nutrient media, and 25 mL of freeze-thaw treated supernatant; 3 tubes per test condition
- Tested absorption at optical density of 750 nm on spectrophotometer over 18 days

Q3: Data Analysis & Results

- **FTCs lead to significantly higher CO_2 emissions due to greater nutrients and increased moisture**
  - Microbes lyses and soil aggregates break apart releasing nutrients for the remaining microbes to consume which increases soil respiration and CO_2 emissions; the first FTC has the greatest impact; diminishing returns for additional FTCs
- **FTCs result in less & slower algae growth**
  - FTCs lead to microbial death, reducing the size of the microbial community available to respire nutrients that drive algae growth





Q4: Interpretation & Conclusions

- **There is a positive correlation between freeze-thaw cycles and soil respiration/CO_2 emissions but not algae growth**
  - FTCs (1) increase nutrients & moisture in the soil driving higher CO_2 emissions and (2) decrease microbial biomass to release nutrients that drive algae growth
- **As permafrost thaws, the Arctic could change from a beneficial carbon sink to a contributor of global warming due to higher CO_2 emissions and less CO_2 absorption due to delayed and reduced algae growth**
- **Future work should:**
  - Investigate different methods of creating the supernatant to determine what best replicates real-world nutrient runoff
    - Freeze soil before adding water, or use peat moss instead of soil
  - Test the impact of different freeze-thaw lengths (ex. 12 hours vs. 24 hours vs. 48 hours)