Soil Matters Too!

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ETP Type: Create a new lesson Subject/Grade: Biology / 9

Abstract

This lesson will introduce students to the basics of decomposition and microbial soil respiration and how these processes influence the carbon cycle. The lesson begins with students using animations and short videos, answering group discussion questions, and a worksheet with stop-and-think questions. They will then design and carry out a laboratory experiment on how soil respiration rates might be influenced by one of the following climate-related variables - temperature, soil moisture, soil nutrients, soil fertility, and soil type using a simple soil respiration chamber and lime-water. In the second part of the lab activity, students learn the basics about permafrost soil and what might happen as this permanently frozen soil begins to thaw due to a warming atmosphere. They will consider possible carbon cycle feedback loops to a warming atmosphere if the permafrost continues to thaw.

Focal Standard(s)

LS 2-5 **Develop a model to illustrate the role of** photosynthesis and **cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.** [Clarification Statement: Examples of models could include simulations and mathematical models.] [Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.]

Additional Standards:
ESS 3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment Boundary : Assessment is limited to one example of a climate change and its associated impacts.]

Science and Engineering Practices:
SEP2 Developing and using models
SEP3 Planning and carrying out investigations
SEP4 Analyzing and interpreting data
SEP8 Obtaining, evaluating, and communicating information

Measurable Objective(s)

After completing this investigation, students will be able to:

- Describe how carbon is stored in soil
- Describe the role of soil respiration in transferring carbon from the soil to the atmosphere

- Describe the possible impact of a warming climate on permafrost

Formative Assessment(s)

Students will answer stop and think questions and lab analysis questions. Student responses will be assessed for accuracy and thoroughness of their explanations. https://docs.google.com/document/d/1Lu2EJXdBilMCTBqV2ImfydKZqHQE787k3y33mS4_Ipc/edit?usp=sharing

Summative Assessment

Students will take the Climate Change/Human Impact Unit Test at the end of the unit. The test will consist of multiple choice, matching, True/False questions as well as a short answer section made up of level 3 type (higher-order thinking) questions. Student responses will be assessed for accuracy. https://docs.google.com/document/d/1kGmLeQ39fQD3V8SN09g_t2Ffug4W07ibTG6AVxDeABY/edit?usp=sharing

21st Century Skills and Applications

Critical Thinking and Problem Solving- I plan to have my students perform a similar experiment to the one I did at Stanford. They will analyze soil samples and collect qualitative data. My students will answer discussion questions in the beginning of the lesson, then set up and design an experiment in order to collect accurate qualitative data from soil samples, answer pre-Lab questions, and analyze the data in lab analysis questions. I plan on sharing with them my lab project I did at Stanford and how I analyzed soil samples to understand the role of microbial respiration in the cycling of carbon.

Communication and Collaboration- My students will communicate and collaborate on designing the soil experiment and work together to set up the lab equipment and materials, perform the lab, communicate with discussion questions and in collecting qualitative data results. Initiative and Self-Direction- Students will need to design their experiment in groups, set up the lab stations at each table, collect data accurately, break down and clean up the lab project.

Students will reflect on the 21st Century Skills they develop from this unit by looking back on their first whole class inquiry lab from the beginning of the school year and note their improvements and areas that they still need to work on. This will be completed orally as a whole class discussion on review day.

Fellowship Description

This summer I worked in Dr. Scott Fendorf's Soil Biochemistry lab with graduate student, Hannah Naughton on her project with soils from East River Floodplain near Crested Butte, CO. In collaboration with a team from several institutions, we received field samples and data throughout the summer from the East River site. Soil carbon quality was assessed through soil incubations coupled with Gas Chromatography and carbon quantity will be determined with an Elemental Analyzer for carbon and nitrogen. Porewater and soil water extracts were analyzed for dissolved organic and inorganic carbon and nitrogen using a Total Organic Carbon analyzer. The project is a combination of wet lab work, instrumental analysis, and data analysis. Ultimately, the project aims to develop a model for soil carbon cycling that uses carbon functional designation and oxidation state plus soil mineralogy to predict energy available for microbial respiration.

During my teacher fellowship I focused on 3 specific techniques:

1. Soil incubations followed by gas chromatography measurements to assess the potential for different soils and carbon types to produce greenhouse gases (CO_2, N_2O, CH_4).
2. Analyze solid soil carbon, nitrogen, texture, and pH to understand soil environment relevant to microorganisms
3. Ferrozine Assay and pH testing to determine the concentration of iron in the different soils.

In addition to performing the above techniques, I gained many specific lab skills for working in a soil biogeochemistry lab. Some of these skills include: working with soils and acids in the anoxic glove box, making Ferrihydrite mineral, using a large and small centrifuge, labelling and preparing lab equipment and materials properly for several soil testing techniques. These preparation steps have included: making acid baths, sterilization techniques such as, using the autoclave, making anoxic water, vacuum techniques, and all the steps of cleaning glass vials and rubber stoppers. I have also learned how to extract pore water and flood water samples, how to take gas samples, how to load a gas chromatography machine, how to properly dispose of acid waste (using syphon technique), using amberlite in filters, calibrating a pH meter, and measuring pH of pore water and floodwater samples.

We worked together to test the hypothesis that anaerobic conditions in soils, largely an outcome of flooding conditions, result in low-energy regimes that inhibit microbial respiration and thus cycling of soil carbon into the atmosphere. The East River Floodplain near Crested Butte, CO lets us constrain inputs of carbon (from plants and upriver) and outputs (downriver, back into soil, and as gas), allowing us to reconstruct the soil processes responsible for mobilizing it.

Some careers that the skills obtained in my experience can apply to are: a vast range of science lab technician occupancies and assistants, lab management, soil and water quality specialist, county agriculture agent, and soil conservationist.

Fellowship Connection to School/Classroom

During this summer research project, I gained an understanding of soil chemistry and microbiology concepts as well as routine lab protocols. I am planning to take the content knowledge and lab experience from this fellowship to help improve the planning and implementation of lessons and labs for my Climate Change and Human Impact Unit. In addition, this experience is enabling me to incorporate the subtopics of soil chemistry, microbial respiration, and permafrost into my school's climate change curriculum which is followed by all of our on-level biology (Living Earth) classes at Leigh High School. I created a 3-4 day long lesson on the carbon cycle focusing on the soil (geosphere reservoir), microbial respiration within the soil and permafrost within a 3 week long unit. I used the soil sampling techniques and knowledge I've gained from my fellowship experience to develop an on-level soil biology lab not only for my classes but for all the biology classes at Leigh. I am also planning on having one or several of the graduate students I worked with this summer (Hannah, Alandra or Randall) to come be a guest speaker at my school and speak in front of all of our Biology classes (and perhaps other sciences classes) in the gym about the research work they do at Stanford.

Instructional Plan

Soil Matters Too! 3 Days (95 min. blocks)
This lesson consists of an introductory/informational day, a lab experiment day, and lab results/information/activity day.
NOTE: This lesson was created from a modified version of a published lesson from EarthLabs. The original lesson can be found here:
https://serc.carleton.edu/earthlabs/carbon/soil_carbon_cyc.html
Student lab activity link: https://serc.carleton.edu/eslabs/carbon/lab5.html
In addition, I have provided a document that summarizes the modifications made
https://docs.google.com/document/d/1A68sPWT4zCx1o84czMm2aMOUlbE-D7WyBfS7VCacbD8/edit?usp=sharing

Day 1
Opening:
Students will get HW stamped (vocabulary definitions) at the beginning of class while they answer warm up questions (5 minutes).
Vocabulary HW:
https://docs.google.com/document/d/1rmfKPgnLyf7Xp6lW9zkO6suFZ4rECxEDSEkVUjtSu98/edit?usp=sharing
Warm up:
https://docs.google.com/document/d/1q-YagRIKwHkOARKvr07Kj42AqcVI6UAeC7P0I_12oaA/edit?usp=sharing

Introduction and Background
Students will then get chromebooks and open the Google Doc called the Student Activity Sheet: Soil Matters Too
(https://docs.google.com/document/d/1SPYgnyRFZwJi2eNyYy_dcdDOWNoxsplILGC3xUrizFM/edit?usp=sharing)

Guided Practice:
Students will read the introduction and background sections in class individually and then watch the video clips all included in their EdPuzzle accounts. We will *check for comprehension* by reviewing answers to the questions on each video clip in Edpuzzle as well as some discussion questions as we go at STOP signs (80 minutes).
Model:
Students will learn about the Carbon Cycle and Nitrogen Cycle Models in diagrams and videos.
Independent Practice:
Students will then be given their Lab Activity Sheet and start reviewing it and answering the stop and think questions section for HW (10 minutes).
(https://docs.google.com/document/d/1Lu2EJXdBilMCTBqV2ImfydKZqHQE787k3y33mS4_Ipc/edit?usp=sharing)

Day 2
Students will get HW stamped on stop and think questions on Student Lab Sheet.
Students will be asked if they have any questions about the HW questions, on the lab procedures, etc. Instruction will be given on where materials can be found and how to set up equipment and proper clean up procedures for today (5 min.).

Guided Practice:
Students will design their experiment by filling out all bubbles (sections) on their lab sheet. They will select from a list of independent variables on the board. They will also decide at what temperatures they will test (2 of 3 choices: ambient, 60W lamp or heat lamp). They will then answer the pre-lab questions at their tables. Next, they will follow the investigation directions and set up their experiment samples, set up their lab stations and clean up (90 min.). When finished, if they have time they can start the next section on the Google Doc on Soil cowboys. Will we check for lab results at the beginning of the next class (block schedule).

Day 3
Students will begin class by immediately gathering lab results in their lab groups. They will fill out the results section on their lab sheet. Next, once all results have been recorded students will clean up their lab stations and then continue to part 3 (15 min.). They will answer the Post-Lab questions for HW.
Guided Practice:
Students will get chromebooks and continue the lesson (Part B). Students will continue to read and learn about the connections between soil microbes, soil respiration and climate change. They will deepen their understanding by continuing to watch video clips on soil solutions and permafrost on EdPuzzle and answer questions. We will *check for comprehension* by reviewing answers to the questions on each video clip in Edpuzzle as well as some discussion questions as we go at STOP signs (50 minutes).
Model and Independent Practice::
Students will learn about the layers of permafrost by examining a diagram of permafrost soil layers and answering discussion questions in lab groups (20-25 min.). If time, students will then be given the rest of class time to work on their Lab Activity Sheet (answering Post-Lab analysis questions).

NOTES:
*Students will reflect on the 21st Century Skills they developed from this unit as a whole class discussion on review day.
*Test Questions will be added to Unit Summative Assessment and implemented at end of the end after a review day.

Links to attachments:
Vocabulary HW (completed before Day 1)
https://docs.google.com/document/d/1rmfKPgnLyf7Xp6lW9zkO6suFZ4rECxEDSEkVUjtSu98/edit?usp=sharing
Warm Up Questions (completed Day 1)
https://docs.google.com/document/d/1q-YagRIKwHkOARKvr07Kj42AqcVI6UAeC7P0I_12oaA/edit?usp=sharing
Student Activity:Soil Matters Too! Google Doc (informational document to follow all 3 days)
https://docs.google.com/document/d/1SPYgnyRFZwJi2eNyYy_dcdDOWNoxsplILGC3xUrizFM/edit?usp=sharing
Student Lab Sheet (for lab on Day 2 and to be turned in for points/formative assessment)
https://docs.google.com/document/d/1Lu2EJXdBilMCTBqV2ImfydKZqHQE787k3y33mS4_Ipc/edit?usp=sharing

Test Questions (to be added to Unit Summative Assessment)
https://docs.google.com/document/d/1kGmLeQ39fQD3V8SN09g_t2Ffug4W07ibTG6AVxDeABY/edit?usp=sharing
Original EarthLab Lesson vs Modified ETP Lesson Comparison
https://docs.google.com/document/d/1A68sPWT4zCx1o84czMm2aMOUlbE-D7WyBfS7VCacbD8/edit?usp=sharing

Supply List

60W lamps
Heat lamps
Ring stands and clamps
Mycorrhiza fungi (1 bag for 5 classes)
Duct tape
scissors
Soil
Sugar
Deionized water
Lime Water (calcium hydroxide), 500 mL
Glass apparatus tubing (5mm) - hollow
Amber rubber tubing - 3/16th inch Rubber Tubing, Amber, 1/8" Bore, 1/32" Wall, 10 ft Soil test kits
LaMotte® N-P-K Soil Test Kit
LaMotte® Soil pH TesTab Kit
Soil Moisture and Light Meter, Sav-A-Plant II
Teacher lab Demo of sterilized soil set up (control)

Student Activity: Soil Matters Too! (Google Doc)
Student Lab Sheet

Bibliography

Dunlap, Candace. "Lab 5: Soil and the Carbon Cycle." *Using Media to Enhance Teaching and Learning*, EarthLabs Project, 28 Apr. 2017, serc.carleton.edu/earthlabs/carbon/soil_carbon_cyc.html.

Keywords

Soil lab, microbial respiration, greenhouse gases lab, permafrost, climate change

Links to Files in this ETP

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Student Lab Sheet (for lab on Day 2 and to be turned in for Points/formative assessment)
https://docs.google.com/document/d/1Lu2EJXdBilMCTBqV2ImfydKZqHQE787k3y33mS4_Ipc/edit?usp=sharing
Test Questions (to be added to Unit Summative Assessment)
https://docs.google.com/document/d/1kGmLeQ39fQD3V8SN09g_t2Ffug4W07ibTG6AVxDeABY/edit?usp=sharing
Original EarthLab Lesson vs Modified ETP Lesson Comparison
https://docs.google.com/document/d/1A68sPWT4zCx1o84czMm2aMOUlbE-D7WyBfS7VCacbD8/edit?usp=sharing