Soil Science in Your Backyard- a Lesson plan for High School Students

Summary: A two day seminar will be hosted by the instructor. The first day will be an introductory lecture describing the background of soil science and the second day will be a hands-on activity where students will analyze the texture and chemistry of soil samples from home and compare that data to the texture and chemistry of a degraded soil sample from an agricultural area.

Before you present this seminar:

- Make sure to purchase the necessary materials for soil texture and chemical testing
- Find a source to acquire agricultural depleted soil samples
- Do some research for colleges in your area and reach out to a grad student or a college student studying Environmental Biology for the Day 2 slide 15 "Talk with an Expert" class discussion.
- Check out the recipe for the "dirt" pudding dessert in the materials section of these lecture notes and consider giving them to your class after the presentation!
- Optional: purchase native flower seeds for your region and hand out at the end of day 2

Learning Goals

Objectives:

- Students learn a basic background of soil and why it is important to the global ecosystem
- Students will engage in a hands-on activity and learn about chemical and textural differences in soil samples with differing compositions.
- Students will show their understanding by filling out a worksheet focused on soil texture and chemical makeup

Vocabulary Terms:

- **Arable-** used or suitable for growing crops.
- **Ecotoxicity-** potential for biological, chemical or physical stressors to affect ecosystems.
- **Steaming soil-** a farming technique that sterilizes soil with steam in open fields or greenhouses. Pests of plant cultures such as weeds, bacteria, fungi and viruses are killed through induced hot steam which causes vital cellular proteins to unfold.
- **Antimicrobial resistance-** the development by a disease-causing microbe, through mutation or gene transfer, of the ability to survive exposure to an antimicrobial agent that was previously an effective treatment.
- **Erosion-** the process of eroding or being eroded by wind, water, or other natural agents.
- **Soil compaction-** the process in which stress applied to a soil causes densification as air is displaced from the pores between the soil grains.
- **Nutrient cycling-** the cyclic movement and exchange of inorganic and organic matter back into the production of matter.
- **Inoculants-** agricultural amendments that use beneficial rhizosphericic or endophytic microbes to promote plant health.

- **Urbanization-** the process of making an area more urban.
- **Climate change-** a change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels.
- **Deforestation-** the removal of a forest or stand of trees from land that is then converted to non-forest use.

Context for Use

This is an introductory presentation and activity for high school biology/ environmental students.

Subject: Environmental Science, Soils and Agriculture
Resource Type: Lab Activity
Grade Level: High School (9-12)

Description and Teaching Materials

Introduction:

The guiding questions for this activity are "Why does soil health matter?" and "How does the health of a soil impact its diversity, soil texture, and chemical makeup?"

Materials:

- Student soil samples (ask students to bring about ¼ cup of soil in a plastic bag)
- A sample of degraded/depleted soil (from a nearby farm or agricultural area). Depending on if the students work alone or are put into groups, the provided sample of degraded/depleted soil should come out to about ¼ of a cup for 1 group or 1 student.
- A plastic tablecloth or tarp to cover up student desk/table for soil samples
- Enough nitrile gloves for the instructor and each student (link to buy nitrile gloves in bulk: https://tinyurl.com/5n74vz38)
- Plastic cups to hold water for the soil texture experiment(https://tinyurl.com/3hyamc3r)
- Transfer pipettes for water (https://tinyurl.com/3z7a4w4y)
- Soil testing kits- a few different options, based on budget buying these in bulk may be pricey. (https://tinyurl.com/3u5t2jdv) (https://tinyurl.com/yckmcb4y) (https://tinyurl.com/4e9b9m46)
- Ingredients for dirt cups- optional, but fun! (recipe: https://tinyurl.com/2jtb5ced)
- Flower seeds- also optional- this link brings you to seeds that are native to the Northeast US. (https://tinyurl.com/2p9han2n)

Methods:

Day 1:

- Give Lecture (powerpoint slides 1-12) reading off of the provided lecture notes to guide you. Take questions from the students after the midday break/lunch and also after you finish the provided material for Day 1.

Day 2:

- Give Lecture (powerpoint slides 13-20) reading off of the provided lecture notes to guide you. Take questions after the break and after you finish the last section on soil microbes.

Suggested Lecture Notes

Day 1: Morning

Slide 1 Hello class, I'm [Instructor name] and welcome to a 2 day seminar where we'll be learning all about soil and why it's important to us.

Slide 2 Here is the schedule for the next two days. We'll be learning about soil today, and doing hands-on activities tomorrow.

Slide 3 Ask these questions out loud to the class. If the students are quiet, ask "what do you think would happen if we didn't have soil at all?"

Slide 4 Soil is useful to us and to our planet. Soil and fungi have an interesting relationship- after an organism dies, its nutrients are recycled back into the environment by the mushrooms and the organic matter is left on the forest floor. Soil is composed of minerals from rocks and small amounts of decaying organisms.

Slide 5 A carbon sink is able to absorb carbon dioxide from the atmosphere. Soil, plants, and oceans are natural carbon sinks. Plants take CO2 from the atmosphere during photosynthesis with some of this carbon moving to the soil as plants die and decompose. Carbon sinks help in controlling global warming. Without carbon sinks, the amount of CO2 in the atmosphere would increase global warming.

Slide 6 Soil degradation comes from both natural and human activity. Many aspects of farming, development, and urbanization contribute to a quick decline in soil quality. A characteristic of good soil health is its ability to drain water. Soil compaction from heavy machinery like tractors can lead to poor drainage and cause runoff and flooding.

Slide 7 Ask the students what they think some consequences of soil degradation are. Some consequences include: loss of organic matter in the soil which results in the inability of ecosystems to support animals and plants, reduction in nutrient exchange between soil and plants, acceleration of surface runoff, less water filtration in the soil, and increased susceptibility for erosion.

Slide 8 Here is a graph that shows how much farmland the world has had from 1600 to 2016. You can see the pretty dramatic decrease in arable (farmable) land. As we use land for farming and other agricultural uses, the soil loses nutrient value and soil quality declines and can be lost forever. Fertilizers are used to make up for and supplement missing nutrients and to enhance, sometimes artificially, good soil structure and drainage capabilities.

Slide 9 As soil becomes contaminated over time, through chemical pollutants, industrial wastes, toxic fertilizers and pesticides; it becomes less and less usable and less able to sustain life and a healthy ecosystem. Plants can't grow and life cannot survive off of polluted land. All species (human, animal, insect, marine, and plant) suffer decline in health and in number. Soil is not able to contain water runoff and flooding. And soil erosion worsens as vegetation and forest areas die off.

Slide 10 **Now it's about time for a break, students can have lunch or a brief amount of time to stretch and walk around. When students get back from break, before starting the slides up again, ask if any of them have questions about the previous material.**

Slide 11 There are actually some common contaminants in urban and suburban soil that you could have in your backyard or find in a local park. The possibility of contamination should not prevent you from starting a garden, though, because the concentration of the contaminants is very low. Understanding soil health and possible contaminants can be helpful to identifying, correcting and restoring soil areas. You can improve the quality of the soil in your backyard or in a homemade garden by using raised beds or reusing plastic containers, and planting species like native flowers.

Slide 12 Read the instructions to the students on the slide about how to prepare for tomorrow. Before coming in for Day 2 of the seminar, make sure you have the depleted soil sample ready (about ¼ cup of soil per student or group of students) from an agricultural area. If you live in a city area and students don't commonly have backyards or gardens, split students up into groups and have only one student acquire a sample from a local park or from a home garden.

Slide 13 Before starting the activities for Day 2, lay out a plastic tablecloth or tarp to cover the workspace that the students will be using. Per each station- per one student or one group- set out a plastic cup of tap water with a pipette, one degraded agricultural soil sample, however many pairs of nitrile gloves a group needs, and the chemical/pH testing kits. Using an extra soil sample or a sample from a student, model how to do the soil texture test and show what a soil ribbon is (1 to 2 inch piece of soil that comes out when you squeeze the ball of soil between your forefinger and your thumb). Clarify to the class that loamy sand is more sand than soil, while sandy loam is more soil than sand.

Slide 14 Read the questions to the class. What observations do they have when they compare their soil to each other? To the depleted soil?

Slide 15 **Now it's about time for a break, students can have lunch or a brief amount of time to stretch and walk around. When students get back from break, before starting the slides up again, ask if any of them have questions about the previous material or activity.**

Slide 16 This slide is where you would arrange a brief talk with a graduate student or a college student studying environmental biology in your area. Discussion topics are on the slide. Have students ask any questions they may have to the expert.

Slide 17 Lastly, we'll be talking about soil microbes. Soil microbes are crucial to nutrient cycling and keeping the soil healthy. A healthy soil sample should have a large amount and a large variety of microbes.

Slide 18 Soil steaming is used as an agricultural practice to sterilize soil with steam so as to eradicate the soil microbes so that healthy microbes can then be added in.

Slide 19 And here are the five types of soil microbes- you've probably heard of bacteria and fungi, but there might be some new names on here! Nematodes are heavily studied in biology research labs because they have a fast life cycle, are easy to breed, and are able to replicate human diseases.

Slide 20 This is the end of the powerpoint. Now would be a good time to pass out the "dirt" dessert cups or the native flower seeds if you chose to make/buy them. If your school has access to microscopes and you have extra time at the end of Day 2, consider allowing your students to look at their samples under the microscope.

Bibliography:

Begum, T. (2021, April). *Soil degradation: The problems and how to fix them*. Soil Degradation: the problems and how to fix them. Retrieved March 4, 2022, from https://www.nhm.ac.uk/discover/soil-degradation.html

Bell , T., Borrelli, K., Isbell, S., Fleishman, S., Kaminsky , L., & Cloutier, M. (2022, February 22). *Understanding and managing soil microbes*. Penn State . Retrieved March 4, 2022, from https://extension.psu.edu/understanding-and-managing-soil-microbes

Borrelli, P., Robinson, D., Panagos, P., & Ballabio, C. (2020, August 24). *Land use and climate change impacts on global soil ... - PNAS*. Proceedings of the National Academy of Sciences. Retrieved March 4, 2022, from https://www.pnas.org/content/117/36/21994

Ersek, K. (2018). *5 types of soil microbes and what they do for plants*. 5 Types of Soil Microbes And What They Do For Plants. Retrieved March 4, 2022, from https://www.holganix.com/blog/5-types-of-soil-microbes-and-what-they-do-for-plants#:%7E:text=There%20are%20five%20different%20types,boost%20soil%20and%20plant%20health

Fett, W. (2020, May 14). *Biology of soil - lesson 4 - issues of soil degradation*. Iowa Agriculture Literacy Foundation. Retrieved March 4, 2022, from https://www.iowaagliteracy.org/Article/Biology-of-Soil-Lesson-4-Issues-of-Soil-Degradation

Fineschi, S., & Loreto, F. (2020, March 24). *A survey of multiple interactions between plants and the urban environment*. Frontiers in Forests and Global Change. Retrieved March 4, 2022, from https://www.frontiersin.org/articles/10.3389/ffgc.2020.00030/full

Food and Agriculture Organization of the United Nations. *Chapter 4. environmental, health and socio-economic impacts of soil pollution*. FAO. Retrieved March 4, 2022, from https://www.fao.org/3/cb4894en/online/src/html/chapter-04-2.html

U.S Department of Agriculture- Agricultural Research Service. (2022). *National Soil Erosion Research in West Lafayette, IN*. National Soil Erosion Research : USDA ARS. Retrieved March 4, 2022, from https://www.ars.usda.gov/midwest-area/west-lafayette-in/national-soil-erosion-research/

Ward, J., Maxwell, E., & Brouwers, E. (2007, January). *Investigating the Environmental Effects of Agriculture Practices on Natural Resources*. Scientific Contributions of the U.S. Geological Survey to Enhance the Management of Agricultural Landscapes. Retrieved March 4, 2022, from https://pubs.usgs.gov/fs/2007/3001/pdf/508FS2007_3001.pdf

World Wildlife Fund. (n.d.). *What is erosion? effects of soil erosion and land degradation*. WWF. Retrieved March 4, 2022, from https://www.worldwildlife.org/threats/soil-erosion-and-degradation

Yokoyama, D. M. (2020, May 27). *C. elegans as a model organism*. News-Medical.net. Retrieved March 4, 2022, from https://www.news-medical.net/life-sciences/C-elegans-as-a-Model-Organism.aspx

For reference, here is the attribution for the Agricultural area graph on slide 8: