You're my Soil-mate

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Adapted from: by Stewart A, Spring 2022

Field(s) of Interest: Environmental Science, Chemistry, Biology, Agriculture

Brief Overview:
Mentees will learn about the different types of soil, their connections to agriculture, food systems, and soil processes. At the end of the lesson, mentees should be able to understand soil pH, soil horizons, soil filtration, and overall impacts of soil health.

Agenda:

- Introduction (5 min)
- Module 1: All about that base (10 min)
- Module 2: Feeling sedimental (15 min)
- Module 3: #No filter (10 min)
- Module 4: Rooting for you (5-10 min)
- Conclusion (5 min)

Main Teaching Goals/Key Terms:	**Mentor Development Goals:**
➔ Soil ➔ Soil pH ➔ Soil management ➔ Soil horizons ➔ Organic material ➔ Filtration ➔ Poullant ➔ Aquifer	● **Planting Connections** ● **Clean Up, Everybody, Everywhere** ● **Group Growth** ● **Recall!**

Background for Mentors

Module 1

- **pH level**
  - Neutral
  - Acidic
  - Basic
- **Soil management**
- **pH tolerance**

The **pH level** of soil is the measurement of how acidic or alkaline the soil is. The pH scale ranges from 0 to 14. If soil has a pH of 7 it is **neutral**. If the soil has a pH below 7 it is **acidic.** If the soil has a pH above 7 it is **basic.** The optimal range for soil pH is between 5.5 and 7.5.

Factors that influence soil pH include parent material from which the soil developed, climate, vegetation, and human activities. Soil that is excessively basic or acidic is harmful because it negatively impacts microbial activity, nutrient balance, and soil structure. Some factors that cause soil to become too acidic include acid rain and pollution. Some factors that cause soil to become too basic include reduced organic matter and deforestation. Certain plants thrive in more acidic/basic environments. **pH tolerance** is the range of soil pH values in which a plant species grows and thrives. For instance, blueberries, ferns, and hydrangeas prefer basic soil.

Overall, Soil pH is important because it directly affects the availability of nutrients to plants. Many nutrients such as nitrogen, phosphorus, and potassium are optimally available to plants within a certain pH range. When soil pH deviates from the range, certain nutrients may become toxic to the plant. **Soil management** is often used to manage soil pH. Some of the most common practices include adding calcium carbonate to raise pH in acidic soil. Likewise, for alkaline soils, adding sulfur will help to lower the pH.

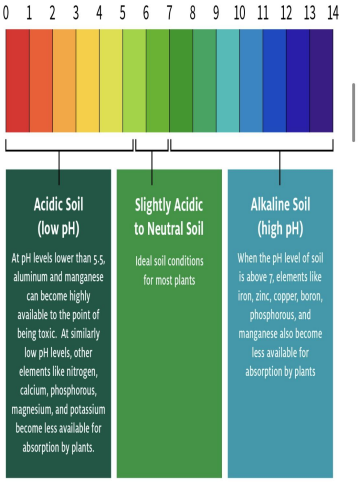


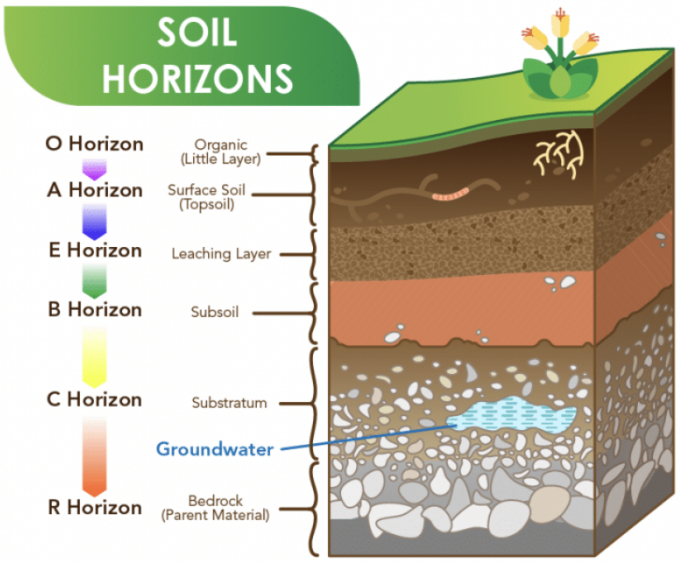
Figure 1: *Soil pH scale*

Module 2

- **Soil horizons**
  - Bedrock (R-layer)
  - Parent material (C-layer)
  - Topsoil (A-layer)
- **Organic material (O-layer)**

There are different types of soil, each with its own unique characteristics. The standard six **soil horizons** are bedrock, parent material, subsoil, eluviation, topsoil, and organic. However, for this lesson, we will be focusing on the main four layers, bedrock, parent material, topsoil, and **organic material.** Depending on the environment the soil has adapted to, it may not include certain layers. For instance, desert environments usually have a very thin or non-existent organic material layer.

At the bottom of the soil horizon is **bedrock**, also known as the solid rock layer. Weathering of the bedrock contributes to the formation of parent material. **Parent material** is the next layer of soil, also known as subsoil. This layer is made up of minerals, fragments of weathered rock, and sediment. Parent material has minimal weathering. Next is **topsoil** which is a mix of mineral particles from parent material as well as organic material. This is good material for plants and other organisms to live in! Lastly, is the **organic material layer** which is made out of decomposed organic matter such as leaves, twigs, and plant residues. As aforementioned, organic material is not present in all soil types. Although it is crucial for improving soil structure and fertility.



Module 3

- **Filtration**
- **Aquifer**
- **Pollutant**
- **Permeable/impermeable**

Soil layers naturally filter water. **Filtration** is the process in which solid particles in a fluid are removed by a medium that retains the solid particles but allows the fluid to pass through.

As water seeps deeper into the ground, it will eventually reach an impermeable layer and either collect or flow sideways. This creates an underground layer of **permeable** soil that is saturated with water. This body of permeable rock is known as an **aquifer**. Aquifers can contain or transmit groundwater. Fun fact: The largest aquifer in North America (the Ogallala) runs from South Dakota all the way south to Texas.

When water enters permeable soil, it makes its way through the spaces between the particles in the soil. Soil with larger particles has larger holes, resulting in fast-draining water. While soil with small particles drains slower. Certain soils, such as clay, make it very hard for water to seep through and are almost **impermeable**. Another example of an impermeable surface is granite. Water flows over the particles into cracks in granite but cannot get through.

Unfortunately, human activities can cause a **pollutant** to accumulate in the groundwater. Examples of pollutants include pesticides, oil, and toxic chemicals. Soil pollution is dangerous because although soil naturally filters particulate matter, it is unable to filter toxic chemicals.

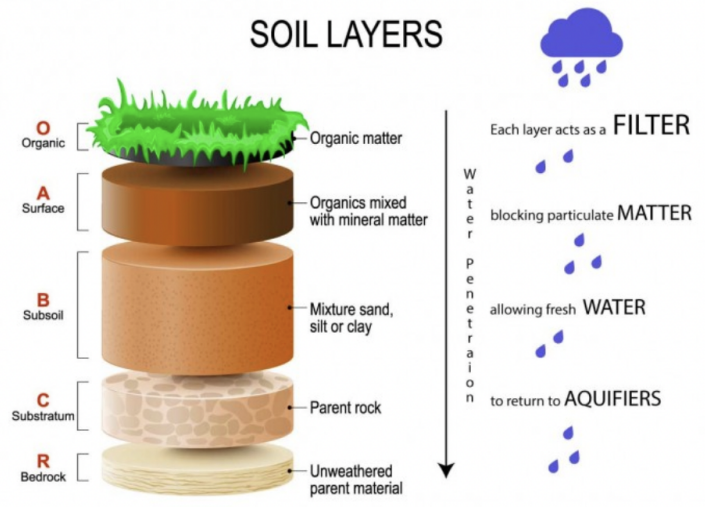


Figure 1: *Soil filtering through the horizons*

Introduction

Knowledge about soil and its processes is important in understanding more about the environment mentees live in as well as the role soil plays in our food systems. Additionally, soil pH is tied to climate change since the rise of greenhouse gases in the atmosphere is causing acid rain which lowers the pH of soil. Soil is also related to food and water sources given that water travels through soil in order to reach aquifers. Taken together, soil is the basis for every meal we eat and every beautiful landscape we admire.

Concepts to Introduce	**Questions to Pique Interest**

● Soil
  ○ The upper layer of earth in which plants grow, typically consists of a multitude of organic materials and microorganisms
● Organic Matter
  ○ Present in soil and essential for soil processes
● Filters
  ○ Essential to remove unwanted toxic material from products
● Agriculture
  ○ Cultivation of soil for crops and domesticated animals, food systems connection
● Decomposition and Decomposers
  ○ Worms, bacterium, fungi, and insects break down material in the soil
	● What is the difference between soil and dirt?
	● What is soil made out of?
	● Is soil alive?
	● Where does water go during a rainstorm?
	● Where is the biggest aquifer?

Scientists, Current and Past Events	**Careers and Applications**
● Dust Bowl of the 1930s ○ Caused by poor soil management ○ https://www.aaas.org/dust-bowl-wake-call-environmental-practices ● Indigenous regenerative agriculture ○ Discusses how intercropping preserves biodiversity ○ https://nfu.org/2020/10/12/the-indigenous-origins-of-regenerative-agriculture/sasss	● Soil is used to grow the food we eat every day! ● Occupations involving soil include ○ Farmer ○ Soil scientist ○ Toxicologist ○ Research Assistant ○ Environmental engineer

Module 1: All about that base

Mentees will perform a set of reactions on healthy soil and dry soil to determine what makes the soil acidic or basic. Ultimately, mentees will learn what makes the soil a healthy environment for plants to grow.

Teaching Goals

1. **pH level:** measuring how acidic or alkaline soil is.
2. **Soil management:** methods used to manage soil pH
3. **pH tolerance:** the range of soil pH values in which a plant species grows and thrives

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MD Goals

1. **Planting Connections:** 🌱🍀Let's plant some seeds in the mentees' heads! The kinds of seeds that help mentees visualize pH levels! try providing concrete examples of things with varying pH levels. You can talk about acidic items like lemons compared to basic items such as soap. Think about things that the mentees would encounter every day and focus on making connections!! 🍋
    a. You can make a connection to a temperature scale! Just like how there is a spectrum of temperatures, you can have a spectrum of pH values! 🌡️

Materials

- 3 plastic cups
- Soil
- Vinegar
- Baking soda
- pH testing strip (1 per mentee)

Different Methods for Teaching

1. Explain that adding vinegar/baking soda is a method of soil management
    a. Altering the pH is a common practice to make a soil environment more habitable

Procedure

1. Mentors will set up three cups full of soil
    - Neutral: add water
    - Basic: add water and baking soda
    - Acidic: add water and vinegar
2. Have the mentees choose a cup to test
3. Mentees will predict the soil type based on the pH

Figure 1: Basic pH test strip

Figure 2: Acidic pH test strip

Module 2: Feeling Sedimental

The mentees will make a model of soil layers. Pebbles represent bedrock, perlite represents the parent material, soil itself represents topsoil, and mulch represents organic material.

Teaching Goals

1. **Soil horizons:** the six standard levels of soil
2. **Organic material:** the top layer, made up of decomposed organic matter such as leaves and twigs.

MD Goals

1. **Clean Up, Everybody Everywhere**
   https://www.youtube.com/watch?v=xC9znRr8FG0

Materials

- Clear plastic cups (1 per group)
- Pebbles
- Perlite
- Soil
- Mulch

As this lesson involves mentees working with the different layers of soil, it can get a little ‘dirt’-y. Leaf thyme 🍀 at the end of the lesson to clean up. Feel free to ask mentees for help to ensure that the classroom is left in a clean state after the lesson. Stress to mentees that you won’t move onto the next activity if the class is a mess. 🧽🧹🧼  	

Different Methods for Teaching

1. Draw out the layers on the board!

Procedure

1. To the bottom of the cup add pebbles to represent bedrock.
2. Next, add the perlite to represent the parent material.
3. Now add the soil to represent the topsoil.
4. Finally, add the mulch at the top to represent organic material.

Module 3: #Nofilter

Mentees will make their own soil filters, first without any modifications and then adding a "pollutant" to the soil. Mentees will observe how water is filtered through each of these and see the effects pollutants have on the water supply.

Teaching Goals

1. **Filtration:** the process in which particles or impurities are removed from a fluid
2. **Pollutant:** physical, chemical, or biological materials that contaminate the environment
3. **Aquifers:** a body of permeable rock that can contain or transmit groundwater
4. **Permeable:** a surface that allows liquids or gasses to pass through it

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MD Goals:

1. **Group Growth**: When working in a small group with the kids, they might all be over eager to use the materials and do the experiment. Make sure all the kids have time to see the experiment and pass around the demo so they all can see! You can tell them they each have 10 seconds to look at the build, or give each mentee a different "job" to do!

Although this can be stressful, remember you are doing a great job when all the mentees are eager to participate :))))

🤪🥰😊

Materials

- Plastic cup (one per group)
- Pebbles
- Sand
- Soil
- Coffee filter
- Rubber band
- Food coloring (represents pollutant)

Procedure

Setting up the filter

1. Place stones into the bottom of the cup
2. Put the coffee filter on the top of the cup, and keep it in place with a rubber band
3. Pour sand into the coffee filter about 1/4-1/2 deep
4. Pour about 2 tbsp of soil on top of the sand

Regular Aquifer

5. Pour small amounts of water into the cup
6. Observe the aquifer that develops at the bottom (*see Figure 1)*

Figure 1: regular aquifer

Polluted Aquifer

7. Place a few drops of food coloring on top of the soil
8. Pour water into the filter
9. Observe the polluted aquifer that develops at the bottom (*see Figure 2)*

Figure 2: polluted aquifer

Closing Activity: Rooting for you!

Mentees will pot their own plants to take home.

Teaching Goals	**Materials**
● Review former teaching goals **MD Goals** ● **Recall!** - Take this opportunity to reinforce all the previous teaching goals and connect them to the build! This last take-home activity will synthesize the whole lesson into a project that mentees can take home and take care of. ○ Talk to the students about the pH level of the soil they are using. 🌱 ○ Ask mentees what the different layers of the soil are and which ones are in their pot. 🪴 ○ Talk about how they will water their plant and how they will filter out the bad toxins of their plant. 🌵 The following week, you can ask students how their plants are growing and if they notice any differences in their soil.	● 1 seed tray per mentee ● 2 tbsp of soil per mentee ● 1 pinch of seeds per mentee

Teaching tips:

- You need very few seeds per mentee. So use sparingly.

Procedure

1. Mentors will cut out the seed tray so that each mentee gets one section
2. Mentees will plant the seeds into the soil
3. Remind the mentees:
    a. Keep the soil pH balanced
    b. Make sure the soil has organic matter
    c. Water their plant with clean water

Figure 1: *Potted seeds in the seed tray*

Conclusion

By introducing mentees to soil and the different applications involved with it including its ties to the ecosystem and climate change, this lesson is able to garner a greater understanding of the environment around us, agricultural processes, and revolutionary advancements made in STEM. Because of soil, we are able to maintain such a large population and a high quality of life. Ultimately, this lesson is meant to pique interest in environmentalism.

References

Polluted versus non polluted aquifer
At home filtration experiment