

Unit C: Traits of Soil

Lesson 4: Water and Air of Soil

Student Learning Objectives: Instruction in this lesson should result in the students achieving the following objectives:

1. Identify the differences between types of water in the soil
2. Differentiate uses of water in soil
3. Recognize different measures of water in the soil
4. Identify different forces of water in the soil
5. Differentiate air in soil compared to air in atmosphere

Recommended Teaching Time: 6 Hours

Recommended Resources: The following resources may be useful in teaching this lesson

- A PowerPoint has been provided

List of Equipment, Tools, Supplies, and Facilities:

Writing surface
PowerPoint Projector
PowerPoint Slides
Transparency Masters
Laboratory Sheets – one for each student
Sponges
Buckets of water

Terms: The following terms are presented in this lesson (shown in italics and on PowerPoint Slide 2)

- Gravitational Water
- Capillary Water
- Hygroscopic Water
- Saturation
- Field Capacity
- Wilting Point
- Air Dry

Interest Approach: Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

This lab needs to be set up 2 weeks ahead of time for this class. Use LS: C4-1 as a reference guide for each student. Have the students get three soil samples of the exact same weight. Record that weight on LS: C4-1. One sample, bake until it

is completely dried, 176 degrees Celsius for 3 hours should do that. Take the weight of that sample once complete and compare it to the original weight. Next take one sample and place it in a cool place like a refrigerator. Then weigh it before the class and compare that weight to the original. Finally have the third sample just sitting out in the classroom for two weeks. Weigh that sample and compare to the original. Give the students these weights and have them figure out the percentage of weight lost for each sample. Then ask them why the difference between the three occurred. Ask them what was lost or what was exchanged. Ask them why that happened differently in each sample. The final answer should be that the water was lost out of the soil and some of the air was exchanged in the different samples. Use this discussion to lead into the lesson.

Summary of Content and Teaching Strategies

Objective 1: Identify the differences between types of water in soil

(PowerPoint Slide 3)

I. There are three stages of water found in soil

- A. **Gravitational water**- free water that flows freely through soil due to the force of gravity.
 1. Gravitational water is found in the macropores. It moves rapidly out of well drained soil and is not considered to be available to plants.
 2. It can cause upland plants to wilt and die because gravitational water occupies air space, which is necessary to supply oxygen to the roots.
 3. Drains out of the soil in 2-3 days

(PowerPoint Slide 4)

- B. **Capillary water**-water found in the small holes of soil.
 1. Most, but not all, of this water is available for plant growth
 2. Capillary water is held in the soil against the pull of gravity. Forces acting on Capillary Water micropores exert more force on water than do macropores. Capillary water is held by cohesion (attraction of water molecules to each other) and adhesion (attraction of water molecule to the soil particle). The amount of water held is a function of the pore size (cross-sectional diameter) and pore space (total volume of all pores). This means that the tension (measured in bars) is increasing as the soil dries out.

(PowerPoint Slide 5)

- C. **Hygroscopic water**- water that forms very thin films around soil particles forming a tight bond. This water is unavailable to plant use.
 1. Not held in the pores, but on the particle surface. This means clay will contain much more of this type of water than sands because of surface area differences.
 2. Hygroscopic water is held very tightly, by forces of adhesion. this water is not available to the plant
 3. Gravity is always acting to pull water down through the soil profile. However, the force of gravity is counteracted by forces of attraction between water

molecules and soil particles and by the attraction of water molecules to each other.

To demonstrate the three stages of water found in soil take a sponge and a bucket of water and give it to groups of four. Have that group soak the sponge in water for 1 minute, while squeezing it to pull in all the water. Then have the next student pick it up out of the water. Explain that Gravitational water is the water draining off the sponge. Then have them pass the sponge. The next person needs to squeeze the water out of the sponge. The water being squeezed out is called capillary water. Finally, hand the sponge off to the last student. Have that student feel the sponge. There is still moisture in the sponge. But it will not come out of the sponge. That is what we call hygroscopic water. It is there, but not available to anything.

Objective 2: Differentiate uses of water in soil

(PowerPoint Slide 6)

- II. Water is used in many different formats when found within soil.
 - A. Water is used for plant growth.
 - 1. Plants absorb water available to them for growth throughout their lifespan.
 - 2. Too much water could "drown" the plant causing it to die.
 - 3. Roots of a plant MUST be able to exchange gases within the soil in order to survive.

(PowerPoint Slide 7)

- B. Water is used to form tight bonds between clay particles.
 - 1. Water not available to plants causes tight bonds to clay particles. These clay particles then form a tight bond with one another.
 - 2. This is hygroscopic water that forms these bonds.
- C. Water is used for animal life.
 - 1. Animals living in the soil need some water to stay alive.
 - 2. Too much water could wash the insects and animals away.
- D. Water is used for human use and consumption.
 - 1. Wells are dug through the soil to where water is located deep in the soil. This water can be used to drink, cook, clean, water plants, etc.

Have students complete LS: C4-2 to understand the importance of water in the soil. Using the soil from the previous laboratory exercise have some of the soil completely soaked (Sample 1), some of the soil at a good level of wetness (Sample 2), and some of the soil VERY dry (Sample 3). Then have the students work in groups and plant any plant they want into each of the three different soil types. Every day for 2 weeks they will soak the 1st Sample thoroughly, water properly the 2nd Sample, and not touch the 3rd Sample. Every day they will take notes on what the plant does. Discuss with the students how the water is used by the plant and needed each day.

Objective 3: Recognize different levels of water in soil

(PowerPoint Slide 8)

III. There are different measures of water found in the soil.

A. Saturation

1. All soil pores are filled with water.
2. This condition occurs right after a rain.

B. Field capacity

1. Moisture content of the soil after gravity has removed all the water it can.
2. Usually occurs 1-3 days after a rain.

C. Wilting point

1. Soil moisture percentage at which plants cannot obtain enough moisture to continue growing.

(PowerPoint Slide 9)

D. Hygroscopic water

1. Water absorbed from the atmosphere and held very tightly by the soil particles, so that it is unavailable to plants in amounts sufficient for them to survive.

E. Oven dried

1. Soil that has been dried in an oven at 105 degrees C for 12 hours. All soil moisture has been removed.
2. This point is not important for plant growth but is important for calculations since soil moisture percentage is always based on oven dry weight.

F. Plant available water

1. Water that is held in the soil.
2. Plants are able to uptake this water found in the soil.

Split students into groups. Have each group come up with an example and explanation of each level of water found in the soil. Make this an assignment they turn in for a grade.

Objective 4: Identify different forces of water in soil

(PowerPoint Slide 10)

IV. Water can cause different forces that can be found in the soil.

A. Adhesion

1. The attraction of soil water to soil particles and other particles.

B. Cohesion

1. The attraction of water molecules to other water molecules.

C. Capillarity

1. A capillary is a very thin tube in which a liquid can move against the force of gravity. The narrower the tube the higher the liquid rises due to the forces of adhesion and cohesion

Take a large beaker and fill with water. Second, get a clear straw, a larger clear tube, and your hand. First, place the straw in the water and show how the water will travel up the straw. Then put the larger tube in there and show the difference in level of water and the amount of water left in the tube and straw when taken out of the water. Finally, take a drop of water on your finger and place it on your hand. Have the students watch it travel across your hand. Then do it again and show how the water will travel in the same exact pattern due to the cohesion of water.

Objective 5: Differentiate air in soil compared to air in atmosphere

(PowerPoint Slide 11)

V. The air found in soil is very different from the air found in the atmosphere. The air in soils is not exposed to moving air currents, and is much more moist or humid than atmospheric air. It also tends to be very rich in carbon dioxide, and poor in oxygen. Oxygen is removed by living organisms, and carbon dioxide is left behind. This carbon dioxide leaks out of the soil, slowly replenishing the atmospheres carbon dioxide supplies.

Provide each student with a copy of LS: C4-3 and have them complete the laboratory exercise. Have students split into groups of four. These groups will take a dry clod of soil. With that clod, they will take it to a bucket of water and gently drop it into the water. Have students take notes on how long water bubbles come up and how severe the bubbles are. Those bubbles are air leaving the soil clod as water replaces it in the pore spaces.

(PowerPoint Slide 12)

Review/Summary: Use the student learning objectives to summarize the lesson.

Have the students respond to the questions on PowerPoint Slide 12. Student responses can be used to determine which objectives need to be reviewed.

Application: Have students write a one page paper. This paper must describe how water and air are found in the soil. They should explain what happens when it rains, and what happens when it is dry. This paper should explain why it is important to know about air and water in the soil and how knowing could help humans properly use soil.

Evaluation: A sample test has been provided.

Answers to Sample Test:

Part One: Matching

1=e, 2=d, 3=a, 4=c, 5=f, 6=b

Part Two: Completion

1. Oven Dry
2. Field Capacity
3. Saturation
4. Roots
5. Plant Available Water

Part Three: Short Answer

1. Saturation- all pores filled with water, Field Capacity- all gravitational water removed, Wilting point- no water available to plants, Hygroscopic- soil is air dry and no water available to plants, Plant available water- water able to be absorbed by plants.
2. Cohesion- being attracted to other water, Adhesion- attraction to soil, and Capillarity- water that can move against gravity, very thin tube.

Sample Test

Name _____

Test

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Part One: Matching

Instructions. Match the term with the correct response. Write the letter of the term by the definition.

- | | | |
|-------------------|------------------|----------------|
| a. Carbon Dioxide | c. Wilting Point | e. Hygroscopic |
| b. Adhesion | d. Cohesion | f. Water Well |

- _____ 1. Water unavailable to plants.
_____ 2. The attraction of water molecules to soil.
_____ 3. The type of gas that is exchanged with oxygen within soil.
_____ 4. Point when plants cannot absorb enough water from the soil.
_____ 5. Common way humans use water from soil.
_____ 6. The attraction of water molecules to other water molecules.

Part Two: Completion

Instructions. Complete the following statements.

1. When you take a soil sample and bake it until no water is left in the sample, it is known as _____.
2. _____ is the level of soil water that occurs usually 1-3 days after a rain.
3. When it rains and all the pores fill up with water, _____ occurs.
4. _____ of a plant MUST be able to breathe and exchange gases while being securely held in the group.

5. _____ has the ability to be absorbed by plant roots.

Part Three: Short Answer

Instructions. Use the space provided to answer the following questions.

1. Explain the different levels of water found in the soil.

2. What are the three types of water forces in water?

LS: C4-1

WEIGHT OF SOIL

Name _____ **Date** _____

**Record the weights of the samples found on the table in the proper line below.
Then find weight lost from each sample.**

Sample 1: Oven dried sample

Original weight: _____

After you weigh this sample, bake the sample at 176 degrees Celsius for 12 hours.

Sample weight after oven dried: _____

Total weight lost in sample: _____

Percent weight lost in sample: _____

Sample 2: Air dried sample

Original weight: _____

After you weight this sample, sit it out at room temperature for 12 hours.

Sample weight after air dried: _____

Total weight lost in sample: _____

Percent weight lost in sample: _____

Sample 3: Cool dried sample

Original weight: _____

After you weigh this sample, store in cool dry place for 12 hours.

Sample weight after stored: _____

Total weight lost in sample: _____

Percent weight lost in sample: _____

Why is there a difference in percent weight lost in each sample?

What was lost or exchanged in each sample?

Why was this loss different in each sample?

LS: C4-2

TYPES OF WATER IN SOIL

Name _____

Date _____

Using the soil from the previous laboratory exercise have some of the soil completely soaked (Sample 1), some of the soil at a good level of wetness (Sample 2), and some of the soil VERY dry (Sample 3). Then have the students work in groups and plant any plant they want into each of the three different soil types. Every day for 2 weeks they will soak the 1st Sample thoroughly, water properly the 2nd Sample, and not touch the 3rd Sample. Students will take notes on what the plant does in each container using the space below. Students will compare observations with the rest of the class at the end of 2 weeks.

Name of Plant used: _____

Day 1	Day 2	Day 3	Day 4	Day 5
1				
2				
3				

Day 6	Day 7	Day 8	Day 9	Day 10
1				
2				
3				

LS: C4-3

TYPES OF WATER IN SOIL

Name

Date _____

Take a dry clod of soil. Fill a bucket with water and softly drop the clod of soil into the bucket. Take note how frequently bubbles come up out of the bucket and for how long. Answer the questions below after the activity is completed.

Weight of soil clod:

Surface Area of soil clod:

Frequency of bubbles after 5 seconds:

Frequency of bubbles after 10 seconds:

Frequency of bubbles after 15 seconds:

Frequency of bubbles after 30 seconds:

Frequency of bubbles after 45 seconds:

Amount of time bubbles came up out of

1. Why do we need to know the weight of the soil sample?
 2. What could be a difference in a heavy sample and a light sample? Which would have more pore spaces?
 3. Would surface area have a difference in length of bubble release? Why or why not?