Nebraska Soil Science Curriculum

Soil Infiltration: Factors that affect it, problems that exist, management of it

Approximately 90 minutes

Content and lab derived from the USDA-NRCS Guides for Educators. Please see the Guides for additional helpful pictures and diagrams.

Objectives

By the end of the lesson, students will know or be able to:

- Define: infiltration rate, restrictive layers, soil aggregates, soil porosity, steady-state infiltration
- List and describe inherent factors that affect soil infiltration
- Describe soil infiltration management practices
- Explain soil infiltration problems and how they affect soil function
- Measure soil infiltration and interpret results

Materials

- Guided notes (one per student)
- Clear plastic cup filled with marbles
- Clear plastic cup filled with Play-Doh
- Water
- 8 ½ x 11 paper that
- Laboratory supplies (see Guided Notes Lab)
- Notecards with terms

Preparatory Work

- Print all necessary copies
- Secure permission to collect soil samples from the land owner
- Create note cards with key terms
- Create note cards with definitions
- Hide note cards in the classroom

Enroll the Participants – Approximately 4 minutes

Set up the clear plastic cups – one filled with marbles, the other with Play-Doh – in an area where they are visible to all students.

Ask students to hypothesize which cup will provide the quickest flow rate of the water.

Pour an equal amount of water into each of the cups and encourage students to monitor the two rates.

Use the following questions to facilitate a conversation with the students:

What caused one rate to be faster than the other?
How might this demonstration be comparable to how water and soil interact together?

Inform students that during this lesson, the class will explore soil infiltration rates, what affects, problems that exist and management of it.

Provide the Experience – Defining key terms – Approximately 3 minutes

Direct students to search the room for note cards with key terms and definitions on them for this lesson.

Instruct students to work together to match the terms and definitions.

Label the Information – Approximately 5 minutes

Review the terms and definitions using the accompanying PowerPoint or the information found here:

Infiltration Rate: a measure of how fast water enters the soil, typically expressed in inches per hour but recorded in minutes for each inch of water applied to the soil surface

Restrictive Layers: compacted layers and layers of dense clay, bedrock or other restrictive features than limit infiltration below the surface of the soil.

Soil Aggregates: soil particles held together by organic matter and related substances. Well aggregated soils have higher infiltration rates and are less prone to erosion.

Soil Porosity: Amount of pore space in the soil. Soils with higher porosity have more pore space and higher infiltration rates than those with lower porosity.

Steady-State Infiltration: The infiltration rate is steady and does not increase or decrease as more water is added. It typically occurs when the soil is nearly saturated.

Demonstrate the Relevance – Approximately 3 minutes

Instruct students to discuss with someone near them how each of the terms might affect plant growth in soils.

Provide the Experience – Inherent Factors Affecting Soil Infiltration – Approximately 2 minutes

Refer back to the cup of marbles and cup of clay.

Ask the students the following questions:

Which material as larger pore space?
How does pore space affect infiltration rate?

Label the Information – Approximately 2 minutes

Share the following information with the students:

Soils with a sandy texture has large pores and water moves through it quickly, like the marbles.

Soils with a clayey texture has small pores and water moves through it slowly, like the Play-Doh.

Soil texture, as discovered in the previous labs, is an inherent factor, meaning it cannot be changed.

Demonstrate the Relevance – Approximately 4 minutes

Ask students to predict what type of soil they believe exists around the school, in their yard, in their fields, etc. Elicit responses.

Provide the Experience – Managing Soil Infiltration – Approximately 4 minutes

Share with students that management practices affect the following:

Surface crusting
Compaction
Soil Organic Matter

Ask students to discuss how surface crusting, compaction and soil organic matter might affect infiltration rates.

Label the Information – Approximately 15 minutes

Share the following information with the students and encourage them to add it to their guided notes:

- Soil crusting
    - Soils dry out, causing pore space to increase as cracks form
    - Water fills the cracks quickly, wetting the soil
    - As water becomes wetter, the infiltration rate slows because of restrictive layers
- Compaction
    - Results from equipment and tillage practices
    - Minimizes pore space

    - Slows water movement through the soil profile
- Soil Organic Matter
    - Bare soil is more drastically affected by erosion by rain drops
    - Dislodged soil particles fill in and block surface pores
    - OM binds soil particles together, forming aggregates; aggregates increase porosity and infiltration rates
    - OM encourages a living environment for organisms such as earthworms; organisms move about in the soil and increase pore space
- Improve Infiltration Rates by
    - Avoiding soil disturbance and equipment operation when soils are wet
    - Using designated field roads or rows for equipment traffic
    - Reducing the number of trips across the space
    - Sub-soiling to break up existing compacted layers
    - Using continuous no-till
    - Adding solid manure or other organic materials
    - Using rotations with high-residue crops, such as corn and small grain and perennial crops, such as grass or alfalfa
    - Planting cover crops and green manure crops
    - Farming on the contour
    - Establishing terraces to minimize run-off and erosion

Demonstrate the Relevance – approximately 3 minutes

Instruct students to identify something their family does (in their fields, garden or yard) or something another individual in the community does to minimize soil compaction. Also consider challenging students to identify something they could do.

Provide the Experience – Soil Infiltration Problems – Approximately 5 minutes

Divide students into five small groups and provide each group with one of the following soil infiltration problems. Instruct each groups to discuss and be prepared to present what the problem could cause and potential solutions.

Rainfall rate exceeds the soil's infiltration capacity
Runoff moves downslope or causes ponding

Runoff removes nutrients, chemicals and soil
Aeration of soil is poor because of slow infiltration and ponding

Label the Information – Approximately 7 minutes

Instruct small groups to share their thoughts on the results of the problem and their possible solutions.

Fill in with the following information:

- Rainfall rate exceeds the soil's infiltration capacity
    - Water ponds, causing drowning of plants
- Runoff moves downslope or causes ponding
    - Erosion results, plants drown
- Runoff removes nutrients, chemicals and soil
    - Decreases soil productivity, off-site sedimentation of water bodies occurs, water quality diminishes
- Aeration of soil is poor because of slow infiltration and ponding
    - Poor root function
    - Poor plant growth
    - Reduced availability of nutrient to plants
    - Reduced cycling of nutrients by soil organisms

Demonstrate the Relevance – approximately 4 minutes

Discuss with students how a farmer is economically affected by poor soil infiltration and how consumers are economically affected as well.

Provide the Experience – Measuring and Interpreting Soil Infiltration – Approximately 3 minutes

Review the laboratory scenario with students. Students can find the scenario in their guided notes.

A local farmer recently purchased some recreational ground and plans to turn the space into farm ground. One concern the farmer has is regarding the amount of vehicular traffic that has occurred on the former recreational ground. The worry is that the transportation has negatively affected the ground's ability to infiltrate water.

Label the Information – Approximately 15 minutes

Review and identify each of the supplies from the soil testing kit that will be used during the lab activity.

- 3-inch-diameter ring
- Plastic driver (mallet)
- Small block of wood
- Plastic wrap
- Plastic bottle marked at 107 mL (for 1 inch of water) or graduated cylinder
- Distilled water or rainwater
- Stopwatch or timer

Review the steps of the laboratory activity and provide any instructions specific to your classroom expectations and time.

Demonstrate the Relevance – approximately 25 minutes

See the attached laboratory guided notes for the steps to complete the laboratory. Review the results and analysis steps of the lab

Review the Content – Approximately 4 minutes

Review the process students used to test the soil infiltration rates. Discuss how soil infiltration relates to each of the other lab topics covered during the unit.

Celebrate Student Success – Approximately 2 minutes

Congratulate students on their discovery of infiltration rates and their understanding of how infiltration rates relate to other lab topics.

Guided Notes: Soil Infiltration

Vocabulary Matching

Infiltration Rate

Restrictive Layers

Soil Aggregates

Soil Porosity

Steady-State Infiltration

Inherent Factors Affecting Soil Infiltration

Soil Infiltration Management Practices

Soil crusting

Compaction

Soil Organic Matter

Improve Infiltration Rates by:

Problems Associated with Soil Infiltration

Rainfall rate exceeds the soil's infiltration capacity

Runoff moves downslope or causes ponding

Runoff removes nutrients, chemicals and soil

Aeration of soil is poor because of slow infiltration and ponding

Guided Notes: Soil Infiltration Laboratory

Soil Infiltration Scenario

A local farmer recently purchased some recreational ground and plans to turn the space into farm ground. One concern the farmer has is regarding the amount of vehicular traffic that has occurred on the former recreational ground. The worry is that the transportation has negatively affected the ground's ability to infiltrate water.

Laboratory Supplies

- 3-inch-diameter ring
- Plastic driver (mallet)
- Small block of wood
- Plastic wrap
- Plastic bottle marked at 107 mL (for 1 inch of water) or graduated cylinder
- Distilled water or rainwater
- Stopwatch or timer

Laboratory Steps

Select a test site that provides at least two areas that are under different management. (As an example, in a row crop field, the two areas would be a wheel traffic row and a row without wheel traffic.) If possible, measure the bulk density of each location prior to doing this lab.

Plan to conduct multiple ring measurements since a single ring measurement is only an estimate.

Conduct the test during a time when the surface soil is not unusually dry. Add water to the surface if necessary and allow enough time for the water to soak in prior to conducting the test or conduct the test after rain or irrigation.

Infiltration Test

1. Clear all residue from the soil surface.
2. Drive the ring to a depth of three inches using a small sledge and plastic impact driver or block of wood.
3. Gently firm the soil around the inside of the ring to avoid any gaps.
4. Line the ring with plastic wrap so that it covers the inside of the ring and drapes over the side.
5. Pour 107 mL of distilled water or rainwater into the plastic-lined ring.
6. Gently pull plastic wrap away.
7. Record the time it takes for water to infiltrate soil. Stop time is when the soil is "glistening" from the water.
8. Repeat steps 2, 3 and 4 with another inch of water to estimate steady-state infiltration.
9. Record results in Table 1.
10. The ring can be removed with soil intact for use indoors in the respiration test and/or bulk density test. Consult with your teacher.

Table 1. Infiltration data sheet

Location	Soil Texture	First Inch of Water		First Infiltration Time (minutes)	Infiltration Rate (in/hr)	Second Inch of Water		Date:	
		Start Time	End Time			Start Time	End Time	Second Infiltration Time (minutes)	Steady State (in/hr)

Did the rate change from the first to the second inch? Why or why not?

Was a steady-state infiltration rate achieved? How do you know? Do you need to add a third inch of water?