Background

Soil is sometimes described as the skin of the earth: the earth’s outermost, thin (but very important) covering. While our skin functions by preventing water and other substances from entering and exiting our bodies, the earth’s skin works best when it allows water to enter! The entry of water into soil is called infiltration.

Water that infiltrates the soil becomes available to plant roots and other soil organisms, aids decomposition and nutrient cycling, and may percolate down through the soil to recharge groundwater. Water that infiltrates the soil is also important for what it does NOT do: it does not run off the landscape.

Runoff carries away soil particles and nutrients, reducing soil quantity and quality. Runoff carrying sediment, agricultural chemicals, and nutrients flows into surface waters, reducing water quality. Better infiltration thus reduces both soil erosion and pollution of surface waters.

Infiltration is affected by both physical and biological factors. Infiltration rates are higher in soils that are not compacted and have proportionally more sand and less clay. Plant roots and other soil organisms improve infiltration rates by creating channels through the soil and increasing sponge-like organic matter. Perennial roots like those of most prairie plants persist throughout the year, improving infiltration during seasons when row crops are not actively growing.

Vocabulary

Infiltration rate: The rate at which water enters soil.
Percolation: Downward movement of water through spaces within the soil.
Erosion: Movement of soil or sediment by water, wind or ice.
Runoff: Water that flows across the landscape, potentially carrying pollutants with it.
Physical factors: In soils, the sizes of particles, amount of pore space, and water content are physical (not chemical or biological) factors.
Biological factors: In soils, living things and their activities such as roots and the channels they make into the soil.
Perennial: Living for many years.
TEACHER PREPARATION

• Locate a field site where students will be able to find specific testing locations with some bare ground and differing amounts and kinds of herbaceous plants (not trees or shrubs).

• Gather materials for each group:
  a. School cafeteria kitchens are a good source for large vegetable cans. Remove both ends from the cans, and mark each can with permanent marker about 2-inches (5 cm) from one end.
  b. Print one instruction sheet (Appendix A) and one data sheet (Appendix B) per 2 students.

• Bring the following materials to the field site to share with the class:
  a. At least one set of sturdy pruners for larger stems
  b. Rubber mallets or small sledge hammers (1 per 4 students, if possible)
  c. A bucket or jugs of water for refilling bottles
  d. Trash bag for used plastic wrap

Note: Younger students may need assistance or close supervision using a mallet or hammer.

ACTIVITY

Introducing the activity:

1. Ask students, “When it rains, where does the water go?” Accept their responses and follow up with questions that encourage them to think more deeply about the movement of water in our landscape.

2. Introduce the terms “infiltration” and “runoff.” You can do a simple demonstration of infiltration by filling a clear plastic cup or jar halfway with semi-dry, sieved soil; tamping the soil down lightly and filling the cup the rest of the way with water. For comparison, set up a second cup of soil with 5-10 toothpicks (simulating roots) inserted through the soil to the bottom of the cup. Ask students what they notice as the water soaks into the soil in each of the cups.

3. Ask students to think of several reasons why infiltration is beneficial. Guide the discussion toward the following: more water in the soil for plants, less water running off into streams, less flooding, less erosion and less pollution.

4. If you have access to a Prairie Roots display, ask students to think about the ways roots could affect infiltration. Living and dead/decomposing roots form channels (“routes”) for water to follow. Help students imagine all of the other things that lived around the plant’s root system and consider how the movements of worms and arthropods affect soil infiltration.

5. Share images of different kinds of plant roots (Appendix C and Appendix D). Ask them to think about how different types, amounts or diversity of roots would affect infiltration. Stress the differences between crop plants that grow for only one season and perennial prairie plants that remain in the soil in all seasons and live for many years.

6. Explain that students will be going outside to test different locations to measure how plant roots affect infiltration.
Instructions for students - Printable handout - Appendix A

Activity instructions are adapted from the following resource: Soil Infiltration. NRCS Soil Quality Kit - Guides for Educators. (See Resources for a link to this website.)

SAFETY: Be careful of sharp edges on cans! Use care when handling hammer or mallet.

1. Group roles:
   a. Field technician - handles the materials and follows the procedures carefully.
   b. Data recorder - reads instructions and records predictions, data and other observations on the data sheet.
   c. Time manager - times the trials (carries the stopwatch or cell phone).

2. Go to the field area with your class.

3. Find two specific testing locations with different amounts or kinds of plants. Record a description of each location.

4. Record predictions about how fast water will infiltrate into the soil in the two sites.

5. Set up the testing materials:
   a. Use scissors or trimmers to trim plant stems to the ground level. Clear all debris from the soil surface. Be careful NOT to disturb roots or the soil.
   b. Place the marked end of the can on the cleared soil surface. Place the board across the top of the can and tap it into the soil (with mallet or hammer), until you can no longer see the 2-inch mark. Gently firm soil around the inside of the can.

6. Time the infiltration rate:
   a. START the timer as you pour one 500-ml bottle of water onto the soil surface inside the can. This models a 1-inch rainfall event.
   b. STOP the timer when the water is absorbed into the soil surface so that it is just glistening.
   c. Record the time it took for the 500-ml of water to infiltrate the soil.

7. Leave the can in place! Repeat the procedure with another 500-ml of water. Record the time. IF the water is absorbed just as quickly the second time, pour and time a third bottle.

8. Do the same steps at your other testing location.

9. Calculate and record the infiltration rate: divide 60 (minutes per hour) by the time (in minutes) it took for the last bottle of water to be absorbed.

10. Collect and return all materials.

ASSESSMENTS

Questions for class discussion and/or individual written or oral assessment:

a. Do the data support your predictions?

b. Which locations had the highest infiltration rates? What characteristics did they have?

c. Which locations would have more trouble with erosion? Why?

d. Which locations would capture more rain for plants and other soil life? Why?

e. How hard was it to get each can into the soil? Was one site more compacted than the other was? How do you think compaction affects infiltration?

f. Consider the locations that had slower infiltration. What could be done to improve their infiltration rate? Why would that be a good idea?
EXTENSIONS

1. If necessary technology is available, create a video to present the background, research question, methods, evidence and conclusions of infiltration tests.
2. Research the infiltration rates needed for raingardens or septic systems and compare these rates with the ones measured in the Activity.
3. Test infiltration rates of different areas around the school campus. Research ways to improve infiltration and reduce runoff, and create a plan for the school grounds. Present plan to the school board.
4. Research and create posters to illustrate the impact of perennial roots on the water cycle, through decreased runoff, increased infiltration and groundwater recharge.
5. Investigate the role of infiltration in water-quality issues in the community, and research possible solutions. Create a video to promote farming techniques that use roots to improve infiltration and decrease runoff.
6. Create maps or dioramas of a watershed to show the effects of different types of land use on infiltration and runoff.

ADAPTATIONS FOR DIVERSE AUDIENCES

• For students with physical disabilities, choose accessible field sites. Students may choose or be assigned group roles such as timer or recorder to enable their participation.
• For English language learners, use demonstrations and visual materials to introduce vocabulary. See the “Suggestions for Introducing the Activity.”
• Students with different learning needs and developmental levels may benefit from the use of visual materials in the activity introduction. Some mathematical problem-solving is required to calculate infiltration rates; some students may need additional support. Assessing student learning orally rather than in written forms may be more appropriate for some students.
• Students from urban environments may need more background on plant needs and the differences between annual crop plants and perennial prairie plants.

RESOURCES

• Soil Infiltration. NRCS Soil Quality Kit - Guides for Educators. www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053268.pdf
• Chapter 2 - Soil and Water. Food and Agriculture Organization of the United Nations. www.fao.org/docrep/r4082e/r4082e03.htm
STANDARDS

5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth’s resources and environment.
MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
MS-ESS2-2 Construct an explanation based on evidence for how geoscience processes have changed Earth’s surface at varying time and spatial scales.
MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

APPENDICES

A. Printable Instructions for Students
B. Printable Data Sheet
C. Images

Prairie Roots lesson plans created by the Tallgrass Prairie Center with funding from the Iowa Living Roadway Trust Fund.

2017

tallgrassprairiecenter.org
INSTRUCTIONS FOR STUDENTS

SAFETY: Be careful of sharp edges on cans! Use care when handling hammer or mallet.

1. Group roles:
   a. Field technician - handles the materials and follows the procedures carefully
   b. Data recorder - reads instructions and records predictions, data, and other observations on the data sheet
   c. Time manager - times the trials (carries the stopwatch or cell phone)

2. Go to the field area with your class.

3. Find two specific testing locations with different amounts or kinds of plants. Record a description of each location in Table 1.

4. Record predictions in Table 1 about how fast water will infiltrate into the soil in the two sites.

5. Set up the testing materials:
   a. Use scissors or trimmers to trim plant stems to the ground level. Clear all debris from the soil surface. Be careful NOT to disturb roots or the soil.
   b. Place the marked end of the can on the cleared soil surface. Place the board across the top of the can and tap it into the soil (with mallet or hammer), until you can no longer see the 5-cm mark. Gently firm the soil around the inside of the can.

6. Time the infiltration rate:
   a. START the timer as you pour one 500-ml bottle of water onto the soil surface inside the can. This models a 1-inch rainfall event.
   b. STOP the timer when the water is absorbed into the soil surface so that it is just glistening.
   c. In Table 2, record the time it took for the 500-ml of water to infiltrate the soil.

7. Leave the can in place! Repeat the procedure with another 500-ml of water. Record the time. IF the water is absorbed just as quickly the next time, pour and time another bottle.

8. Do the same steps at your other testing location.

9. Calculate and record the infiltration rate: divide 60 (minutes per hour) by the time (in minutes) it took for the last bottle of water to be absorbed.

10. Collect and return all materials.

tallgrassprairiecenter.org
TABLE 1

<table>
<thead>
<tr>
<th>Location</th>
<th>Amount of Vegetation (bare soil, thin plant cover, thick plant cover)</th>
<th>Type of Vegetation (examples: prairie, lawn grass, corn, weeds)</th>
<th>Predictions</th>
<th>Faster or slower infiltration? Why?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE 2

<table>
<thead>
<tr>
<th>Location</th>
<th>Infiltration Trials</th>
<th>Infiltration Rate (inches per hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st inch Infiltration Time (minutes)</td>
<td>2nd inch Infiltration Time (minutes)</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

QUESTIONS:

1. Do the data support your predictions?

2. Which locations had the highest infiltration rates? What characteristics did they have?

3. Which locations would have more trouble with erosion? Why?

4. Which locations would capture more rain for plants and other soil life? Why?

5. How hard was it to get each can into the soil? Was one site more compacted than the other was? How do you think compaction affects infiltration?

6. Consider the locations that had slower infiltration. What could you do to improve their infiltration rate? Why would that be a good idea?
Soil cores taken from a prairie grass stand (left) and an adjacent bean field (right) just after harvest.