K-12 IYS Activity

Soil Science Society of America

"Pouring" Through the Soil for Clean Water

Summary

Students will alter the distribution of pore sizes in a school garden soil by variously compacting or not compacting tilled moist or dry soils and observing the effects of either irrigation or rainfall on water infiltration and capture, runoff rate, and/or water ponding.

Learning Objectives/ Outcomes

1. To learn that compacting soil decreases the volume of large pores and reduces infiltration of precipitation and run-on water and increases ponding and runoff of water.
2. To learn that wet soils are weaker than dry soils, and adding weight (mass) to wet soils more easily reduces macropores and hydraulic conductivity.
3. To learn factors that affect water infiltration and storage and water runoff (i.e., surface soil aggregation, landscape slope, soil texture, soil organic matter).

Materials (per student, group etc.)

- Access to a schoolyard garden or other garden
- rototiller or garden spades
- water source
- hose-sprinkler system

Ages of Audience

1. Elementary
2. Middle School High School
3. Adults

Recommended group size?

Less than 20

Where could you offer this?

1. Local school
2. Community garden

What type of room do you need?

1. Classroom seating
2. Lab/work benches
   Although the follow-up discussion could occur in a classroom, the smaller demonstration with the pans and screens should be done in a lab

Type of Lesson (may be more than one)

1. Hands-on (participants touch the stuff)
2. Outdoor
3. Indoor (some portion)
4. Experiment (follow procedure, get results, interpret results)
5. Small group exercise/discussion critical thinking

Time Needed

1. Scientist prep time + clean up time: time to accumulate equipment
2. Participant/class time: varies depending on the extent of incorporation of optional exercises; 45 minutes per session, which can include 2-4 sessions

Methods/Procedures

- Till an area of soil uniformly using a rototiller or garden spades without destroying medium-sized aggregates. Maintain an untilled area adjacent to the tilled area. Once the soil has been tilled to a "fluffy" consistency, stomp down on half of the tilled area to compact it.
- Irrigate the soil in each of the three areas (untilled, tilled and uncompacted, tilled and compacted) using a garden sprinkler (or using natural rainfall if a storm event is due).
- Observe and comment on the fate of the water (i.e., infiltrates, ponds, runs-off) and, if appropriate, water-transported constituents (such as sediment).

Either create a new garden or work on an existing garden at an elementary, middle, or high school.

This exercise can be performed on soil whose initial moisture content varies, which would provide soil of varying strength and resulting pore size distributions upon compacting. The garden soil exercise can be conducted either in the early fall or mid-spring. A digital camera can be used to take pictures or videos of the water transport during each of the mini-experiments.

- After the initial water transport observations are made, permit the soil to dry and re-till the compacted soil to its formerly fluffy consistency (thus, increasing macroporosity). Observe the differences among water infiltration and storage and runoff or ponding after the addition of more irrigation (or precipitation).

Other options for demonstrating the influences of external factors on the capability of soil to filter water include:

1. siting the garden on slopes of varying degree to demonstrate that water that does not infiltrate into the soil can run off and carry with it potential pollutants (sediment and sediment-attached contaminants);
2. adding varying amounts of organic matter such as compost to the soil to demonstrate how organic matter in soil can increase infiltration and water-holding capacity or storage via its effects on increasing porosity and absorbing water—such compost can be either or incorporated into the tilled soil or placed on top to generate varying effects;

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3. including a food dye in the irrigation water as a surrogate for a pollutant to see how soil can intercept the pollutant and prevent its loss via surface transport.

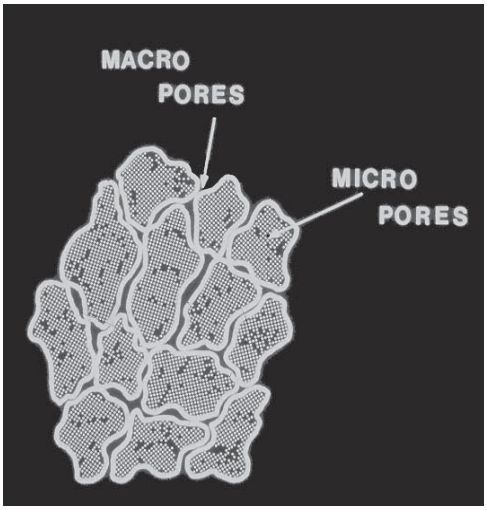
Multiple combinations of such treatments should form the basis for discussion about how interactive factors such as tillage, soil strength, soil moisture, slope, and organic matter can influence the soil's ability to capture and clean water.

These effects of porosity on water infiltration and transport can be demonstrated on a smaller scale by adding soils with different properties (i.e., clayey vs. sandy, compacted vs. uncompacted, organic-matter-amended vs. unamended) onto a screen in a pan. The initial depth of the soil should ideally be at least 4 inches (6 inches is better); the compacted soil would have the same initial mass but be compacted to a smaller volume by reducing the depth. Carefully add the same volume of water to each soil by pouring water through a sieve onto the soil surface to achieve a diffuse coverage and avoid rapid, concentrated point-source flow. Then measure how much water infiltrates through the soils in a given time period. As a slight variation, tilt the pans slightly to increase the slope and see how this changes how much water runs though the soil and how much runs off.

Discussion Questions

The observations and discussion are illustrated by slides of macropores and micropores. Use the digital pictures/videos to facilitate classroom discussion. Key questions to prompt discussion:

1. What factors affect water infiltration, storage, and runoff in soils?
2. How and why do the following factors affect infiltration, storage, runoff?
   a. Surface soil aggregation
   b. Compaction
   c. Porosity—the size and distribution of pores
   d. Landscape slope
   e. Soil texture
   f. Soil organic matter content
3. What kind of pollutants might move in the same way as the food dye in the irrigation water?
4. Discuss the movement and fate of pollutants through vs. over soils
5. From the lessons learned, what practices would you implement or avoid at your homes, schools, etc.?
6. You may wish to have older students watch this video about soil compaction, and discuss how cover crops are an alternative to tillage implements for keeping soil pores: https://www.youtube.com/watch?v=GTUVRieYoZ8&list=PL4J8PxoprpGa3wFYSXFu-BW_mMatleIt0&index=9



1) Macro- and micro-pores illustrated in soil. Water flows more rapidly through the larger macro-pores.

2) Freshly tilled garden with uncompacted soil on left and compacted soil on right after rainfall. Compacted soil shows water ponded on soil surface because macro-pores were compressed into micro-pores, which do not drain water as well.

Additional Resources

http://www.fao.org/ag/ca/training_materials/cd27-english/sm/soil_moisture.pdf

http://passel.unl.edu/pages/informationmodule.php?idinformationmodule=1130447033&topicorder=3&maxto=7

http://extension.oregonstate.edu/polk/sites/default/files/MG_Handouts/ec_1561_improving_garden_soil_with_organic_matter.pdf

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