

SOIL: AN ESSENTIAL RESOURCE

75 MINUTES + TAKE HOME
ASSIGNMENTS
SBI3C, SCH3U,
SVN3M, SBI4U

A high school lesson plan provided by the University of Guelph

Soil connects us. For plants, insects, fungi, and bacteria, soil provides the resources necessary for sustaining life: shelter, food and water. Similarly, for us humans, soil provides essential goods and services such the food we eat and is the first step in filtering municipal drinking water. This lesson demonstrates different soil management strategies used on farms & the direct impacts they can have on the environment.

Curriculum Alignments and Expectations

- Investigate how chemical compounds (e.g., fertilizers, herbicides, pesticides) and physical factors (e.g., amount of sun and water, quality of soil, pH of soil) affect plant growth
- Analyse the origins and cumulative effects of pollutants that enter our water systems (e.g., landfill leachates, agricultural run-off, industrial effluents, chemical spills), and explain how these pollutants affect water quality
- Evaluate a variety of agricultural and forestry practices with respect to their impact on the economy and the environment
- Evaluate some of the human health issues that arise from the impact of human activities on the environment

Learning Objectives

- Learn how soil management can impact soil physical properties and contribute to provide ecological good and services or environmental concerns
- Consider the benefits and risks of different soil management practices on crop yields, soil degradation and water quality
- Understand how soil science research is conducted and how knowledge is applied to find solutions to the problem of soil degradation.

Assessment Strategies and Success Criteria

- Open-ended questions
- Essay assignment
- Group discussion
- Inquiry through experimentation

Cross Curricular Links

- Regional Geography – Patterns of Natural and Human Systems
- Forces of Nature: Physical Processes and Disasters – Human Use of the Physical Environment
- Career Studies – Identifying Trends and Opportunities
- The Environment and Resource Management – The Earth's Ecosystems
- Living in a Sustainable World – Ecosystem Characteristics

Materials

- Two 14-oz tin cans
- Permanent marker
- Two 1-Cup measuring cups
- Hammer & Block of wood
- Plastic grocery bag
- Timer
- Trowel
- Wire drying rack
- Two medium-sized bowls
- Water



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TEACHER NOTES

Begin with an introduction into soil health and ecosystem services. Ask students what they know about soil, and how humans benefit from soil. Can soil be healthy?

Soil is a system with **physical, chemical and biological** components. **“Soil health” refers to the continued capacity for a soil to function as a living ecosystem that sustains plants, animals and humans.** Some ecological goods and services soil provides; food production, and the first step in maintaining clean and safe drinking water for municipalities. Soils have physical, chemical and biologic components that work together to provide these services. Humans can influence soil health with how they manage the land by changing the dynamic soil traits. Inherent soil traits are not able to be influenced by human management, they include texture, colour or depth to bedrock. Dynamic properties, like organic matter content, nutrient concentration or water holding capacity (water infiltration), can be changed to improve or worsen an agricultural soil.

1. Activity 1: Infiltration Test (At home or in-class)

Required Materials: Two 14-oz tin cans, permanent marker, two 1-Cup measuring cups, hammer, block of wood, plastic grocery bag, timer, trowel, wire drying rack, 2 medium-sized bowls

Watch the [video for visual instructions](#).

2. Cut the top and bottom off two 14oz tin cans (consider using a can opener) and, using permanent marker, make a line around the can 2” below the top. Choose two locations to take your samples: ideally one in a garden, and one on a grassed area nearby. Place the can on the ground and the block of wood over top; hammer the can into the ground up to the mark on the middle. Fill the can with 1C of water to soak the ground. Cut a sheet of plastic from a grocery bag and place it over the can. Fill the plastic with 1 cup of water. Remove the plastic, allowing the water to enter the ground, and time how long it takes for the water to infiltrate. Record the time on the observation sheet and repeat. Do the same for the second location.
3. Using a trowel, dig around the cans, and extract the can and soil being careful not to disturb the soil inside. Shave off excess soil on the bottom. Place a wire drying rack on top of two bowls, and place the two soil cores on top of the drying rack above the bowls. Pour another 1-2C of water into each can and allow the water to drain into the bowls below. Record your observations on the observation sheet.
4. Soil from places with more organic matter and less disturbance, like lawns, should have more and clearer water collected than soil from places that have been heavily tilled, like gardens. Soil is not the only thing that can be swept away in erosion. Essential nutrients like phosphorus and nitrogen can also be lost in run-off. When too much nitrogen and phosphorus enter freshwater systems problems such as eutrophication can arise (see next activity).



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5. Explanation of Common Observations

- i. The drainage water is cloudy or muddy:
This may be common with garden soil. Gardens are often subjected to tillage by the gardeners. Tillage breaks up soil aggregates, so individual soil particles are more likely to be carried away from their original location, resulting in the murky water.
- ii. The drainage water is clear:
Lawn grasses are perennial, and their roots help to stabilize the soil and hold it together. Because lawns don't get tilled, the water runs clear because soil aggregates remain intact, and individual soil particles are less likely to be picked up by the water.
- iii. It takes longer for water to infiltrate through soil from gardens than lawns or forests:
If it's taking longer for the water to infiltrate, that means that there are less pathways for water to move through the soil. These pathways are called **macropores**. Macropores are created by roots and soil organisms, and can be destroyed by tillage or compaction. Water that infiltrates slowly and pools on top can quickly leave sloping fields, taking soil and nutrients with it.

6. Activity 2: Is No-Till that Simple?

Have students read the [story of Larry and Marge Dyck from Campden Grain](#). Have them identify the soil management strategies used, as well as each advantage & disadvantage.

Conventional Tillage

Advantages

- Tillage exposes the soil to the air helping it to dry out and warm up so crops can be planted sooner
- Warmer soil temperature means crops begin to grow sooner, potentially more yield and profit
- Breaks up aggregates creating good seed-to-soil contact for better seed germination

Disadvantages

- More time spent preparing for planting, increased fuel costs for equipment
- Destroys pathways made by soil organisms that allow for water filtration
- More susceptible to erosion and nutrient loss from the field

No-Till

Advantages

- Water can infiltrate easier because pathways are preserved
- Aggregates are more strongly held together so if run-off does occur, soil and nutrients are less likely to be taken
- Less time spent doing field preparation for planting

Disadvantages

- Without the right planting equipment, the soil won't crumble around the seed leading to poorer germination
- Crop residues keep the soil wetter and cooler for longer, which delays spring planting and may lead to a lower crop yield and less income
- Farmers may be more dependent on herbicides to kill weeds

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Cover Crops

Advantages

- Add nutrients to soil for future crops
- Increase soil aeration
- Protects the soil from erosion

Disadvantages

- Difficult to find the right one for your field
- Added complexity for planting the following spring

Raising Animals on Farm

Advantages

- Manure application to increase organic matter on farm

Disadvantages

- Expensive to raise multiple types of animals
- Urban neighbours may not be accepting of the smell or noise

Crop Rotation

Advantages

- Rotating crops will ensure that soil is not drained of specific nutrients
- Helps with the need for pesticides

Disadvantages

- Different crops may require different, expensive machinery

7. Soil health is not something that can be improved by using just one management strategy. No-till will not work on every field, but it is an option for some. Other Best Management Practices (BMPs) include using diverse crop rotations, cover crops, and increasing the organic matter content of soil by applying manures and composts.

Farmers are continually innovating new ways

to improve soil health while also providing food for a growing population. Water quality and soil health are uniquely intertwined, and even those living far away from the farms can benefit from improved soil health.

8. Conclude with the idea that we need to make sure that the ecosystem services that soil provides can not only benefit us in the present, but also those 10 or 50 years in the future.

9. Activity 3: Water Quality Protection – Take Home Assignment

Required Materials: water quality protection plans (see additional resources for examples).

Protecting water quality at the source is better for the environment, and often more cost-effective, than trying to treat water after it's been contaminated. The observations made in Activity 1 are similar to what is seen in agroecosystems, though on a much larger scale. Run-off from agricultural fields can contain soil and essential nutrients such as nitrogen and phosphorus. The run-off makes its way from farm fields into nearby surface waters, like creeks and rivers.

In Southwestern Ontario, many smaller rivers and streams converge and eventually empty into Lake Erie, concentrating the eroded soil particles and nutrients from nearby farm fields. High concentrations of nitrogen and phosphorus can trigger algal blooms which use up the oxygen in the water, leading to what's known as eutrophication. Some algae even produce toxins that make it dangerous to drink the water or eat fish from these lakes.

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Reducing soil erosion, and the nutrients lost with it, is one step that can be used to prevent eutrophication from happening.

10. Have the students find their local watershed protection plan and answer one or more of the following questions...

- *What policies, practices and plans exist where you live?*
- *Which (if any) soil management strategies are outlined in this plan?*
- *What changes would you make to the source water protection plan?*
- *How does the Source Water Protection Plan impact your daily life?*

Source Water Protection Plans

Within these links students will be able to find some Source Water Protection Plans, explanatory guides, and yearly reviews.

- [Lake Huron Protection Plan](#)
- [Lake Ontario Protection Plan](#)
- [Lake Erie Protection Plan](#) (4 different plans can be found under “See Plan” button on the home page)
- [Lake Michigan Protection Plan](#)
- [Lake Superior Protection Plan](#)
- [Plans for other areas within Ontario](#)

Additional Resources

- [New Horizons: Ontario’s Agricultural Soil Health and Conservation Strategy](#) (2018). Ontario Ministry of Agriculture, Food and Rural Affairs.
- [Putting Soil Health First: A Climate Smart Idea for Ontario](#) (2016). Environmental Commissioner of Ontario
- [Soil Health Institute. Living Soil Documentary](#) (60 minutes)
- [Soil Science Society of America. Soils Clean and Capture Water](#)
- [SOILS AT GUELPH](#) website
- [Soil and Erosion Demo](#)

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GLOSSARY

Aggregates are soil particles that are bound together by roots, clays, and organic matter. Water and air can still travel through soil aggregates via pores.

Ecological goods and services are the direct economic and cultural benefit provided to humans by ecosystems and nature. For example, soil supports the growth of 90% of the food we eat, and natural areas around streams and creeks can act as flood prevention.

Eutrophication is the creation of a nutrient rich body of water, causing rapid growth of algae or aquatic plants, choking out any life that needs oxygen for respiration.

Macropores are large pores within soil, greater than 0.8mm, often made by roots, earthworms, or other soil biology.

No tillage is the practice of planting crops directly into unmixed soil (also known as “direct seeding”). No-tillage is practiced to reduce erosion by preserving soil structure and keeping crop residues on the soil surface. (see also “Tillage”)

Organic matter is the component of soil made up of carbon-based materials at varying stages of decomposition including dead plants, soil organisms, and the end products of decomposition.

Run-off is water that flows off an agricultural system into surface water systems, bringing nutrients and loose soil along with it.

Soil health is the ability for soil to continue to provide the services that we rely on it for. A healthy soil can grow more crops with fewer inputs, retain more water, and recover from drought quicker.

Tillage is the practice of mixing soil using ploughs, discs, chisels, or other tools. Tillage is practiced to control weeds, incorporate crop residues on the soil surface, and create a fine seedbed to plant into. (see also “No-tillage”)

