STEEPED in SOIL

Activity Book

CANADA

Acknowledgements

Steeped in Soil encourages 4-H'ers to understand and appreciate the importance of healthy soils. This hands-on campaign would not be possible without the commitment of Syngenta, a global agribusiness that has supported 4-H for many years. For more information about Syngenta, please visit **www.syngenta.ca**.

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We would also like to thank our soils advisory panel for providing their expertise and support to ensure the quality and relevancy of the materials contained in this activity guide.

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Dear 4-H Leader(s) and Clubs,

Thank you for participating in 4-H Canada's newest initiative: Steeped in Soil! This program is generously supported by Syngenta, and is meant to increase our members' understanding and appreciation of the important role soils play in our lives.

This year's campaign objectives include:

- Learning about and identifying soils
- Understanding the importance of healthy soils
- Conducting in-the-field activities
- Participating in a nation-wide citizen science experiment

As the foundation for sustainable agriculture and food security, the health of our soils impacts nearly every living thing, and almost everything we eat. Did you know that soil is directly involved in the production of 95% of food worldwide?[i] Encouraging the stewardship of healthy soils also supports the United Nations Sustainable Development Goals, which are global goals all countries are striving to achieve by 2030. In this activity book, we'll dig into some fun ways to learn more about the amazing and essential soil under our feet!

LEARN MORE

The 4-H Canada Leadership Development Pillars are the foundation of our national programming. You can learn more about them here:
www.4-h-canada.ca/programs-and-events

These pillar programs also support the United Nations Sustainable Development Goals, which you can learn more about here:
sustainabledevelopment.un.org/sdgs

Each club will also get to participate in a citizen science activity as part of this initiative. The Steeped in Soils experiment will allow each of your members to participate in a science experiment that will be taking place in clubs across Canada, and will be supporting experiments that are being done around the world! By adding their data and filling in the picture of soil health around the world, 4-Hers will be able to make a real-world impact with this experiment.

Your soils kit includes the following tools:

- Tea bags, electronic scale, and materials to conduct the Steeped in Soils experiment
- pH strips to test different soil samples
- Soil Texture Triangle to determine the texture of different soil samples
- A PowerPoint presentation that you can give to your members before heading outdoors
- This activity book, which is emailed to each participating club, and is available to download from 4-H LEARNS at **www.4-h-learns.org**,

We hope you and your club enjoy this opportunity to understand the importance of soils, learn how to keep our soils healthy, and get dirty!

The Nitty Gritty of Soil

Before we get started with activities, it is good to have some back-'ground' information! This is where we will learn about soils and how to identify different soil types, and why healthy soil is so important for growing the food we need for our environment, and for all life on our planet.

The Basics

Soil is all around us, but where did it come from and how was it made? Soil is formed based on five key factors[ii]:

- **Parent material**: This is the rock that has been worn down, or weathered, over thousands of years to create the mineral matter of the soil. Different types of soil are formed by the weathering of different types of rock. The parent material of a soil might be the bedrock, or rocks left behind by glaciers.
- **Climate**: Temperature and precipitation impact the weathering of the parent material and organic matter.
- **Vegetation and organisms**: Plants break down over time and add nutrients to the soil. Organisms like bacteria, worms, insects, and fungus that live in soil help break everything down even further.
- **Topography**: Whether an area is hilly or flat, and how water and wind move through that area, will affect the formation of soil.
- **Time**: It takes thousands of years (if not millions!) to form soil. Whether this happens slowly or quickly is a key factor in soil formation.

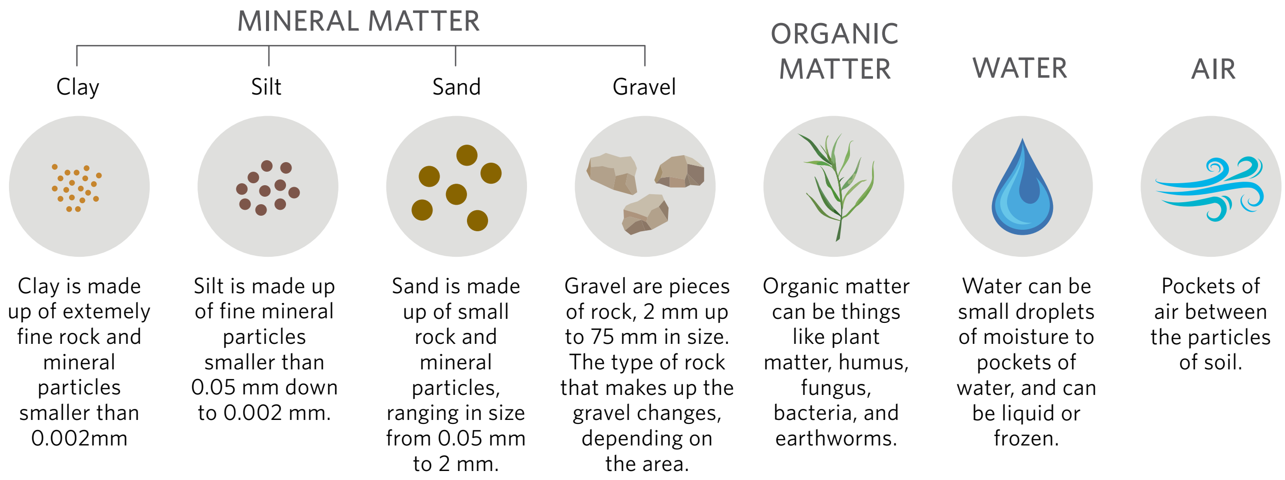
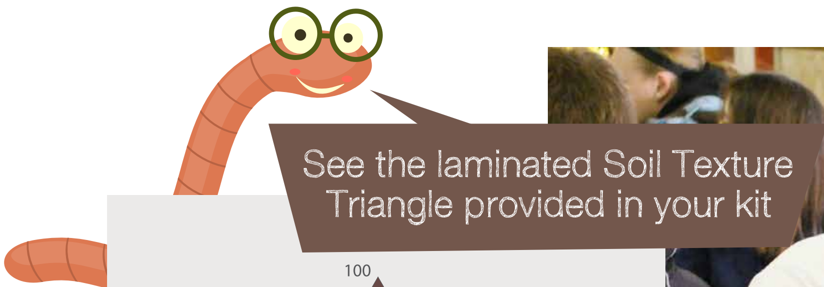


FIGURE 1: Information gathered from **www.ext.colostate.edu/mg/gardennotes/214.pdf**



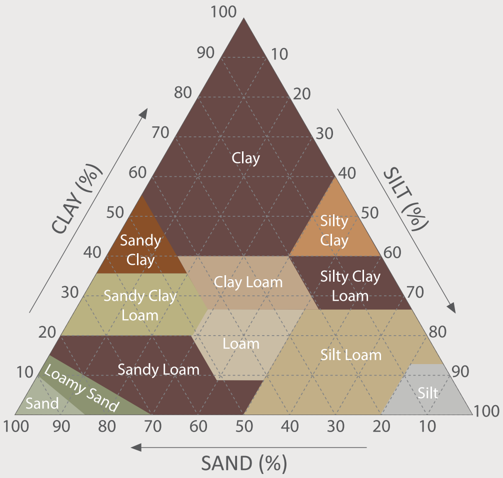


FIGURE 2: Soil Texture Triangle[x]

GO TO the **Let's Dig In! Soil Identification 101** Activity on pg. 14 for more information about the different types of soil and the different types of tests that can be done to identify soils.

All soil is made up of some combination of mineral matter, organic matter, air, and water. Soils can have a mixture of all of these elements, or they may only contain some of these elements (for example, in a desert, water may be lacking, or in compacted soil, the pockets of air may be gone).

Sand, Silt, or Clay?

Soil can have different combinations of sand, silt, and clay. The amounts of each are what determine the type of soil. More clay, less sand, an equal combination of the three—each mixture forms a different type of soil! Gravel can also be part of a soil, but isn't typically used to classify soil.

When looking at the different amounts of sand, silt and clay in a soil, we use a Soil Texture Triangle (**Figure 2**) to make it easier to identify what type of soil we are looking at. You'll notice that "loam" is a word used to describe many types of soil that have a mixture of sand, silt, and clay.

Soil Profile[iii]

Soils are formed by the interaction of the five soil forming factors previously mentioned. The soils that are created by these factors cause different layers to form, which are called soil horizons. They create what is called a soil profile. Soil horizons are identified with different letters, which you can see in **Figure 3**.

You can see an example of what these horizons can look like in real life in **Figure 4**. There are lots of things to think about in a soil profile, including:

- The different types of soils found in each layer – refer to the Soil Texture Triangle in your kit.
- The colours – check out this article about what we can learn from the colour of soil samples: **Soil Color Never Lies**.
- The soil structure—how the soil particles are arranged. Are they loose or packed together?
- Mineral content—testing the mineral content in each layer can tell us about the health of the soil, which you can read more about in the Heath of Our Soils section on pg. 10.
- The thickness of each of these layers—thick or thin, the layers can show signs of erosion (soil being washed away), and how long the soil may have been building up.

All of these things can give us lots of information about the soil's makeup, how the soil was formed, and the relative soil health.

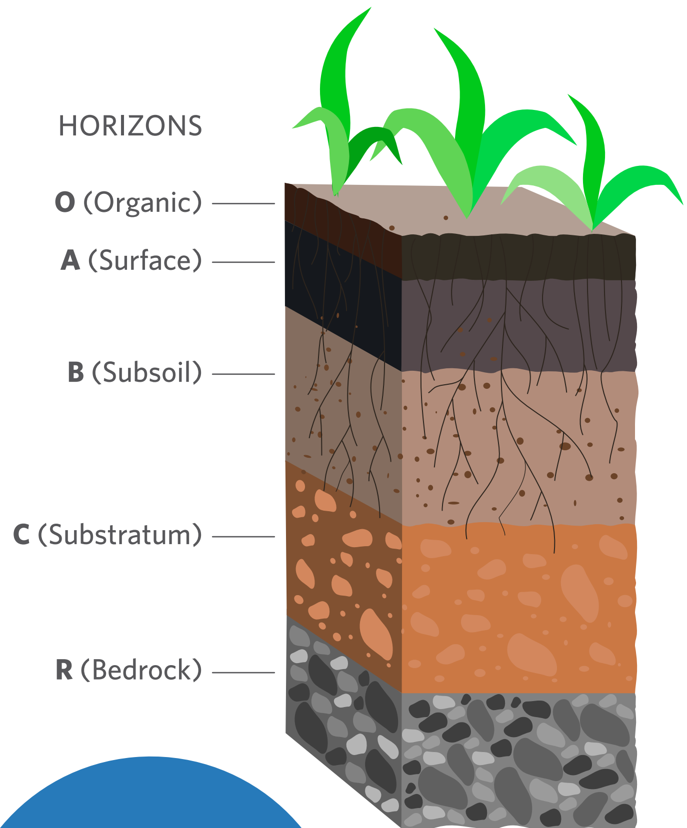


FIGURE 3

FIGURE 4

Horizon O is the top layer of the soil, and is where plants grow, and organic matter starts to break down. The plant cover, or litter, protects the soil below, like a layer of armor, and also helps keeps the soil cool.

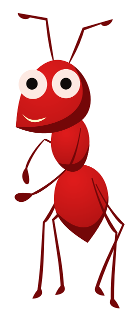
Horizon A is also known as the topsoil, and is where minerals mix with the decomposed organic material.

Horizon B contains the minerals and nutrients draining into it from the layers above.

Horizon C is partly weathered rock, breaking up from the bedrock below.

Horizon R is the bedrock, which is hard and solid. This layer is also called parent material as it was broken to down to form the soil horizons above it, making it 'related' to that soil.

CHECK OUT the Dirt Dessert Activity on pg. 24 for a yummy way to explore soil horizons!



Consider finding a plot of soil you can dig into to have members see the changes in colour, and identify the different layers they find!

STEEPED in SOIL

Did you know that hydrangeas will grow different shades depending on the pH of the soil they are planted in?

Soil pH

The pH of the soil can affect plants' abilities to grow, as it can impact their ability to make use of the nutrients in the soil. Most plants grow in neutral soil (5.5pH-6.5pH), but some prefer more acidic soil, and others more basic soil. Each type of plant can typically grow within a range, but they will be most successful when planted in the ideal soil pH. Farmers will sometimes add lime or carbon to their soil to alter the pH so it is at a level that will support the healthiest crop growth. Check out **Figure 6** for examples of which plants grow best at different pHs!

The pH of the soil tells you how acidic or basic it is. Simply put, pH stands for percentage of hydrogen, and is a measurement of the concentration of hydrogen (H+) that is in a solution. If there is a lot of H+, it is acidic, and if there isn't as much, it is basic. pH is measured on a scale from 1-14, with 1 being the most acidic (for example, battery acid), 14 being the most basic (for example, drain cleaner), and 7 being neutral (for example, water). Check out **Figure 5** for examples of substances along the pH scale.

Soils can be acidic or basic due to the parent material that was worn down to create the soil and/or the environment the soil is in (e.g. amount of runoff, plants growing, and other).

THERE are pH strips included in your kits for you to test soil pH. Follow the instructions in the **pH Preferences Activity** on pg. 21 to test your soil samples!

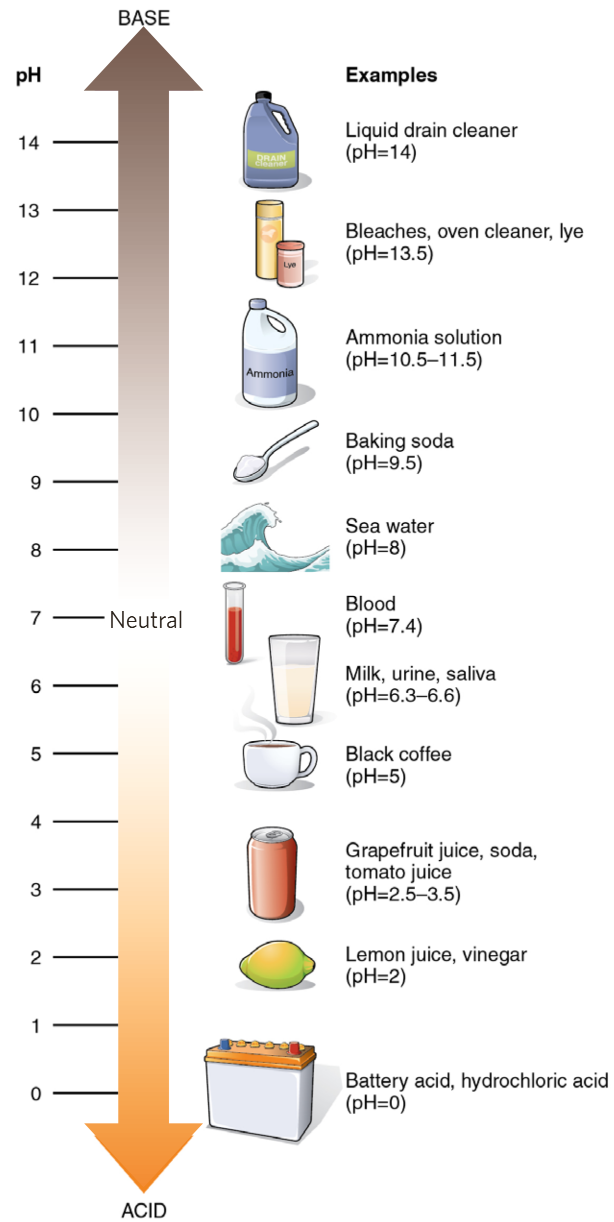


FIGURE 5: pH Scale

ACIDIC OR BASIC?

Basic Soils (pH 6.5-7.0): asparagus, ferns, beets, carrots, eggplant, broccoli, clover, alfalfa.





Neutral Soils (pH 5.5-6.5): most plants (grasses, shrubs, trees), crops (barley, corn, rice, soybeans, wheat), flowers, vegetables, and fruits prefer a neutral soil.



Acidic Soils (pH 4.5-5.5): blueberries, strawberries, radishes, sweet potatoes.

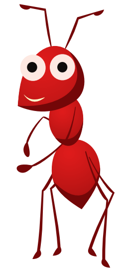



SUSTAINABLE DEVELOPMENT GOALS

2 ZERO HUNGER

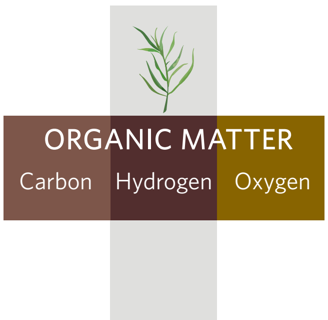
In order to grow enough food to feed 9.8 billion people by 2050, we need to understand how to get the most out of the soil in a sustainable way. What types of soil do the most common crops in Canada need in order to grow their best?

It's alive! A teaspoon of healthy soil has more microbes living in it than there are people on Earth![iii]



The Health of Our Soils

There is a lot going on beneath our feet, with nutrients, earthworms and nematode worms, insects, living microbes, organic matter decaying, and chemical reactions...a dynamic mixture of activity that make our soils healthy! Soil is the foundation for life on Earth, so it is important that we understand how to protect its health.

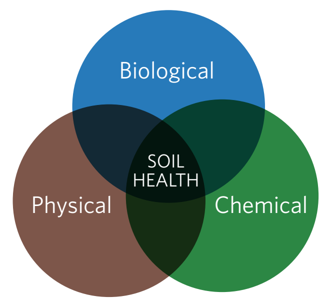


The Big Three

The organic matter in soil—made up of carbon (C), hydrogen (H), and oxygen (O)—is the foundation of soil health. Plants get carbon, hydrogen, and oxygen from the air, and when they decompose they deposit these elements to the soil. Having a high level of organic matter has biological, chemical, and physical benefits.

A Balancing Act

We can figure out the health of soil by examining the physical, chemical, and biological parts of soil and how these three parts interact with each other.[iv] These three parts of the soil are connected to each other and therefore need to be balanced in order to achieve healthy soils.



Biological	Chemical	Physical
• Earthworms • Organic matter • The amount and rate of releasing carbon dioxide (CO_2)—called soil respiration • Nutrients • Total amount of organic carbon in the soil	• Soil pH • Carbon in the soil that can react and be used by plants and microbes • The salts and minerals in the soil	• How the materials making up the soil stick together—called aggregate • How much water the soil can hold • How dense the soil is • How water moves down through the soil—called infiltration • Overall soil structure
WHEN SOILS ARE UNHEALTHY		
• Earthworms and other living things are not found, or are in low numbers • There isn't much organic matter • Soil respiration is too low or too high • Nutrient levels are too low or too high • Uncontrolled growth of particular organisms, such as pathogens and predators	• The pH is too high or low for plants and organisms grow or live • There isn't enough available reactive carbon to support the chemical processes of plant and microbe life • The salt content is too high in the soil and stunts plant growth and ability to absorb water	• The aggregate (how soil sticks together) is weak, and can be easily broken down and washed away by water or wind erosion • Soil can't hold water (runs right through it) • Soil is densely packed—no space for air or water • Water moves very quickly through the soil, or stays on the top and isn't able to soak down into the soil

IN SUMMARY:[v]

- Biologically, organic matter is a food source for organisms, and by having a healthy and diverse soil ecosystem of microbes, diseases and pests are kept in check.
- Physically, the soil structure impacts water filtration and its ability to hold water, and ideally has a strong aggregate with space for air and water.
- Chemically, soil must keep and supply essential nutrients for plants, allow for the decomposition, and buffer changes in pH.

Nutrients in the Soil[vi]

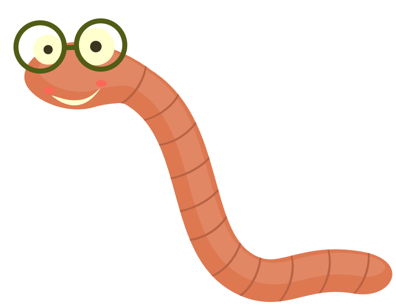
The nutrients found in soil are essential to supporting life on our planet. Three main elements are the most important nutrients for healthy plant growth: nitrogen (N), phosphorus (P), and potassium (K). These are the three common ingredients in fertilizers, and you'll often see NPK on the label. You'll also typically see 10-10-10—which is a fertilizer made up of 10% nitrogen, 10% phosphorus, and 10% potassium.

Nitrogen (N)—Most nitrogen in the soil is unavailable to plants because it is in a form that the plants can't use. Instead, plant roots uptake nitrogen once it bonds with other elements to form minerals (nitrate, ammonium). These minerals are very easily dissolved in water, which means they can move quickly down through the layers of soil. With a changing climate and heavier storms, the water can wash away the usable nitrogen, meaning that the nutrients in the soil can be depleted, and plants won't get the nutrients they need.

Phosphorus (P)—The most common forms of phosphorus in the soil are phosphates. Phosphorus is needed for plant roots to absorb the mineralized nitrogen, and is used at a cellular level in plants to generate energy, grow roots, and develop seeds.

Potassium (K)—Potassium, like nitrogen, is needed in large amounts in the soil in order to support healthy plant growth. Plants use potassium to increase drought and disease tolerance.

Think about a house plant you have at home. Other than water, do you ever give it any kind of "plant food"? What kind of nutrients do you find in that plant food? Can you just give it water? And by giving a house plant more food, will it always grow more?



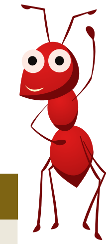
The Nitty Gritty of Soil

December 5 is World Soil Day

In many parts of Canada the soil may be under a blanket of snow on World Soil Day. Think about what is happening to the soil and how you can encourage awareness.

What is happening when the soil is frozen?

- Organic material is decomposing and breaking down
- Gases are being released—more or less depending on the temperature and snow cover
- The soil and snow cover are insulating plants, seeds, and mice, and hibernating species, like beetles, bees, and toads



There are also other elements involved in the health of soil, including calcium (Ca), magnesium (Mg), and sulfur (S), but they are found in much smaller amounts in the soil.

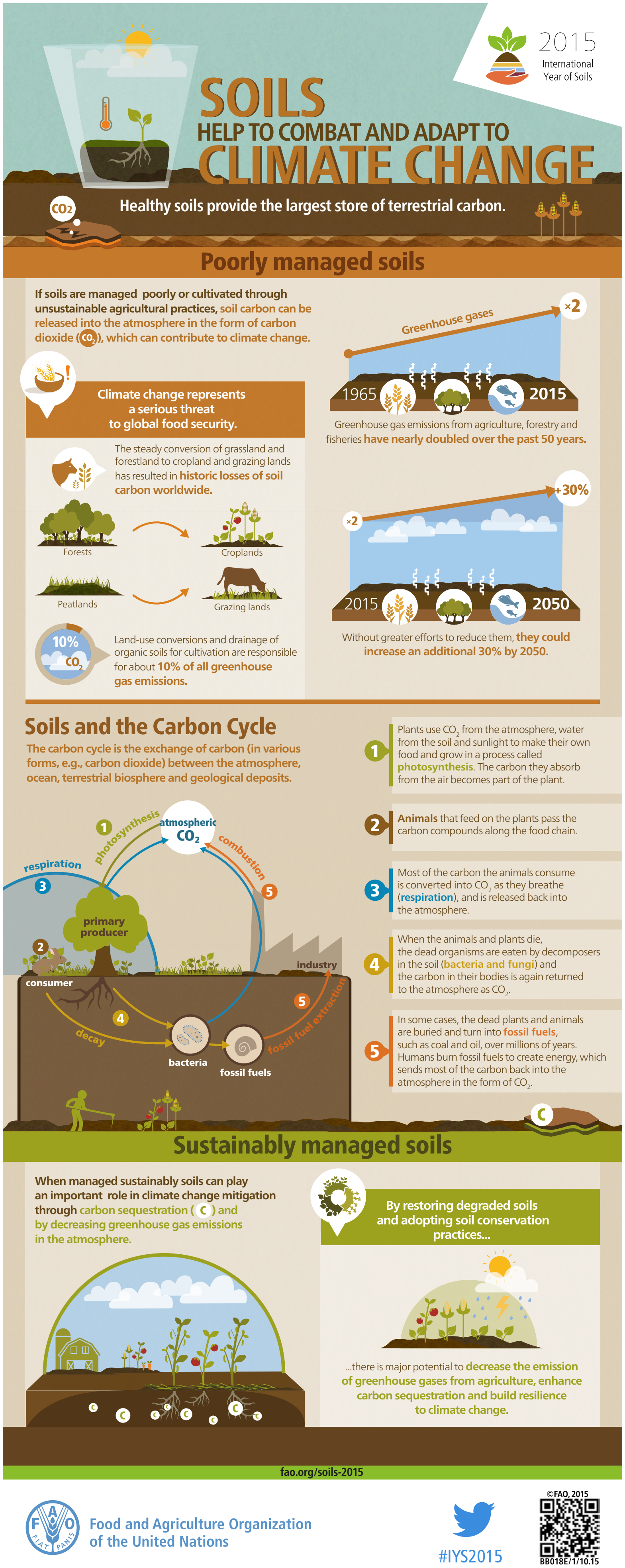
	Nitrogen (N)	**Phosphorus (P)**	**Potassium (K)**
Why is it needed by plants?	Very important in the growth of plant cells and tissues, and the chemicals needed to change sunlight into energy for plants.	Very important in the growth of plants, including changing sunlight into energy for plants.	Very important in the growth of plants, and can help plants resist drought and disease to a certain level.
Code on fertilizer label?	N	P_2O_5	K_2O
Mobility of the nutrient (does it get washed down through the soil easily)?	Can easily be washed away from the soil.	Not mobile in the soil, so it doesn't get washed away.	Can easily be washed away from the soil.
When it is lacking in the soil	Pale green or yellow leaves, and stunted plant growth.	Not as obvious in how it affects crops, but there can be a discolouration.	Browning, yellowing, or curling of leaves.

SUSTAINABLE DEVELOPMENT GOALS

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

The nutrients in the soil are what in turn allow plants to grow. If we continue to take nutrients from the soil, but never replenish them, what will happen? How can we make sure we use our soils sustainably?

STEEPED in SOIL



SUSTAINABLE DEVELOPMENT GOALS

13 CLIMATE ACTION

Carbon and the Carbon Cycle

This infographic is from the Food and Agriculture Organization of the United Nations, from the 2015 International Year of Soils. It explains the importance of carbon in soil.

When soil is poorly managed, and the carbon stored in it is not preserved, it can add to the release of greenhouse gas emissions.

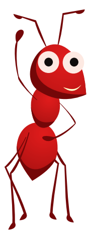
The Carbon Cycle illustrates how carbon cycles through the environment. Plants absorb carbon from the air (carbon dioxide) and it becomes part of the plant. Animals eat the plants, and breathe carbon dioxide back into the atmosphere. When plants and animals decay or deposit waste (for example, leaves, manure), bacteria and fungi break it down and the carbon in their bodies and waste is released into the atmosphere as carbon dioxide, or from the burning of fossil fuels.

When soil is sustainably managed, carbon is stored in the soil and the biomass (the plants and organisms living in the environment), instead of adding to the carbon dioxide in the atmosphere. By managing the carbon in the soil and the biomass, we can reduce the amount of greenhouse gases entering the atmosphere and their impact on our climate.

What are some ways we can protect the carbon stored in the soil? What areas or environments in Canada store the most carbon?

ACTIVITY: Let's Dig In! Soil Identification 101

When working with soil, it is important to know what type of soil you are dealing with. Here are a variety of simple soil identification tests that you and your members can do to figure it out! Try using soil samples from different depths, and from different fields, backyards, and gardens.



Remember: There are three main types of mineral particles found in soil: sand, silt, clay. Sand is the largest particle and is described as having a "coarse" texture (think about the texture of sand at the beach). Clay is the smallest particle and is described as having a "smooth" texture (think about it feeling slippery, sticky, and with no grit, like the clay you might use if you were sculpting something). Silt is the medium sized particle, and is described as having a "medium" texture (think about something between the sand and clay, like a fine grit sand paper).

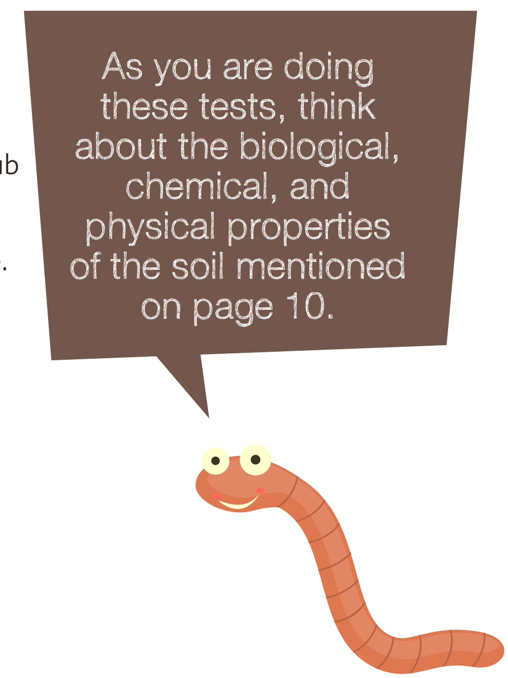
Figure 7 on page 18 gives step-by-step instructions for these tests in a flow chart form.

Feel Test[vii]

This test is really simple and can be used as a general identification test.

1. Take a bit of the soil you are testing, moisten it with a bit of water, and rub it between your fingers.

- If it feels gritty: there is sand in this soil. This soil has a coarse texture.
- If it feels smooth: there is a silt in this soil. This soil has a medium texture.
- If it feels sticky: there is clay in this soil. This soil has a fine texture.



Casting or Squeeze Test

1. Take the soil you are going to test and slightly moisten it.

2. Squeeze the moistened soil in your hand to form a ball.

3. Open your hand and gently poke the soil ball.

- Coarse textured soils (sand or loamy sands) will break with slight pressure.
- Medium texture soils (sandy loams and silt loams) will stay together, but change shape easily.
- Fine textured soils (clayey or clayey loam) will resist breaking, and resemble clay that you may have played with in art class.

Ribbon Test

In this test, you'll get your hands messy and identify the makeup of the soil based on how well it sticks together and produces a 'ribbon'.

1. Squeeze a moistened ball of soil out between thumb and fingers. This will produce a 'ribbon' of soil that squeezes out between your thumb and forefinger.

- Ribbon is less than 2.5 cm
  - Feels gritty = coarse texture (sandy) soil
  - Not gritty feeling = medium texture soil high in silt
- Ribbon is 2.5 cm to 5 cm
  - Feels gritty = medium texture soil
  - Not gritty feeling = fine texture soil
- Ribbon is greater than 5 cm = fine texture (clayey) soil
  - A soil with as little as 20% clay will behave as a clayey soil.
  - A soil needs 45% to over 60% medium to coarse sand to behave as a sandy soil. In a soil with 20% clay and 80% sand, the soil will behave as a clayey soil.

Measurement and the Soil Texture Triangle

In this test, you'll use water to separate your soil sample to figure out how much sand, silt, and clay is in the sample. Please note that this is a test that can take time and be spread over a couple of meetings, so read through the instructions to come up with a plan that is best for your club's meeting schedule.

Figure 6: Measuring soil after it settles in a jar.

1. Spread the soil sample in a thin layer on paper towels or newspaper. Pick out any large clumps, rocks, roots, and leaves. Prepare this ahead of time, or have members set it out one meeting, and come back to it the next meeting.

2. Once the soil sample is dry, break up any remaining clumps to get an even consistency of the soil.

3. Pour the soil into an empty, clear pasta sauce jar, with a lid.

4. Add water until the jar is ¾ full.

5. Put in a teaspoon of powdered, non-foaming dishwasher detergent.

6. Screw on the lid and shake vigorously for 10 to 15 minutes. This shaking breaks up any tiny soil clumps, separating the soil into its different particles (sand, silt, and clay).

7. Soil particles will settle out according to size. After 1 minute, mark on the jar where the particles have settled. This is the depth of the sand.

8. After 2 hours, mark on the jar where the particles have settled. This is depth of the silt.

9. When the water clears, mark this final level on the jar. This is the amount of clay, and typically takes 1-3 days for these clay particles to settle, so the club leader or a senior member could take the jar home and do this measurement for the group.

10. Have everyone record their measurements of the thickness of the sand, silt, and clay layers.

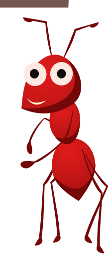
a. Thickness of sand deposit: ______mm

b. Thickness of silt deposit: ______mm

c. Thickness of clay deposit: ______mm

d. Thickness of total deposit: ______mm

Remember: Loam is a type of soil that is a mixture of soil, silt, and clay.



11. Calculate the percentage of sand, silt, and clay. Challenge members to try this math on their own, or have senior members support younger members. Alternatively, do the calculations as a group.

$$\frac{\text{[clay thickness]}}{\text{[total thickness]}} = \_\_\_\_\_ \text{ \% clay}$$

$$\frac{\text{[silt thickness]}}{\text{[total thickness]}} = \_\_\_\_\_ \text{ \% silt}$$

$$\frac{\text{[sand thickness]}}{\text{[total thickness]}} = \_\_\_\_\_ \text{ \% sand}$$

12. Using these percentages, refer to the Soil Texture Triangle in your kit to identify the type of soil.

13. Repeat these steps for each of the different soil samples you are testing.

Sample of calculations:

$$\frac{\text{2 cm of clay}}{\text{10 cm total thickness}} = \text{20\% clay}$$

$$\frac{\text{5 cm of silt}}{\text{10 cm total thickness}} = \text{50\% silt}$$

$$\frac{\text{3 cm of sand}}{\text{10 cm total thickness}} = \text{30\% sand}$$

Using the Soil Texture Triangle, this soil sample would be a silt loam.

Sieving

If you have access to a set of sieves of different sizes, you can filter dry samples by shaking them through the different sieves. You can also make your own with window screening, kitchen sieves, panty hose, fishing nets, or mosquito nets. Get creative and see what you can make!

For example, chicken wire could filter out gravel, window screen could separate the sand, fine plastic mesh could filter the silt, and pantyhose could be fine enough to separate the clay.

The process:

1. Once you've made your set of sieves, arrange them with the largest holes on the top, and the finest sieve on the bottom.

2. Pour your soil sample over the top sieve. The largest particles will remain on top, while the finer particles move through the sieves to the bottom layers.

3. You may have to gently tap the sieves to get your soil sample to get the soil to pass through all of the filters.

Once you've filtered out your soil sample into the different components:

1. Weigh the amount (g) that is filtered out as sand with the digital scale from your kit.

2. Weigh the amount (g) that is filtered out as silt.

3. Weigh the amount (g) that is filtered out as clay.

$$\frac{\text{[clay weight]}}{\text{[total weight]}} = \_\_\_\_\_ \text{ \% clay}$$

$$\frac{\text{[silt weight]}}{\text{[total weight]}} = \_\_\_\_\_ \text{ \% silt}$$

$$\frac{\text{[sand weight]}}{\text{[total weight]}} = \_\_\_\_\_ \text{ \% sand}$$

Using these formulas, compare the percentages to the Soil Texture Triangle to identify the type of soil you have.

CONSIDER WATCHING THIS VIDEO from the Missouri University of Science and Technology for an in-depth look at how to sieve soil samples. While it is at a university level, it will give you an idea of how to conduct this soil test and what you are trying to achieve.

https://www.youtube.com/watch?v=QqxfwpUtEoQ

Soil Test Flow Chart

Consider using this flow chart to walk you through the different tests and help you identify the soil samples you are using.

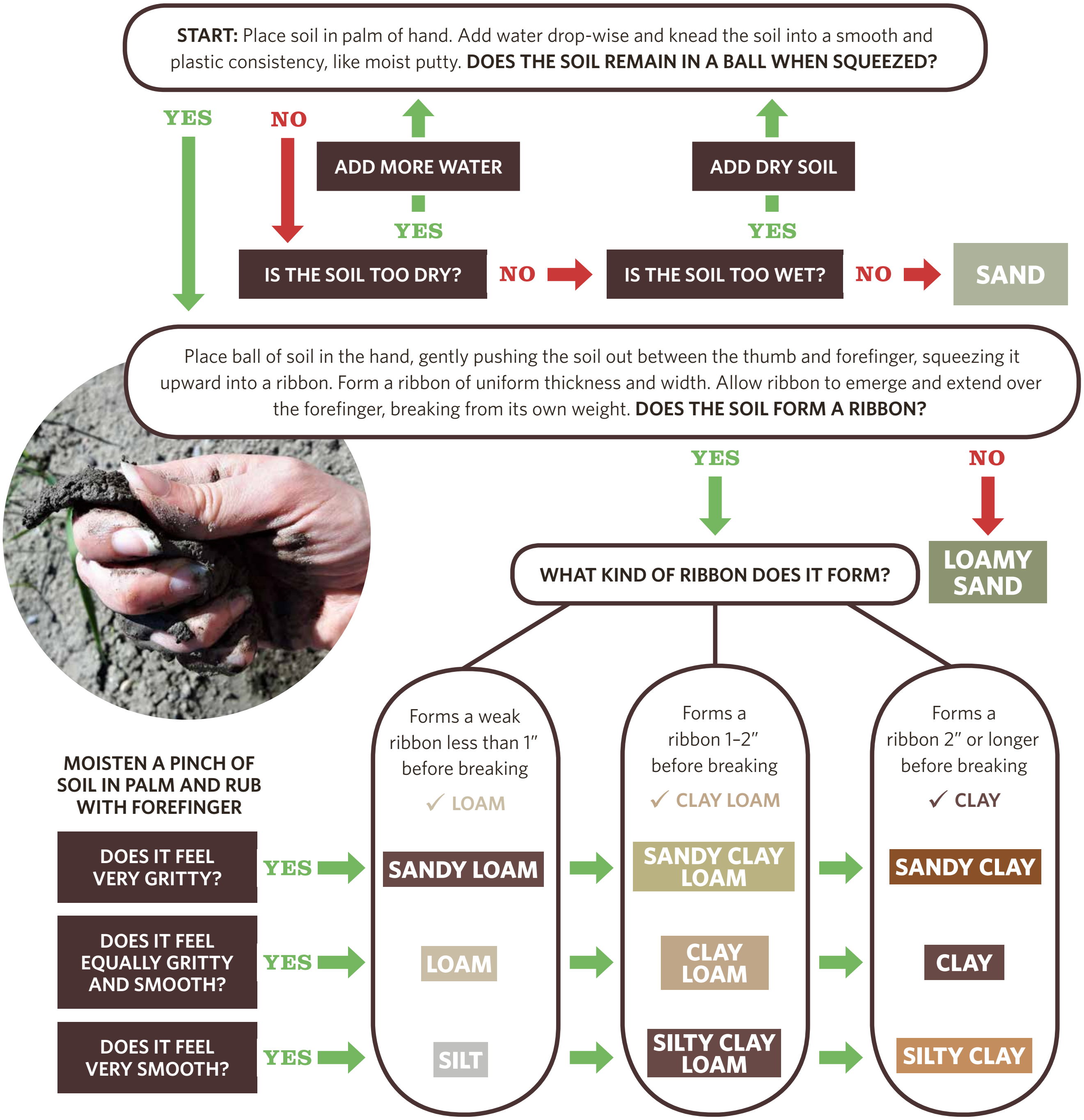


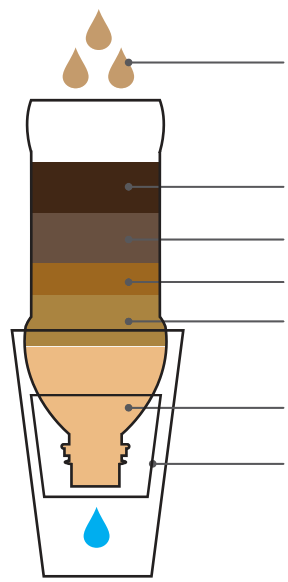
Figure 7: Soil Flow Chart.[viii]

ACTIVITY: Clear As Mud

Soil plays an important role in filtering water, as it trickles down through all of the layers to reach the water table. This activity will show how muddy water can become clear after a journey through soil!

Materials:

- 2 litre pop bottles, with the bottoms cut off—one for each of the filters you want to make
- Yogurt containers that can hold the 2 litre pop bottles
- Coffee filters
- Fine sand or clay (bottom layer)
- Regular sand (next layer)
- Gravel mixed with soil (next layer)
- Potting soil (next layer)
- Leaves, compost, grass (top layer)
- Dirty water—you can make it by adding dirt, leaves, food colouring, or pieces of paper.



Instructions:

1. Turn the pop bottle upside down and place in the yogurt container to keep it upright and steady.

2. First put in the coffee filter. This will represent the super fine particles and compaction that water has to pass through slowly in the real world.

3. Add a layer of fine sand or clay. Then add the regular sand, followed by gravel mixed with soil, potting soil, and topping it off with some grass, leaves, or compost.

4. Carefully give the bottle a couple of firm whacks on your work surface to settle the layers.

5. Mix up your dirty water and slowly pour it over the top layer of your soil filter.

6. Leave it to slowly filter through the layers. This may take a while, so come back to it periodically throughout your meeting.

*Even though the water coming out of the filter might look clean, it is not safe to drink.

Discussion:

- What does the water look like after it passes through the soil filter?
- What would happen if you removed the top layer of grass and leaves? What would happen if you removed one of the other layers? What would happen if you really compacted the soil? Consider redoing the activity to see what water filtration looks like in areas that have lost soil layers due to erosion, compaction, or desertification.
- How might your results change if you simulated a heavy rain storm (dumping in all of the dirty water quickly) or a light rain (sprinkling water on slowly)?
- Could these layers of soil filter out different things like oil? Or fertilizer?

SUSTAINABLE DEVELOPMENT GOALS

6 CLEAN WATER AND SANITATION

In order to have clean water to drink, it takes thousands of years for it to slowly pass through the soil into the groundwater. What can we do to protect soils that act like a filter for the water we drink? What can we do to reduce runoff into clean water?

ACTIVITY: pH Preferences

As mentioned earlier, the pH of the soil tells you how acidic or basic it is. Simply put, pH stands for percentage of hydrogen, and is a measurement of the concentration of hydrogen (H+) is in a solution. If there is a lot of H+, it is acidic, and if there isn't as much, it is basic. pH is measured on a scale from 1-14, with 1 being the most acidic (for example, battery acid), 14 being the most basic (for example, drain cleaner), and 7 being neutral (for example, water). Check out **Figure 4** for an example of the pH scale.

Materials:

- Different types of soil
- Trowel to dig up soils
- pH strips
- Small containers
- Water—test the water with a pH strip first to make sure it as close to pH 7 as possible. If your tap water is too acidic or basic, then consider using bottled water.

Instructions:

1. Head outside to gather different types of soil. Consider having members bring in samples of soil from their homes so you have a wider range of soil environments to test.

2. Put in a few tablespoons of the first type of soil you want to test into a small container.

3. Add water to the container until the soil is covered. Then gently shake or stir the soil until it mixes with the water and makes a soupy, liquid mud.

4. Dip the pH strip into the liquid, pull it out, and shake off any excess bits of soil.

5. Compare the pH strip with the guide on the container to figure out the pH of that soil sample.

6. Repeat steps with the other types of soil.

Discussion:

- What was the pH of each of the soils tests? What would grow well in those soil types?
- Was there a difference between different soil layers (depths) that were tested?
- How could we change the pH of soil? Research how gardeners and farmers are able to change the pH of soil.

ACTIVITY: Wonder Worms!

Worms are little but mighty! They create holes, allowing more air and water to get into the soil. They break down organic material, and their castings (manure) have nutrients that are useful to plant and keep our soils healthy. But which type of soil do worms prefer?

Experiment Ethics: Taking care of these squirmy creatures!

It is important to treat animals involved in our experiments and activities with respect. Worms should be kept in a dark, cool, humid environment until the experiment begins. Wash hands before handling the worms, and handle them gently. When you're done the experiment, put the worms outside in a compost pile or garden soil. And finish by washing your hands again.

Materials:

- Box with a lid so that it is dark inside when closed
  - The corners of the box will be filled with soil. A smaller box will need less of each type of soil; a larger box will need more soil.
- Soils
  - Sand
  - Potting soil
  - Gravel
  - Crushed dead leaves
- Spray bottle of water
- Four bowls
- Worms—sourced from outside or a bait shop

Instructions:[ix]

1. As this is a messy experiment so it's best to do this outside or on a table with a plastic table cover.

2. In the box you're using, take the sand and put enough into the box so that it fills the corner and is deep enough that an earthworm can burrow down into it, but won't touch the other types of soil when you add them in next.

3. Then pour out the sand into a bowl and measure the amount (for example, 500 mL). Measure out the same amount of the three other soils, so that you have the same amount of each type.

4. Taking the sand again, spray it with water, counting each spray, and mix in the water until the sand feels wet, but there aren't puddles of water at the bottom of the bowl. Record the number of sprays it took to get it wet enough.

5. Take the wet sand and put it back into one of the corners of the box.

6. Repeat step 4-5 for the gravel, potting soil, and dead leaves, using the same number of squirts of water for each of these that you used for the sand, and noting which corner each of the different types goes into. Remember, the soils shouldn't be touching each other.

Take this further by checking out these experiments:

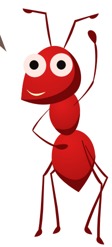
Which food do worms like? **www.sciencebuddies.org/science-fair-projects/project-ideas/Zoo_p064/zoology/earthworm-behavior-food?from=Blog#procedure**

How do worms improve the soil? **www.nuffieldfoundation.org/practical-biology/investigating-response-worms-soil-improvers**

It's not just worms that are active in our soils! Insects, fungi, and bacteria are hard at work to break down plant material, and introduce nutrients back into the soil. Check out the Innovative Farmers Association of Ontario and Soils Conservation Council of Canada's **#SoilYourUndies** experiment to see what happens when you bury a pair of cotton underwear in soil for a couple of months.

Get more information about the experiment here:

www.soilcc.ca/soilsweek/2017/Soil-Your-Undies-Protocol.pdf



7. Add in the other three types of soil, into different corners, noting where each one goes.

8. Put the prepared box in a cool area, or outside—not in direct sunlight.

9. Add the worms to the middle of the box, equal distance from the four different soils in the corner.

10. Observe the worms—their behaviour and where they go—for a couple of minutes, and then put on the lid.

11. Leave the worms in the covered box for 24 hours. Take off the lid and go carefully through each pile of soil to look for the earthworms, moving the soil to another container or an empty part of the box if needed.

12. Keep track of how many earthworms you find in each soil. Record the total number of earthworms you found in each soil.

Discussion:

- Where did the worms initially go? Where did they move to after a couple of minutes?
- Which soils had the most earthworms burrowed into them?
- Which soils had the least number of earthworms?
- What type of soil do you think earthworms like best? Why do you think they like that type of soil the best? It is important to remember that just because an earthworm is found in one of the soils, it doesn't mean that soil is a good, nutritional environment for worms. What other factors, besides a soil containing food, might cause an earthworm to go into the soil that it did?
- How would the earthworms respond if you used different mixtures of soil? Try it and see!
- If worms make our soils healthier, how do we make our soils a healthier home for worms?

SUSTAINABLE DEVELOPMENT GOALS

15 LIFE ON LAND

Soil supports almost all living things. What are some things that you could do to improve the soil environment for organisms like worms, or fungus? Do some research and create a plan for your backyard or garden!

ACTIVITY: Dirt Dessert

Create a yummy treat to illustrate the different layers of soil, with this edible soil horizon profile! This is a great activity to do with younger members, so consider partnering with a Cloverbuds club in your area and do this activity together. Refer to the section on Soil Horizons, pg. 7 for more information.

Materials:

- Large clear glass punch bowl or casserole dish (or clear cups for members to make individual soil profiles)
- Examples of ingredients you could use for the different layers (feel free to use other ingredients!):
  - Whole chocolate cookies, shredded coconut, to represent the litter layer of Horizon O
  - Crushed chocolate cookies to represent Horizon A
  - Crushed graham crackers to represent Horizon B
  - Chocolate pudding to represent clay deposits
  - Rice Krispies, and chocolate 'rock' candy to represent Horizon C
  - Brownies, to represent Horizon R
  - Gummy worms, gummy insects

Instructions:

1. Start the activity by digging a hole outside to show members what the different soil horizons can look like. If that isn't possible, or to supplement what you see in the field, look at different soil profiles online (**Example**).

2. Either working together around a punch bowl, or individually in clear cups, have members design their own soil horizon profile dessert.

Ask them:
a. What will you use for bedrock?
b. What will you use for the different layers of subsoil?
c. What will you use for the top soil?
d. Where might organisms like worms and insects live?

3. Build up the dessert, layer by layer, and look at the layers through the side of the bowl or cups.

4. With a spoon, dig into the dessert, all the way to the bottom layer. Serve, and enjoy all of these delicious layers of 'soil'!

Discussion:

- Challenge members to identify the different soil horizons in the dessert they've created.
- What would happen if before serving, you added milk to simulate rain?
- When you looked outside, or online, why did some of the different soil profiles look like? Why might they be different? What do soil profiles look like around the world?
- How might fun activities like this make people more interested in and aware of the importance of soil?

Brainstorm with your members what other kinds of things they could do that would help to encourage other people to care about soil.

ACTIVITY: Visit a Soil Superhero!

Many people across Canada have dedicated their lives to improving soil health. You can learn a lot from these people and they are often very happy to share their knowledge with you!

Identify a Soil Superhero in your community. Some places to look include:

- Local farmers who are working to improve soil health, decrease erosion, or trying new methods to see what results they get
- Soil Conservation Council of Canada—see if they have someone in your area
- Local soil or environmental conservation organizations, with a focus on research, and agriculture
  - Provincial agriculture offices will likely be able to recommend a group in your area
- College and university soil or agriculture programs
- Gardening experts
- Local science teachers

There are people who are passionate about soil everywhere—you just need to do some digging! Did you find someone who is perfect, but doesn't live in your area? Try having them Skype into your club meeting, and connect via webcam!

Once you've identified someone, invite them to meet with your club to explain what they do and where they work, and to share their knowledge about soils.

The expert may want to come to your club's meeting space to give a presentation, or may want to take your club out to the field to do some hands-on soil exploration. If it can be arranged, an in-the-field visit with an expert is always a great way to incorporate some hands-on learning, and see real examples of the information being discussed. Consider going outside and doing some of the **Let's Dig In! Soil Identification 101** (pg. 14) tests with an expert.

Discussion:

- What kind of things does this Soil Superhero do to protect or learn more about soils?
- Did you learn a lot? What was the coolest thing you learned from the Soil Superhero?
- What is something your members can do to better protect our soils?

Steeped in Soil Experiment

This experiment is an opportunity for members across the country to participate in a citizen science project that is happening around the world! By participating in this experiment, your club will help to map the bacterial activity in soil in your community. This information will help researchers to figure out where carbon is being stored and where soils are healthy, and help to better understand the connection between soil and climate change. Students and other citizen scientists from dozens of different countries have all been participating by gathering soil decay information. This data is being used to make a global soil map. Now 4-H members in Canada have a chance to take part!

This experiment, also called **TeaTime4Science**, was established by the Tea Bag Institute—a research project developed and tested by a team of researchers from the University of Utrecht, Umeå University, The Netherlands Institute of Ecology and the Austrian Agency for Health and Food Safety Ltd., and supported by the European Union.

Overview

Members will be weighing and then burying one green tea bag and one rooibos tea bag in the ground, and leaving the tea bags to decay for three months. Over this time period, the tea will decay, showing what happens to plant material in the soil as it breaks down and returns nutrients to soil, and carbon to the air. The members will then dig up the tea bags and weigh the tea inside to see how much is left. This will show how much decay has taken place.

Background

In the soil, there are decomposers—tiny organisms, earthworms, fungi and bacteria—that eat up the organic matter and turn it into nutrients and soil, and also release gases like carbon dioxide. This gas can be reabsorbed by plants, completing the carbon cycle (learn more about the carbon cycle on pg. 13). However, carbon dioxide is also a 'greenhouse gas'—a gas in the atmosphere that can impact climate change. The microscopic decomposers in the soil are affected by temperature—they break things down more slowly in cold climates and more quickly in warmer climates. This means that in colder climates, less carbon dioxide will be released into the air and more is stored in the soil. By mapping decay around the world, researchers can figure out where carbon is being stored, where soils are healthy, and how this all feeds into the bigger picture of climate change and the health of our planet.

In this experiment, we are using two different types of tea to test decomposer activities: green tea and rooibos tea. These different teas break down at different rates, so we get a better sense of what is happening in the soil when we measure both together and compare the results. Green tea breaks down more quickly, while rooibos tea takes longer to decompose.

DECOMPOSITION

When organic, or plant material is being broken down, the materials that decompose easily are the first to go. In plant matter like these tea leaves, it is the sugars in the plant tissue that break down first. Then the more difficult materials are broken down and the decomposition process continues until what is left isn't decomposable. Have you ever seen a leaf on the ground and all that is left is the vein structure? These are the bits of plant material that are left over when the 'easy' part of decomposition is over. The rest of the leaf will break down over a much longer period of time.

As mentioned before, decomposers are responsible for breaking things down in our soil. While worms play an important role in breaking things down, in our experiment they won't be involved because they can't break through the mesh tea bags. So, this means that it is microorganisms—bacteria and fungi—that will be breaking down the tea.

SO WHY ARE WE USING TWO DIFFERENT TYPES OF TEA?

Imagine you were designing a race between a tortoise and a hare, and before the official race, you wanted to know if the race course was easy, intermediate, or difficult. If you had just the tortoise (or just the hare) test the course, you'd get one set of results. But if you had them both test it, you could compare their results, and it would lead you to one of three conclusions:

1. If the hare and the tortoise finished at the rate you'd expect, it is probably an intermediate race course.

2. If the hare finished really quickly, and the tortoise finished faster than you'd expected, it is probably an easier race course.

3. If the hare took a really long time to finish, and the tortoise was moving even more slowly than you'd expected, it is probably a really difficult race course.

Comparing that example to our tea bags in the soil, we would expect the green tea to be like the hare (breaks down quickly), and the rooibos tea to be like the tortoise (breaks down slowly):

1. If the rooibos and green tea breaks down at the rate we expect, it is probably a soil with active decomposers, working at the rate we expect.

2. If the green tea breaks down very quickly, and the rooibos tea also breaks down more than you'd expect, it is a probably soil with very active decomposers, which means carbon is being released back into the atmosphere more quickly than we'd expect. Things that can speed up decomposition include: heat, moisture, and the presence of more nutrients in the soil.

3. If the green tea breaks down slowly, and the rooibos tea barely breaks down at all, it is probably soil with very inactive or slow decomposers, which means carbon is being stored in the soil and being released back into the atmosphere more slowly than we'd expect. Things that slow down decomposition include: cold, acidity, soil compaction, and drought.

The decomposition rate of the tea bags depends on:

1. *Environmental conditions* (humidity, acidity, the amount of nutrients in the soil, moisture, temperature). These factors affect the activity and health of the microorganisms, and how much food they need.

2. *The chemical properties* of the material that is going to be decomposed (for example, a branch compared to a flower or plastic compared to paper). This is because microorganisms prefer some materials over others. Just like humans, microorganisms love to eat sugar but are not so fond of harder materials like wood.

3. *The types of decomposers in the soil*. Fungi and bacteria all break down the different parts of the plant material at different speeds, as each of them has its own preferences.

www.teatime4science.org/about/background-relevance/

SO, WHAT DOES THIS MEAN?

Soil scientists are looking at the results of this test to see where soils are active, over active, or inactive. Think of it like a teeter totter – too many things on either side will tip the teeter totter, instead of keeping it level. Too much decomposition due to climate change or human activity is not good. Very slow decomposition due to drought or soil compaction isn't good either! And if there was no decomposition at all, the cycle of nutrients would stop and plants would eventually die from lack of food. Around the world, and even across Canada, the soil naturally has different levels of activity. By looking at the decomposition, or activity of our soils, we can help to figure out whether our soils are active in a balanced way or if that activity is becoming unbalanced.

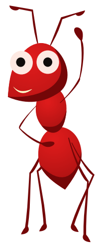
Healthy soils are the foundation of our environment, agriculture, and life itself! By understanding how our soils are decomposing things like tea bags, we can figure out different decomposition rates and how active our soils are. And then, we can use that information to make better choices about how to care for our soils, and support sustainable agriculture and food security around the world!

Materials—provided in your kit

- 20 green tea bags
- 20 rooibos tea bags
- Tongue depressors, to mark the test site
- Electronic scale

Check out the 4-H Canada video of the Steeped in Soil experiment, for an easy-to-follow example of the experiment.

youtu.be/HPFdr_Bq0o4/



Other materials needed

- Copies of the Steeped in Soil Member Tracking Sheet (page 34)
- Trowel or shovel to dig test holes
- Ruler to measure the test hole depth
- Permanent marker to label the tea bags and tongue depressor
- Smart phone or camera to take a picture of the site where you bury the tea bags

Time

2–3 hours over three months

Instructions

1. Distribute the supplies and tracking sheets. Each member or group should get one green tea bag, one rooibos tea bag, tongue depressors to mark the site, and a tracking sheet. All other materials can be shared.

2. Before heading outside, have members weigh each of their tea bags using the electronic scale and record the weight on their tracking sheet.

3. Using a permanent marker, write a G for green (or R for the rooibos tea bags) on the label to make it easier to identify the bag after it decays.

4. Have your members go outside, where you will be burying the tea bags. Using a smart phone, or Google Maps after the fact, note the GPS coordinates of where you are (latitude, longitude; for example, 45.385560, -75.708913) on the tracking sheet

- Consider having members bury their tea bags at home, so that you can gather results from a wider range of soil environments. For example, examine wet vs. dry soils, or compare a forest, lawn, and field.
- If you have fewer than 20 members, have your members bury more than one pair (one green, one rooibos) of tea bags in different locations. If you have more than 20 members, have them work together to decide where they want to bury their tea bags.

5. Dig a narrow hole 8 cm deep, trying not to disturb much of the soil around the hole. Bury one green tea bag, keeping the tag above the soil. Mark with a tongue depressor.

- Consider brightly decorating your tongue depressors ahead of time to make them easier to find three months later.

6. 15 cm away from this hole, dig a second 8 cm deep hole, and bury one rooibos tea bag, keeping the tag above the soil. Mark with a tongue depressor and take a picture to help you recover the bags in a few months.

7. Following the tracking sheet provided, record the date you buried the tea bags, where you buried the tea bags, what the environment is like, and other observations.

8. Repeat steps 2-6 with all of the remaining pairs (1 green, 1 rooibos) of tea bags.

9. Now, be patient and wait three months! Have members mark their calendars, send out a reminder, or plan a club meeting for this date so that you all remember to dig up the tea bags.

10. After approximately 90 days, go back to your different test sites and dig up the tea bags. Refer to your photo or the GPS coordinates if you need to. Record the date you do this, so you know exactly when your experiment ended. It doesn't have to be exactly 90 days—as long as you record when your experiment starts and ends, you can be out by 5-14 days.

11. Once you've dug up the green and rooibos tea bags from a test site, you need to remove any of the soil sticking to the bags, and dry them out. Start by gently knocking off any larger clumps of soil on the outside of the bag (do not wet the tea bag in an effort to remove the soil). Then dry them out by putting them in direct sun, or over a heater for 3-4 days.

12. Once dry, gently tear open the green tea bag and tap out the tea leaves onto the electronic scale. Record the weight.

13. Repeat step 11 with the rooibos tea bag.

14. Repeat steps 9-12 at all of the other sites where you buried tea bags.

15. The tea bags should be treated as garbage after the experiment. Make sure all tea bag material (including the string and label) are picked up from the burial places and put into waste after the experiment. Remember that these tea bags can't be put in a compost since they won't decompose.

16. Share your results:

1. Compile all of your members' tracking sheets in the spreadsheet that was included in your Steeped in Soil digital resource download. Click here if you need to download it again: **www.dropbox.com/sh/6j1aj0cdilz7fdc/AACw-mnXc9nF8U8xqfHwtpH3a?dl=0**
2. Email your club tracking spreadsheet to **mfound@4-h-canada.ca**
3. See the map of data points of this global experiment here: **www.teatime4science.org/data/map/**

Resources

Syngenta www4.syngenta.com/who-we-are/about-our-business/our-stories/climate-smart-soils

Soil Conservation Council of Canada www.soilcc.ca/resources.htm

Canadian Soil Information Service sis.agr.gc.ca/cansis/

International Year of Soils 2015, Food and Agriculture Organization of the United Nations www.fao.org/soils-2015/resources/information-material/en/

Nutrients for Life www.nutrientsforlife.ca/learning-materials/download-resources/middle-school/

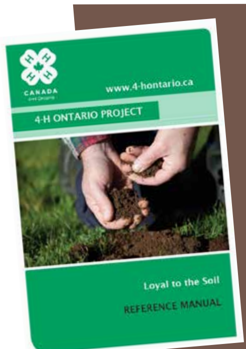
Soils of Canada www.soilsofcanada.ca/

Soil Health Institute Resources soilhealthinstitute.org/resources/

TeaTime4Science www.teatime4science.org/

United States Department of Agriculture, Soil Quality Indicator Sheets www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/health/assessment/?cid=stelprdb1237387

United Nations Sustainable Development Goals sustainabledevelopment.un.org/sdgs



Interested in digging even deeper into the topic of soils with your club?

Check out 4-H Ontario's *Loyal to the Soil* project, which was launched in 2017 and is a full, year-long project your club could undertake. Contact your provincial office for more information about how to obtain a copy.

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viii. Soil Flow Chart. http://www.ext.colostate.edu/mg/gardennotes/214.pdf

ix. https://www.sciencebuddies.org/science-fair-projects/project-ideas/Zoo_p061/zoology/which-soil-type-do-earthworms-like-best#procedure

x. By Mikenorton (Own work) [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons. https://commons.wikimedia.org/wiki/File%3ASoilTexture_USDA.png

xi. Tea4Science. Soil Lessons: Soil Science Society America. http://www.soils4teachers.org/files/s4t/lessons/lesson-plan--tea4science.pdf

xii. http://www.agr.gc.ca/eng/news/scientific-achievements-in-agriculture/agro-ecosystem-productivity-and-health/soil-activity-in-winter-soil-doesn-t-sleep-under-its-blanket-of-snow/?id=1417701649928

PHOTOS:

Figure 1: Diagram by Em Dash Design, illustrations © Shutterstock (information from: www.ext.colostate.edu/mg/gardennotes/214.pdf)

Figure 2: Soil Texture Triangle. By Mikenorton (Own work) [CC BY-SA 3. (https://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons. https://commons.wikimedia.org/wiki/File%3ASoilTexture_USDA.png, image © Shutterstock

Figure 3: Soil Horizons illustration © Shutterstock

Figure 4: Soil Horizons image. Radosław Drożdżewski (Zwiadowca21) (Own work) [CC BY-SA 3.0 https://upload.wikimedia.org/wikipedia/commons/0/02/Profil_glebowy.jpg

Hydrangea: By Thomas Dyrehauge (http://bloomit.dk) [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia Commons. https://commons.wikimedia.org/wiki/File%3AHydrangea-flower.jpg

Figure 5: pH Scale

Blueberries: By PhreddieH3 at English Wikipedia (Transferred from en.wikipedia to Commons.) [Public domain], via Wikimedia Commons. https://commons.wikimedia.org/wiki/File%3APattsBlueberries.jpg

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Ferns: fir0002 | flagstaffotos.com.au [GFDL 1.2 (http://www.gnu.org/licenses/old-licenses/fdl-1.2.html)], via Wikimedia Commons. https://commons.wikimedia.org/wiki/File%3AFerns_at_melb_botanical_gardens.jpg

Beets: By Diógenes el Filósofo (Own work) [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons. https://commons.wikimedia.org/wiki/File%3ABetabel.JPG

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Alfalfa: Gary D Robson [GFDL (http://www.gnu.org/copyleft/fdl.html) or CC-BY-SA-3.0 (http://creativecommons.org/licenses/by-sa/3.0/)], via Wikimedia Commons. https://upload.wikimedia.org/wikipedia/commons/e/ef/Alfalfa_round_bales.jpg

Soil Sieve. http://civilblog.org/2013/05/14/sieve-analysis-of-soil-is-2720-part-4-1985/

Figure 6: https://www.todayshomeowner.com/diy-soil-texture-test-for-your-yard/

Leaf: Figure 7: https://goo.gl/images/oS4v4L

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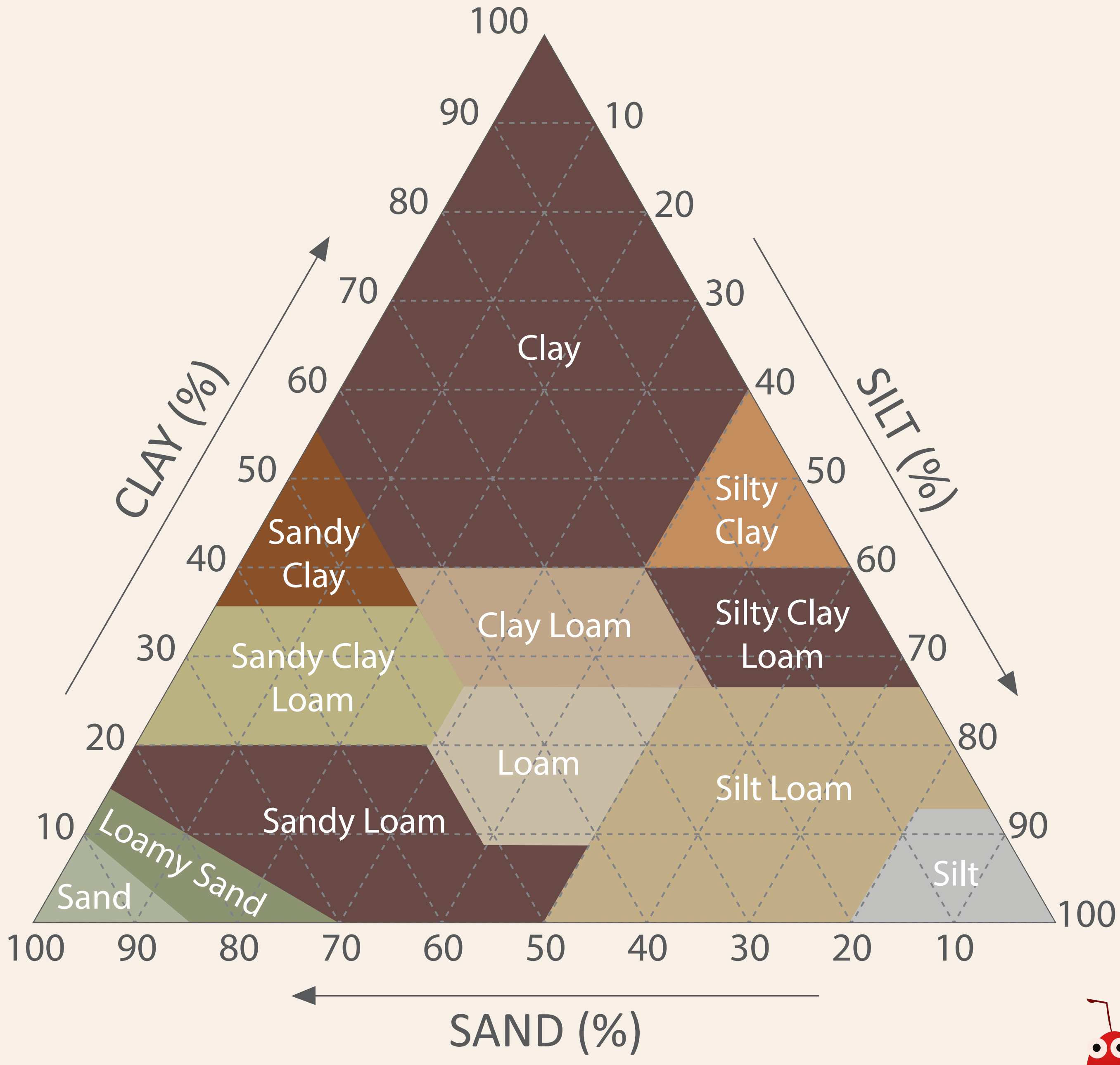
SOIL TEXTURAL TRIANGLE



To classify the texture of a soil sample, use this diagram. Soil texture is made up of the proportion of the three different components: **SILT**, **SAND**, and **CLAY**. Follow to find the name for the soil type.

FOR EXAMPLE: If the soil sample is made of 60% sand, 10% clay and 90% silt, find 60% along the side of the triangle marked "Sand". Then find 10% along the side of the triangle marked "Clay". Follow the lines from 60% Sand and 10% Clay and where they intersect, you will find the soil type: sandy loam.

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Learn To Do By Doing

Steeped In Soil

MEMBER TRACKING SHEET

Your name: ____

Location: Latitude:____________ Longitude: ____________

Date you buried the tea bags (yyyy-mm-dd): ________/_____/_____

Date you recovered the tea bags (yyyy-mm-dd): ________/_____/_____

Initial weight of green tea: ____________ g **Initial weight of rooibos tea:** ____________ g

Final weight green tea: ____________ g **Final weight rooibos tea:** ____________ g

Shading of the soil (no shade, little shade, shaded half of the day, shaded most of the day, always shaded):

____

Human Impact (no impact, little impact, reasonable impact, strongly impacted, soil completely disturbed):

____

Average air temperature during the period the tea was buried: ____________ °C

Soil texture (sand, silt, clay): ______________________________

Vegetation type (crop, grass, lake, wetland, urban, deciduous forest, evergreen forest): ______________

Ground cover (grass, leaves, gravel, plants, no cover): ______________________

Moisture in the soil (dry, damp, wet): ______________________________

Depth that the tea bags were buried at: ____________ cm

Depth of roots in this soil: ____________ cm

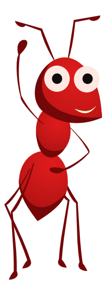
Comments about this experiment: ______________________________

____

____

____

____



National Soil Conservation Week

During the third week of April each year, the Soil Conservation Council of Canada promotes soil conservation awareness, encouraging Canadians to not treat soil like dirt and to actively work to keep our soils healthy.

How will your club celebrate National Soil Conservation Week?

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Notes

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