Soil and Slope

Get the dirt on your dirt with these soil science investigations

Gardening Connection:
Gardening provides an excellent hands-on opportunity to introduce soil science.

Time Required:

3 class periods

Grade Level:

Upper Elementary – High School

EDUCATOR NOTE:
Your county's Conservation District, Master Gardeners Program, or Extension Agent may be good resources for help with soil activities.

OBJECTIVES

Students will be able to:

1. Define & measure slope, percolation, and pH
2. Identify clay, sand, and silt soil particles
3. Collect soil samples and conduct soil investigations

Subjects

Biology / Botany
Math

Vocabulary

Percolation
pH
Slope

Project Connections

WET - The Pucker Effect
Just Passing Through
PLT - Water Wonders
Soil Stories

BACKGROUND

Soil:
The health and composition of your garden soil is a significant factor in determining what plants you will be able to grow and whether those plants will thrive.

Healthy soil is a mixture of organic and inorganic matter, living things, space, and water. Its nutrient-content and composition affect the health of garden plants. The inorganic components consist of weathered rock, water, air, and minerals. The organic matter, which becomes humus, comes from decomposing plants, animals, and manure. Air and water fill the spaces between the organic and inorganic particles.

Soil contains different sized pieces, or particles. Scientists classify soils by the proportion of these particles. Sand, silt, and clay make up three of the different particle sizes.

Clay is the smallest particle. Soils with high clay content are tightly packed with little or no spaces between the particles. With few spaces to hold air or water or for roots to penetrate, soils high in clay content are not conducive to growing plants. Soils that contain mostly sand, the largest particle size, are also not well-suited for growing. Water drains easily through the large spaces of sandy soil, making it just as unsuitable for plant growth. Silt particles are smaller than sand, but larger than clay and give soil a good texture. Loam soils are a combination of sand, silt, and clay. They are optimal for most plant growth because this mixture of soil contains some spaces between particles, allowing for proper water drainage, moisture retention, and air retention for plant roots and microorganisms living in the soil.

Percolation:
When discussing soil, geology, and school gardens, percolation is defined as the movement of water through the pores in soil or permeable rock. The percolation rate is how fast (or slow) water moves through the pores in soil or permeable rock and depends on the composition of that soil.

Percolation rate of the soil is an important factor to consider in a school garden because most plants require "well-drained" soil. This is soil in which water passes quickly after a rainfall or watering, but still holds nutrients. If water moves too quickly through soil, the plants may not be able to absorb the water (and nutrients) they need. If water moves to slowly through soil, soil remains soggy. Soggy soil means soggy roots which can result in root rot and wilted plants. Soil is considered well-drained if it drains one to two inches every hour (this activity includes a percolation test to determine if the area is well-drained).

The best well-drained garden soils, or loams, have a mix of large particles including organic matter and sand with smaller particles of clay and silt. This combination allows water to pass through quickly but holds nutrients and moisture needed by plants. Sandy soil is well-drained, but water moves through it too quickly and it doesn't hold many nutrients. It can drain one to two inches in as few as 10 minutes. Clay soils hold nutrients but are most often poorly drained. It can take much longer than an hour, even days, to drain an inch or two. Whether it takes less than 10 minutes or more than an hour, soil drainage can be improved by adding organic matter.

pH:
pH is a measure of how acidic or basic something is. It is measured on a scale of 0 to 14. Things are considered acidic if their pH is between 0 and 7; something is considered basic if its pH is between 7 and 14. The pH of soil is important because it affects how nutrients are absorbed by plants. Many plants grow best in soil that is slightly acidic to neutral. The most common Kansas garden vegetables will require soil pH of five to seven. Soil that is too acidic can be toxic to some plants. Soil pH can sometimes be identified by appearance either looking at the types of plants growing or examining soil layers. With very acidic soils, there is little incorporation of the organic surface layer into the other, mineral layers of the soil.

Most school gardens will be reclaiming land that was yard or playground and no longer covered in native vegetation. A soil pH kit, sending a sample to the local extension service, or a simple do-it-yourself test can assess pH with varying degrees of accuracy. Acidity can be reduced (or the pH *raised*) by adding a lime amendment to the soil. pH can be lowered in basic soils (to make the soil more neutral or acidic) by incorporating compost.

Slope:
The incline of an area of land is its slope. Slope affects drainage, stability, and erosion and is an important component in garden design. Water from rain and watering events is not absorbed by soil on steep slopes because it rolls quickly downhill. There is also a greater chance for erosion by this water moving quickly across the surface. The slope of a plot of land is generally expressed as a percentage. This activity includes an activity and a conversion table for determining the slope of an area of land.

It is important to know the percolation rate, pH, and slope of your soil. It is also important to know the requirements of the plants selected for the garden.

MATERIALS

- Baking soda
- Hand trowels
- Soil sample examples of sand, silt, and clay
- Tin can with both lids removed
- Jars – baby food and pint
- Measuring sticks
- Measuring cups
- Ruler
- String
- Vinegar
- Baking Powder
- Food Coloring
- Water
- One 20 gallon clear plastic tub filled with 6 basketballs
- One 5 gallon clear plastic tub filled with 10-15 soft balls
- One shoebox size clear plastic tub filled with 20 golf balls

PROCEDURES

Engage

Slope: Have students imagine that they are going on a picnic and need to find a location to eat. What are some things they would look for?

Ask students if they would want to have their picnic on a hill and allow them to expand on some of the possible issues with eating on a hill. Their list may include having trouble sitting on the hill, their food sliding off plates, and drinks tipping over.

Have students think about what would happen if someone spilled their drink on the ground above the picnic blanket and share their thoughts. Tell students that the several factors would affect the spilled drink. These include the composition of the soil, the soil's percolation rate, and the slope of the hill. These factors, in addition to the groundcover, would affect whether the spilled drink would be absorbed into the ground or quickly run down the hill. These factors also affect plants that are rooted in the soil.

Soil: Introduce the concept of soil types. Soil contains different sized pieces, or particles. Scientists classify soils by the proportion of these particles. Sand, silt, and clay make up three of the different particle sizes.

Common Soil Textures				
Particle Size	Feel	Nutrient Holding Capacity	Air Space	H20 Availability
Sand 2.0 - .05mm	Gritty	Low	Many Large	Low
Silt .05mm - .002mm	Smooth	Medium	Many Fair/Small	Good
Clay <.002mm	Sticky	High	Few Tiny	Slow Movement of Water

To demonstrate the differences in particle size between sand, silt and clay, use a basketball to represent sand, a softball to represent silt, and a golf ball to represent clay. Each ball represents just one particle of either sand, silt or clay. Fill three clear plastic tubs with basketballs, softballs, and golf balls. Have students compare and contrast the amount of space between the balls (representing air space between soil particles). Explain that the best garden soils (loam) have a mixture of sand, silt, and clay. This can be represented by putting some of all three types of balls into one tub. For more information about the characteristics of loam soil, see resources section.

Explore
Soil Composition
Divide students into small groups and take them outside to collect soil samples. Assign at least one group to collect their soil sample from the proposed garden location.

Have each group collect 100 ml of dry soil. Put each soil sample into a jar and slowly add water until the soil is covered by two inches. Place the lid back on the jar securely. Have students take turns shaking the jar vigorously for several minutes. Ask students to share their predictions of what will happen in the jars.

Allow the jars to settle for at least two hours before observing.

Have students make observations of their jars after the soil sample has settled. What happened? Were their predictions correct? What does this tell them about their soil sample? Observing the layers created by the settling soil sample is a useful way to learn about the composition of the soil.

The larger the particle, the faster it settles. These particles reach the bottom first and form the lowest layer. The next layer is formed by the next largest particles form the next layer up and so on. Gravel would settle out first, followed by sand, silt, and clay. Humus usually settles out last or even makes up a layer of "floaties" because it contains dead leaves or sticks which contain a lot of air. The air makes the leaves and sticks lighter and they will float until they soak up enough water to weigh them down.

Explain
Part I
Soil Composition and Percolation
Explain to the group that soil composition also affects the percolation rate, or how quickly soil absorbs water.

Ask students to think about why it is important for soil to absorb water and have them share their ideas. If water is unable to penetrate or move through soil at all, plants get no water and are also not able to absorb nutrients that are dissolved in water.

If water moves too quickly through soil, the plants may not be able to absorb the water (and nutrients) they need. If water moves to slowly through soil, soil remains soggy. Soggy soil means soggy roots which can cause plants to wilt or the roots to rot.

Ask students to think about sandy soils and predict how water percolates through soil of this type. Sandy soil is well-drained, but water moves through it too quickly and it doesn't hold many nutrients. It drains quickly, sometimes in a matter of minutes.

Ask students to think about clay and make predictions. Clay soils are bound very tightly and hold nutrients but are most often poorly drained. Clay soils take much longer, even days, to drain.

Well-drained garden soils, or loams, have a mix of large particles including organic matter and sand with smaller particles of clay and silt. This combination allows water to pass through quickly but holds nutrients and moisture needed by plants.

Direct students back to the jars of water and soil samples. Observe the sample(s) that came from the (proposed) garden site. Have students predict the percolation rate of the garden soil.

Part II
Percolation Investigation
Select a location in the (proposed) garden location. A simple tin can with both ends removed can be used for this investigation. Press the can into the ground; it may be necessary to place a board over the top of the can and gently tap it into the ground with a hammer or mallet). Remove any soil from inside the can.

Place a ruler into the can and fill it with five inches of water. Create a data table and record how much water has percolated into the soil in ten minute intervals. Continue until the water has completely percolated into the soil.

Percolation rates can be converted into rate / hour by multiplying the number of inches the water has dropped in a ten-minute period by six. For example, if the water in the can drops .25" in ten minutes, the rate would be 1.5" / hour. A percolation rate of one to two inches per hour is optimum for most vegetables.

If the water disappears very slowly during the observation period, ask students what might be the reason for the slow percolation. Possibilities include that the soil is already saturated; the soil is comprised mostly of clay; there is a layer of rock close to the surface of the ground. If the soil has a high sand content, it will drain very quickly.

Variation for younger students:
Dig a hole in the (proposed) garden site approximately six inches deep and twelve inches wide. Fill the hole with water. When the hole has drained, fill it a second time.

Watch how quickly the water drains from the hole the second time and document when the water has been absorbed completely. Remind students that soils that are too sandy will drain quickly, sometimes in as little as 10 minutes. Soil that has too much clay will drain very slowly – and may not drain for a day or more. Well-drained soils should take approximately 30 minutes to drain using this hole-method.

Elaborate
Students can do additional soil investigations as they explore their garden site. Two investigations related to the soil and physical location of the garden site include determining pH and slope.

pH:
Ask students what they know about pH. Tell them that pH measures the acidity or alkalinity of a soil – is soil acidic or basic(alkaline).

Draw a horizontal line on the chalkboard with a 0 on the far left, a 7 in the middle, and a 14 on the far right. Tell students that the scale for measuring pH is 0 to 14 with 7 being neutral.

As you would label a timeline, write "pure, distilled water" at 7. Fill in the chart with other items that the students can relate to: lemon juice (pH of 2), bleach (pH of 13), milk of magnesia (ph of 10), and tomato juice (pH of 4).

Share with students that the pH of soil is important because it affects how nutrients are absorbed by plants. Many plants grow best in soil that is slightly acidic to neutral, and most of the common vegetables that will grow in the school garden will require soil pH of five to seven.

Fill in the chart with some common plants. Plants that benefit from a pH in the 4.0 – 5.0 range include blueberries and cranberries, spruce and pine trees, and ferns. Plants benefiting from pH in the 5.0 – 5.5 range include potatoes, sweet potatoes, and radishes. Beans and carrots prefer pH of 5.6 – 6.0, while broccoli, cabbage, sweet peas, lettuce, pumpkins, onions, and melons all thrive in a pH of 6.0 – 7.0.

Using a sample of soil from the (proposed) garden site, have students place a one-fourth cup scoop into a glass bowl. Add one-half cup of vinegar. Alkaline or basic soils will bubble or fizz with the addition of the vinegar.

If nothing happens, scoop a fresh one-fourth cup sample into a second glass bowl. Add one-half cup of water to the sample and stir. Then add one-half cup of baking soda. If the soil bubbles of fizzes, it is highly acidic.

If nothing happens, the soil is most likely in mid-ranges of the scale. For truly accurate pH results, have students send a soil sample to the local extension office for testing. A soil testing kit with a pH test can also be used.

Slope:
Ask students to think about their picnic scenario and the spilled drink. They have already learned about percolation and the composition of the soil, but remind them that there were other factors that affected what would happen to the spilled liquid. One of those factors was the slope of the hill.

Tell students that the slope of an area is its incline or how steep it is. Since water flows downhill, slope affects things like drainage and direction of water flow and erosion. The slope of a plot of land is generally expressed as a percentage. Tell students that they will be learning how to determine the slope and expressing it as a percentage.

Take students to the (proposed) garden site (or have them conduct this activity in groups around the school yard at areas of varying slopes). Provide each group with string and meter sticks, a baby food jar filled with colored water and a level line (mark where the water is in the jar when the jar is on a flat

surface – this jar will serve as the group's level), and a 50 – 100" measuring stick. Give the following instructions to each group:

1. Place one end of the long (50 – 100") stick on the slope you want to measure.
2. Have one group member hold the stick level.
3. Have one group member hold the baby food jar on the stick.
4. Raise or lower the stick until the water in the jar is level with the level line.
5. Have a member of the group measure (with the string or measure stick) the number of inches above ground that the end of the stick is.

The students will be creating a triangle with the ground one side of the triangle, the level stick a second side of the triangle, and the string or measuring stick the third and final side of the triangle.

When the measurement has been made, use the following conversion table to determine slope:

Stick length (inches)	Distance end of stick is above ground	Multiply by conversion factor	Slope (expressed as a percentage)
100"		x1	= %
50"		x2	= %
25"		x4	= %

For example, if a 50" stick is used and the distance from the end of the stick to the ground was 5", the slope is 5 x 2 = 10 or 10%.

In the classroom, have students share their data by reporting their results in a classroom data table.

For a vegetable garden, it is recommended to find an area with a slope of 1.5% or less. Steeper slopes mean more run-off and less water getting to the roots of vegetables. If the school grounds do not have any level areas that can be planted, modifications may need to be made or a rain garden could be considered.

Evaluate

Based on the results from the soil investigations, students should prepare a summary of the type of soil in the proposed garden location. Students should also include information on the slope of the area by drawing a cross-section view of the slope of the (proposed) garden site.

Have students include steps to improve the soil based on what they have learned. In most cases, percolation and acidity can be improved by adding organic matter or compost. Some students may propose finding an alternative site.

Extension Ideas

Have students develop and implement investigations that demonstrate percolation through different soil types including sand, silt, clay, and a well-balance loam.

Resources:

K-State Research and Extension Resources for Soil Sampling and Soil Improvement
http://www.kansasgreenschools.org/files/Soil%20improvemets.pdf

Soil Discovery Sites for Kids
http://school.discoveryeducation.com/schooladventures/soil/index.html
http://www.blm.gov/nstc/soil/Kids/index.html

Soil Education Resources
http://soils.usda.gov/education/
http://www.nacdnet.org/education/resources/soils/
http://www.hort.purdue.edu/ext/loam.html
www.soil-net.com

Soil Activities
http://soils.usda.gov/education/resources/lessons/texture
http://soils.usda.gov/education/resources/lessons/crayons/index.html
http://www.il.nrcs.usda.gov/news/publications/education/filtrationfs/fs_filtration.html