**The relationship between agriculture and the environment**

**Specific soil conservation practices used by farmers**

(Grades 9th-12th)

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| **Introduction**: Pull key information from wiki <https://en.wikipedia.org/wiki/Soil_conservation>  **Video:** https://vimeo.com/channels/soilstories  **Hands On**:  (A)<http://www.agclassroom.org/teacher/matrix/lessonplan.cfm?lpid=551&grade=9&author_state=0&search_term_lp=soil>  (B) Ph soil test <http://www.agclassroom.org/teacher/matrix/lessonplan.cfm?lpid=317> |

How Much Is Dirt Worth?

Purpose

Students will understand that topsoil is a limited resource with economic value. Activities include slicing up an apple to demonstrate the distribution of Earth’s soil resources and exploring scenarios involving the dollar valuation of soil.

Materials

* Large apple
* Knife
* Cutting Board
* *Earth's Soil Resources Pie Chart* activity sheet

Essential Files (maps, charts, pictures, or documents)

* [Earth's Soil Resources Pie Chart](http://naitc-api.usu.edu/media/uploads/2017/01/20/EarthsSoilResources_activitysheet_1.pdf" \t "_blank)

Vocabulary

**conservation tillage:** farming methods that reduce the intensity or frequency of tilling in order to maintain some ground cover throughout the year and disturb the soil as little as possible while still providing the conditions needed to grow a productive crop

**contour planting:** tilling and planting crops on the contour, or at a right angle to the slope, which slows water flowing downhill and reduces erosion

**cover crops:** crops grown between periods of regular production for the purpose of protecting and improving the soil; generally a crop with fibrous roots (like clover, various grasses, vetch, etc.) that will hold soil and often a legume that will add nitrogen to the soil

**nonrenewable resource:** a limited natural resource that cannot be replaced or reproduced at a rate that will meet demand over the long term

**strip cropping:** planting in strips or bands of alternating crops that serve as barriers to erosion; crops that have fibrous roots hold the soil better than crops with tap roots, and taller crops act as wind buffers

**sustainable agriculture:** an approach to agriculture that focuses on producing food while improving the economic viability of farms, protecting natural resources, and enhancing quality of life for farmers and society as a whole

**value:** usefulness or importance of something; also, the amount of money that something is worth

Background Agricultural Connections

Agriculture is an important part of the economy of the United States. In 2013, more than 16 million people had farm- and agriculture-related jobs. Agricultural exports are translated into billions of dollars for United States trade. On poor soil, it costs farmers more to produce good crops, and this cost is passed on to the consumer—you—in higher prices at the grocery store. Erosion reduces agricultural productivity and washes sediment into rivers, lakes, ocean gulfs and bays, affecting fisheries and recreation opportunities in these water bodies. Soil loss affects our country’s economy and our lives.

Interest Approach – Engagement

1. Ask your students to name some items that they would consider valuable. Students may list items that are of monetary or sentimental value.
2. Next, ask students if they believe that soil is valuable. Discuss why or why not. Guide the class discussion to help students begin to understand that soil is a valuable resource. Inform students that they will be learning why soil is valuable.

Procedures

**Activity 1: Slicing Up Earth’s Land Resources**

1. This activity uses an apple to demonstrate the distribution of Earth’s soil resources. Ask students to fill in the *Earth’s Soil Resources Pie Chart* activity sheet while you perform the following demonstration.
2. Cut the apple into four equal wedges. Three of these quarters represent the oceans, which occupy 75% of Earth’s surface. Set these aside.
3. The remaining quarter represents land area, which occupies 25% of Earth’s surface. Take this quarter, and cut it in half, so you have two, one-eighth sections.
4. One of these sections represents deserts, swamps, mountains, and polar regions; this half of our land, or one-eighth (12.5%) of Earth’s surface, is not suitable for people to live or grow crops on. Set this section aside.
5. The other eighth represents land where people can live. There are some places where people can live, but crops can’t be grown. Slice this section lengthwise into four equal parts. Now you have four 1/32nd pieces of an apple, each representing 3.1% of Earth’s surface.
6. The first section represents the areas of the world with rocky soils that are too poor for any type of food production. Set this section aside.
7. The next two sections represent land that is too wet or too hot for food production. Set these sections aside also.
8. The fourth section represents the area of the world that is most suitable for development and agricultural cultivation. The best lands for agriculture are often desirable places to build homes and towns as well.
9. Carefully remove the peel of the last 1/32nd section. This small bit of peel represents all the soil of our earth upon which humans depend for food production.

**Activity 2: Cost versus Value**

1. Discuss the economic, environmental, and societal value of soil. Then demonstrate some scenarios involving the dollar valuation of soil. Use the following examples or develop your own.
2. Say you have 1 acre of land and 7 inches of topsoil. If every inch is worth $10 (round numbers simplify the math), your topsoil would be worth $70.
3. Suppose you lose ½ inch of topsoil each year to erosion. How much money would you be losing each year? *($5.00 of topsoil from one acre)* What is your topsoil now worth?*($65.00)* At your current rate of topsoil loss, how many years will it take to lose all seven inches? *(14 years)*
4. Discuss other losses that would occur (crops will be less productive, your income will go down, you will feed fewer people with the crops grown on your acre, sediment will wash into lakes and rivers downstream). How much would you be willing to pay to prevent erosion of your topsoil?
5. Discuss the following questions:
   * Since soils provide our food, how can we place a value on them? Who pays for soil conservation? Who benefits from soil conservation?
   * What is an acre of farmland worth? What is an acre of city worth?

**Concept Elaboration and Evaluation**

After conducting these activities, review and summarize the following key concepts:

* Soil is a natural resource necessary to grow the crops that provide our food.
* Soil is a valuable and limited resource that is not renewable.
* It is important to preserve soil through conservation practices.

Suggested Companion Resources

* [Apple as Planet Earth video](http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=576) (Multimedia)
* [Dust Bowl: CBS 1955 Documentary](http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=20) (Multimedia)
* [FDR's Fireside Chat: Dust Bowl](http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=21) (Multimedia)
* [Soil Science Videos](http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=470) (Multimedia)
* [Soil, Not Dirt](http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=261) (Multimedia)
* [School Gardens: A Guide for Gardening and Plant Science](http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=283) (Teacher Reference)
* [Soil Science Society of America](http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=500) (Website)
* [Unlock the Secrets in the Soil](http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=769) (Website)
* [Web Soil Survey](http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=579) (Website)

Sources/Credits

Adapted from materials provided by Oklahoma Agriculture in the Classroom.

## What's Your pH?

### Purpose

In this lesson students will measure the pH of a soil sample and learn how pH affects the availability of nutrient uptake by plants. Students will determine if and how their soil pH should be modified through the application of soil amendments.

### Materials

**For the class:**

* Sand
* Soil
* White vinegar (or 0.5 M solution of hydrochloric acid)
* Drain cleaner containing potassium hydroxide (or 0.5 M solution of sodium hydroxide)
* pH meters
* pH testing kit based on barium sulfate
* pH test strips (1-12 range) and litmus paper for quick acid/ base indicators
* Distilled water
* Internet access for research (this part may be done at home for homework)

**For each group:**

* Plastic 100 ml beaker
* 3 paper cups
* Spoon and stir stick
* Waterproof markers

**For each student:**

* What's Your pH? Lab worksheet

### Essential Files (maps, charts, pictures, or documents)

* [Answers to Commonly Asked Questions (additional information)](http://naitc-api.usu.edu/media/uploads/2015/09/14/Answers_to_Commonly_Asked_Questions_1.pdf" \t "_blank)
* [Answer Key-What's Your pH?](http://naitc-api.usu.edu/media/uploads/2015/09/11/Answer_Key-Whats_Your_pH.pdf" \t "_blank)
* [What's Your pH? Lab worksheet](http://naitc-api.usu.edu/media/uploads/2015/09/11/Whats_Your_pH_Lab_worksheet.pdf" \t "_blank)

### Vocabulary

**Compost:** A mixture made of decaying organic material used to fertilize plants and amend soils.

**amendment:** Any material added to soil to make it more productive. This could include fertilizer, or compost.

**pH:** Power of hydrogen. A measure of the alkalinity or acidity of a substance.

### Background Agricultural Connections

This lesson is one in a series of related lessons to introduce students to chemistry and environmental science concepts. Activities are modeled after real-life challenges that modern farmers face while producing our food, fiber, and fuel. Labs are inquiry based and promote critical thinking skills.

### Interest Approach – Engagement

1. Ask students if they know what an agronomist does. Introduce them to this career field by explaining that agronomists help farmers prepare and maintain their soil to achieve the maximum plant growth. They are an expert in the science and technology of producing and using plants for food, fuel, fiber, and land reclamation. They work in areas of plant genetics, plant physiology, meteorology, and soil science. Explain that agronomists help farmers achieve the maximum production from their land. They know the specific needs of plants and find methods of making soil as productive and fertile as possible.
2. Watch the Agricultural Careers video clip, [Agronomist.](https://www.youtube.com/watch?v=reasLCdcy88&list=PL7B61381EE0438243&index=34" \t "_blank)
3. Inform your students they will:
   * Explore soil pH
   * Learn how soil pH affects plant nutrient availability
   * Research how soil amendments may alter pH
   * Use online resources to identify crops that grow best in slightly acidic or alkaline soils

### Procedures

**Preparation**

* Before the lesson, prepare three soil samples. Samples should be close to 5.0, 6.5, 8.0 pH. This will require a little trial and error. Mix a little bit of soil with a lot of sand to make a soil mixture with little buffering capacity (the more clay and organic matter in soil, the higher the resistance to change in pH). The sandy texture of the soil will reduce the soil’s resistance to changing pH when you add acid or base forming materials.
* White vinegar may be used to lower the pH of the soil sample. (You may also use 0.5 M solution of hydrochloric acid if you need a stronger acid to change the pH or if you don’t want students to guess that the soil sample is acidic based on the vinegar odor.)
* A drain cleaner may be used to raise the pH of the soil sample. (You may also use 0.5 M solution of sodium hydroxide if you need a stronger base to change the pH.) Note: Traditional agricultural methods of adding lime to raise the pH and adding elemental sulfur to lower the pH takes months to alter pH, so we use drain cleaner and vinegar in this lab to instantly adjust our soil samples to our desired pH.
* Use an electronic pH meter to periodically measure the pH of the soil as acid and base are added until the desired level of acidity or alkalinity is reached. Label each soil sample 1, 2, and 3. The soil pH should be known by you, but not by your students.

**Lab:**

1. Tell students that in this lab they will act as agronomists, testing soil pH and advising farmers on methods for amending the soil for maximum crop productivity.
2. Ask students if they know what pH is. Ask students if they can predict whether some common household items are acidic or alkaline. Do a demonstration to show students the pH levels of items such as lemon juice (pH 2.3), orange juice (pH 3.5), vinegar (pH 4.3), milk (pH 6.4), dish soap (pH 10), saliva (pH 6-8), or soda (pH 2-3).
3. Ask students for ideas on why it would be important for farmers to know the pH of their soil. Use lesson background information to discuss the definition and importance of soil pH.
4. Tell students that they will be testing soil samples that were sent in from three farms. Demonstrate to the students how to use each of the three pH testing methods.
   * Use a pH testing kit based on barium sulfate in powdered form, where a small sample of soil is mixed with distilled water which then changes color according to the acidity or alkalinity.
   * Use pH paper. A small sample of soil is mixed with distilled water into which a strip of pH paper is inserted. Show students how to compare results to the pH paper color chart.
   * Use an electronic pH meter, in which a rod is inserted into moistened soil and measures the concentration of hydrogen ions.
5. Instruct students to complete the information on their lab reports. When finished, discuss class results and have groups share their recommendations for each farmer based on the soil pH test.

Alternative Activities:

Activity 3.2.2 Life, Death, and PH.

Purpose: In this lesson students will test two soil samples that will be labeled as Richard and Sally Petunia, which one will be highly acidic and the other will be a neutral soil sample. The students will hypothesize what role PH could have played, and will then begin the lab. They will use their instruction and the LabQuest equipment to find the PH to determine if PH was in fact the reasons the Richard the Petunia is dead and relate their findings with their hypothesis.

Preparation: The teacher or instructor will need to gather a bag of topsoil, which the size will vary based on the group you will be teaching. Then divide the soil equally into two large tubs, and label on tub as Richard petunia and the other as sally petunia. Then you will need to obtain a bottle of soil acidifier or coffee grinds, and mix generously with the soil for Richard Petunia.

Materials:

* Soil Samples for Sally and Richard Petunia
* LabQuest®
* Vernier pH Sensor
* Computer station with Internet access
* 100 ml Graduated cylinder
* 2 16 oz plastic cups
* Distilled water
* Rinse bottle
* 2 plastic spoons
* Paper towel
* Permanent marker pen
* Pencil
* Paper Handout

Procedures:

1. Start off by introducing the students to the concept of PH and its importance to water and nutrient uptake.
2. Explain the death of Richard Petunia, and his wife and hint at PH most likely being the cause. Pass out the handouts, and explain it is very important for them to read through the instructions
3. Show students the Soil Samples previously prepared, and allow them to collect sample into plastic cups for testing.
4. Allow students to start part one. The students must develop a hypothesis for how PH killed Richard.
5. Start Part 2 by labeling the cups Sally and Richard Petunia.
6. Place four tablespoons or 80 grams of soil from the Richard (Also referred to as sample A) sample into the cup labeled Richard, and four tablespoons or 80 grams of soil into the cup labeled sally (Also referred to as sample B).
7. Add 100ml of distilled water to each cup, and stir for 1 to 2 minutes or until all particles or settled at the bottom of the cup.
8. Repeat steps 9 for Sally Petunia Sample.
9. Follow these instructions to operate the LabQuest:

* Connect the pH Sensor to LabQuest and choose “New” from the File menu.  
    
  Important: For this experiment, your teacher already has the pH Sensor soaking in a beaker with solution. Be careful not to tip over the beaker when connecting the sensor to the LabQuest interface.
* On the Meter screen, tap “Mode”. Change the data-collection mode to Selected Events.
* Select Average over 10 seconds and select OK.

Start data collection.

* Rinse the tip of the sensor with distilled water and place into the liquid part of Sample Cup A. Important: Leave the probe tip submerged while data is being collected for 10 seconds, but do not allow the tip of the sensor to settle into the soil.
* Tap “Keep”.
* Repeat data collection by again tapping “Keep”. Leave the probe tip submerged for the full 10 seconds.
* Stop data collection by tapping stop.
* Tap “Table” to view the data. Average the two pH values for the sample and record the average for sample A in Table 1.

1. Make sure to report all PH findings in the listed Graph.
2. Clean up as directed by instructor and return all equipment and materials used to proper stations.
3. Please take 2 minutes to research the proper soil PH for petunias
4. Answer questions and wait to go over them with the instructor.

ThoughtCo.: Red Cabbage Indicator

Purpose: It is important for agriculturalists to understand the PH of soils to be able to allow plants the optimal environment to grow. A chemical called anthocyanin, which causes the red pigment in the cabbage also lets us test for the presence of acids and bases. While there are many methods for testing PH, this is a simple and easy way to test for PH in minutes.

Preparation: The instructor will need to get the red cabbages, and have the red cabbages pre sliced and ready to blend so as to save time for the students. The instructor will also need all the glassware, and chemicals listed to test their PH.

Materials List:

* Red Cabbage
* Blender
* Knife
* Boiling Water
* Coffee Filters
* One Large Pitcher
* Six 250ml Beakers

Testing chemicals:

* Ammonia
* Baking Soda
* Lemon Juice
* Vinegar
* Aspirin
* Tums

Procedures:

1. Blend chopped cabbage, and add enough boiling water to cover the cabbage. Allow this mixture to set in until the color leaches out.
2. Use the coffee filter to separate solids from the liquid and pour into the large pitcher.
3. Pour 100ml of the liquid into the 250ml beakers to use a PH indicator.
4. Mix in each of the listed chemicals and record PH.

Colors/PH:

Red-2

Purple-4

Violet-6

Blue-8

Blue and Green/10

Greenish Yellow/12

**Helpful Websites for Student Research**

Colorado State University Extension

* Listing of yard and garden publications available for free download
  + [www.ext.colostate.edu/pubs/pubs.html](http://www.ext.colostate.edu/pubs/pubs.html" \t "_blank)

University of California Agriculture and Natural Resources

* Listing of publications
  + [www.ucanr.edu/Publications\_524](http://ucanr.edu/Publications_524/" \t "_blank)
* Sample costs and profitability analysis of various crops
  + [www.ucanr.org/freepubs/freepubsub.cfm?cat=1&subcat=17](http://ucanr.edu/freepubs/freepubsub.cfm?cat=1&subcat=17" \t "_blank)

**Concept Elaboration and Evaluation:**

After conducting these activities, review and summarize the following key concepts:

* Agronomy is the science of soil management and crop production.
* Agronomists as well as Soil Scientists use their knowledge of chemistry and pH to help farmers achieve maximum plant growth. This in turn helps provide a more plentiful food supply.
* Nutrients can be added, or amended in the soil.

**Variations**

* Instead of preparing soil samples of varying pH values, have students collect soil samples from their home, neighborhood, or community (while being respectful of private property). Test the pH of the soil samples and investigate explanations for differences in pH.
* In addition to testing the soil pH of the samples that the students collect, also test the soil texture. This is an important factor in the amount of lime or elemental sulfur needed to change the soil pH. Here’s a guide to soil texture by feel: soils.usda.gov/education/resources/lessons/texture

### Enriching Activities

* Have students collect soil samples from your school garden. Test the pH of the soil samples and research the type of soil amendments that could be added to correct the pH level if needed. As a class, come up with a detailed plan to amend the soil pH, purchase and apply the soil amendment, and monitor the pH for any changes over the next couple of months. Soil samples should be cored from the first six inches of soil.

### Suggested Companion Resources

* [Everything is Chemical](http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=671) (Multimedia)
* [Feeding the World and Protecting the Environment](http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=462) (Multimedia)
* [Science of Soil Digital Explorations](http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=339) (Multimedia)
* [Soil Science Videos](http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=470) (Multimedia)
* [From the Ground Up: The Science of Soil](http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=149) (Website)
* [Soil Science Society of America](http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=500) (Website)

### Sources/Credits

This lesson was funded in 2011 by the California Department of Food and Agriculture’s (CDFA) Fertilizer Research and Education Program (FREP). Chemistry, Fertilizer, and the Environment was designed to reinforce chemistry and environmental science concepts while educating students about the relationships between food, plant nutrients, farmers and the environment.

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