

Soil Science Curriculum

January 2018

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Soil Science Curriculum

Content and lab derived from the USDA-NRCS Guides for Educators. Go to www.nrcs.usda.gov/soils for the Guides and additional pictures and diagrams. This lesson plan was adapted for South Dakota from the University of Nebraska Institute of Agriculture and Natural Resources, CROPWATCH.

January 2018

Components and Physical Properties of Soil

Approximately 90 minutes

Objectives

By the end of the lesson, students will know or be able to:

- Define aggregate, the four components of soil (mineral matter, organic matter, air and water), and bulk density
- Describe the basic characteristics of the three soil textures – sand, silt and clay
- Create models of seven soil structures – granular, platy, wedge, blocky sub-angular, blocky angular, prismatic, and columnar
- Explain factors that affect aggregate stability
- List and explain factors that affect soil structure
- Differentiate between soil structure and aggregate stability
- Explain what causes soil color

Preparatory Work

- Make necessary copies
- Obtain necessary supplies
- Review “Separating the Components of Soil” Lab

Materials

- Legos (10-15 per group of 4 students)
- Canning jar or 24 oz. pop bottle (cleaned with label removed)
- Soil sample
- About 2 cups of water
- 1 teaspoon of Borax
- Blank paper to spread out soil sample
- Permanent Marker
- “Separating the Components of Soil” Lab Sheet – 1 per student
- Guided Notes sheet – 1 per student
- 3 jars
- Handful of marbles
- Handful of small beads
- Approximately ½ cup of sugar
- Clay or Play-doh
- Pictures of various soils from around the world

Components and Physical Properties of Soil

Enroll the Participants *(Approximately 7 minutes)*

Students will build a house with Legos. Divide the class into groups of four students and give each group a bag of 10-15 different Legos. Instruct the class to work with their group to build a house with their Legos in two minutes. After two minutes, guide the class through a discussion about similarities and differences in the houses. Relate these similarities and differences to soils components and properties.

Although each group made a house, they all are made up of different sizes, colors, design and shapes. Explain to your class that soil is just like these houses, it varies in shape, size, design, and color. In this lesson, students will gain and demonstrate an understanding of soils components and physical properties.

Note: You could substitute children's blocks, office supplies, or any variety of materials for the Legos in this activity.

Provide the Experience – Definition and Description of Soil Characteristics and Components *(Approximately 15 minute set up, 24 hour wait time, and 10 minute data collection and review)*

Using the “Separating the Components of Soil Lab”, verbally discuss the steps of the lab. Have students prepare their soil sample and fill their jar. When they finish shaking the jars, place them in an area where they won't be disturbed for at least 24 hours.

After 24 hours, have students carefully observe their samples, record data, and complete the discussion questions.

Note: This lab can be done in small groups rather than individually. Also, it is important that the jars are not disturbed during settling and observing.

Label the Information *(Approximately 2 minutes)*

Instruct students to record the four components of soil and the basic characteristics of soil texture in their guided notes.

Sand: > 2mm
Silt: .05-2.0mm
Clay: <.05mm

The four components of soil include: mineral matter 45 percent, organic matter 5 percent, air 25 percent, and water 25 percent. Therefore, soil is 50 percent solid and 50 percent pore space.

Demonstrate the Relevance *(Approximately 5 minutes)*

Pass around three jars: one containing marbles, another containing small beads, and the third sugar. Use this visual to facilitate discussion on particle size and pore space. Consider using the following discussion points:

- The larger the particle sizes of a soil, the larger the pore space.
- The ration to soil and water will change with the dampness of soil.
- Most soils are a mixture of many different sized particles.
- What impacts particle size during soil formation?

Components and Physical Properties of Soil

Provide the Experience – Create Model of Seven Soil Structures, Explain Factors that Affect Aggregate Stability and Soil Structure, and Define Bulk Density

(Approximately 10 minutes)

Show students a picture with the seven soil structures and provide each student with clay. Encourage students to select one type of soil structure and build a model, tell them not to discuss their model during construction. After a few minutes, as students complete their model, guide the class through a gallery walk of the different models. As students identify each other's model, have them discuss each type of aggregate. Keep models intact to use throughout the class today.

Label the Information *(Approximately 5 minutes)*

Encourage students to draw a diagram of each structure on their Guided Notes sheet.

Share with students the definition for soil structure, aggregates, and bulk density. Refer back to the clay models as appropriate.

- Soil structure is the way in which the individual particles (sand, silt, and clay) are arranged into larger distinct aggregates.
- Soil aggregates are groups of soil particles, often called peds, which bind together more strongly than to neighboring particles and can usually be separated easily.
- Bulk density is the weight of dry soil per unit volume (usually measured as grams/cubic centimeter)

Demonstrate the Relevance *(Approximately 10 minutes)*

Discuss factors that affect soil structure and aggregate stability. Students should capture this in their Guided Notes.

Aggregate stability

- Amount of clay
- Chemical elements
- Organic matter
- Biological activity

Soil structure

- Organic matter
- Soil organisms
- Tillage
- Freezing and thawing
- Water movement

Guide a discussion differentiating between soil structure and aggregate stability. Students should highlight this discussion in their notes using the Venn diagram. Consider using the following information to help facilitate discussion.

- All soil-forming factors, especially climate, influence the type of structure that develops within soil.
- Consider the definition of soil structure and aggregates.
- How are aggregates and soil structure related?
- Use models to demonstrate aggregate stability and soil structure.

Explain that there are many other differences in soil, including color.

Components and Physical Properties of Soil

Provide the Experience – Explain the Causes and Indications of Soil Color

(Approximately 5 minutes)

Gather pictures of a variety of soils in several colors from around the world.

Examples: red desert sand in Arizona, gray desert sand in Nevada, white sand of New Mexico, black soil of the midwest, redbed soil in Oklahoma, yellow soil of the Yellow River beds in China, or green sand of Hawaii.

Show the students each picture and have them guess where each soil can be found.

With a partner, have the students discuss “What causes color differences in soil?” Have a few students share highlights from their discussion.

Thank students for their thoughts and participation.

Label the Information *(Approximately 5 minutes)*

Instruct the students to write the two main causes of color in soil, humus content and iron compounds in their Guided Notes.

Also discuss and record the basic soil color indications:

- Indicator of different soil types
- Indicator of certain physical and chemical characteristics
- Due to humus content and chemical nature of the iron in the soil

Demonstrate the Relevance *(Approximately 5 minutes)*

Show students the “Soil Organic Matter Color Chart” and explain its use for measuring soil organic matter. Preview the “Measuring the Organic Matter Lab” in the next lesson. Pass the chart around and encourage students to predict the amount of organic matter in area soils.

Review the Content *(Approximately 10 minutes)*

Instruct the students to create a “Top 10 List of Components and Physical Properties of Soil”. Students should revisit their Guided Notes sheet to help them review information. You might consider having students work with partners or in small groups to encourage discussion. Have students share one item from each list.

Celebrate Student Success *(Approximately 2 minutes)*

Thank students for their contributions to the class and describe how they can make more informed choices about soil management. If your students will participate in a Land Evaluation Competition, explain to them that their knowledge of components and physical properties of soil will help them differentiate soil horizons and determine soil texture and permeability.



Components and Physical Properties of Soil

Components and Physical Properties of Soil

Guided Notes: Components and Physical Properties of Soil

Completed by _____

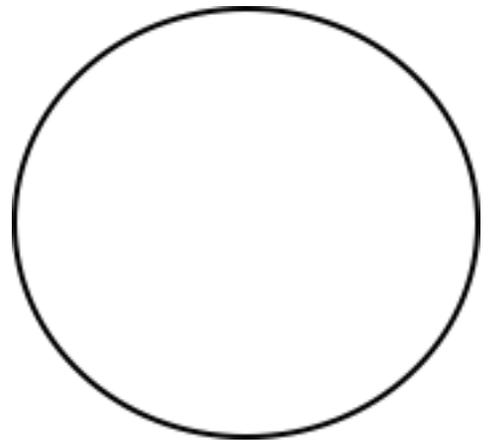
Components of Soil

Solid portions - _____% of soil volume: mineral and organic matter.

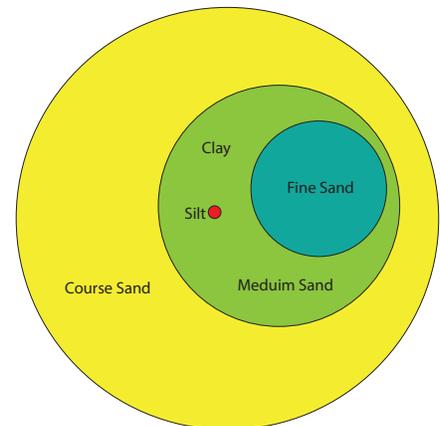
- _____, which accounts for about _____% of the soil, is partially decomposed rock material. It is the sand, silt, and clay that is found in the soil.
- _____, which accounts for about _____% of the soil, is partially decomposed plant and animal matter. Most organic matter is from plant leaves, roots, and stems.

Pore spaces _____% of soil volume: air and water.

- _____ accounts for about _____% of the soil. When soils are wet the amount of air will be less. When soils are dry the amount of air will be more.
- _____, which accounts for about _____% of the soil, is also part of the pore space in the soil. When it rains water will enter the soil or flow off of the soil's surface.



Soil Particle	Size
	> 2mm
	.05mm - 2mm
	< .05mm



Components and Physical Properties of Soil

Draw the Soil Structure:

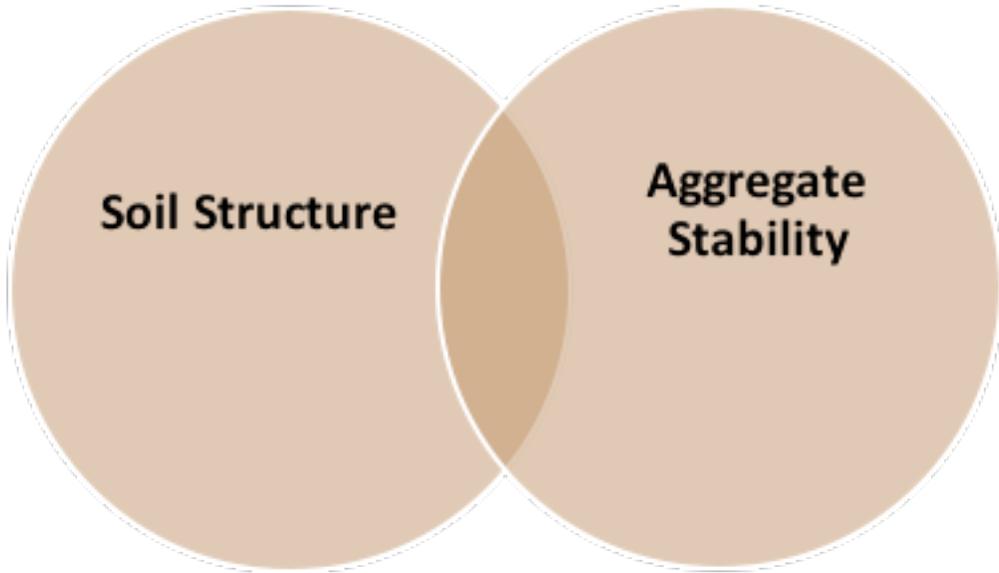
Granular	Platy	Wedge
Blocky Sub-Angular	Blocky Angular	Prismatic
Columnar		

Soil Structure

Soil Aggregates

Bulk Density

Components and Physical Properties of Soil



Causes of Soil Color

- _____
- _____

Soil Color Indications

- _____
- _____
- _____
- _____

Components and Physical Properties of Soil

Separating the Components of Soil Lab

Student _____

You will need:

- Canning jar or 24 oz. pop bottle (cleaned with label removed)
- Soil sample
- About 2 cups of water
- 1 teaspoon of Borax
- Blank paper to spread out soil sample
- Permanent Marker

Follow these instructions:

1. Spread soil sample on blank paper.
2. Remove large rocks, trash and roots.
3. Break down large pieces of soil.
4. Fill jar or pop bottle $\frac{1}{4}$ full of soil.
5. Add water until the jar is $\frac{3}{4}$ full.
6. Add one teaspoon of borax.
7. Tightly put the lid on the jar and label it with the students' name.
8. Shake jar vigorously for about 5 minutes to break apart all soil aggregates.
9. Leave the jar undisturbed for at least 24 hours.
10. After at least 24 hours, observe the soil in the jar. Be careful not to disturb the soil.
11. Record your findings on the chart below and answer the discussion questions.

Layer	Description/Observation: (Color, texture, size, amount...)
Top	
Middle	
Bottom	

Components and Physical Properties of Soil

Using your observations answer the following discussion questions:

1. Describe the differences of all three layers.

2. Describe similarities of all three layers.

3. Compare your sample to other samples in the class.

4. Using what you know, what do you think is the makeup of each layer? Why?

Top Layer:

Middle Layer:

Bottom Layer:

5. Why might some samples have more or less than three layers?

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January 2018

Soil Organic Matter

Approximately 90 minutes

Objectives

By the end of the lesson, students will know or be able to:

- Define soil organic matter
- Explain the role of inherent factors affecting soil organic matter
- Explain the five soil organic matter management practices
- Explain how soil organic matter relates to soil function
- Estimate organic material needed to increase soil organic matter
- Measure soil organic matter

Preparatory Work

- Make necessary copies
- Obtain necessary supplies
- Prepare five flip charts

Materials

- Dry erase markers
- Soil samples high in organic matter
- Clay or Play-Doh
- Guided notes sheet – one per student
- Soil Glue Lab sheet from NRCS – one per student
- 2 wide mouthed jars
- 2 pieces of ½-inch wire mesh
- 2 clods of soil, each about the size of an egg from two different sites
- Water
- Poster making supplies
- Measuring Soil Organic Matter lab – one per student
- Soil Color Chart
- Plastic bucket
- Squirt bottle with water
- 5 sheets of poster paper or flip charts
- Markers

Soil Organic Matter

Enroll the Participants *(Approximately 3 minutes)*

Write “Soil Organic Matter” on the board. As students walk into the classroom, greet them at the door with a dry erase marker. Instruct each student to write something they know about the phrase or a question they have on the board.

After all students have written on the board, review several of the responses with the class. Explain to the class that this lesson will investigate soil organic matter.

Provide the Experience – Define Soil Organic Matter and Explain Roles of Inherent Factors Affecting Soil Organic Matter *(Approximately 15 minutes)*

Divide students into small groups and provide each group with a soil sample high in organic matter. Within their group, have the students collect observations for look, feel, and smell of the soil.

Note: Consider finding a soil sample with established vegetation that may have organic matter in various stages and visible living organisms.

After a few minutes, encourage students to share their observations with the class.

State that, in this lesson, the class will continue to explore soil organic matter.

Label the Information *(Approximately 3 minutes)*

Instruct students to capture the definition of soil organic matter in their guided notes.

Soil organic matter is the organic component of soil, consisting of three parts:

- Plant residues and small living soil organisms
- Actively decomposing matter
- Humus, a stable organic matter

Also, guide students through factors affecting organic matter. Encourage students to capture this information in their guided notes page.

Demonstrate the Relevance *(Approximately 5 minutes)*

Pass around three jars: one containing marbles, another containing small beads, and the third sugar. Use this visual to facilitate discussion on particle size and pore space. Consider using the following discussion points:

- The larger the particle sizes of a soil, the larger the pore space.
- The larger the pore space, the more water will infiltrate and move through soil.
- Most soils are a mixture of many different sized particles.
- What impacts particle size during soil formation?

Soil Organic Matter

Provide the Experience – Create Model of Seven Soil Structures, Explain Factors that Affect Aggregate Stability and Soil Structure, and Definition of Bulk Density

(Approximately 10 minutes)

Show students a picture with the seven soil structures and provide each student with clay or Play-Doh. Encourage students to select one type of soil structure and build a model, tell them not to discuss their model during construction. After a few minutes, as students complete their model, guide the class through a gallery walk of the different models. As students identify each other's model, have them discuss each type of aggregate. Keep models intact to use throughout the class today.

Label the Information *(Approximately 5 minutes)*

Encourage students to draw a diagram of each structure on their Guided Notes sheet.

Share with students the definition for soil structure, aggregates, and bulk density. Refer back to the clay models as appropriate.

- Soil structure is the naturally occurring arrangement of soil particles (sand, silt, and clay) into larger distinct units called peds through pedogenic processes.
- Soil aggregates are groups of soil particles, which bind together more strongly than to neighboring particles and can usually be separated easily along planes of weakness.
- Bulk density is the ratio of oven-dried soil (mass) to its bulk volume, which includes the volume of particles and the pore space between the particles.

Demonstrate the Relevance *(Approximately 10 minutes)*

Discuss factors that affect soil structure and aggregate stability. Students should capture this in their Guided Notes.

Aggregate stability

- Amount of clay
- Chemical elements
- Organic matter
- Biological activity
- Tillage

Soil structure

- Organic matter
- Soil organisms
- Tillage
- Freezing and thawing, wetting and drying

- Water movement
- Chemical elements

Guide a discussion differentiating between soil structure and aggregate stability. Students should highlight this discussion in their notes using the Venn diagram. Consider using the following information to help facilitate discussion.

- All soil-forming factors, especially climate, influence the type of structure that develops within soil.
- Consider the definition of soil structure and aggregates.
- How are aggregates and soil structure related?
- Use models to demonstrate aggregate stability and soil structure.

Explain that there are many other differences in soil, including color.

Soil Organic Matter

Provide the Experience – Explain the Causes and Indications of Soil Color

(Approximately 5 minutes)

Gather pictures of a variety of soils in several colors from around the world.

Examples: red desert sands in Arizona, gray desert sands in Nevada, white sands of New Mexico, black soils of the mid-west, redbed soils in South Dakota, yellow soils of the Yellow River beds in China, or green sands of Hawaii.

Show the students each picture and have them guess where each soil can be found.

With a partner have the students discuss, “What causes color differences in soil?” Have a few students share highlights from their discussion.

Thank students for their thoughts and participation.

Factors affecting organic matter in soil:

- Climate
 - Organic matter decomposes more quickly in warm and humid climates than cool dry climates
- Soil Texture
 - Soil aeration: more oxygen in the soil speeds up the decomposition process
- Vegetation
 - Prairie soils have more organic material added to the soil than forest soils because of vegetation

Demonstrate the Relevance *(Approximately 5 minutes)*

Guide students through a short discussion on organic matter and its formation. Encourage students to describe the organic matter in the soil in your area. Use the following questions to guide your conversation:

- What type of vegetation creates organic matter in our area?
- Compared to the rest of the country, does organic matter decompose more quickly or slowly? Why?
- How do animals impact organic matter in our area?
- How is organic matter different in different soils, even in our town?

Conclude this conversation by having a discussion about why they believe organic matter is important to soils.

Provide the Experience - Management Practices and Organic Matter Related to Soil Function *(Approximately 20 minutes)*

Demonstrate soil organic matter’s role in surface soil stability using the “Soil Glue” demonstration and have students complete the “Soil Glue – Student Exercise” with their thoughts and observations.

Soil Organic Matter

Label the Information *(Approximately 5 minutes)*

While discussing management practices of soil organic matter, have students capture the following information in their Guided Notes.

- Use of conservation cropping systems
 - Diverse crop rotations, solid manure, high residue crops, grasses, or perennial plants properly grazed or hayed help improve organic matter
- Reducing or eliminating tillage
 - Tillage exposes the organic matter to the air and can result in the lowering of stable organic matter
- Reduce erosion
 - When soil erodes organic matter goes with it
- Soil-test and fertilize properly
 - Proper fertilization encourages root growth for more organic matter in the soil
- Use of perennial forages
 - Provides for annual die back and regrowth of plants

Instruct students to list the benefits of organic matter as it relates to soil function:

- Nutrient Supply
 - As organisms decompose, nutrients are released in a plant usable form
- Water-Holding Capacity
 - Organic matter has the ability to hold up to 90 percent of its weight in water
- Soil Aggregation
 - Improved soil aggregation improves soil structure
- Erosion Prevention
 - Erosion is reduced because water infiltration and soil stability are increased

Explain how each benefit impacts soil function. Consider using the information above to help guide your instruction.

Demonstrate the Relevance *(Approximately 20 minutes)*

Students will create an advertisement for soil organic matter. Explain to students that they have been hired by the National Soils Corporation to create a TV, radio, or magazine advertisement for the sale of organic matter. They have 10 minutes to use the materials provided to create their advertisement that will be shared with that class. Explain to students that they must include a definition or description of organic matter and at least three benefits organic matter has to soil. Divide the class in to groups of 3-4 students.

Note: Provide a variety of props for TV commercials and poster supplies for the magazine advertisement.

Allow students to present their advertisements to the class. After all groups have presented, thank the students for their engagement and willingness to share.

Soil Organic Matter

Provide the Experience – Measure Soil Organic Matter

(time varies with number and location of samples)

Measuring Soil Organic Matter

Gather necessary materials and inform students you will be giving important instructions for measuring soil organic matter. Ask students to follow along in their “Measuring Soil Organic Matter – Lab Sheet”

At the conclusion of the laboratory exercise, instruct students to clean up and return materials to designated areas.

Note: Consider reviewing the NRCS Soils Video “Soil Organic Matter” to aid in this laboratory experience.

Label the Information *(Approximately 3 minutes)*

Students will briefly describe the process of measuring soil organic matter using a soil color chart in their Guided Notes.

Demonstrate the Relevance *(Approximately 5 minutes)*

Instruct students to complete the questions in the “Measuring Soil Organic Matter – Lab Sheet.” After a few minutes, briefly discuss these questions as a class.

Review the Content *(Approximately 10 minutes)*

Prior to class place five posters/flip charts around the room labeled with: What is Organic Matter?, Factors that Affect Organic Matter, Management of Organic Matter, Benefits of Organic Matter, and Measuring Organic Matter.

Divide the class into five groups and assign one group to each flip chart. Give them one minute to write down as much as they can about that topic on their flip chart and then have them rotate and repeat at each flip chart. When they return to their original flip chart, instruct them to summarize all of the information on the chart and review the information to the class. Allow each group two minutes to summarize their information and 30 seconds to present to the class.

Thank each group as they finish presenting for their summarization.

Celebrate Student Success *(Approximately 2 minutes)*

Thank students for their contributions and congratulate them for demonstrating their understanding of soil organic matter. Take a minute to preview the next lesson.

Soil Organic Matter

Soil Organic Matter

Guided Notes: Soil Organic Matter

Notes completed by _____

Soil Organic Matter:

Factors Affecting Soil Organic Matter

- _____
- _____
- _____

Soil Organic Matter Management

- _____
- _____
- _____
- _____
- _____

Benefits of Soil Organic Matter

- _____
- _____
- _____

The _____ chart provides an estimate of the amount of organic matter in the soil.

Steps to measure soil organic matter:

1. _____
2. _____
3. _____
4. _____

Soil Organic Matter

Measuring Soil Organic Matter – Laboratory (USDA-NRCS)

Completed by _____

Materials Needed to Measure Soil Organic Matter

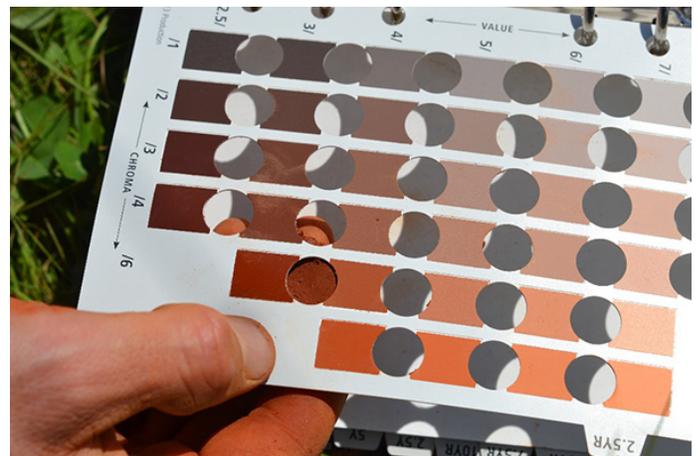
- _____ Soil color chart for estimating organic matter
- _____ Plastic bucket and probe for gathering and mixing soil samples
- _____ Squirt bottle with water (to moisten soil if dry)
- _____ Pen, field notebook, sharpie, and zip lock bags (for labeling soil samples taken back to the classroom)

Considerations – Soil organic matter typically is measured in a lab. The University of Illinois soil color chart provides an estimate of the amount of soil organic matter in mineral soils formed under grass, as many soils are in the Midwest and other natural grassland regions around the world. It can be used for other soils, but is not as accurate. Please read color chart instructions for details and other considerations. Other accepted methods to estimate organic matter such as color charts for other types of soils, lab testing, or tools can be used.

In-field Estimate for Soil Organic Matter (refer to color chart for more guidance)

1. Soil Sampling: Soil organic matter is highly variable. At least 10 small samples are gathered randomly from an area that represents the soil type and management history from the surface 0-6 inch depth and placed in the small plastic bucket and mixed. You may also estimate organic matter at each sample site and average organic matter readings for the area you are assessing. Repeat for each sampling area.
2. Use moist soil. If the sample is dry moisten it.
3. Match the soil with the color that it most closely matches (Figure 3) organic matter color chart (or other method of estimating organic matter content). Record associated organic matter content in Table 3 and complete calculations in interpretations section of this document (suggest averaging several samples).

Figure 3. Soil color chart (Munsell.com).



Soil Organic Matter

1. What is organic matter?

2. What visible types of organic matter did you observe in your samples?

3. How does color help determine soil organic matter?

4. What predictions do you have for the future organic matter of the soil in your sampled area? Why?

5. Why is organic matter important to the soil you sampled?

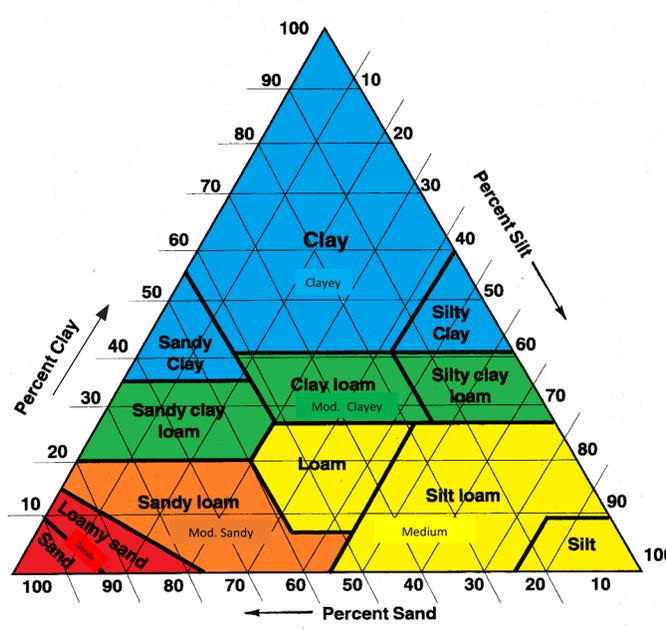
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January 2018

Using Soil Textural Triangle

Approximately 45 minutes



The diagram is a ternary plot with vertices representing 100% Sand (bottom-left), 100% Silt (bottom-right), and 100% Clay (top). The plot is divided into 12 soil texture classes:

- Clay** (top): Clayey (60-100% clay)
- Sandy Clay** (left side): 35-60% clay, 15-35% sand
- Silty Clay** (right side): 35-60% clay, 15-35% silt
- Sandy clay loam** (left side): 27-35% clay, 12-35% sand
- Clay loam** (center): 27-35% clay, 12-35% silt
- Silty clay loam** (right side): 27-35% clay, 12-35% silt
- Loam** (center): 7-27% clay, 40-60% silt
- Sandy loam** (left side): 7-27% clay, 40-60% sand
- Silt loam** (right side): 7-27% clay, 40-60% silt
- Loamy sand** (bottom-left): 0-7% clay, 70-85% sand
- Medium** (bottom-center): 0-7% clay, 35-60% silt
- Silt** (bottom-right): 0-7% clay, 85-100% silt

Objective
By the end of the lesson, students will know or be able to:

- Use the soil textural triangle to distinguish between different types of soil

Preparatory Work

- Make necessary copies
- Review soil textural triangle use

Materials

- Soil Textural Triangle
- Guided Notes Page – one per student
- Guided Practice Page – one per student
- Answer key for teachers
- Three rulers or straight edges

Enroll the Participants - Use the Soil Textural Triangle to Distinguish between Different Types of Soil (Approximately 3 minutes)

Show a large picture of a Soil Textural Triangle to the class or give each student their own copy of the triangle. Ask if anyone has seen this before or how they believe it's used. Accept all answers until someone can identify it as a textural triangle used for determining soil texture.

Definition of Soil Texture

The weight proportion of the soil separates less than 2.0 mm in size (sand, silt and clay). Or, more commonly, the relative proportions of sand, silt and clay:

Sand = 2.0 to 0.05 mm

Silt = 0.05 to 0.002 mm

Clay = <0.002 mm

Sand, silt and clay in various proportions make up 12 soil texture classes

Using Soil Textural Triangle

Provide the Experience *(Approximately 5 minutes)*

Write the sample problem below on the board. Encourage students to work in small groups to determine the appropriate soil textural class. Allow groups to work together to solve the problem, wait until each group has determined the correct soil textural class.

Sample Problem:

75% Sand

15% Silt

10% Clay

Answer:

Sandy Loam

Congratulate students for their success in using the soil textural triangle.

Label the Information *(Approximately 10 minutes)*

After each group has successfully identified the soil textural class, explain to students that they will be writing a “How-to Guide” for this tool. In small groups, encourage students to write step by step instructions for using the soil textural triangle to accurately determine soil textural classes. After about five minutes, invite one group to share their “Soil Textural Triangle How-to Guide” with the class. Encourage each student to capture these instructions in their own words on their Guided Notes page.

Demonstrate the Relevance *(Time varies with students)*

Encourage students to work through the practice problems on the Guided Practice sheet. While students are practicing, move through the room offering support and encouragement to students that may find some challenges.

Review the Content *(Time varies with each group)*

When the majority of the class is finished, go through the problems as a group and check for understanding. Consider having each student provide an answer to ensure all students have grasped the material.

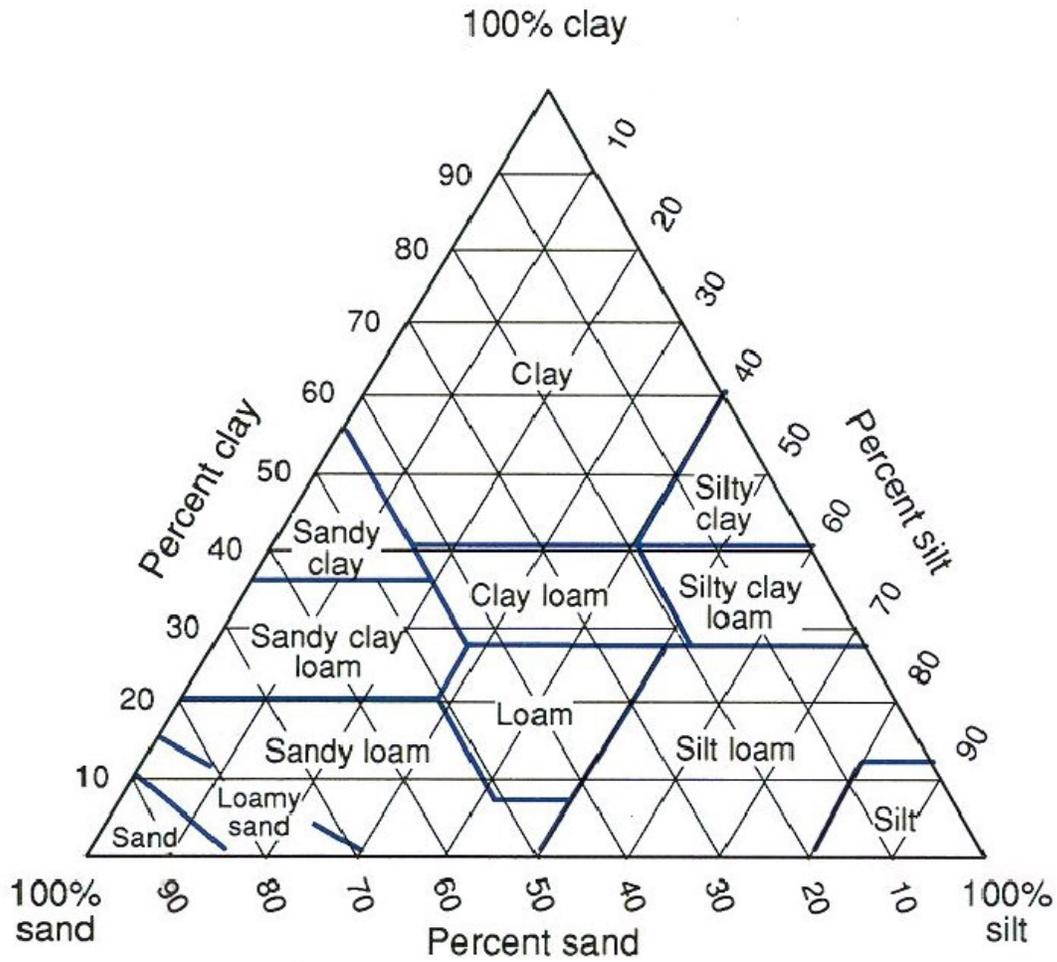
Celebrate Student Success *(Approximately 2 minutes)*

Thank students for their hard work and focus while demonstrating the use of a soil textural triangle. Congratulate students on their ability to determine appropriate soil textural classes as this is important in crop production, landscaping, and even construction. Explain that they will use this information as they determine soil texture and permeability in the land judging competition.

Using Soil Textural Triangle

Guided Notes: Soil Textural Triangle

Notes completed by _____



Soil Textural Triangle How-To Guide:

Using Soil Textural Triangle

Guided Practice: Soil Textural Triangle

Completed by _____

Determine the appropriate soil textural class using the soil textural triangle for each problem below:

1. 40% Sand
50% Silt
10% Clay

2. 70% Sand
15% Silt
15% Clay

3. 35% Sand
15% Silt
50% Clay

4. 20% Sand
60% Silt
20% Clay

5. 30% Sand
40% Silt
30% Clay

7. Which soil textural class do you believe is best for growing plants? Why?

6. Complete the chart using the soil textural triangle.

% Sand	% Silt	% Clay	Texture
5		50	
27	35		
	31	33	
22	23		
10		7	
	7	23	

Using Soil Textural Triangle

Guided Practice: Soil Textural Triangle KEY

Completed by _____

Determine the appropriate soil textural class using the soil textural triangle for each problem below:

1. 40% Sand
50% Silt
10% Clay

Silt Loam

2. 70% Sand
15% Silt
15% Clay

Sandy Loam

3. 35% Sand
15% Silt
50% Clay

Clay

4. 20% Sand
60% Silt
20% Clay

Silt Loam

5. 30% Sand
40% Silt
30% Clay

Clay Loam

6. Complete the chart using the soil textural triangle.

7. Which soil textural class do you believe is best for growing plants? Why?

Answers will vary. Consider there are three general categories of soil texture: coarse texture (sandy soil); medium texture (loamy soil); and fine texture (clay soils). Coarse soil texture soils warm up faster in the spring. Soils with finer textures hold water and nutrients better than coarse textures. Sandy soils usually have good aeration, but can't hold water well. So, both water and nutrients can easily leach through the soils. Clay soils retain more water and nutrients than sand, but there is little infiltration of the water and less oxygen for the plant due to smaller pore space than those of coarser textures. Loam is the ideal soil, holding water, nutrients, and oxygen in a balance of sand, clay and organic matter.

% Sand	% Silt	% Clay	Texture
5	45	50	Silty Clay
27	35	38	Clay Loam
36	31	33	Clay Loam
22	23	55	Clay
10	83	7	Silt
70	7	23	Sandy Clay Loam

Soil Science Curriculum

Content and lab derived from the USDA-NRCS Guides for Educators. Go to www.nrcs.usda.gov/soils for the Guides and additional pictures and diagrams. This lesson plan was adapted for South Dakota from the University of Nebraska Institute of Agriculture and Natural Resources, CROPWATCH.

January 2018

Soil Moisture by Feel and Appearance

Approximately 90 minutes

Objectives

By the end of the lesson, students will know or be able to:

- Define irrigation water management, available water capacity, percent available, soil moisture deficit, and in/ft depleted
- Explain the significance of irrigation water management
- Explain key factors that impact observations made in the feel and appearance method
- Differentiate between percent available water capacities in different soil types
- Obtain a soil sample using a probe, auger or shovel
- Squeeze the soil sample firmly to form an irregularly shaped “ball” of soil
- Squeeze the soil sample out of the hand between the thumb and forefinger to form a soil “ribbon”
- Observe the soil texture, ability to ribbon, firmness and surface roughness, water glistening, loose soil particles, soil/water staining on fingers and soil color

Preparatory Work

- Make necessary copies
- Obtain needed supplies
- Cut out Vocabulary Puzzle
- Determine a location for students to collect soil samples

Materials

- Vocabulary Puzzle
- 4 containers (containing soil, water, air, & a plant)
- Guided Notes sheet – one per student
- 4 clear cups (two with holes at the bottom)
- Sand
- Clay
- Soil Probe
- Soil Auger
- Shovel
- Modeling Clay
- Estimating Soil Moisture by Feel and Appearance handout

Enroll the Participants *(Approximately 5 minutes)*

Place four containers containing water, a plant, soil, and air in the front of the classroom. Give the students about one minute to discuss what these four things have in common, with their partner. After a short time, ask students to share their ideas with the class. Explain to students that they will learn how managing soil, air and water can benefit plant growth.

Soil Moisture by Feel and Appearance

Provide the Experience – Define Irrigation Water Management, Available Water Capacity, Percent Available, Soil Moisture Deficit, and in/ft Depleted *(Approximately 35minutes)*

Vocabulary Puzzle: Cut the vocabulary puzzles into enough pieces so each student has once piece.

Randomly hand out a puzzle piece to each student. Instruct students to find the other students with pieces to their puzzle and assemble their key word. Once each puzzle is assembled, instruct students to become familiar with the definition on their puzzle. Have each group share their vocabulary term and its definition with the class.

Label the Information *(Approximately 3 minutes)*

Instruct students to capture the definitions of each of the following terms in their Guided Notes sheet.

- Irrigation water management: applying water according to crop needs in an amount that can be stored in the plant root zone of the soil
- Available water capacity: the amount of water that a soil can store that is available for use by plants
- Percent available: currently available soil moisture as a percent of available water capacity
- Soil moisture deficit: the amount of water in a soil that can be readily absorbed by plant roots of most crops
- in/ft depleted: inches of water currently needed to refill a foot of soil to field capacity

Demonstrate the Relevance *(Approximately 2 minutes)*

Explain to students that these terms will be key throughout this lesson so it is important to have a basic understanding to be built upon later.

Provide the Experience – Explain the Significance of Irrigation Water Management *(Approximately 5 minutes)*

Lead a brief discussion on irrigation and water usage. Consider discussing management of the High Plains Aquifer, the recent drought, or local irrigation water issues.

Pose the question to students, “Why is it important to manage irrigation water?” Look for answers such as water conservation, cost of water, sustainability, benefits to crops, use by other agronomic inputs, etc.

Label the Information *(Approximately 5 minutes)*

Encourage students to record the significance of irrigation water management in their guided notes. Guide them through a brief conversation about each of these points as they are review the information.

Determine:

- How much water is available for plant use
- When irrigation should be used
- How much irrigation water needs to be applied
- How to conserve irrigation water

Soil Moisture by Feel and Appearance

Demonstrate the Relevance *(Time varies)*

Guide the students through a class discussion on irrigation water management. Elicit personal experiences about irrigation water management from the students. These could be related to production agriculture, a flower or vegetable garden, or even turf grass in their yard.

Provide the Experience – Differentiate between Percent Available Water Capacities in Different Soil Types *(Approximately 5 minutes)*

Poke several small holes in the bottom of two clear cups. Fill one cup about half way with sandy soil and the other with clayey soil. Place each cup over another cup or container to catch draining water. Add equal amounts of water to each cup of soil and observe. Encourage students to watch the water as it percolates, or filters through the soil. After a few minutes, measure the amount of water in the bottom containers.

Note: This could also be demonstrated with several different sponges with a variety of pore sizes. Determine how much water each sponge can hold and compare the results.

Label the Information

Instruct students to record their observations in their Guided Notes sheet.

Soil Texture	Percolation Speed	Water in cup	Water on top of the sample	Notes
Sandy Soil				
Clayey Soil				

Demonstrate the Relevance *(Approximately 5 minutes)*

Encourage students to complete the review questions for this demonstration in their Guided Notes with a partner. After a few minutes, guide the class through a discussion of their answers.

- What are the differences in filtration of sand and clay?
- Why do these differences exist (consider pore space)?
- How does this demonstration relate to available water capacity?

Provide the Experience – Obtain a Soil Sample *(Approximately 2 minutes)*

Show students a soil probe, auger, and a shovel. Ask students what these tools are used for. Look for the answer “collecting soil samples.”

Soil Moisture by Feel and Appearance

Label the Information *(Approximately 5 minutes)*

Introduce students to each of these tools and briefly explain how each tool is used. Encourage students to draw a picture of the tool and a description in their Guided Notes. Consider demonstrating proper use of each tool.

Demonstrate the Relevance *(Time varies)*

Allow students to collect soil samples that will be used later in the lesson using a shovel, auger, and soil probe. Encourage students to use each tool and collect samples at various locations and at various depths. Instruct students to place their sample in a bucket or bag and label with the location of the sample.

Provide the Experience – Estimate Soil Moisture and Texture by Feel and Appearance and Explain Key Factors that Impact Observations *(Approximately 10 minutes)*

Give each student a small portion of modeling clay or play-doh and have them follow along as you demonstrate the process of estimating soil moisture and texture by feel and appearance.

1. Squeeze the sample firmly in your hand several times to form an irregular shaped “ball”.
2. Squeeze the soil sample out of your hand between thumb and forefinger to form a ribbon.
3. Observe texture, ability to ribbon, firmness and surface roughness of ball, water glistening, loose soil particles, soil/water staining on fingers, and soil color.

Allow students to practice this process with the clay several times. Observe individual students and offer guidance through this process.

Label the Information *(Approximately 5 minutes)*

Instruct students to write the step by step instructions for estimating soil moisture and texture by feel and appearance in their Guided Notes.

Also discuss and encourage students to record key factors that impact observations made in the feel and appearance method:

- Rock fragments
- Organic matter
- Bulk density

Demonstrate the Relevance *(Time Varies)*

Using the collected soil samples, instruct students to test various soils for soil texture and soil moisture.

Guide students through the “Texture by Feel Procedure” graphic to determine soil texture. Encourage students to work with a partner using the same soil to determine soil texture.

Using the “Estimating Soil Moisture by Feel and Appearance” guide, encourage students to work with a partner and several soil samples to determine the available water capacity.

Soil Moisture by Feel and Appearance

Review the Content *(Approximately 5 minutes)*

Instruct students to complete the “Learned what? So what? Now what?” chart in their Guided Notes. After a few minutes allow students to work in small groups to add to their chart. As students are working, listen to their conversations and select a few a key concepts being discussed and ask those students to share their information aloud with the group.

Celebrate Student Success *(Approximately 2 minutes)*

Thank students for their participation and willingness to get dirty to discover more about soil. Congratulate students on their ability to collect soil samples, and determine soil texture and soil moisture by feel and appearance. Explain that this skill will be important in the land evaluation competition to identify soil texture and permeability.

Take a few minutes to preview the next lesson.

Soil Moisture by Feel and Appearance

Guided Notes: Soil Moisture by Feel and Appearance?

Notes Completed by: _____

1. Irrigation water management:

Available water capacity:

Percent available:

Soil moisture deficit:

in/ft depleted:

2. Why is irrigation water management important?

3. Percent Available Water Capacity

Soil Texture	Percolation Speed	Water in cup	Water on top of soil sample	Notes
Sand				
Clay				

Soil Moisture by Feel and Appearance

What are the differences in filtration of sand and clay?

Why do these differences exist (consider pore space)?

How does this demonstration relate to available water capacity?

4. Collecting a Soil Sample:

Soil Probe

Soil Auger

Shovel

5. Feel and Texture Method:

1.

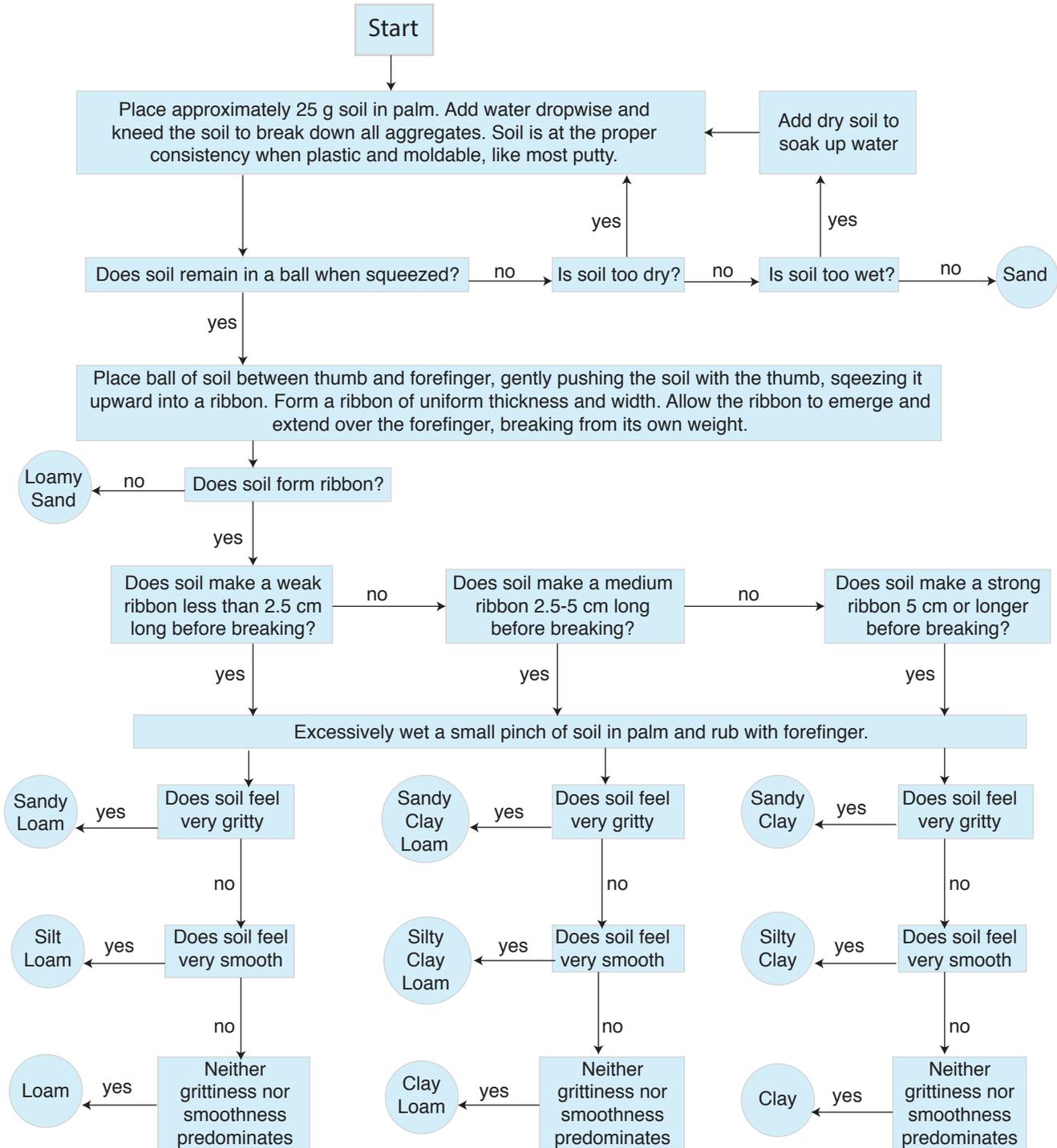
2.

3.

Soil Moisture by Feel and Appearance

Factors that Impact Observations in Feel and Texture Method:

Soil Texture by Feel Procedure



Soil Moisture by Feel and Appearance

Vocabulary Puzzle: Cut out each box. Then, cut each box into pieces so there are enough pieces for each student to have one piece. Example if there are 25 students in class cut each box into five pieces for a total of 25 puzzle pieces.

Irrigation water management: is applying water according to crop needs in an amount that can be stored in the plant root zone of the soil.

Available water capacity: is the amount of water that a soil can store that is available for use by plants

Percent available: currently available soil moisture as a percent of available water capacity

Soil moisture deficit: is the amount of water in a soil that can be readily absorbed by plant roots of most crops

in/ft depleted: inches of water currently needed to refill a foot of soil to field capacity

Soil Science Curriculum

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January 2018

Soil Health Measurement

Approximately 180 minutes

Objectives

By the end of the lesson, students will know or be able to:

- Define soil health, soil series, and erosion
- Describe two methods to assess soil health
- Create a model that represents signs of erosion
- List and describe causes of erosion
- Explain the role of soil management in determining soil health
- Determine percent slope of a specific land area
- Explain how climate impacts soil
- Explain how longitude and latitude impact soil
- Identify environmentally sensitive areas
- Determine when to properly sample soil
- Determine where to sample soil
- Explain the guidelines for selecting sampling sites
- Explain the need for collecting multiple samples
- Use the South Dakota Soil Health Card

Preparatory Work

- Make necessary copies
- Obtain necessary supplies
- Review South Dakota Soil Health Card
- Determine where Building a Soil Erosion Model Activity will be completed to plan accordingly with time and supplies
- Determine where soil samples will be taken, where soil health will be measured, and the location of slope measuring

Materials

- 4 Soil Samples
- Guided Notes Page – one per student
- 2 Balls
- Several marking flags
- Shovel
- Soil probe
- Plastic bags
- Markers
- South Dakota Soil Health Card – one per student

Enroll the Participants *(Approximately 5 minutes)*

Present four very different soil samples to the class. Have them individually rank the samples best to worse. Discuss students' rankings of the soil samples.

- Why did you rank 1 before 2, 2 over 3, and 3 over 4?
- Why is student A's ranking so different from student B?
- Are some soils really better than others?

Soil Health Measurement

Provide the Experience – Soil Health and Health Assessment *(Approximately 5 minutes)*

Instruct students to work as a class to brainstorm a list of characteristics of “good soil”. Allow the class a few minutes and discuss their list. After a short discussion inform students that this lesson will allow them to identify and measure soil health.

Label the Information *(Approximately 2 minutes)*

Instruct students to capture the definition of soil health and two methods of assessment.

Soil health integrates the physical, chemical, and biological components of soil and their interactions.

There are two fundamental ways to assess soil health:

- Take measurements periodically over time to monitor changes or trends in soil health
- Compare measured values to a standard or reference soil condition

Demonstrate the Relevance *(Approximately 5 minutes)*

Lead students through a discussion about soil health. Consider using the following questions to help guide the discussion:

- Why is soil health important?
- Who monitors soil health?
- What factors affect soil health?
- How is soil health assessed?

Provide the Experience – Describe the Role of Soil Management, how Climate, Longitude and Latitude Impact Soil, and Identify Environmentally Sensitive Areas

(Approximately 5 minutes)

When going to the doctor, before a diagnosis can be made patients must provide doctors with important information. Ask students what this information is called. *Answer: medical history.* Lead the class in a brief discussion on medical history.

- What is included in a medical history?
- Why is this important to doctors?

Just as doctors need a medical history for diagnosing people, soil scientists need information about a site before recommendations can be made.

Soil Health Measurement

Label the Information *(Approximately 10 minutes)*

Instruct students to complete the graphic organizer about field or site characterization using the following information:

Field or site characterization is important information for evaluating soil health.

Soil series is the name of soil found in the county soil survey.

Signs of erosion include gullies, rills, development of pedestals, exposed areas of subsoil, wind damage or plants.

Management history includes a description of past and present land and crop management; kind, amount and method of fertilization; prior tillage; and land leveling.

Slope and topography includes percent slope at sampling sites and note any hills, knolls, ridges, potholes, depressions, etc.

Location of field includes a record of longitude and latitude.

Climatic information includes the precipitation and high and low average temperatures for each month.

Location of environmentally sensitive areas includes location of ponds, creeks, wetlands, or other environmentally fragile sites.

Demonstrate the Relevance *(Approximately 10 minutes)*

As students complete their graphic organizers, instruct students to complete “Why is this important?” bubbles on their graphic organizer. Invite students to share their responses to each of these questions with the class. Guide students through a brief discussion of site characteristics using the graphic organizers as a guide.

Provide the Experience – Create a Model and Describe the Causes of Erosion

(Approximately 5 minutes)

Ask the class to define erosion in a picture; give them a few minutes to draw their definition. After a short time, ask a few students to show their pictures.

Inform students that this lesson will also allow them to take a closer look at erosion and how it affects soil health.

Soil Health Measurement

Label the Information *(Approximately 10 minutes)*

Instruct students to record the definition, causes, and characteristics of erosion. Soil erosion involves the breakdown, detachment, transport, and redistribution of soil particles by forces of water, wind, or gravity.

Type of Erosion	Causes	Picture or Example
Water Erosion	<ul style="list-style-type: none">• Lack of protection against raindrop impact,• Decreased aggregate stability,• Long and steep slopes,• Intense rainfall or irrigation events when plant or residue cover is at a minimum,• Decreased infiltration by compaction or other means.	
Mechanical Erosion	<ul style="list-style-type: none">• Removal by harvest of root crops,• Tillage and cultivation practices that move soil downslope.	
Wind Erosion	<ul style="list-style-type: none">• Exposed surface soil during critical periods of the year,• Occurrence of wind velocities that are sufficient to lift individual soil particles,• Long, unsheltered, smooth soil surfaces.	

Demonstrate the Relevance *(Time varies)*

Provide students with the “Demonstrating Erosion” activity guide and review the activity and rubric. Set a due date for the activity and any parameters that are specific to your students’ needs and your classroom. Determine whether the activity will be completed in the classroom or as homework to be completed outside of the classroom and plan accordingly. Upon completion of the project encourage students to present their erosion model to the class.

Provide the Experience - Determine Slope *(Approximately 5 minutes)*

Set a ball on a flat surface another on an incline. Watch the ball on the incline roll down and the one on a flat surface stay put. Ask students why this happened. Look for a student to answer “slope”. Guide a discussion about the importance of slope in soil health. Look for ideas such as the steepness and length of the slope influence the speed with which water runs off a field and the amount of soil carried away in the runoff water. The steepness of the slope also affects the ease of cultivation, use of farm machinery, and suitability of the site for septic tank disposal fields, homesites, playgrounds, paths, trails, golf courses, streets, and roads.

Soil Health Measurement

Label the Information *(Approximately 15 minutes)*

Instruct students to capture the slope information in their Guided Notes.

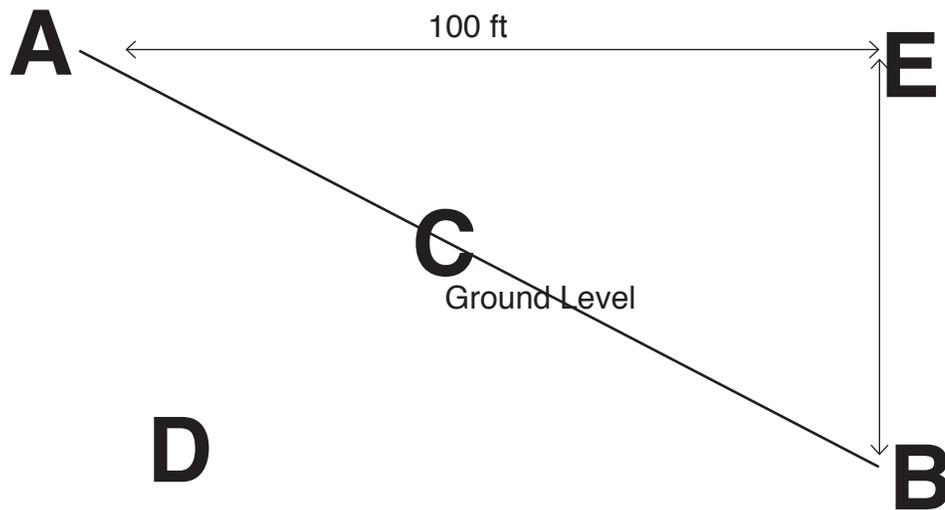
Slope is the steepness of the land usually measure in a percentage.

Draw a diagram to represent slope.

Instruct students to complete the practice slope calculations in their Guided Notes. Review the correct answers with students to gauge their understanding.

Demonstrate the Relevance *(Approximately 4 minutes)*

Select an area for students to practice slope measurements. Create several sites by placing two marking flags 100 feet apart at each site. Encourage students to estimate the slope difference between the two flags.



Flags are 100 feet apart (A and B). From the approximate center of the 100 feet (C), step about 15 steps toward the low side of the slope (D). With a straight edge or using your arm extended at the ground level of (A), swing your body keeping straight edge or your arm level, locating point (E) directly above flag (B). The measurement of (E) to the ground is percent, or foot of fall, in elevation from (A) to (B).

Note: There are several “tricks” to measuring slope. Consider asking an experienced land judging coach or agricultural instructor for advice and other strategies. Also, GPS devices can be helpful to accurately determine the slope of an area.

Soil Health Measurement

Provide the Experience – Determine When and Where to Sample and Discuss Soil Sampling Guidelines *(Approximately 5 minutes)*

Instruct students to work in a group of three to create a recipe for sampling soil and it is important to include materials needed and specific instructions. After a few minutes, invite a few groups to share their recipes.

Label the Information *(Approximately 10 minutes)*

Encourage students to capture the soil sampling guidelines in their Guided Notes. Discuss soil samples as students record the information.

When to sample?

- Annual sampling of a field is recommended
- Sample when the climate is most stable and there have been no recent disturbances such as after harvest or the end of the growing season

Where to sample?

- Consider rows, soil type, management, plant growth, salt affected areas, erosion, slope, and drainage
- Select sample sites that are representative of the field
- For trouble spot assessment, select areas that are representative to trouble spots
- When comparing management systems, make sure sites selected for comparison have the same soil type
- When making changes to soil, make sure samples are taken after each change

How many samples?

- Sample number will depend on the variability of the field
- Take a minimum of three samples on any one soil type

Demonstrate the Relevance *(Time varies with site location)*

Allow students to make a soil sampling plan for an area and collect samples in small groups. Show students the field that they will be using for sampling and measuring soil health. Allow students to determine when to sample, where to sample, and how many samples to take, using the guidelines from their notes. Instruct students to visit the site and record their plan for collecting soil samples. After each group has recorded their soil sampling plan, instruct the group to justify their plan to another group. Then, allow them to collect samples. Remind students to label each sample in a plastic bag.

Label the Information *(Time varies)*

Instruct students to record their observations on the soil health card during evaluation.

Soil Health Measurement

Demonstrate the Relevance *(Approximately 5 minutes)*

When the class finishes collecting data and completing the card, lead a discussion on soil health. Consider using the following questions to guide the discussion:

- Who might use the soil health card?
- Why is it important for South Dakota to have its own soil health card?
- What are the benefits of using the soil health card?
- Do you think using this card will provide soil managers with enough information to make informed soil management decisions?
- What other data might soil managers need to know about a site?

Review the Content *(Approximately 10 minutes)*

What am I? Instruct students to create two riddles from the information in this lesson. They must present their riddle to two different partners with the partners trying to solve the riddle. Consider using the example below to help guide students.

*I am caused by one of the most important life sustaining substances on earth but destroy soil.
What am I? Answer: Water erosion.*

Celebrate Student Success *(Approximately 3 minutes)*

Thank students for their engagement and participation. Congratulate them on their ability to evaluate soil health. Explain that this skill will be useful throughout their lives, if they plant a field or garden or build a house, fence, or even a swing set. Congratulate them on their ability to successfully measure slope and erosion and begin determining soil class in the land evaluation contest. Preview information in the next lesson.

Soil Health Measurement

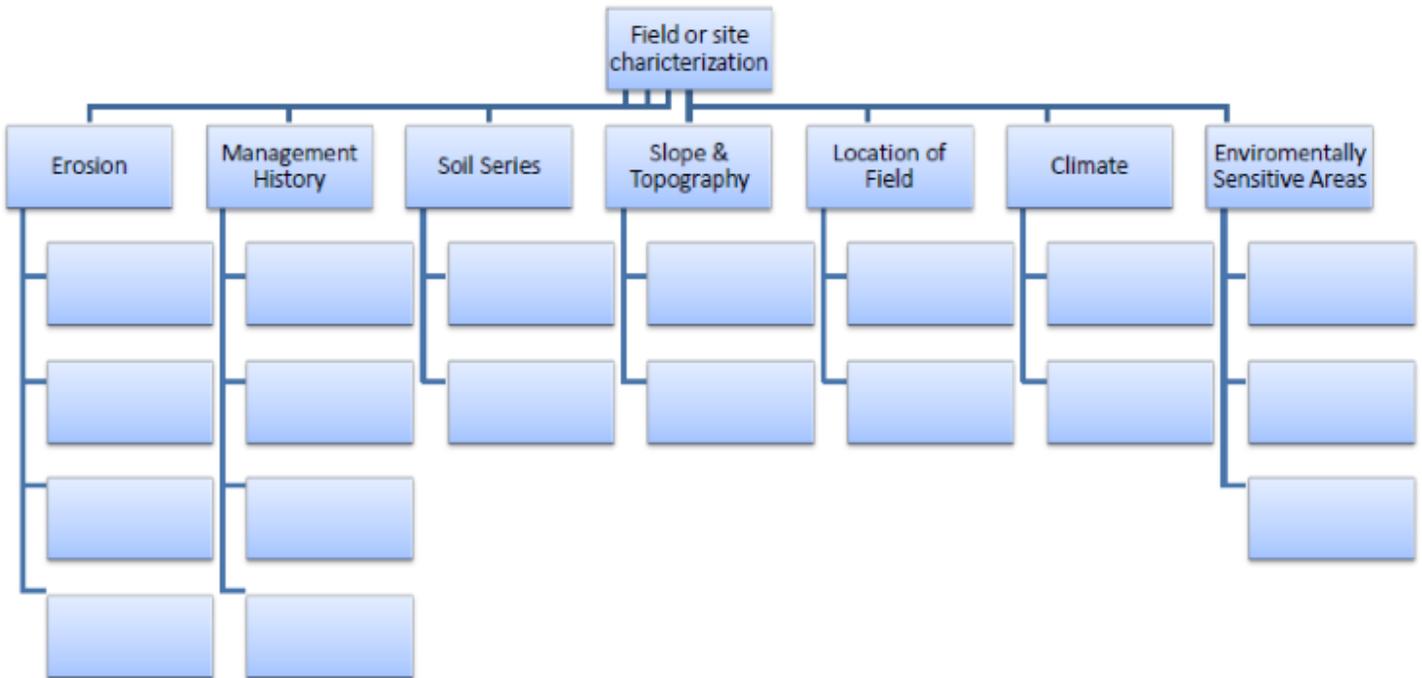
Guided Notes: Mearuring Soil Health

Notes completed by _____

Characteristics of "good soil":

Soil Health:

Assessing soil health:



Soil Health Measurement

• Management History

• Soil Series

• Signs of Erosion

• Slope and Topography

• Location of Field

• Climate

• Environmental Sensitivity

Soil Health Measurement

Erosion is?

Type of Erosion	Causes	Picture or Example

Soil Health Measurement

What is slope?

Diagram slope:

Soil Health Measurement

Determine the slope percentage in each of the following problems:

- A.** Flag 1 – elevation 30 feet
Flag 2 – elevation 0 feet
Distance – 100 feet

- B.** Flag 1 – elevation 5 feet
Flag 2 – elevation 0 feet
Distance – 100 feet

- C.** Flag 1 – elevation 20 feet
Flag 2 – elevation 0 feet
Distance – 50 feet

- D.** Flag 1 – elevation 3 feet
Flag 2 – elevation 0 feet
Distance – 50 feet

- E.** Flag 1 – elevation 5 feet
Flag 2 – elevation 0 feet
Distance – 50 feet

- F.** Flag 1 – elevation 12 feet
Flag 2 – elevation 0 feet
Distance – 100 feet

Soil Sampling Guidelines:

When to sample?

Where to sample?

How to sample?

Soil Health Measurement

Building A Structure : Erosion Model

Student Name: _____

Activity Due Date: _____

Using products found around your home, construct a soil erosion model that includes all three types of soil erosion (wind, water, and mechanical). Use products that accurately represent the characteristics of each soil erosion type as discussed in class and found in the resources provided to you as well as any research you conduct on the internet or in other printed resources.

Your soil profile may be a 2-D or 3-D display, edible, have movement, be stationary, or have any other creative characteristic you can imagine. The goal is that you will be able to describe each type of erosion accurately because of creating this model.

The rubric below will be used for scoring this activity.

CATEGORY	4	3	2	1
Scientific Knowledge	Explanations indicate a clear and accurate understanding of scientific principles underlying the construction and modifications.	Explanations indicate a relatively accurate understanding of scientific principles underlying the construction and modifications.	Explanations indicate relatively accurate understanding of scientific principles underlying the construction and modifications.	Explanations do not illustrate much understanding of scientific principles underlying the construction and modifications.
Plan	Plan is neat with clear measurements and labeling for all components.	Plan is neat with clear measurements and labeling for most components.	Plan provides clear measurements and labeling for most components.	Plan does not show measurements clearly or is otherwise inadequately labeled.
Construction -Materials	Appropriate materials were selected and creatively modified in ways that made them even better.	Appropriate materials were selected and there was an attempt at creative modification to make them even better.	Appropriate materials were selected.	Inappropriate materials were selected and contributed to a product that performed poorly.
Construction - Care Taken	Great care taken in construction process so that the structure is neat, attractive and follows plans accurately.	Construction was careful and accurate for the most part, but 1-2 details could have been refined for a more attractive product.	Construction accurately followed the plans, but 3-4 details could have been refined for a more attractive product.	Construction appears careless or haphazard. Many details need refinement for a strong or attractive product.

Soil Health Measurement

Determine the Slope KEY

A. 30%

B. 5%

C. 40%

D. 6%

E. 10%

F. 12%

Soil Science Curriculum

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January 2018

Soil Bulk Density

Approximately 135 minutes

Objectives

By the end of the lesson, students will know or be able to:

- Define ammonification, available water holding capacity, nitrification, bulk density, denitrification, respiration, soil porosity, soil water filled pore space, soil water content, gravimetric, and volumetric water content
- List and explain factors that affect soil bulk density
- List and describe soil bulk density management processes
- Measure soil bulk density and interpret data

Preparatory Work

- Secure several locations with different land uses and soil types to drive a soil sample.
Examples: garden, grassland, crops

Materials

- Sponge
- Pumice stone
- Penny
- Balloon
- Fishing sinker
- Marble
- Terms and definitions
- Laboratory supplies (see Guided Notes Lab)

Enroll the Participants *(Approximately 4 minutes)*

Show students the following items in comparison and ask students which item is most dense within each pair.

Same volume but differing weights

- Half a cup of water and half a cup of oil

Same weight but differing volumes

- A pound of feathers and a pound of lead

Facilitate a discussion with students to ask them what is meant by “dense” and to define “density.”

Preview with students that the density of soil helps us indicate the soil’s compaction and health.

Provide the Experience – Soil Bulk Density Key Terms *(Approximately 5 minutes)*

Provide 10 students each with a key term and 10 other students each with a definition associated with a key term. Instruct students to locate their matching partner.

Soil Bulk Density

Label the Information *(Approximately 10 minutes)*

Instruct students to share their terms and definitions with the class.

Ammonification: Occurs in the nitrogen cycle when soil organisms decompose organic-nitrogen ($C-NH_2$) converting it to ammonia (NH_4^+).

Available Water Holding Capacity: Soil moisture available for crop growth; also defined as the difference between field capacity and wilting point, typically shown in inches/feet.

Nitrification: Occurs in the nitrogen cycle when soil organisms convert ammonia (NH_3) and ammonium (NH_4^+) into nitrite (NO_2^-) and next to nitrate (NO_3^-)-nitrogen which is available to plants.

Bulk Density: Weight of dry soil per unit of volume, more compacted soil with less pore space will have a higher bulk density.

Denitrification: Conversion and loss of nitrate (NO_3^-)-nitrogen as nitrogen gases (N_2 , N_2O , NO) when soil becomes saturated with water.

Respiration: Carbon dioxide release from soil comes from several sources (decomposition of organic matter by soil microbes and respiration from roots)

Soil Porosity: Percent of total soil volume made up of pore space.

Soil Water Filled Pore Space: Percent of pore space filled with water.

Soil Water Content, Gravimetric: Weight of soil water per unit of dry soil weight.

Volumetric Water Content: Amount (weight or volume) of water in soil core by volume.

Demonstrate the Relevance *(Approximately 7 minutes)*

Instruct students to talk together and formulate ideas about how soil bulk density affects soil health. Elicit responses, filling in the following information.

- Bulk density affects the following:
 - Ability of water to infiltrate and move through soil
 - Rooting depth of plants
 - Available water capacity
 - Soil porosity
 - Plant nutrient availability
 - Soil microorganism activity
- Bulk density is a measurement of the weight of dry soil per unit volume
 - 50 percent solids (soil particles and organic matter)
 - 50 percent pore space (filled with air or water)

Soil Bulk Density

Provide the Experience – Factors Affecting Bulk Density *(Approximately 5 minutes)*

Reiterate that soil bulk density is the weight of dry soil and that the weight is comprised of 50 percent solids and 50 percent pore space.

Instruct half of the class to discuss and develop a list of factors that might affect the solids (soil particles and organic matter) found in soil. Instruct the other half of the class to discuss and develop a list of factors that might affect the pore space (space for water or air) found in soil.

Label the Information *(Approximately 5 minutes)*

The following factors affect soil bulk density:

- Soil organic matter
- Soil texture
- Density of soil mineral
- Packing arrangement of aggregates

Here are additional key points about bulk density:

- Presence and amount of rock fragment, soil depth and soil texture affect the water capacity of soil
- Loose, well-aggregated, porous, high organic matter soils have a lower bulk density
- Sandy soils have a higher bulk density because of less pore space

Demonstrate the Relevance *(Approximately 5 minutes)*

Ask students the following questions:

Q. Based on what you know, what happens to soil bulk density as soil depth increases?

A. Bulk density increases with soil depth because subsurface layers are more compacted.

Q. What happens to bulk density when fields or gardens are tilled?

A. Surface bulk density temporarily decreases because of the soil particles being broken up, but the layers below the surface become more compact, increasing bulk density.

Q. How does a higher bulk density impact the ability of roots to support the plant?

A. The higher the bulk density, the more compact the soil is and the less pore space exists. Higher bulk density makes it difficult for roots to obtain the water and nutrients they need, as well as to grow deep enough to anchor the plant.

Provide the Experience – Soil Bulk Density *(Approximately 3 minutes)*

Ask students how they believe bulk density could possibly be lowered.

Soil Bulk Density

Label the Information *(Approximately 7 minutes)*

Bulk Density Management Practices

- Increase soil organic matter
 - Use no till
 - Use cover crops
 - Use solid manure or apply compost
 - Use high residue crops
- Minimize soil disturbances
 - Avoid equipment operation on wet soil
 - Use designated roads or rows for equipment transportation
- Decrease compaction
 - Reduce the number of trips across the field with equipment
 - Rotate livestock
- Use multi-crop systems
 - Plant crops with a variety of rooting depths

Demonstrate the Relevance *(Approximately 5 minutes)*

Facilitate a discussion with students that is relevant to them; how does bulk density affect a garden's ability to perform? What steps could be taken to decrease soil bulk density in a garden? In a field?

Provide the Experience – Measure and Interpret Bulk Density *(Approximately 90 minutes)*

Introduce each of the laboratory supplies to the students and review the laboratory processes and procedures with the class. See the Guided Notes lab for information. If possible, play the NRCS lab instructions video for students found here [NRCS Soils](#).

Students engage in the lab activity.

Label the Information *(Time varies)*

Students record information and answer lab questions.

Demonstrate the Relevance *(Time varies)*

Discuss with students how bulk density affects the ability of farmers to produce food for consumers.

Review the Content *(Approximately 7 minutes)*

Instruct students to work in small groups to create a poster that they can share with other students about soil bulk density facts.

Soil Bulk Density

Guided Notes: Soil Respiration

Ammonification:

Available Water Holding Capacity:

Nitrification:

Bulk Density:

Denitrification:

Respiration:

Soil Porosity:

Soil Bulk Density

Soil Water Filled Pore Space:

Soil Water Content, Gravimetric:

Volumetric Water Content:

Factors that Affect Soil Bulk Density

How do bulk density, moisture and aeration relate?

How do we manage bulk density?

Soil Bulk Density

Guided Notes: Soil Bulk Density Laboratory

Soil Bulk Density Scenario

Catherine and Ray want to plant a garden in their new yard, but the best location for the garden doesn't even grow grass currently. The ground is very hard, and they think the bulk density of the soil might be too high for good root penetration. They are hopeful that they can improve the bulk density by planting a variety of plants over the next several years. Discuss methods and practices Catherine and Ray could use to improve their garden's compaction/bulk density problem.

Laboratory Supplies

- 3-inch diameter aluminum ring
- Wood block or plastic insertion cap
- Rubber mallet or weight
- Folding trowel
- Flat-bladed knife
- Sealable bags and marker pen
- Scale (1 gram precision)
- 1/8 cup (29.5 mL) measuring scoop
- Ceramic coffee cup
- 18-inch metal rod, probe or space (to check for compaction zone)
- Access to a microwave oven

Laboratory Steps

Bulk density can be measured at the soil surface and/or compacted tillage zone. Bulk density samples should be taken in the same location as infiltration and respiration tests. It may be possible to use the infiltration test sample. For sticky clay soils, a little penetrating oil applied to the ring makes it easier to remove the soil.

Secure several sites with different soil types and/or landuses. For example: garden, grassland, crop, lawn, etc. Ask students to form a hypothesis on which sites will have highest and lowest bulk densities. Test their hypothesis with lab exercise results.

Soil Bulk Density

Step-by-Step Procedure

1. Carefully clear all residue and then drive the ring to a depth of three inches with a small mallet or weight and a block of wood or plastic cap.
2. Remove the ring by cutting around the outside edge with a small 4-inch serrated butter knife and using the small folding trowel underneath of it.
3. Carefully lift the ring out, preventing loss of soil by holding the trowel under it.
4. Remove excess soil from the bottom of the cylinder with serrated butter knife.
5. Place the sample in a plastic sealable bag and label it.
6. Weigh the sample in the bag and record its weight in Table 1.
7. Weigh an identical clean, empty plastic bag and record its weight in Table 1.
8. Weigh an empty microwavable cup to be used in step 9 and record its weight in Table 1.
9. Either extract a subsample or dry and weigh the entire sample to determine water content and dry soil weight:
 - a. Mix the sample thoroughly in the bag by kneading it with your fingers.
 - b. Take a 1/8 cup level scoop of loose soil (not packed down) from the plastic bag and place it in the cup weighted in step 8. Use more than one scoop to increase accuracy of the measurement.
10. Weigh the moist subsample in the cup before drying it and record the weight in Table 1.
11. Place the cup containing the subsample in a microwave and dry the sample for two or more 4-minute cycles at medium power.
12. To determine if soil is dry, weigh the subsample in a cup after each 4-minute cycle. When the weight no longer changes after a drying cycle, it is dry.
13. Record its weight in Table 1.

Interpretations

Complete Table 1 for bulk density and soil water content determination and compare the results to the same soil texture listed in Table 2 to determine relative restrictions to root growth or compaction concerns. Complete Tables 3, 4 and 5 for soil water and porosity determination.

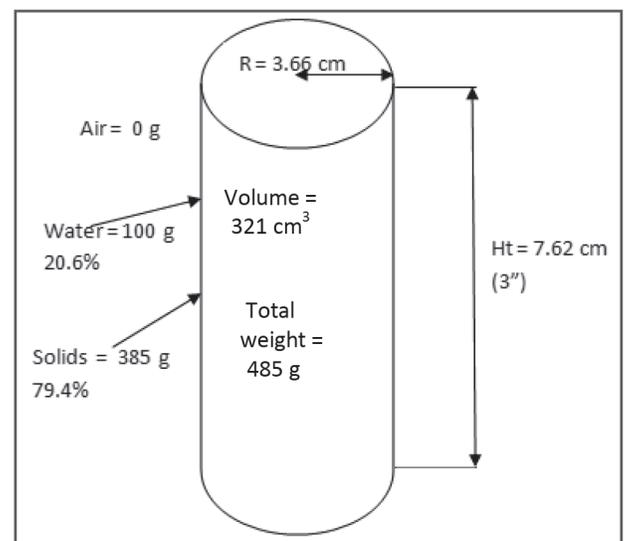


Figure 11. Example of soil core dimensions, volume and weight by component.

Soil Bulk Density

Table 1. Bulk density and soil water content (core method). Refer to calculations below for details.

Sample Site	(a) Weight of field moist soil + sample bag (grams)	(b) Weight of sample bag (grams)	(c) Weight of cup (grams)	(d) Weight of cup + moist soil (grams)	(e) Weight of moist soil (grams) (d-c)	(f) Weight of dry soil + cup (grams)	(g) Dry weight of soil (grams) (f-c)	(h) Soil water content (grams/gram) (d-e)/(g)	(i) Soil bulk density (g/cm ³)

Volume of Soil Core (cm³) (refer to Figure 11)

$$\pi r^2 \times \text{height}$$

Example 1 (refer to Figure 11)

$$3.14 \times (3.66 \text{ cm})^2 \times (7.62 \text{ cm}) = 321 \text{ cm}^3$$

Soil Water Content Using a Subsample (g/g)

$$\frac{(\text{weight of moist soil} - \text{weight of oven dry soil})}{\text{Weight of oven dry soil}}$$

Example 1 (e - g)/(g)

$$\frac{(34\text{g} - 27\text{g})}{27\text{g}} = 0.259 \text{ g of water/g of soil}$$

Calculating the Dry Weight of the Bulk Sample Based on Soil Water Content of Subsample (grams)

$$\text{Dry wt of soil bulk sample} = \frac{[\text{Wt of field moist soil} + \text{bag (grams)} - \text{Wt of bag (grams)}]}{[1 + \text{Soil Water content (g/g)}]}$$

Example 1: dry wt of bulk sample = $[(a - b)/(1 + h)] = (490 \text{ g} - 5 \text{ g}) / (1 + .259) = 385 \text{ g}$

Soil Bulk Density

Bulk Density Calculation (g/cm³)

Bulk Density = Dry wt of bulk sample ÷ volume of soil core

Example 1: bulk density = 385g ÷ 321 cm³ = **1.20 g/cm³**

Table 2. General relationship of soil bulk density to root growth based on soil texture

Soil Texture	Ideal bulk densities for plant growth (grams/cm ³)	Bulk densities that affect root growth (grams/cm ³)	Bulk densities that restrict root growth (grams/cm ³)
Sands, loamy sands	< 1.60	1.69	> 1.80
Sandy loams, loams	< 1.40	1.63	> 1.80
Sandy clay loams, clay loams	< 1.40	1.60	> 1.75
Silts, silt loams	< 1.40	1.60	> 1.75
Silt loams, silty clay loams	< 1.40	1.55	> 1.65
Sandy clays, silty clays, clay loams	< 1.10	1.49	> 1.58
Clays (> 45% clay)	< 1.10	1.39	> 1.47

Soil Water Content and Porosity Calculations

Table 3. Soil water content

Sample Site	Soil Water Content (by Wt) (g/g) (from h in Example 1)	Bulk density (g/cm ³) from Example 1	* Volumetric water content (g/cm ³)	** Inches of water/ft. of soil depth
Example 1	0.259	1.2 g/cm ³	0.3108 g/cm ³	3.7 in/ft

Soil Bulk Density

* Volumetric water content (g/cm³) = soil water content (g/g) x bulk density (g/cm³)

** Inches of water/ft. of soil depth = volumetric water content x 12 in/ft

Table 4. Soil porosity (%)

Sample Site	Bulk Density (grams/cm ³) from Table 2	Calculation 1 - (soil bulk density / 2.65)	* Soil porosity (%)
Example 1	1.2grams/cm ³	1 - (1.2/2.65)	0.547 or 54.7

* Soil porosity (%) = 1 - (soil bulk density / 2.65). The default value of 2.65 is used as a rule of thumb based on the average bulk density of rock with no pore space.

Table 5. Soil water filled pore space (%)

Sample Site	Volumetric water content (grams/cm ³) from Table 3	Soil porosity from Table 4	Volumetric Water Content / Soil porosity x 100	* Soil Water-Filled Pore Space
Example 1	0.3108 grams/cm ³	0.547	0.3108 g/cm ³ / .547 x 100	.568 or 56.8%

* Soil water-filled pore space (%) = (volumetric water content / soil porosity) x 100



Soil Bulk Density

Ammonification

Occurs in the nitrogen cycle when soil organisms decompose organic-nitrogen converting it to ammonia.

Available Water Holding Capacity

Soil moisture available for crop growth; also defined as the difference between field capacity and wilting point, typically shown in inches/foot.

Nitrification

Occurs in the nitrogen cycle when soil organisms convert ammonia and ammonium into nitrite and next to nitrate-nitrogen which is available to plants.

Bulk Density

Weight of dry soil per unit of volume, more compacted soil with less pore space will have a higher bulk density.

Denitrification

Conversion and loss of nitrate-nitrogen as nitrogen gases when soil becomes saturated with water.

Respiration

Carbon dioxide release from soil comes from several sources (decomposition of organic matter by soil microbes and respiration from roots)

Soil Porosity

Percent of total soil volume made up of pore space.

Soil Water Filled Pore Space

Percent of pore space filled with water.

Soil Water Content, Gravimetric

Weight of soil water per unit of dry soil weight.

Volumetric Water Content

Amount (weight or volume) of water in soil core by volume.

Soil Science Curriculum

Content and lab derived from the USDA-NRCS Guides for Educators. Go to www.nrcs.usda.gov/soils for the Guides and additional pictures and diagrams. This lesson plan was adapted for South Dakota from the University of Nebraska Institute of Agriculture and Natural Resources, CROPWATCH.

January 2018

Soil Biology Respiration

Approximately 180 minutes

Soil biology respiration refers to the production of carbon dioxide when soil organisms respire. This includes respiration of plant roots, the rhizosphere, microbes and fauna.

Soil biology respiration is a key ecosystem process that releases carbon from the soil in the form of CO_2 . CO_2 is acquired from the atmosphere and converted into organic compounds in the process of photosynthesis. Plants use these organic compounds to build structural components or respire them to release energy. When plant respiration occurs below-ground in the roots, it adds to soil respiration. Over time, plant structural components are consumed by the biota in the soil which then releases CO_2 . When this CO_2 is released by below-ground organisms, it is considered as soil respiration.

The amount of soil respiration that occurs in an ecosystem is controlled by several factors. The temperature, moisture, nutrient content and level of oxygen in the soil can produce extremely disparate rates of respiration. These rates of respiration can be measured in a variety of methods.

Soil biology respiration rates can be largely affected by human activity. This is because humans have the ability to and have been changing the various controlling factors of soil respiration for numerous years. Tillage and fertilization by humans also has the potential to affect respiration rates.

Objectives

By the end of the lesson, students will know or be able to:

- Define soil respiration and soil microbes
- Explain the role of soil respiration in determining soil health
- Diagram the role of soil respiration in the cycle of life on earth
- List and explain inherent factors that affect soil respiration
- List and describe soil respiration management processes
- Interpret management impacts on soil respiration and soil organic matter
- Measure soil respiration and interpret data

Preparatory Work

- Place a plant cutting in a plastic baggie several hours prior to teaching this lesson so that respiration is visible

Materials

- Lab materials (see Lab Guided Notes)
- Baggie that seals
- Plant cutting

Soil Biology Respiration

Enroll the Participants *(Approximately 4 minutes)*

Show or pass around the sealed baggie with the plant cutting inside of it. Inquire to students as to what they know about why the water droplets formed inside of the baggie even though you placed only a plant cutting inside of the baggie.

Hold up the second (empty) plastic baggie and breathe into it to demonstrate the formation of water droplets because of your breath. Again, inquire about what students know.

Content to share:

- Living organisms conduct the process of respiration.
- It's easy to see signs that a human is breathing (a rising chest or abdomen, sound of breathing, feel of breath, etc.)
- We can see that plants are breathing through the cutting in the baggie

Provide the Experience – Key Terms and Soil Health *(Approximately 5 minutes)*

Separate students into small groups of three or four.

Provide each small group with a soil sample. (It will be helpful if some of the samples have bugs, worms, crop residue or other living organisms in them.)

Instruct small groups to investigate their soil and determine what in the soil affects the respiration that occurs in the soil. Elicit student responses.

Label the Information *(Approximately 4 minutes)*

Direct students to their Guided Notes and encourage them to capture the following information.

- Soil respiration is a measure of the carbon dioxide released from the soil by microbes decomposing soil organic matter and from the respiration of plant roots.
- Soil respiration indicates soil health (soil organic matter content, soil organic matter decomposition and the level of microbial activity).
- Soil Microbes: Soil organisms that are responsible for soil respiration and many important soil processes such as nutrient cycling.
- Respiration: Release of carbon dioxide from several sources (decomposition of soil organic matter by soil microbes, and respiration from plant roots).
- Mineralization: Organic matter decomposition releasing nutrients in a plant available form that occurs during respiration.
- Ammonification: Production of ammonium from soil organic matter decomposition.
- Denitrification: Anaerobic conversion and loss of nitrate-nitrogen to nitrite and nitrogen varieties of gases.
- Nitrification: An aerobic microbial process converting soil ammonium nitrogen to plant available nitrate.

Soil Biology Respiration

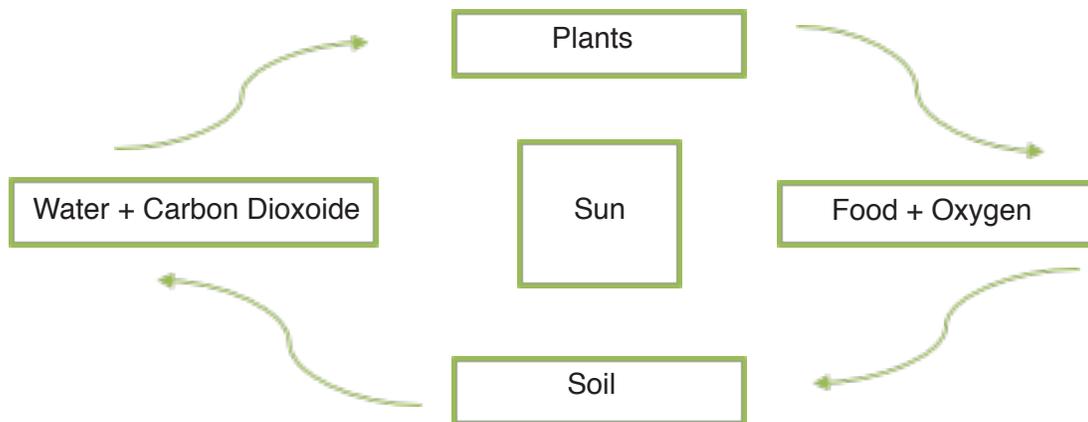
Demonstrate the Relevance *(Approximately 7 minutes)*

Instruct students to talk together and formulate ideas about how soil organic matter and respiration affect soil health.

Elicit responses, filling in the following information.

- Respiration rate can be based on the amount of soil organic matter present.
 - Soil organic matter is a food source for microbes and when microbes are present and working, respiration is higher.
 - When soil organic matter is absent or low, there is less decomposing activity.
 - Soil microbes are responsible for soil respiration and may important soil processes (such as bacteria, fungi, protozoa, algae).
 - One heaping table spoon of soil can contain over nine billion microbes, more than all the people on earth.

Share the following diagram. Encourage students to complete the diagram in their guided notes.



Provide the Experience – Factors Affecting Soil Respiration *(Approximately 5 minutes)*

Instruct students to work in small groups. Provide each small group with one of the following factors that affect soil respiration. Instruct students to discuss how their group's factor might affect soil respiration.

Factors:

- Climate/Weather
- Biological activity
- Soil moisture
- Amount and health of soil organic matter
- Soil texture

Soil Biology Respiration

Label the Information *(Approximately 10 minutes)*

- Climate/Weather
 - Cannot be changed
 - Affects temperature, moisture and indirectly affects biological activity
- Biological activity
 - Varies with the seasons and times of day
- Soil moisture
 - As moisture increases, respiration rates increase until the pores are overly saturated, resulting in lower oxygen content and lower soil organism respiration
 - Sixty percent pore space saturation (field capacity) is ideal for respiration
 - Dry soils have low respiration rates because of less support for biological activities
- Amount and health of soil organic matter
 - Affects microbe activity
- Soil texture
 - Clay – soil organic matter is “protected” from decomposition
 - Sand – too little organic matter
 - Medium texture (silt and loam) – favorable for soil respiration

Demonstrate the Relevance *(Approximately 5 minutes)*

Facilitate a discussion with your students about the larger economic effects of poor soil respiration. Depending on the demographics of your students, use references that make sense to them – farming or from the stand point of a consumer. Consider using the following questions as a guide:

- How can poor soil respiration affect a farmer whose income depends on the crop grown in that soil?
- How can poor soil respiration affect the prices we see for our food in the grocery store?

Provide the Experience – Soil Respiration Management *(Approximately 3 minutes)*

Continue the facilitated discussion by asking the following question:

- What do you think we can do as producers and consumers to ensure a productive soil respiration rate?

Label the Information *(Approximately 7 minutes)*

Soil Respiration Management Practices

1. Leave crop residues on the soil surface.
 - a. Residues with low C:N ratios decompose faster than those with high C:N ratios
 - b. High residue crops + added Nitrogen = higher decomposition rates and accrual of organic matter
2. Use no-till practices.
 - a. Tilling decreases soil biology which then slows decomposition of organic matter
 - b. Minimize equipment use in fields
 - c. Minimize farm equipment use in general when soils are wet
 - d. Use designated locations for equipment traffic
3. Use cover crops.
 - a. Roots provide respiration
4. Add organic matter.
 - a. Nourishes microbes
5. Plant long season crops.
 - a. Provides a living root for the entire growing season to maximize soil biology

Soil Biology Respiration

Demonstrate the Relevance *(Approximately 15 minutes)*

Direct students to the following chart in their Guided Notes and instruct them to list some short term and long term impacts they can think of for each management practice and application. Use the key below to facilitate the discussion after a short time.

Table 1. Interpreting management impacts on soil respiration and Soil Organic Matter (SOM).

Management Practice	Application	Short Term Impacts	Long Term Impacts
Solid manure or organic material application	Provide additional carbon and nitrogen source for microbes to breakdown and increase biomass production.		
High residue crops or cover crops used in rotation with high C:N ratio	High C:N ratio crops and added nitrogen increase decomposition and accrual of soil organic matter.		
Tillage such as annual disking, plowing, etc.	Stirs the soil providing a temporary increase in oxygen for microbes to break down carbon sources.		
Crop residue management	Leave residue on the surface increasing ground cover to protect the soil.		
Nitrogen fertilizer or manure application	Provides nitrogen (energy) source for microbes to break down high C:N ratio residue quicker.		
Vehicle or farm equipment traffic	Compacts soil decreasing pore space, water movement, oxygen for microbes and nitrogen loss from denitrification.		

Soil Biology Respiration

Management Practice	Application	Short Term Impacts	Long Term Impacts
Solid manure or organic material application	Provide additional carbon and nitrogen source for microbes to breakdown and increase biomass production.	Increased respiration when manure begins to breakdown and increased biomass production.	Positive impact on soil structure, fertility and soil organic matter content.
High residue crops or cover crops used in rotation with high C:N ratio	High C:N ratio crops and added nitrogen increase decomposition and accrual of soil organic matter.	High C:N ratio crop residue tie up nitrogen temporarily in order to break down residue, increased soil moisture, decreased erosion.	Positive impact on long term soil health, fertility and soil organic matter content.
Tillage such as annual disking, plowing, etc.	Stirs the soil providing a temporary increase in oxygen for microbes to break down carbon sources.	Provides a flush of nitrogen, other nutrients and carbon dioxide release immediately after tillage. Increases erosion rates, decomposition rate of residue, and other carbon sources.	Declines in soil organic matter, soil health, soil fertility.
Crop residue management	Leave residue on the surface increasing ground cover to protect the soil.	Increased crop residue cover can tie up nitrogen temporarily in order to break down residue, increased soil moisture, decreased erosion and cooler soil temperatures.	Positive impact on long term soil health, fertility and soil organic matter content.
Nitrogen fertilizer or manure application	Provides nitrogen (energy) source for microbes to break down high C:N ratio residue quicker.	Temporary increase in respiration due to increased rate of breakdown of organic materials.	When managed correctly, has an overall positive impact on soil organic matter and soil health by increasing production levels and residue amounts.
Vehicle or farm equipment traffic	Compacts soil decreasing pore space, water movement, oxygen for microbes and nitrogen loss from denitrification.	Decreases respiration, yields, water infiltration and increases runoff.	Production declines, increased soil erosion and runoff, decreased soil health, compacted soils and reduced microbial activity.

Soil Biology Respiration

Provide the Experience – Measure and Interpret Soils Respiration

(Approximately 90 minutes)

Introduce each of the laboratory supplies to the students and review the laboratory processes and procedures with the class. See the Guided Notes lab for information.

Students engage in the lab activity.

Label the Information *(Time varies)*

Students record information and answer lab questions.

Demonstrate the Relevance *(Time varies)*

Discuss with students how their activities affect soil respiration rates.

Review the Content *(Approximately 7 minutes)*

Instruct students to work in small groups to create a jingle that includes a minimum of three facts they learned during the soil respiration lesson and laboratory activity. Students share their jingle with the class.

Celebrate Student Success *(Approximately 3 minutes)*

Thank students for their engagement and participation.

Soil Biology Respiration

Guided Notes: Soil Respiration

Notes completed by _____

Soil Microbes:

Respiration:

Mineralization:

Ammonification:

Dentrification:

Nitrification:

Soil Biology Respiration

Factors Affecting Soil Respiration

- Climate/Weather

- Biological activity

- Soil moisture

- Amount and health of soil organic matter

- Soil texture

Soil Respiration Management Practices

1. Leave crop residues on the soil surface.

2. Use no-till practices.

3. Use cover crops.

4. Add organic matter.

5. Plant long season crops.

6. Drain wet soil.

Soil Biology Respiration

Table 1. Interpreting management impacts on soil respiration and Soil Organic Matter (SOM).

Management Practice	Application	Short Term Impacts	Long Term Impacts
Solid manure or organic material application	Provide additional carbon and nitrogen source for microbes to breakdown and increase biomass production.		
High residue crops or cover crops used in rotation with high C:N ratio	High C:N ratio crops and added nitrogen increase decomposition and accrual of soil organic matter.		
Tillage such as annual disking, plowing, etc.	Stirs the soil providing a temporary increase in oxygen for microbes to break down carbon sources.		
Crop residue management	Leave residue on the surface increasing ground cover to protect the soil.		
Nitrogen fertilizer or manure application	Provides nitrogen (energy) source for microbes to break down high C:N ratio residue quicker.		
Vehicle or farm equipment traffic	Compacts soil decreasing pore space, water movement, oxygen for microbes and nitrogen loss from denitrification.		

Soil Biology Respiration

Guided Notes: Soil Respiration Laboratory

Soil Respiration Scenario

Tom and Molly are troubled about the performance a field they recently purchased and planted to corn. The field was highly tilled with little crop residue. The equipment used on the field by the prior owner had very narrow tires, and there is no consistent path used for traveling to the irrigation pad. They are curious about what might be the problem and plan to test the soil respiration rate today.

Laboratory Supplies

- Solvita® sample jar for correct volume of soil or a 3-inch diameter aluminum cylinder and lid
- Foil-pack containing a special gel paddle
- Solvita® key for reading results
- Solvita® interpretation guide to estimate differences in soil health, respiration and potential nitrogen release
- Aluminum foil or cap when aluminum cylinder is used
- Solvita® soil life respiration test (paddles)
- Soil thermometer or controlled room temperature
- Small plastic bucket for each group of students
- Baggies with a zipper closure

Laboratory Steps

When soils are mixed, respiration temporarily increases because of the aeration caused by mixing. This is similar to the temporary increase in respiration caused by tillage. As oxygen availability increases, organic matter breaks down quicker.

Consider using an intact soil core in the 3-inch diameter aluminum cylinder rather than mixing soil. An intact core better reflects respiration for no-till applications, while a mixed sample will better reflect respiration either immediately after tillage or post tillage (at least one day after mixing). To get an accurate comparison of different management systems, several soil samples representing different management systems can be compared.

Soil Biology Respiration

Step-by-Step Procedure

1. Soil Sampling - Gather a minimum of 10 small samples from an area that represents similar soil type and management history with a probe from the surface 0-6 inch depth. Place the samples in the small plastic bucket. Repeat this step for each sampling area.

(Soil respiration is variable, both spatially and seasonally, and is strongly affected by organic matter, manure applications, oxygen levels, soil moisture, salinity and soil temperature. Use fresh soil samples, gathered just before the test.)
2. Mixing - Mix soil in the plastic bucket just well enough to be homogeneous and remove roots, residue, large stones and residues from sample and place in a labeled plastic zip bag.
3. Add Water if Needed - The sample should have ideal moisture (near field capacity) for growing conditions. If field conditions are dry it is best to add water 24 hours prior to sampling. If needed, water can be added prior to starting the test in the classroom.
4. Put Sample Into Solvita® Jar - Shortly after sampling put moist mix of soil up to fill line in the Solvita® jar. As you fill, tap the bottom of the jar on a hard surface to ensure there are no voids.
5. Use the Color Gel - Insert color gel paddle into soil with the gel facing out next to the clear side of the jar. Be careful not to jostle or tip the jar. Screw the lid on very tightly and record the time on the lid. Keep the jar in the classroom at a controlled temperature of 68-75 degrees Fahrenheit and out of sunlight for 24 hours.
6. Read and Record Results - Read gel color after 24 hours and record results on Table 3.
7. Answer discussion questions and complete interpretations section of Table 3. Refer to Solvita® soil test instructions for additional information and interpretations.

Interpretations

Respiration levels reflect soil health based on the level of carbon dioxide respiration. Rates are impacted by the health of soil, soil organic matter content, and can be used to approximate quantity of nitrogen released per year in an average climate. The rate of carbon dioxide released is expressed as $\text{CO}_2\text{-C lbs/acre-3"/day}$.

High soil respiration rates are indicative of high biological activity. This can be a good sign of a healthy soil that readily breaks down organic residues and cycles nutrients needed for crop growth. Solvita® response may go from an inactive condition (0-1 blue-gray) to a very active state (3.5-4.0 green-yellow) as soil respiration increases from desirable management measures such as diverse crop rotations, and no-till.

In some cases, heavily manured soils or soils high in organic content can attain a very high rate (5 yellow). This can be detrimental when decomposition of stable organic matter occurs. It is generally desirable to have at least green color 3. It typically takes several years for a soil to improve from a low biological status to a more active one. With proper residue management, diverse crop rotations, organic matter additions and avoidance of destructive tillage practices, the time to reach a more optimum condition is shortened.

Soil Biology Respiration

Table 2. Basic soil biological health

Solvita Test - Color/Colorimetric Number				
0-1 Blue-Gray	1.0-2.5 Gray-Green	2.5-3.5 Green	3.5-4.0 Green-Yellow	4-5 Yellow
Soil Respiration Activity				
Very Low Soil Activity	Moderately Low Soil Activity	Medium Soil Activity	Ideal Soil Activity	Unusually High Soil Activity
Associated with dry sandy soils, and little or no organic matter	Soil is marginal in terms of biological activity and organic matter	Soil is in a moderately balanced condition and has been receiving organic matter additions	Soil is well supplied with organic matter and has an active population of microorganisms	High/Excessive organic matter additions
*Approximate Level of CO₂ - Respiration				
<300 mg CO ₂ /kg soil/wk	300-500 mg CO ₂ /kg soil/wk	500-1000 mg CO ₂ /kg soil/wk	1000-2000 mg CO ₂ /kg soil/wk	>2000 mg CO ₂ /kg soil/wk
<9.5 lbs CO ₂ - C/acre-3" d	9.5-16 lbs CO ₂ - C/acre-3" d	16-32 lbs CO ₂ - C/acre-3" d	32-64 lbs CO ₂ - C/acre-3" d	>64 lbs CO ₂ - C/acre-3" d
Approximate Quantity of Nitrogen (N) Release Per Year (Average Climate)				
<10 lbs/acre	10-20 lbs/acre	20-40 lbs/acre	40-80 lbs/acre	80->160 lbs/acre

*Source: Doran, J. (2001) USDA-ARS Soil Health Institute correlation of Solvita® and field soil respiration. Calculations based on a 3-inch soil core (7.6 cm).

Soil Biology Respiration

Table 3. Soil respiration levels and interpretations.

Sample Site	Median 24-hr Soil or Room Temp.	Time-frame	Start Time	End Time	Gel Color & Colorimetric Number	Soil Activity Rating (Table 1)	Avg. Respiration Level lbs CO ₂ -C/acre-3"/d	Quantity of N Released lbs/ac/yr

What did you expect in terms of the soil respiration levels?

What surprised you about the soil respiration levels?

What do you expect to happen to the soil organic matter based on the soil respiration rates? (improve, decline, remain the same) Why?

Soil Science Curriculum

Content and lab derived from the USDA-NRCS Guides for Educators. Go to www.nrcs.usda.gov/soils for the Guides and additional pictures and diagrams. This lesson plan was adapted for South Dakota from the University of Nebraska Institute of Agriculture and Natural Resources, CROPWATCH.

January 2018

Soil Electrical Conductivity

Approximately 180 minutes

Objectives

By the end of the lesson, students will know or be able to:

- Define electrical conductivity, cation-exchange-capacity, dS/m, E_{Ce} method, EC1:1 method, saline soil, sodic soil, anion, cation, nitrification, and denitrification
- Explain the role of electrical conductivity in soil health
- List and describe inherent factors that affect soil electrical conductivity
- Describe the necessity and factors of salinity management
- List and describe problems related to electrical conductivity
- Describe how electrical conductivity affects soil function
- Measure soil electrical conductivity and interpret results

Preparatory Work

- Print all necessary copies
- Secure permission to collect soil samples from the land owner

Materials

- Guided notes (one per student)
- Small sample of salt
- 8-½ x 11" paper stating "Climate"
- 8-½ x 11" paper stating "Soil Texture"
- 8-½ x 11" paper stating "Soil Minerals"
- Land to take soil samples
- All laboratory supplies (see Lab Guided Notes)

Enroll the Participants *(Approximately 4 minutes)*

Show students a container of table salt.

Facilitate a discussion with the students using the following questions as a guide.

Where do we typically see and use salt?
How might salt affect plant and soils?

Preview that during this lesson the class will explore how salts affect a soil's ability to grow productive plants.

Soil Electrical Conductivity

Provide the Experience – Defining Key Terms and Explaining the Role of Electrical Conductivity (EC) in Soil Health *(Approximately 5 minutes)*

Direct students to their guided notes and instruct them to work in pairs to define the terms they may know from another science class.

After a short time, elicit definitions from students and fill in with additional information where needed.

Label the Information *(Approximately 10 minutes)*

Review the terms and definitions using the information found here:

Anion: A negatively charged ion.

Cation: A positively charged ion.

Cation-Exchange Capacity (CEC): Capacity of soil to exchange cations. Soils with high clay or organic matter content have a higher CEC than those soils low in clay and organic matter.

Denitrification: Conversion and loss of nitrate-nitrogen to atmosphere in various gas forms, due to lack of oxygen when soil becomes saturated with water.

dS/m: Unit of measurement for electrical conductivity of soil in deciSiemens per meter.

EC_e Method: Standard accepted laboratory method for soil EC testing using a saturated paste extract.

EC_{1:1} Method: Soil EC testing method using a 1:1 soil-water mixture that must be adjusted for soil texture.

Nitrification: Conversion of ammonium compounds in organic material, or fertilizer into nitrites and nitrates by soil bacteria, making nitrogen available to plants.

Nitrogen Oxides: Family of nitrogen gases that can be generated by human activities and released to the atmosphere.

Saline Soil: Soil with a high content of soluble salts which negatively affect soil processes, productivity and overall soil health.

Sodic Soil: Soil with a high content of sodium salts and poor structure. Water infiltration and drainage is prevented.

Soil Electrical Conductivity: A measure of the amount of soluble salts in soil.

Soil Electrical Conductivity

Demonstrate the Relevance *(Approximately 4 minutes)*

Instruct students to add the following points to their notes:

1. Soil electrical conductivity affects yields, crop suitability, plant nutrient availability and soil microorganism activity such as emission of greenhouse gases and respiration.
2. Excess salts hinder plant growth by affecting the soil-water balance.
3. Arid and semi-arid climates naturally have a higher salt content.
4. It is possible to have saline soils, sodic soils and saline/sodic soils.
5. Salinity and Sodicity are influenced by humans through cropping, irrigation and land management practices.

Provide the Experience – Inherent Factors Affecting Soil EC *(Approximately 5 minutes)*

Divide the class into three small groups. Provide each group one of the 8 ½ x 11 papers with one of the following words on it:

Climate
Mineral Content/Parent Material
Soil Texture

Instruct the small groups to write on the papers how they believe each of the factors affect soil electrical conductivity.

After a short amount of time, ask groups to rotate to a new factor and add their thoughts to that paper.

Rotate a second time so all groups discuss all three factors.

Ask the groups that started at each factor to review for the class all of the ideas that were added to the paper.

Label the Information *(Approximately 7 minutes)*

Inform students that there three inherent factors that affect soil electrical conductivity; these factors cannot be changed.

Direct students to their guided notes and add the following information about each inherent factor:

- Climate
 - Salts are more easily flushed through soil located in areas of high rainfall
 - Salts are flushed below the root zone into groundwater or streams
 - Salts accumulate in soils found in dry areas
- Mineral Content/Parent Material
 - Salts come from the weathering of minerals and rocks found in soil
- Soil Texture
 - Clay with high cation-exchange capacities have high electrical conductivity
 - Clay with lower cation-exchange capacities have low electrical conductivity
 - Salts can't leach through restrictive layers and therefore accumulate do to high clay content or compaction

Soil Electrical Conductivity

Demonstrate the Relevance *(Approximately 4 minutes)*

Ask students to make some predictions about the electrical conductivity (salinity) of the soil in your area based on the climate and soil texture of the area.

Encourage curiosity and inform students that they will be testing salinity soon.

Provide the Experience – Managing Soil Electrical Conductivity *(Approximately 1 minutes)*

Write the following categories down on the white board or a location that is visible to all students:

Cropping Irrigation Land Use Application of Fertilizer/Compost/Manure

Ask students to share their initial thoughts about how these items might relate to management of soil electrical conductivity.

Label the Information *(Approximately 12 minutes)*

Share the following information with the students and encourage them to add it to their guided notes:

- Cropping
 - Leave crop residue to add organic matter and to limit evaporation
 - Low organic matter + poor infiltration + poor drainage + saturated soil + compaction = increased EC and a decrease in the soil's ability to buffer
- Irrigation
 - The salinity of water affects the salinity of soil
 - Extra water can help flush salts from the soil
- Land Use
 - Ensuring that the least amount of compaction and erosion occur improves soil EC
- Application of Fertilizer/Manure/Compost
 - Monitoring of municipal waste is necessary
 - Nitrogen increases salinity

Demonstrate the Relevance *(Approximately 3 minutes)*

Share the following affects with students:

As EC increases, soil microorganism activity decreases, affecting respiration, residue decomposition, nitrification and denitrification.

Sodic soils have poor soil structure and poor infiltration or drainage as well as increased toxicity.

EC indirectly indicates the amount of water and water-soluble nutrients available for plant uptake.

Soil Electrical Conductivity

Provide the Experience – Measuring and Interpreting Soil Electrical Conductivity

(Approximately 4 minutes)

Review the laboratory scenario with students. Students can find the scenario in their guided notes.

Riley, an area agronomist was recently contacted by a farmer concerned about the performance of last fall's crop. Despite efforts made by the farmer, the crop yield decreased consistently over the past couple of years. Since the farmer has never tested the field's soil electrical conductivity and several surrounding farms have had problems with sodic soils, Riley recommends that the tests be run.

Label the Information *(Approximately 15 minutes)*

Review and identify each of the supplies from the soil testing kit that will be used during the lab activity.

- Soil probe for gathering soil samples
- Plastic bucket for mixing soil samples
- 1/8-cup (29.5-mL) measuring scoop
- Calibrated 120-mL shaking vial with lid
- Squirt bottle
- Distilled water or rainwater
- Calibrated 120-mL shaking vial with lid
- EC probe (blue with black cap)
- Probe holder with field calibration resistor (470 ohm)
- 1.41-dS/m calibration solution
- Pen, field notebook, sharpie and zip-lock bags

Review the steps of the laboratory activity and provide any instructions specific to your classroom expectations and time.

Demonstrate the Relevance *(Approximately 120 minutes)*

See the attached laboratory guided notes for the steps to complete the laboratory. Review the results and analysis steps of the lab.

Review the Content *(Approximately 4 minutes)*

Instruct students to verbally review the steps used to complete the laboratory experience and to discuss the results observed in their particular group.

Celebrate Student Success *(Approximately 2 minutes)*

Congratulate students on their discovery of EC level results for their tested soil. Encourage students to continue being curious.

Soil Electrical Conductivity

Guided Notes: Soil Electrical Conductivity

Anion:

Cation:

Cation-Exchange Capacity (CEC):

Denitrification:

dS/m:

ECe Method:

EC1:1 Method:

Nitrification:

Nitrogen Oxides:

Saline Soil:

Sodic Soil:

Soil Electrical Conductivity:

Soil Electrical Conductivity

Notes about Soil Electrical Conductivity:

Climate

Soil Texture

Mineral Content

Cropping

Irrigation

Land Use

Application of Fertilizer/Compost/Manure

Soil Electrical Conductivity

Guided Notes: Soil Electrical Conductivity Laboratory

Soil EC Scenario

Riley, an area agronomist was recently contacted by a farmer concerned about the performance of last fall's crop. Despite efforts made by the farmer, the crop yield decreased consistently over the past couple of years. Since the farmer has never tested the field's soil electrical conductivity and several surrounding farms have had problems with sodic soils, Riley recommends that the tests be run.

Laboratory Supplies

- Soil probe for gathering soil samples
- Plastic bucket for mixing soil samples
- 1/8-cup (29.5-mL) measuring scoop
- Calibrated 120-mL shaking vial with lid
- Squirt bottle
- Distilled water or rainwater
- Calibrated 120-mL shaking vial with lid
- EC probe (blue with black cap)
- Probe holder with field calibration resistor (470 ohm)
- 1.41-dS/m calibration solution
- Pen, field notebook, sharpie and zip-lock bags

Laboratory Steps

Soil electrical conductivity is variable. Therefore, multiple samples should be taken from multiple locations. Look over sampling area for large bare spots, areas with short plants, areas where plants are growing better or other areas of possible salinity. These areas should be sampled separately.

1. Calibration: Ensure the electrical conductivity probe is calibrated before starting. Calibrate the probe by immersing it in a standard salt solution (1.41 dS/m) at 25 degrees Celsius (77 degrees Fahrenheit) and turning adjustment knob on probe with a screwdriver until the probe reads 1.4. Then insert the electrical conductivity probe into calibration resistor on the probe holder and record the reading for future use. Future readings are taken at the same temperature.
2. Soil Sampling: Soil samples collected from the 0 to 3-inch depth for use with a hand-held EC meter may be useful in identifying salinity-affected patterns. To determine salt concentrations in the root zone and the type of ions involved, it is recommended that a 0 to 6-inch and 6 to 24-inch soil sample be collected.
3. Tamp down one sampling scoop of mixed soil by striking the scoop carefully on a hard level surface and place soil in the plastic mixing vial. Add one scoop of distilled water to the same vial. The vial will contain a 1:1 ratio of soil to water, on a volume basis.
4. Tightly cap the vial and shake 25 times.
5. Remove the cap, turn on the electrical conductivity probe and insert it into the soil-water mixture in the vial, keeping the probe tip well in the center area of the soil suspension. Take the reading while soil particles are still suspended in solution. To keep soil particles from settling, stir gently with the electrical conductivity probe. Do not immerse the probe above maximum immersion level.

Soil Electrical Conductivity

6. After the reading stabilizes for about 10 seconds, record EC1:1 in dS/m.
7. Save the soil-water mixture for measurement of pH, nitrate, nitrite and phosphorus if applicable.
8. Turn off and thoroughly rinse the electrical conductivity probe with distilled water and replace the cap.
9. Record the soil EC1:1 reading(s) and complete the rest of Table 4 by comparing readings to values in Tables 1, 2 and 3.
10. Answer discussion questions.

Table 1. Soil EC influence on microbial processes and gaseous nitrogen production in soils amended with sodium chloride or nitrogen fertilizers (after Smith and Doran, 1996 (Tables 10-5 & 10-6) and Adviento-Borbe et al., 2006).

Process	EC _{1:1} Range (dS/m)	Relative Decrease/Increase (%)	Threshold EC _{1:1}
Respiration	0.7 to 2.8	-17 to -47	0.7
Decomposition	0.7 to 2.9	-2 to -25	0.7
Nitrification	0.7 to 2.9	-10 to -37	0.7
Denitrification	1.0 to 1.8	+32 to +88	1.0
Anaerobic N ₂ O gas production (high nitrate)	0.02 to 2.8	+1500 to +31,500	1.0-1.5
Anaerobic N ₂ O gas production (low nitrate)	0.5 to 2.0	+200 to +90,000	0.7-1.0

Soil Electrical Conductivity

Table 2. Salinity classes and relationship between EC1:1 to ECe values (Smith and Doran, 1996 adapted from Dahnke & Whitney, 1988).

Texture	Degree of Salinity (Salinity Classes)					
	Non-Saline	Slightly Saline	Moderately Saline	Strongly Saline	Very Saline	Ratio of EC _{1:1} to ECe
EC _{1:1} Method (dS/m)						
Coarse to loamy sand	0-1.1	1.2-2.4	2.5-4.4	4.5-8.9	9.0+	0.56
Loamy fine sand to loam	0-1.2	1.3-2.4	2.5-4.7	4.8-9.4	9.5+	0.59
Silt loam to clay loam	0-1.3	1.4-2.5	2.6-5.0	5.1-10.00	10.1+	0.63
Silty clay loam to clay	0-1.4	1.5-2.8	2.9-5.7	5.8-11.4	11.5+	0.71
EC _e Method (dS/m)						
All textures	0-0.2	2.1-04	4.1-8.0	8.1-16.0	16.1+	N/A

Soil Electrical Conductivity

Table 3. Salt tolerance and yield decrease beyond EC threshold (Smith and Doran, 1996; EC1:1 based on Hoffman & Maas 1977).

Crop(s)	Threshold EC _e (dS/m)	Threshold EC _{1:1} (dS/m)	Yield Decrease (%) per EC _{1:1} Unit (dS/m) Beyond Threshold
Barley	8.0	4.5 to 5.7	5.0
Sugar Beet	7.0	3.9 to 5.0	5.9
Wheat	6.0	3.4 to 4.3	7.1
Perennial Ryegrass	5.6	3.1 to 4.0	7.6
Soybean	5.0	2.8 to 3.6	20.0
Tall Fescue	3.9	2.2 to 2.8	5.3
Crested Wheatgrass	3.5	2.0 to 2.5	4.0
Rice, Common Vetch	3.0	1.7 to 2.1	12.0
Tomato	2.5	1.4 to 1.8	9.9
Alfalfa	2.0	1.1 to 1.4	7.3
Corn, Potato	1.7	1.0 to 1.2	12.0
Berseem Clover, Orchardgrass, Grapes, Peppers	1.5	0.8 to 1.1	5.7
Lettuce, Cowpea	1.3	0.7 to 0.9	13.0
Green Bean	1.0	0.6 to 0.7	19.0

Soil Electrical Conductivity

Table 4. Soil EC (salinity) in surface soil and interpretations.

Site	Soil EC _{1:1} (dS/m)	Texture	Degree of Salinity	pH	Nitrate Estimate (ppm)	Microbial Processes Impacted	Crops Impacted

What about the soil EC test results differed from your expectations? How?

Compare soil EC results to values in Tables 1, 2 and 3. Are EC levels ideal for crops or forages grown and soil microbial processes? Why or why not?

Soil Science Curriculum

Content and lab derived from the USDA-NRCS Guides for Educators. Go to www.nrcs.usda.gov/soils for the Guides and additional pictures and diagrams. This lesson plan was adapted for South Dakota from the University of Nebraska Institute of Agriculture and Natural Resources, CROPWATCH.

January 2018

Web Soil Survey

Approximately 180 minutes

Objectives

By the end of the lesson, students will know or be able to:

- Explain the purpose of Web Soil Survey
- Use Web Soil Survey

Preparatory Work

- Make necessary copies
- Review Web Soil Survey
- Review and determine where and when “You’re the Developer” project will be completed

Materials

- Soil Survey Manuals
- Web Soil Survey Webquest – one per student
- My Home Soil Map – one per student
- You’re the Developer Rubric – one per student
- Computers with internet access
- Notecards – one per student
- Supplies for “You’re the Developer”



Enroll the Participants (Approximately 5 minutes)

Show students a soil survey manual and ask them to predict what information might be found within it. Ask students to give instructions on how to use the soil survey manual. Lead a brief discussion on soil survey. Explain that these manuals are used to determine soil type and characteristics but can be time consuming to use. Share with the class that the United States Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS) has created a site to make collecting this information easier. Explain that this lesson will allow students to explore Web Soil Survey.

Web Soil Survey

Provide the Experience – Explain the Purpose and Use of Web Soil Survey

(Approximately 45 minutes)

Provide each student with a copy of the Web Soil Survey Webquest and access to a computer with internet. They will need to visit <https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/> and follow instructions on the Webquest. Consider allowing students to work with a partner as they navigate through this site.

Note: Consider reviewing a power point created by the USDA-NRCS to familiarize yourself with the Web Soil Survey: http://websoilsurvey.sc.egov.usda.gov/App/Help/WSS_HomePage_HowTo_3_0.pdf

Label the Information *(Approximately 45 minutes)*

Provide each student with a copy of “My Home Soil Map” and access to a computer with internet. They will need to visit <https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/> and follow instructions on the handout.

Demonstrate the Relevance *(Times vary)*

You’re the Developer. Assign students to small groups and give them the “You’re the Developer Rubric.” Explain to the class that they have been hired by a developing company to develop a 10-acre area in your county. As the instructor, you can assign them a 10-acre plot or allow them to select their own plot. They must work as a team to research their land and determine a plan for development. They must create a map of their plan and a written statement justifying their development decisions. Upon completion of the project allow each team to present their development proposal to the class.

Review the Content *(Approximately 10 minutes)*

Provide each student with a postcard. Instruct the class to send a postcard to a student that missed this lesson. Encourage students to draw a postcard picture related to the Web Soil Survey lesson on the front of the card and write a note summarizing the lesson to the missing student on the back. Consider asking a few students to share their postcard with the class.

Celebrate Student Success *(Approximately 3 minutes)*

Thank students for their engagement, creativity, and participation. Congratulate them on their ability to properly use Web Soil Survey. Explain that this skill will be useful throughout their lives as they live and work on the land. Congratulate students on having a stronger understanding of soil management which will allow them to successfully participate in the land evaluation competition.

Web Soil Survey

Web Soil Survey Webquest

Name: _____

Follow the instructions below to become familiar with Web Soil Survey. Open an internet window and go to <https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/> . Answer the questions with each step to help you understand the Web Soil Survey.

1. Read through the introduction on the home page. Continue reading through “Four Basic Steps.

What does WSS stand for?

What does AOI stand for?

What percent of the country is covered by the WSS?

What will the soil map show you?

What is the cost to download a finished map?

2. Click green “Start WSS” button. A new window should open with Web Soil Survey.

3. Find your hometown using the quick navigation bar.

What options do you have for finding a specific area in the navigation section?

Web Soil Survey

4. Define your hometown as your AOI using the buttons at the top of the map.

List four buttons at the top of the map and describe how they are used.

5. Under AOI Information, give your map a name.

What is the size of your AOI?

When was the data collected for your AOI?

6. Continue by clicking on the “Soil Map” bar at the top of your screen.

Which soil types are the most common in your AOI?

7. Click the “Soil Data Explorer” bar at the top of your screen.

8. Use the “Suitability and Limitations” section to answer the following questions:

Identify the 10 categories of data included in this section.

Web Soil Survey

Using the specific categories, “View Rating” button, and the “Legend” identify five suitabilities and five limitations of your AOI.

Soil in this AOI is suitable for...	Limitations for this soil include...

9. Using the “Soil Properties and Qualities” button, complete the chart for your AOI map. Identify two common soil types in your area and record the definition and rating for each listed soil health property.

	pH	Erosion (T Factor)	Organic Matter Rating	Water Holding Capacity
Definition of the property				
Soil Type				
Soil Type				

10. “Finally, click on the “Shopping Cart” bar at the top of your screen.

11. Click “Check Out” and “get now” to generate your personalized report.

Web Soil Survey

12. Read through your Custom Soil Resource Report.

Identify specific information from your report and describe how the information can be used.

Specific information from report	Page number	How can this information be used?

Web Soil Survey

Web Soil Survey – My Home Soil Map

Name: _____

Follow the steps from the Web Soil Survey Webquest to help you navigate through this project.

1. Find your home, neighborhood, or land important to your family and describe how you navigated to this AOI. Include the address of this land.

2. According to your AOI, how many acres are included on your map?

3. Describe the soils found within your area:

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent AOI

Web Soil Survey

4. Complete the chart below using each of the soils found in your AOI. Include the rating for each of the soil qualities listed.

Soil Type	pH	Erosion (T Factor)	Organic Matter Rating	Water Holding Capacity	Parent Material Name	Flooding Class	Ponding Class

5. Complete the chart below using each of your soils to determine the suitability and limitations of your soils.

Soil Type	Dwellings with Basements	Lawns and Landscapes	Roads and Streets	Farmland Classification	Range Production (normal year)

Web Soil Survey

6. Draw a map of the AOI labeling current structures and uses and include soil types (symbols).

7. How might this information be beneficial to you as a land manager?

Web Soil Survey

You're the Developer

Student Name: _____

Activity Due Date: _____

You have been hired to develop a 10-acre plot of land in your county. You will create a map of your development proposal and a written justification of your plan. Use Web Soil Survey to determine the best uses of your land. Consider the needs of your county and the features of your land.

The rubric below will be used for scoring this activity.

CATEGORY	4	3	2	1
Title	Title tells the purpose/content of the map, is clearly distinguishable as the title (e.g. larger letters, underlined, etc), and is printed at the top of the map.	Title tells the purpose/content of the map and is printed at the top of the map.	Title tells the purpose/content of the map, but is not located at the top of the map.	Purpose/content of the map is not clear from the title.
Map Legend/Key	Legend is easy-to-find and contains a complete set of symbols, including a compass rose.	Legend contains a complete set of symbols, including a compass rose.	Legend contains an almost complete set of symbols, including a compass rose.	Legend is absent or lacks several symbols.
Neatness of Color and Lines	All straight lines are ruler-drawn, all errors have been neatly corrected and all features are colored completely.	All straight lines are ruler-drawn, most errors have been neatly corrected and most features are colored completely.	Most straight lines are ruler-drawn, most errors have been neatly corrected and most features are colored completely.	Many lines, corrections of errors, and/or features are not neatly done.
Scale	All features on map are drawn to scale and the scale used is clearly indicated on the map.	Most features on map are drawn to scale and the scale used is clearly indicated on the map.	Many features of the map are NOT drawn to scale even though a scale is clearly indicated on the map.	Many features of the map are NOT drawn to scale AND/OR there is no scale marker on the map.
Evidence and Examples	All of the evidence and examples are specific, relevant and explanations are given that show how each piece of evidence supports the author's position.	Most of the evidence and examples are specific, relevant and explanations are given that show how each piece of evidence supports the author's position.	At least one of the pieces of evidence and examples is relevant and has an explanation that shows how that piece of evidence supports the author's position.	Evidence and examples are NOT relevant AND/OR are not explained.
Accuracy	All supportive facts and statistics are reported accurately.	Almost all supportive facts and statistics are reported accurately.	Most supportive facts and statistics are reported accurately.	Most supportive facts and statistics were inaccurately reported.

Soil Science Curriculum

Content and lab derived from the USDA-NRCS Guides for Educators. Go to www.nrcs.usda.gov/soils for the Guides and additional pictures and diagrams. This lesson plan was adapted for South Dakota from the University of Nebraska Institute of Agriculture and Natural Resources, CROPWATCH.

January 2018

Soil pH: What Affects it, What it Affects, Managing it and Testing it

Approximately 135 minutes



Objectives

By the end of the lesson, students will know or be able to:

- Define acidity, alkalinity, buffering capacity, and soil pH
- List and describe inherent factors that affect soil pH
- Describe how to manage soil pH
- Describe how soil pH affects soil function
- Measure and interpret soil pH

Preparatory Work

- Print all necessary copies
- Secure permission to collect soil samples from the landowner

Materials

- Guided notes (one per student)
- 8-½ x 11 paper that says “Climate”
- 8-½ x 11 paper that says “Mineral Content”
- 8-½ x 11 paper that says “Soil Texture”
- Land to take soil samples
- All laboratory supplies (See Lab Guided Notes)
- Post-it notes

Enroll the Participants *(Approximately 4 minutes)*

Show students the supplies that will be used during the lab portion of this lesson: soil probe, plastic bucket, pH test strips, measuring scoop, shaking vial, squirt bottle, distilled water, and notebook.

Ask students which of the tools they can identify and facilitate a brief class discussion about the tools.

Share with students that this multi-day lesson focuses on soil pH and that after learning about key definitions and management practices, the class will apply the information in a laboratory experience to test soil pH.

Soil pH: What Affects it, What it Affects, Managing and Testing it

Provide the Experience – Defining Key Terms *(Approximately 3 minutes)*

Direct students to their guided notes and instruct them to match each of the terms with one of the provided definitions.

Label the Information *(Approximately 4 minutes)*

Review the terms and definitions using the information found here:

Acidity: having a pH of less than 7

Alkalinity: having a pH of greater than 7

Buffering Capacity: a soil's ability to maintain its pH when changes are being made to the soil

Soil pH: a measure of the soil's acidity or alkalinity. The soils for pH values range from 1 to 14 starting with 1 for extremely acidic and 14 as extremely alkaline. Typical soil pH values range from 5.0 to 8.5.

Demonstrate the Relevance *(Approximately 4 minutes)*

Instruct students to construct one sentence that includes and demonstrates the definitions of each of the four terms addressed in this lesson. Students may share the sentences with the class or with other students.

Instruct students to add the following points to their notes:

1. Soil pH is an indicator of soil health.
2. Soil pH affects crop yields, crop suitability, plant nutrient availability and soil microorganism.
3. Soil pH can be managed by applying nitrogen and lime, and by using cropping practices that increase soil organic matter and overall soil health.

Provide the Experience – Inherent Factors Affecting Soil pH *(Approximately 5 minutes)*

Divide the class into three small groups. Provide each group one of the 8-½ x 11 papers with one of the following words on it:

Climate
Mineral Content
Soil Texture

Instruct the small groups to write on the papers how they believe each of the factors affect soil pH. After a short amount of time, ask groups to rotate to a new factor and add their thoughts to that paper.

Rotate a second time so all groups discuss all three factors.

Ask the groups that started at each factor to review for the class all of the ideas that were added to the paper.

Soil pH: What Affects it, What it Affects, Managing and Testing it

Label the Information *(Approximately 7 minutes)*

Inform students that the three factors they discussed are known as “inherent factors” that affect soil pH; these are factors that cannot be changed.

Direct students to their Guided Notes and add the following information about each inherent factor:

- Climate
 - Increased temperature and rainfall cause increased leaching rates and increased soil mineral erosion rates
 - Increased leaching yields lower pH
 - Decreased leaching and rain cause pH to either increase or remain steady
- Mineral Content
 - The soil parent material can be high in carbonates (limestone) which will maintain a long term higher pH throughout the soil profile
 - High organic matter content yields a higher buffering capacity
 - Organic matter amount can be changed through management practices
- Soil Texture
 - High clay content yields a higher buffering capacity due to slower leaching rates
 - Clay content amount cannot be changed
 - High sand content yields a lower buffering capacity due to large pore spaces and fast leaching rates
 - High sand content means the organic matter content is low, which means the buffering capacity is low, percolation rate is high and the pH is low

Demonstrate the Relevance *(Approximately 5 minutes)*

Facilitate a discussion with students about the soil in your area. Here are a few guiding questions to use during the discussion:

- What are the pH characteristics of the soil in our area?
- How does that affect our farms, yards and gardens?
- How does the pH correction affect our environment and maintenance costs?

Provide the Experience – Managing Soil pH *(Approximately 3 minutes)*

Show students pictures of a forest, grassland and crop field.

Instruct students to use what they know about soil pH and inherent factors to determine how the pH might vary between each of the three types of lands.

Elicit student responses.

Soil pH: What Affects it, What it Affects, Managing and Testing it

Label the Information *(Approximately 12 minutes)*

Share the following information with the students and encourage them to add it to their Guided Notes:

- Soil pH is affected by land use, management and vegetation
 - Forests have a medium level of organic matter
 - Grasslands have a high level of organic matter
 - Croplands have the lowest level of organic matter of these three types of land
- As land moves from forest to grassland and from grassland to cropland:
 - Organic matter can be lost
 - Soil minerals are removed (during harvest)
 - Erosion may increase
 - Nitrogen and sulfur are added to the soil
 - pH may increase or decrease with management
- Acidification can be limited or corrected by:
 - Adding lime yields an increased pH
 - Applying nitrogen and sulfur in the correct amounts and at the times when plants are using them
 - Diversifying crop rotations
 - Applying organic matter
 - Using no-till practices and cover crops

Demonstrate the Relevance *(Approximately 3 minutes)*

Direct students to the chart in their Guided Notes. Fill in the following pH preference data for the crops listed in the chart.

Corn:	6.8
Wheat:	6.8
Soybeans:	6.8
Oats:	7.5
Barley:	7.5
Alfalfa:	6.8-7.5
Timothy:	6.8
Carrots:	6.0
Tomatoes:	7.5
Cucumbers:	7.5

Provide the Experience – Soil Functionality and pH *(Approximately 3 minutes)*

Inform students that a soil's pH indicates its suitability for plant growth.

Direct students to discuss with a partner how pH might affect key needs of plants in their growth process.

Soil pH: What Affects it, What it Affects, Managing and Testing it

Label the Information *(Approximately 7 minutes)*

Encourage students to capture the following information in their Guided Notes:

- A pH level that is too low or too high can cause:
 - Nutrient deficiencies because of leaching
 - A decline in microbial activity because of improper environment for the microbes
 - A decrease in crop yields
 - A deterioration of overall soil health
 - An inhibition of the nitrogen cycle (low pH)
 - Limited effectiveness of herbicide and insecticide degradation
 - Limited solubility of heavy metals
 - A lack of effectiveness and carry-over of herbicides

Demonstrate the Relevance *(Approximately 4 minutes)*

Instruct students to form pairs and discuss what current practices they think affect soil pH and how each of these soil problems affects farms and gardens.

Provide the Experience – Measuring and Interpreting Soil pH *(Approximately 3 minutes)*

Review the laboratory scenario with students. Students can find the scenario in their guided notes.

Marge and Jim are planning to have a garden during the next spring and summer growing season. They recently moved to a new home in a new town and do not know much about the soil in the area. Marge and Jim taken their gardening seriously, both for consumption of the food as well as for entering their crops competitively at county and state fairs. It's really important that the garden is successful. To help guarantee success, Marge and Jim plan to conduct tests to measure their soil's pH levels.

Label the Information *(Approximately 15 minutes)*

Review and identify each of the supplies from the soil testing kit that will be used during the lab activity.

- Soil probe for gathering soil samples
- Plastic bucket for mixing soil samples
- Roll of pH test strips
- 1/8-cup (29.5-mL) measuring scoop
- Calibrated 120-mL shaking vial with lid
- Squirt bottle
- Distilled water or rainwater
- Pen, field notebook, sharpie and zip-lock bags

Review the steps of the laboratory activity and provide any instructions specific to your classroom expectations and time.

Soil pH: What Affects it, What it Affects, Managing and Testing it

Demonstrate the Relevance *(Approximately 125 minutes)*

See the attached laboratory Guided Notes for the steps to complete the exercise. Review the results and analysis steps of the lab.

Review the Content *(Approximately 4 minutes)*

Provide each student with two Post-it notes. Instruct students to write down what they know about soil pH on one note and on the other write down what they wonder or are curious about in regards to soil pH. Ensure student names are on the Post-it notes and collect them to continue the class discussion and guide students in their capstone project.

Celebrate Student Success *(Approximately 2 minutes)*

Congratulate students on their discovery of pH level results for their tested soil. Encourage students to continue being curious during each of the laboratory activities of the soil science unit.

Soil pH: What Affects it, What it Affects, Managing and Testing it

Guided Notes: Soil pH

Vocabulary Matching

Soil pH:	Soil pH is less than 7
Alkalinity:	A measure of soil acidity or alkalinity
Acidity:	Soil's ability to resist pH change
Buffering Capacity:	Soil pH is greater than 7

1. Soil pH is an indicator of _____.
2. Soil pH affects _____, _____, _____ and _____.
3. Soil pH can be managed by applying _____ and _____, and by using _____ that increase soil _____ and overall soil health.

Management of Acidity Notes

Plant	Ideal pH
Corn, Wheat, Soybeans, Timothy	6.8
Oats, Barley, Tomatoes, Cucumbers	7.5
Alfalfa	6.8-7.5
Carrots	6

Soil pH: What Affects it, What it Affects, Managing and Testing it

Guided Notes: Soil pH Laboratory

Soil pH Scenario

Marge and Jim are planning to have a garden during the next spring and summer growing season. They recently moved to a new home in a new town and do not know much about the soil in the area. Marge and Jim taken their gardening seriously, both for consumption of the food as well as for entering their crops competitively at county and state fairs. It's really important that the garden is successful. To help guarantee success, Marge and Jim plan to conduct tests to measure their soil's pH levels.

Laboratory Supplies

- Soil probe for gathering soil samples
- Plastic bucket for mixing soil samples
- Roll of pH test strips
- 1/8-cup (29.5-mL) measuring scoop
- Calibrated 120-mL shaking vial with lid
- Squirt bottle
- Distilled water or rainwater
- Pen, field notebook, sharpie and zip-lock bags

Laboratory Steps

Soil pH level is highly variable, depending on field location and time of year, as well as what is growing. It is affected by fertilizer placement in rows or between rows, soil texture, organic matter content and applications of manure or fertilizer.

In-Field Quick Hand Test

1. Using a soil probe, gather at least 10 small samples randomly from the area that represents the soil type and management history to be tested. Ensure that each sample is taken at a depth of six inches.
2. Place each sample into the plastic bucket provided.
3. Remove large stones and plant residue from the sample.
4. Mix the soil together.
5. Rub wet soil across your palms to neutralize your hands. Discard this soil.
6. Place a scoop of mixed soil in your palm and saturate the soil with distilled water or rainwater.
7. Squeeze the wet soil gently until the water runs out of the cup of the hand and onto the side of the soil sample.
8. Touch the end of a 1-inch-long piece of pH test strip directly to the water so that the tip is barely wet and the solution can be drawn up the strip at least 1/4-inch to 1/2-inch beyond the area masked by soil.
9. Compare the color of the pH test strip approximately one-third of the way up the colored portion of the strip to the color chart on the dispenser of the test strips.
10. Record the soil pH and interpretations in Table 1. Use Figures 1 and 2 to complete the chart.

1:1 Soil-Water Soil pH Test in Classroom

1. Complete Step 1 from the In-Field Quick Hand Test.
2. Tamp down one sampling scoop (29.5 mL) of mixed soil by striking the scoop carefully on a hard, level surface. Place the sample in the plastic mixing vial.
3. Add one scoop (29.5 mL) of water to the same vial. The vial will contain a 1:1 ratio of soil to water, on a volume basis.
4. Place the cap on the vial tightly and shake the vial 25 times.

Soil pH: What Affects it, What it Affects, Managing and Testing it

5. Let the sample settle for one minute.
6. Remove the vial cap and gently pour 1/16-inch of soil-water solution carefully into the lid.
7. Let the sample sit in the lid for two or three minutes.
8. Take the end of a 1-inch-long piece of pH paper and immerse it 1/16 inch into the solution until the liquid is drawn up at least 1/4-inch to 1/2-inch beyond area covered by soil.
9. Compare the color approximately one-third of the way up the colored portion of the strip to the color chart on the dispenser.
10. Record the soil pH and interpretations in Table 1. Use Figures 1 and 2 to complete the chart.

Table 1. Soil pH and Interpretations

Site	Soil pH	Soil pH Category (i.e. very acid)	Nutrients Impacted by Soil pH	Crops Impacted by Soil pH Level	Notes

Soil pH: What Affects it, What it Affects, Managing and Testing it

Figure 1. Soil pH Category

How soil pH affects availability of plant nutrients

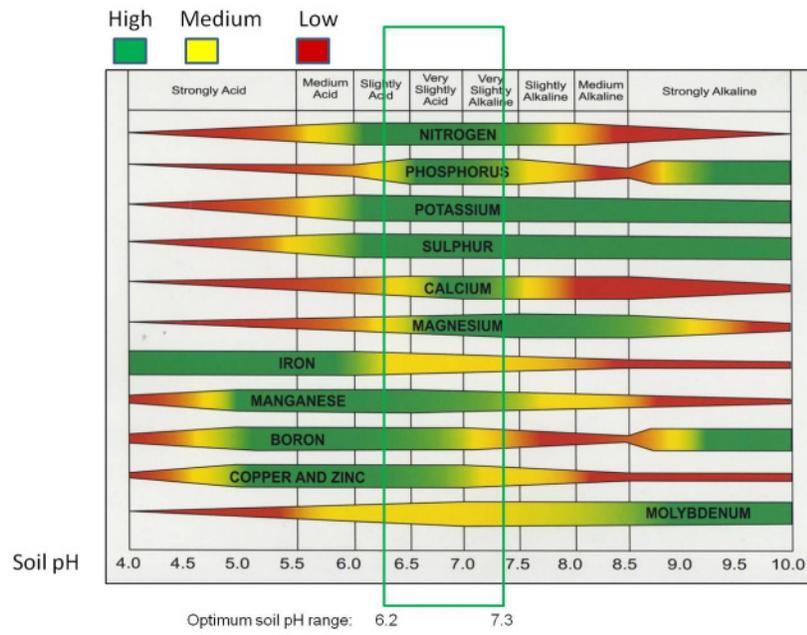


Figure 2. Plant pH Preferences

Plant	Ideal pH
Corn, Wheat, Soybeans, Timothy	6.8
Oats, Barley, Tomatoes, Cucumbers	7.5
Alfalfa	6.8-7.5
Carrots	6

Notes completed by _____

Climate

Soil Texture

Mineral Content

Soil Science Curriculum

Content and lab derived from the USDA-NRCS Guides for Educators. Go to www.nrcs.usda.gov/soils for the Guides and additional pictures and diagrams. This lesson plan was adapted for South Dakota from the University of Nebraska Institute of Agriculture and Natural Resources, CROPWATCH.

January 2018

Soil Nitrogen

Approximately 85 minutes

Objectives

By the end of the lesson, students will know or be able to:

- Define ammonification, ammonium, bulk density, denitrification, immobilization, leaching, mineralization, nitrate-nitrogen, nitrification, soil nitrogen fixation, and volatilization
- List and describe inherent factors that affect soil nitrogen
- Describe factors of nitrogen management
- Identify plants with nitrogen deficiency
- Diagram the nitrogen cycle
- Measure soil nitrate/nitrite and interpret results
- Calculate subsample soil water content, dry weight of soil, volume of water, adjusted ppm soil nitrate-nitrogen, estimated bulk density, pounds of nitrate-nitrogen/acre/depth sampled, and water nitrate content

Preparatory Work

- Print all necessary copies
- Secure permission to collect soil samples from the land owner
- Cut apart terms/definitions
- Cut apart individual management points

Materials

- Terms and Definitions
- Clear plastic cup with gravel in it
- Clear plastic cup with play-doh or clay pressed into it
- Rice
- Water
- Management areas
- Land to take soil samples
- All laboratory supplies (See Lab Guided Notes)

Enroll the Participants *(Approximately 5 minutes)*

Instruct students to inhale a deep breath. Ask students what is in the air they inhaled. Elicit responses.

Share the following information:

- The air we breathe in is 78 percent nitrogen, 21 percent oxygen and contains trace amounts of carbon dioxide, argon, helium and other elements.
- Nitrogen is the most abundant atmospheric element, and most limiting crop nutrient.
- The nitrogen processes
 - o Turn nitrogen into useable forms for plants
 - o Lead to nitrogen losses
 - o Add nitrogen through nitrogen fixation, atmospheric deposition and fertilizers

Soil Nitrogen

Provide the Experience – Defining Key Terms: Soil Nitrogen *(Approximately 5 minutes)*

Divide the class of students into 10 small groups. Provide each group with one of the following terms and its definition. Instruct the small groups to develop a creative way to share the definition with the rest of the class. They might draw a picture, act out the definition, develop a creative way to write the term that depicts the definition, etc.

- Ammonification
- Ammonium
- Denitrification
- Immobilization
- Leaching
- Mineralization
- Nitrate-Nitrogen
- Nitrification
- Soil Nitrogen Fixation
- Volatilization

Label the Information *(Approximately 15 minutes)*

Instruct students to capture the definition of each term on their Guided Notes page as the small groups share the information with the class.

Demonstrate the Relevance *(Approximately 4 minutes)*

Instruct students to identify what they already know about each of the terms from other courses they may have taken.

Provide the Experience – Inherent Factors Affecting Soil Nitrogen *(Approximately 5 minutes)*

Post the following factors in a location that is visible to all students:

- Soil drainage
- Soil texture
- Slope steepness
- Rainfall
- Temperature

Site conditions (moisture, soil aeration, salt content)

Facilitate a discussion with the class about how these factors might affect soil nitrogen.

Soil Nitrogen

Label the Information *(Approximately 7 minutes)*

Share the following information with students:

- Soil drainage, soil texture and slope steepness all impact nitrogen transportation and transformation processes that limit the availability of nitrogen to crops or lead to loss.
- Rainfall, temperature and site conditions all impact the rate of nitrogen mineralization from organic matter decomposition, nitrogen cycling and nitrogen losses through leaching, runoff or denitrification. Organic matter decomposition releases nitrogen quickly in warm, humid and aerated soils; it releases slowly in cool, dry, less aerated soils.
- Nitrogen in the nitrate-nitrogen form can leach out of the root zone.
- Leaching rate is affected by soil texture and soil water content.
 - o Large pore spaces = quick leaching
 - o Small pore spaces = water pools = loss of nitrogen as a gas

Demonstrate the Relevance *(Approximately 4 minutes)*

Show students the clear plastic cup with the gravel in it. Pour a small amount of rice on top of the gravel and pour water over the rice. Point out how the rice moves from the top of the gravel down into the large pore spaces. Compare the rice to nitrogen.

Show students the clear plastic cup with play-doh or clay pressed into it. Pour a small amount of rice on top of the play-doh or clay and pour water over the rice. Point out that the rice and water both collect on top of the play-doh or clay. Compare the rice to nitrogen and point out how it might be lost into the atmosphere.

Provide the Experience – Soil Nitrogen Management *(Approximately 10 minutes)*

Post the following 8-½ x 11 inch signs around the classroom or in an open area.

Sandy Soil
Time
Source
Placement
Irrigation Scheduling
Management Strategies

Provide the class with the stack of nitrogen management points. Instruct students to attach their points to the correct management topic.

After all points have been posted, review each management topic and help the students move incorrectly assigned points to the correct location.

Soil Nitrogen

Label the Information *(Approximately 12 minutes)*

Share the following information with the students and encourage them to add it to their Guided Notes:

- Sandy Soil
 - Leaching is a concern because of pore size
 - Nitrogen rate selection is the first concern
 - Rate is determined by assessing the amount of nitrogen needed to optimize yield based on the agronomic, economic and environmental considerations
 - Increase the soil organic matter
 - Avoid compaction
- Time
 - Apply adequate amounts when the plants are growing and will use the nitrogen quickly
 - Apply nitrogen after the plants emerge (side dressing)
 - Apply a portion of nitrogen prior to emergence and a portion following emergence
 - Avoid applying urea materials during warm/humid conditions
- Source
 - Anhydrous Ammonia (least expensive nitrogen source)
 - Urea loss from ammonia volatilization can be reached by incorporation or by using stabilizers.
 - Organic amendments or manure, must be applied uniformly
- Placement
 - Side dressing: applications after plants emerge
 - Knifed applications: placing a band of fertilizer below the soil surface
 - Broadcast applications: uniformly distribute nitrogen
 - Sprinkler irrigation applications: applying fertilizer through the water distribution of an irrigation system
- Irrigation Scheduling
 - Goal: to supply enough water to optimize yield while avoiding excess water, which can increase costs and cause nitrogen to leach below the root zone

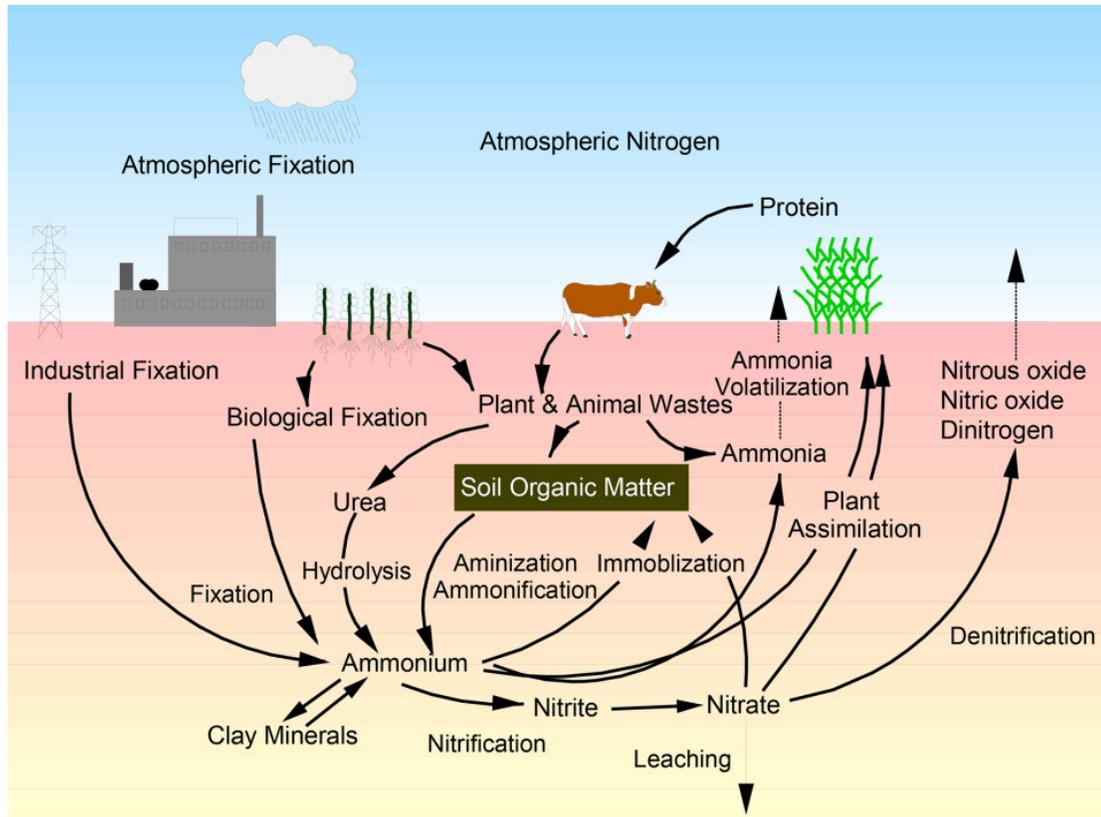
Demonstrate the Relevance *(Approximately 3 minutes)*

Share the following general management strategies with students:

- Management Strategies
 - o Select an ammonium containing fertilizer which provides greater nitrogen recovery by crops
 - o Inject nitrogen if possible to avoid ammonia or volatilization losses
 - o Use nitrogen inhibitors when nitrogen is applied outside of the growing season
 - o Monitor crop nitrogen needs by scouting
 - o Conduct regular soil testing for nitrate and soil salt content
 - o Monitor for the common signs of nitrogen deficiency in plants
 - Yellow “V”-shaped pattern
 - Progresses from the leaf tip to the leaf collar and from lower to upper leaves

Soil Nitrogen

Provide students with the Nitrogen Cycle image with the terms whited out so that students may write the terms in on their blank copy of the cycle.



Nitrogen cycle ("Soil as a Plant Sees It", University of Nebraska, 1991).

Provide the Experience – Measuring and Interpreting Soil Nitrogen

(Approximately 3 minutes)

Review the laboratory scenario with students. Students can find the scenario in their guided notes.

Marty and Stephen notice that the leaves on their sweet corn have been gradually turning yellow progressing from the base of the stalk to the upper leaves on the stalk. After consulting with Ben, a local agriscience student and FFA member, they learned that this description matches that of a nitrogen deficiency in plants. They plan to test their plot for nitrogen levels to determine if that is the cause of the yellowing leaves.

Soil Nitrogen

Label the Information *(Approximately 15 minutes)*

Review and identify each of the supplies from the soil testing kit that will be used during the lab activity.

- Soil probe for gathering soil samples
- Plastic bucket for mixing soil samples
- Nitrate-nitrite test strips
- 1/8-cup (29.5-mL) measuring scoop
- Calibrated 120-mL shaking vial with lid
- Squirt bottle
- Distilled water or rainwater
- Pen, field notebook, sharpie and zip-lock bags

Review the steps of the laboratory activity and provide any instructions specific to your classroom expectations and time.

Demonstrate the Relevance *(Approximately 70 minutes)*

See the attached laboratory guided notes for the steps to complete the laboratory. Review the results and analysis steps of the lab.

Review the Content *(Approximately 4 minutes)*

Facilitate students in making applications of the nitrate-nitrogen information to lives of consumers in the community. Consider discussing blue baby syndrome and the negative effects of heavy nitrates in water for the elderly.

Celebrate Student Success *(Approximately 2 minutes)*

Congratulate students on their discovery of nitrate levels and encourage them to share the information with their parents.

Definitions

Ammonification: Production of ammonium (NH₄) from soil organic matter decomposition and other sources

Ammonium: Form of nitrogen expressed as NH₄, which is a plant-available form of nitrogen that occurs as part of the nitrogen cycle in soil; occurs from soil organic matter decomposition and other sources.

Denitrification: Conversion and loss of nitrate-nitrogen to various nitrogen gases when soil becomes saturated with water.

Soil Nitrogen

Immobilization: The temporary “tying up” of inorganic nitrogen by soil microorganisms decomposing plant residues is not strictly a loss process. Immobilized nitrogen will be unavailable to plants for a time, but will eventually become available again as residue decomposition proceeds.

Leaching: Loss of nitrogen in the form of nitrate-nitrogen which is a water soluble, mobile form, with excess water that moves below the root-zone, or to drainage tile.

Mineralization: Organic matter decomposition which releases nutrients in a plant available form.

Nitrate Nitrogen: Form of nitrogen expressed as NO_3 , which is a plant-available form of nitrogen that occurs as part of the nitrogen cycle in soil. Nitrate is the form of nitrogen most susceptible to leaching loss.

Nitrification: Part of the nitrogen cycle where soil organisms convert ammonia and ammonium to nitrite and next to nitrate-nitrogen which is available to plants.

Soil Nitrogen Fixation: Conversion of nitrogen in the air to organic nitrogen forms, which occurs either by soil organisms or in association with legumes.

Volatilization: Ammonia nitrogen loss from nitrogen fertilizers and other sources. Loss can be especially high when nitrogen fertilizers containing urea are surface-applied directly on moist residue.

Sandy Soil

Time

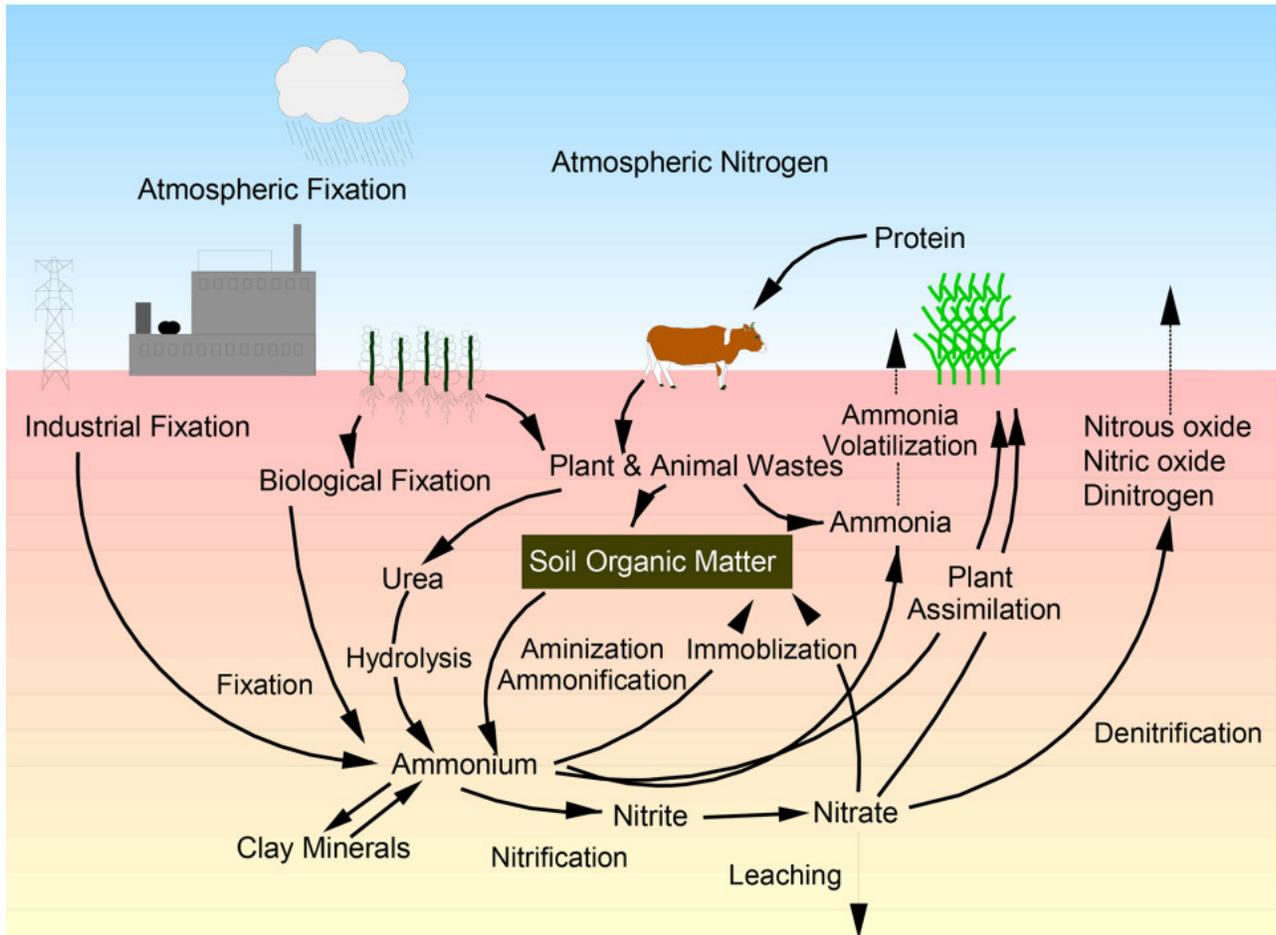
Source

Placement of Nitrogen Fertilizer

Irrigation Schedule

Additional Management Strategies

Soil Nitrogen



Nitrogen cycle ("Soil as a Plant Sees It", University of Nebraska, 1991).

Soil Nitrogen

Guided Notes: Soil Nitrogen

Ammonification:

Ammonium:

Denitrification:

Immobilization:

Leaching:

Mineralization:

Nitrate-Nitrogen:

Nitrification:

Soil Nitrogen Fixation:

Volatilization:

Notes about Factors affecting Soil Nitrogen

Soil drainage

Soil texture

Slope steepness

Rainfall

Temperature

Site conditions

Soil Nitrogen

Nitrogen Management

Sandy Soil	Time	Source
Placement	Irrigation Scheduling	Management Strategies

Guided Notes: Soil Nitrogen Laboratory

Soil Nitrogen Scenario

Marty and Stephen notice that the leaves on their sweet corn have been gradually turning yellow progressing from the base of the stalk to the upper leaves on the stalk. After consulting with Ben, a local agriscience student and FFA member, they learned that this description matches that of a nitrogen deficiency in plants. They plan to test their plot for nitrogen levels to determine if that is the cause of the yellowing leaves.

Laboratory Supplies

- Soil probe for gathering soil samples
- Plastic bucket for mixing soil samples
- Nitrate-nitrite test strips
- 1/8-cup (29.5-mL) measuring scoop
- Calibrated 120-mL shaking vial with lid
- Squirt bottle
- Distilled water or rainwater
- Pen, field notebook, sharpie and zip-lock bags

Laboratory Steps

Electrical conductivity measurements should always be measured first, before measuring nitrate or nitrite on the same sample. Soil phosphate and soil pH can also be measured using the following steps.

Soil nitrate-nitrogen levels are highly variable, depending on management history, field location and time of year. For example, erosion rates, soil texture, organic matter content and applications of manure or fertilizer.

In-Field Quick Hand Test

1. Use the soil probe to gather a minimum of 10 small soil samples randomly from an area that represents the soil type and management history you desire to test. Samples should be taken from a depth of eight inches for the surface test and a depth of three feet for subsurface testing. Place the samples in the small bucket and exclude large stones and residue from the sample. Repeat this step for each sampling area.
2. Neutralize your hands by rubbing moist soil across your palms and discard the soil.
3. Place a scoop of mixed soil in the palm of your hand and saturate it with clean distilled or rain water.
4. Squeeze the soil gently until a water slurry runs out into the cup of your hand on the side.
5. Touch the nitrate test strip tip directly to soil water slurry so that the tip is barely wet so solution is drawn up at least 1/8-inch to 3/16-inch.
6. After one to two minutes, measure nitrate by comparing color of wetted test strips to color picture scale on container test strips were stored. The color that most closely matches the test strip is the amount of nitrate in water saturated soil.
7. To test nitrite levels, the procedure is repeated after nitrate test pad on the end of the strip is cut off to expose the nitrite test strip to the soil slurry.

1:1 Soil-Water Soil Nitrate-Nitrite Test in Classroom

1. Use the soil probe to gather a minimum of 10 small soil samples randomly from an area that represents the soil type and management history you desire to test. Samples should be taken from a depth of eight inches for the surface test and a depth of three feet for subsurface testing. Place the samples in the small bucket and exclude large stones and residue from the sample. Repeat this step for each sampling area.
2. Add one sampling scoop (29.5 ml) of mixed soil that has been tamped down during filling by striking carefully on a hard level surface. Then add one scoop (29.5 ml) of water to the same vial resulting in a 1:1 ratio of soil to water, on a volume basis.
3. Tightly cap the vial and shake 25 times. Let the mixture settle for one minute. Remove cap and gently pour 1/16-inch of the soil water 1:1 mixture carefully into the lid.
4. After setting for two to three minutes in the lid, immerse the end of the nitrate test strip 1/16-inch into 1:1 soil water mixture until the liquid is drawn up at least 1/8-inch to 3/16-inch beyond the area masked by soil.
5. After one to two minutes, measure nitrate by comparing the color of the wetted test strips to color picture scale on container test strips were stored. The color that most closely matches the test strip is the amount of nitrate in water saturated soil.
6. To test nitrite levels, the procedure is repeated after the nitrate test pad on the end of the strip is cut off to expose the nitrite test strip to the soil slurry.

Soil Nitrogen

Interpretations

Soil nitrate-nitrogen is an excellent indicator of nitrogen-cycling in soils, whether carryover nitrogen was used by the previous crop and whether additional nitrogen is needed. High nitrate-nitrogen levels also signal potential for excessive nitrogen applied in the past, high rates of organic nitrogen mineralization and potential for losses from denitrification, leaching or volatilization.

Typically, an early season measurement of 20 parts per million nitrate-nitrogen in topsoil (30 cm) is sufficient to produce a good corn yield and most other high nitrogen-use crops, whereas a value of only 14 parts per million is sufficient where animal manure is applied or where corn or other high nitrogen use crop follows a legume crop. A very high soil nitrate-nitrogen value above 40 parts per million in topsoil will turn off the ability of bacteria and legumes to fix nitrogen. Therefore, nitrogen applications should be managed to keep nitrate-nitrogen levels below this value. Nitrate-nitrogen levels must be adjusted for soil bulk density and moisture content of the soil as shown in Table 1.

Table 1. Average bulk density for soil minerals (texture) and organic matter (Rawls 1983).

Class (texture, organic matter)	Average Bulk Density (g/cm³)
Organic Matter	0.22
Sand	1.56
Loamy Sand	1.54
Sandy Loam	1.50
Loam	1.45
Silt Loam	1.20
Sandy Clay Loam	1.63
Silty Clay	1.55
Clay Loam	1.45
Silty Clay Loam	1.40

Soil Nitrogen

Soil Nitrate Nitrogen Calculations – Use to Complete Table 2

Ex. 1 Data: Silty Clay Loam texture, 8-inch sample depth; 2 percent organic matter estimate from soil color chart; no bulk density (BD) measurement (BD based estimated values from Table 1).

Sampling depth conversion: Sampling depth in centimeters (cm) = inches (sampling depth) x (2.54cm/in)

Ex. 1: 8 inch (sampling depth) x 2.54 = **20 cm sampling depth**

Subsample Soil water content (g/g) = $\frac{(\text{weight of moist soil} - \text{weight of oven dry soil})}{(\text{Weight of oven dry soil})}$

Ex. 1: $\frac{(41.0g - 32.5g)}{32.5g} = 0.262 \text{ g of water/g of soil}$

Dry weight of soil = (weight of soil in scoop) / (1+ soil water content(decimal))

Ex. 1: (41.0gr / (1 + .262g/g)) = 32.5g

Volume (weight) of water = water added to soil in grams + (dry weight of soil x soil water content g/g)

(1ml water = 1g)

Ex. 1: 29.5g + (32.5g x .262g/g) = **38 g**

Adjusted ppm soil Nitrate-N = $\frac{(\text{ppm NO}_3\text{-N of 1:1 mix}) \times (\text{volume of water content in extract \& soil})}{\text{dry weight of soil extracted}}$

Ex. 1: (20ppm x 38.0g) / 32.5g = **23.4 ppm (adjusted)**

Estimated Bulk Density (refer to bulk density educator guide to calculating actual bulk density or use estimate from Table 1 as shown below)

Est. Bulk Density (Table 2) = $\frac{100}{(\% \text{ organic matter/organic Matter BD}) + ((100 - \% \text{ organic matter})/\text{avg soil BD})}$

Ex. 1: $\frac{100}{(2.0/0.22 \text{ g/cm}^3) + ((100 - 2)/1.40 \text{ g/cm}^3)} = 1.26 \text{ g/cm}^3 \text{ (estimated bulk density (BD))}$

Lbs of nitrate-N/ acre/depth sampled = (adjusted ppm NO₃-N) x (cm depth soil sampled/10) x estimated soil bulk density x 0.89 (conversion factor)

Ex. 1: 23.4 ppm NO₃-N X (20 cm/10) x 1.26 g/cm³ (estimated BD) x 0.89 = **52.5 lbs/Nitrate Nitrogen/20cm sampling depth**

Soil Nitrogen

Table 2. Soil nitrate-nitrogen (based on sampling depth).

Site	*Sample Depth (inches or cm)	Nitrate-Nitrogen (ppm) From test strip	*Adjusted Nitrate-Nitrogen (ppm)	*Bulk Density (g/cm ³)	*Lbs of nitrate-Nitrogen/ acre/ depth sampled	**Nitrite-Nitrogen (ppm) from test strip	Notes:
Ex1	8" or 20cm	20ppm	23.4 ppm	1.26	52.5 lbs	NA	Spring Nitrogen-test just prior to planting

* Follow soil nitrate calculation steps based on sampling depth (Ex. 1 is based on 8-inch sample depth).

** When nitrate-nitrogen exceeds 40 ppm, or EC exceeds 0.6 ds/m nitrite should also be measured.

Soil Nitrogen

Water Nitrate or Nitrite Content

Water nitrate and nitrite levels can be estimated for drinking water, irrigation water and other water sources. Cloudy samples, such as runoff or water from ponds, will need to be filtered first before testing. Drinking water treatment should be considered if nitrate levels exceed 10 mg/l nitrate-nitrogen. This is considered the maximum contaminate level by the Environmental Protection Agency.

Consult your local health officials and be aware that nitrate levels in groundwater may vary seasonally. If your water tests high or borderline high, retest your water every three to six months. Nitrates in irrigation water can be credited for nitrogen supplied to crops using the formula footnoted in Table 3.

1. Collect water sample in a small plastic container.
2. Filter the water sample if it is cloudy.
3. Place one or two drops of water on the nitrate-nitrite test strip.
4. After 30 seconds, compare the color to the nitrite scale on the bottle and record the nitrite levels.
5. After 60 seconds, compare the color to the nitrate scale on the bottle and record the nitrate in ppm on Table 3.

Table 3. Water nitrate and nitrite-nitrogen.

Site	Nitrate-Nitrogen (ppm) from test strip	Nitrite-Nitrogen (ppm) from test strip	Irrigation Water Applied (inches/ ac pumped)	Irrigation Water Nitrogen Credit lbs of Nitrogen/acre
EX 1	20ppm	NA	12"	54 lbs N/ac

Soil Nitrogen

Are the soil nitrate levels adequate for crops being grown?

Does the total amount of nitrate-nitrogen in the soil appear too high or too low based on nitrogen application rates, methods and timing of application?

Do you expect nitrate-nitrogen to be lost to leaching, volatilization, denitrification or other losses? Why or why not?

If you tested drinking water for nitrate-nitrogen, do levels exceed 10 mg/l nitrate-nitrogen ppm? If so, what steps should you take?

Soil Science Curriculum

Content and lab derived from the USDA-NRCS Guides for Educators. Go to www.nrcs.usda.gov/soils for the Guides and additional pictures and diagrams. This lesson plan was adapted for South Dakota from the University of Nebraska Institute of Agriculture and Natural Resources, CROPWATCH.

January 2018

Soil Phosphorus

Approximately 135 minutes

Objectives

By the end of the lesson, students will know or be able to:

- Define immobilization, mineralization, phosphorus cycle, phosphorus fixation, and soil phosphate
- Diagram the relationship of phosphorus inputs and soil processes
- List and describe inherent factors that affect soil phosphorus
- Describe phosphorus management techniques
- Identify plants with phosphorus deficiencies
- Measure soil phosphate and interpret results

Preparatory Work

- Print all necessary copies
- Secure permission to collect soil samples from the landowner

Materials

- Guided Notes (one per student)
- Land to take soil samples
- All laboratory supplies (See Lab Guided Notes)

Enroll the Participants (Approximately 4 minutes)

Show students the following diagram and facilitate a discussion about soil phosphorus to determine what they may know about the nutrient from other classes.

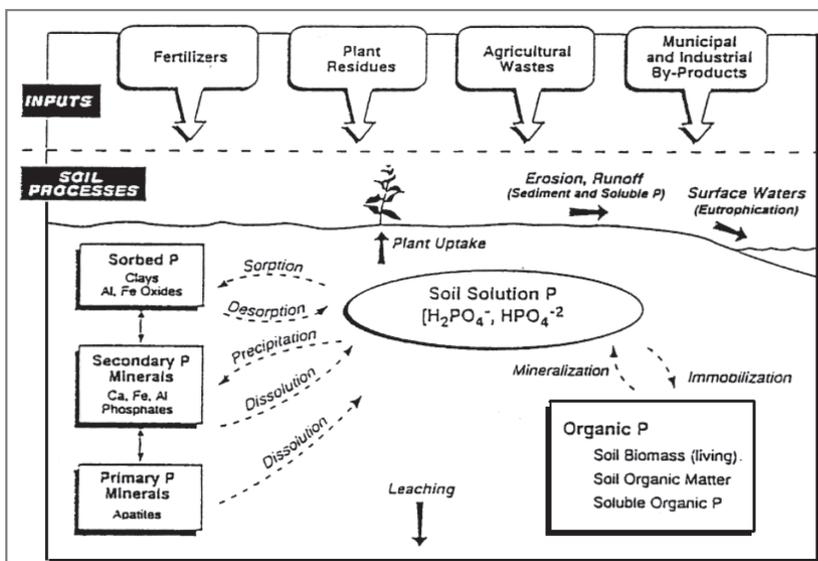


Figure 1. Soil phosphorus cycle (Pierzinski et al., 1994).

Preview with students that during this lesson, the class will explore the relationship of phosphorus to soil and plant growth.

Soil Phosphorus

Provide the Experience – Defining Key Terms *(Approximately 3 minutes)*

List off the five key terms and ask students to share with the class what they currently know about the terms.

Label the Information *(Approximately 5 minutes)*

Review the terms and definitions using the information found here.

Immobilization: temporarily “tying up” of water soluble phosphorus by soil microorganisms decomposing plant residues. Immobilized phosphorus will be unavailable to plants for a time, but will eventually become available again as decomposition proceeds.

Mineralization: nutrients contained in soil organic matter are converted to inorganic forms that are available to crops during respiration.

Phosphorus Cycle: phosphorus cycles between many different forms in soil. Some forms are available to plants and other forms are not. Unavailable forms are generally fixed to iron, aluminum and calcium minerals.

Phosphorus Fixation: phosphate fixates to iron, aluminum and calcium minerals and attached to clay minerals. pH levels affect fixation and availability of phosphorus.

Soil Phosphate: a form of phosphate available to plants and is expressed as PO_4 .

Demonstrate the Relevance *(Approximately 4 minutes)*

Discuss the following key points with the class:

1. Phosphorus is the second most limiting factor in terms of plant growth, next only to nitrogen.
2. Phosphorus plays a key role in plant growth and reproduction – promotes root growth, hardiness, quicker maturity, efficient water use, increased yields and promotes above ground shoot growth.

Provide the Experience – Inherent Factors Affecting Soil Phosphorus

(Approximately 5 minutes)

List the following factors that are affected by soil properties and climate for the class:

Soil aeration
Rainfall
Temperature
Moisture
Salinity

Elicit thoughts from the students as to how each of those factors might affect soil phosphorus.

Soil Phosphorus

Label the Information *(Approximately 7 minutes)*

Share the following points with the class.

Direct students to their Guided Notes and add the following information about each inherent factor:

- Inherent factors affect the rate of phosphorus mineralization from the decomposition of organic matter
- Phosphorus releases quickly in warm, humid areas with well-aerated soil
- Phosphorus releases slowly in cool, dry areas with saturated soil
- Phosphorus is most available in soil with a pH range of 6-7.5
- pH levels of <5.5 or between 7.5 and 8.5 limit phosphorus availability
- Phosphorus is most frequently lost through erosion and runoff

Demonstrate the Relevance *(Approximately 3 minutes)*

Provide the following scenario and question to students and elicit student thoughts.

In a well-aerated soil found in an area that is warm and humid, what would you anticipate the phosphorus levels to be, given a pH of 5.0?

Even though the soil has the right climate and aeration conditions, the pH has a greater influence and will cause the phosphorus availability to be low.

Provide the Experience – Symptoms of Deficiency and Management of Soil Phosphorus *(Approximately 3 minutes)*

Show students pictures of phosphorus-deficient plants. Ask students to identify the characteristics of the plants that they see with the deficiency.

Label the Information *(Approximately 5 minutes)*

Share the following information with the students and encourage them to add it to their Guided Notes:

- Symptoms of a phosphorus deficiency include:
 - Purple leaf tissue
 - Purple coloring moves from the leaf tips to the leaf margins
 - Symptoms appear on lower leaves; leaves may eventually die
- Emerging leaves may be green because plants move phosphorus to youngest leaves
- Cool and wet growing conditions increase symptom occurrence
- Plants with small or poor root systems are very vulnerable
- When root growth is prohibited by these factors, the problem is enhanced:
 - Cool temperatures
 - Too wet or dry
 - Compacted soil
 - Damage from herbicides
 - Damage from insects
 - High salinity
 - Damage to roots

Soil Phosphorus

Demonstrate the Relevance *(Approximately 7 minutes)*

Direct students to their Guided Notes to capture the following information.

- Phosphorus deficiency reduces the yield of plants:
 - Delays maturity
 - Stunts growth
 - Restricts energy utilization by the plant
- Soil pH, organic matter amount and placement of fertilizer affect the availability of phosphorus
- Adding lime to acidic soils can help correct pH to 6.5-7.0
- Place phosphorus two inches below the planted seed
- Make several small applications of fertilizer rather than one big application
- Place the phosphorus near the crop row where the roots have immediate contact with it

Provide the Experience – Measuring and Interpreting Soil Phosphate

(Approximately 3 minutes)

Review the laboratory scenario with students. Students can find the scenario in their Guided Notes.

After walking through several cornfields, Tom and Rik noticed that several plants have purple leaves. Tom recalled from his agronomy class last fall that purple leaves can indicate a shortage of phosphate. Together, they determine that they need to test each of their fields for inadequate phosphate levels.

Label the Information *(Approximately 15 minutes)*

Review and identify each of the supplies from the soil testing kit that will be used during the lab activity.

- Soil probe for gathering soil samples
- Plastic bucket for mixing soil samples
- Phosphate test strips
- 1/8-cup (29.5-mL) measuring scoop
- Calibrated 120-mL shaking vial with lid
- Squirt bottle
- Distilled water or rainwater

Demonstrate the Relevance *(Approximately 125 minutes)*

See the attached laboratory Guided Notes for the steps to complete the laboratory. Review the results and analysis steps of the lab.

Review the Content *(Approximately 4 minutes)*

Instruct students to find a partner and to “interview” one another about key points learned during the soil phosphorus lesson.

Celebrate Student Success *(Approximately 2 minutes)*

Congratulate students on their discovery of phosphorus level results for their tested soil. Encourage students to continue being curious during each of the laboratory activities of the soil science unit.

Soil Phosphorus

Guided Notes: Soil Phosphorus

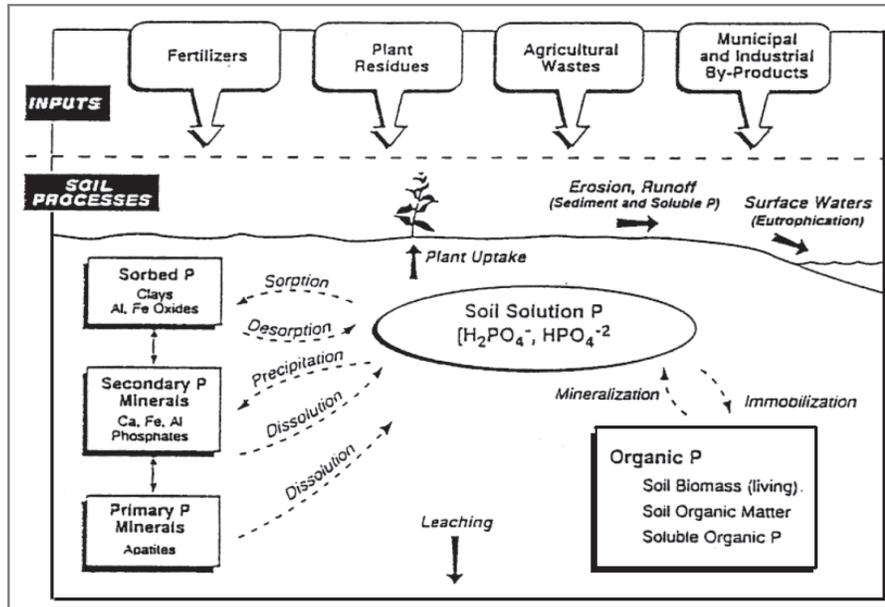


Figure 1. Soil phosphorus cycle (Pierzinski et al., 1994).

Immobilization:

Mineralization:

Phosphorus Cycle:

Phosphorus Fixation:

Soil Phosphate:

Soil Phosphorus

Guided Notes: Soil pH Laboratory

Soil pH Scenario

After walking through several cornfields, Tom and Rik noticed that several plants have purple leaves. Tom recalled from his agronomy class last fall that purple leaves can indicate a shortage of phosphate. Together, they determine that they need to test each of their fields for inadequate phosphate levels.

Laboratory Supplies

- Soil probe for gathering soil samples
- Plastic bucket for mixing soil samples
- Phosphate test strips
- 1/8-cup (29.5-mL) measuring scoop
- Calibrated 120-mL shaking vial with lid
- Squirt bottle
- Distilled water or rainwater
- Pen, field notebook, sharpie and zip-lock bags

Laboratory Steps

Electrical conductivity measurements should always be completed first, before measuring phosphate on the same sample. Soil nitrate-nitrite and soil pH can also be assessed on the same sample using the following steps.

Phosphate levels are variable, depending on field location, past management and time of year. Phosphorus fertilizer placement, soil texture, organic matter content and applications of manure or fertilizer affect the phosphate levels.

In-Field Quick Hand Test

1. Using a soil probe, gather at least 10 small samples randomly from the area that represents the soil type and management history to be tested. Ensure that each sample is taken at a depth of eight inches.
2. Place each sample into the plastic bucket provided.
3. Remove large stones and plant residue from the sample.
4. Mix the soil together.
5. Rub wet soil across your palms to neutralize your hands. Discard this soil.
6. Place a scoop of mixed soil in your palm and saturate the soil with distilled water or rainwater.
7. Squeeze the wet soil gently until the water runs out of the cup of the hand and onto the side of the soil sample.
8. Touch the phosphate test strip into soil water slurry so that the tip is barely wet until the liquid is drawn up at least 1/8-inch to 3/16-inch beyond the area masked by soil.
9. After one to two minutes, measure the phosphate by comparing the color of the wetted test strips to the color scale on the test strip container. The color that most closely matches that of the test strip is the amount of phosphate in water saturated soil. Record the value in Table 1.

Soil Phosphorus

Guided Notes: Soil pH Laboratory

1:1 Soil-Water Soil Phosphate Test in Classroom

1. Complete Step 1 from the In-Field Quick Hand Test.
2. Tamp down one sampling scoop (29.5 mL) of mixed soil by striking the scoop carefully on a hard, level surface. Place the sample in the plastic mixing vial.
3. Add one scoop (29.5 mL) of water to the same vial. The vial will contain a 1:1 ratio of soil to water, on a volume basis.
4. Place the cap on the vial tightly and shake the vial 25 times.
5. Let the sample settle for one minute.
6. Remove the vial cap and gently pour 1/16-inch of soil-water solution carefully into the lid.
7. Let the sample sit in the lid for two or three minutes.
8. Immerse the end of the phosphate test strip 1/16-inch into the 1:1 soil water mixture until liquid is drawn up at least 1/8-inch to 3/16-inch beyond the area masked by soil.
9. After one or two minutes, measure phosphate by comparing the color of the wetted test strips to the color picture scale on the bottle in which test strips were stored. The color that most closely matches the test strip is the index value of phosphate in water saturated soil.
10. Record the soil phosphate value in Table 1.

Table 1. Phosphorus test results and recommendations for corn in South Dakota soils based on standard extractable phosphorus tests and water soluble PO_4 test for a 1:1 soil:water mixture.

Site	Water Soluble PO_4 Test Reading for 1:1 Soil:Water Mixture		Soil P Test Values (ppm) by P-test Method
	PO_4 (ppm)	Relative PO_4 Level	Water Soluble PO_4

Soil Science Curriculum

Content and lab derived from the USDA-NRCS Guides for Educators. Go to www.nrcs.usda.gov/soils for the Guides and additional pictures and diagrams. This lesson plan was adapted for South Dakota from the University of Nebraska Institute of Agriculture and Natural Resources, CROPWATCH.

January 2018

Soil Infiltration: Factors that Affect It; Existing Problems; Management

Approximately 90 minutes

Objectives

By the end of the lesson, students will know or be able to:

- Define infiltration rate, restrictive layers, soil aggregates, soil porosity, and steady-state infiltration
- List and describe inherent factors that affect soil infiltration
- Describe soil infiltration management practices
- Explain soil infiltration problems and how they affect soil function
- Measure soil infiltration and interpret results

Preparatory Work

- Print all necessary copies
- Secure permission to collect soil samples from the land owner
- Create note cards with key terms
- Create note cards with definitions
- Hide note cards in the classroom

Materials

- Guided notes (one per student)
- Clear plastic cup filled with marbles
- Clear plastic cup filled with Play-Doh
- Water
- 8-½ x 11 paper that
- Laboratory supplies (see Guided Notes Lab)
- Notecards with terms

Enroll the Participants *(Approximately 4 minutes)*

Set up the clear plastic cups – one filled with marbles, the other with Play-Doh – in an area where they are visible to all students.

Ask students to hypothesize which cup will provide the quickest flow rate of the water.

Pour an equal amount of water into each of the cups and encourage students to monitor the two rates.

Use the following questions to facilitate a conversation with the students:

What caused one rate to be faster than the other?

How might this demonstration be comparable to how water and soil interact together?

Inform students that during this lesson, the class will explore soil infiltration rates, what affects it, problems that exist and management of it.

Soil Infiltration: Factors that Affect It; Existing Problems; Management

Provide the Experience – Defining Key Terms: Soil Infiltration *(Approximately 3 minutes)*

Direct students to search the room for note cards with key terms and definitions on them for this lesson.

Instruct students to work together to match the terms and definitions.

Label the Information *(Approximately 5 minutes)*

Review the terms and definitions using the information found here:

Infiltration Rate: A measure of how fast water enters the soil, typically expressed in inches per hour but recorded in minutes for each inch of water applied to the soil surface.

Restrictive Layers: Compacted layers and layers of dense clay, bedrock or other restrictive features than limit infiltration below the surface of the soil.

Soil Aggregates: Soil particles held together by organic matter and related substances. Well aggregated soils have higher infiltration rates and are less prone to erosion.

Soil Porosity: Amount of pore space in the soil. Soils with higher porosity have more pore space and higher infiltration rates than those with lower porosity.

Steady-State Infiltration: The infiltration rate is steady and does not increase or decrease as more water is added. It typically occurs when the soil is nearly saturated.

Demonstrate the Relevance *(Approximately 3 minutes)*

Instruct students to discuss with someone near them how each of the terms might affect plant growth in soils.

Provide the Experience – Inherent Factors Affecting Soil Infiltration

(Approximately 2 minutes)

Refer back to the cup of marbles and cup of clay. Ask the students the following questions:

Which material has larger pore space?

How does pore space affect infiltration rate?

Label the Information *(Approximately 2 minutes)*

Share the following information with the students:

Soils with a sandy texture has large pores and water moves through it quickly, like the marbles.

Soils with a clayey texture has small pores and water moves through it slowly, like the Play-Doh.

Soil texture, as discovered in the previous labs, is an inherent factor, meaning it cannot be changed.

Soil Infiltration: Factors that Affect It; Existing Problems; Management

Demonstrate the Relevance *(Approximately 4 minutes)*

Ask students to predict what type of soil they believe exists around the school, in their yard, in their fields, etc. Elicit responses.

Provide the Experience – Managing Soil Infiltration *(Approximately 4 minutes)*

Share with students that management practices affect the following:

Surface crusting
Compaction
Soil Organic Matter

Ask students to discuss how surface crusting, compaction and soil organic matter might affect infiltration rates.

Label the Information *(Approximately 5 minutes)*

Share the following information with the students and encourage them to add it to their Guided Notes:

- Soil Crusting
 - Soils dry out, causing pore space to increase as cracks form
 - Water fills the cracks quickly, wetting the soil
 - As soil becomes wetter, the infiltration rate slows because of restrictive layers
- Compaction
 - Results from equipment and tillage practices
 - Minimizes pore space
 - Slows water movement through the soil profile
- Soil Organic Matter
 - Bare soil is more drastically affected by erosion by rain drops
 - Dislodged soil particles fill in and block surface pores
 - Organic matter binds soil particles together, forming aggregates; aggregates increase porosity and infiltration rates
 - Organic matter encourages a living environment for organisms such as earthworms; organisms move about in the soil and increase pore space
- Improve Infiltration Rates by
 - Avoiding soil disturbance and equipment operation when soils are wet
 - Using designated field roads or rows for equipment traffic
 - Reducing the number of trips across the space
 - Sub-soiling to break up existing compacted layers
 - Using continuous no-till
 - Adding solid manure or other organic materials
 - Using rotations with high-residue crops, such as corn and small grain, and perennial crops, such as grass or alfalfa
 - Planting cover crops and green manure crops
 - Farming on the contour
 - Establishing terraces to minimize run-off and erosion

Soil Infiltration: Factors that Affect It; Existing Problems; Management

Demonstrate the Relevance *(Approximately 3 minutes)*

Instruct students to identify something their family does (in their fields, garden or yard) or something another individual in the community does to minimize soil compaction. Also consider challenging students to identify something they could do.

Provide the Experience – Soil Infiltration Problems *(Approximately 5 minutes)*

Divide students into five small groups and provide each group with one of the following soil infiltration problems. Instruct each groups to discuss and be prepared to present what the problem could cause and potential solutions.

Rainfall rate exceeds the soil's infiltration capacity
Runoff moves downslope or causes ponding
Runoff removes nutrients, chemicals and soil
Aeration of soil is poor because of slow infiltration and ponding

Label the Information *(Approximately 7 minutes)*

Instruct small groups to share their thoughts on the results of the problem and their possible solutions.

Fill in with the following information:

- Rainfall rate exceeds the soil's infiltration capacity
 - Water ponds, causing drowning of plants
- Runoff moves downslope or causes ponding
 - Erosion results, plants drown
- Runoff removes nutrients, chemicals and soil
 - Decreases soil productivity, off-site sedimentation of water bodies occurs, water health diminishes
- Aeration of soil is poor because of slow infiltration and ponding
 - Poor root function
 - Poor plant growth
 - Reduced availability of nutrient to plants
 - Reduced cycling of nutrients by soil organisms

Demonstrate the Relevance *(Approximately 4 minutes)*

Discuss with students how a farmer is economically affected by poor soil infiltration and how consumers are economically affected as well.

Soil Infiltration: Factors that Affect It; Existing Problems; Management

Provide the Experience – Measuring and Interpreting Soil Infiltration

(Approximately 3 minutes)

Review the laboratory scenario with students. Students can find the scenario in their guided notes.

A local farmer recently purchased some recreational ground and plans to turn the space into farm ground. One concern the farmer has is regarding the amount of vehicular traffic that has occurred on the former recreational ground. The worry is that the transportation has negatively affected the ground's ability to infiltrate water.

Label the Information *(Approximately 15 minutes)*

Review and identify each of the supplies from the soil testing kit that will be used during the lab activity.

- 3-inch diameter ring
- Plastic driver (mallet)
- Small block of wood
- Plastic wrap
- Plastic bottle marked at 107 mL (for one inch of water) or graduated cylinder
- Distilled water or rainwater
- Stopwatch or timer

Review the steps of the laboratory activity and provide any instructions specific to your classroom expectations and time.

Demonstrate the Relevance *(Approximately 25 minutes)*

See the attached laboratory Guided Notes for the steps to complete the laboratory. Review the results and analysis steps of the lab.

Review the Content *(Approximately 4 minutes)*

Review the process students used to test the soil infiltration rates. Discuss how soil infiltration relates to each of the other lab topics covered during the unit.

Celebrate Student Success *(Approximately 2 minutes)*

Congratulate students on their discovery of infiltration rates and their understanding of how infiltration rates relate to other lab topics.

Guided Notes: Soil Infiltration

Vocabulary Matching

Infiltration Rate

Restrictive Layers

Soil Aggregates

Soil Porosity

Steady-State Infiltration

Inherent Factors Affecting Soil

Infiltration

Soil Infiltration Management Practices

Soil Crusting

Compaction

Soil Organic Matter

Soil Infiltration: Factors that Affect It; Existing Problems; Management

Improve Infiltration Rates by:

Problems associated with soil infiltration

Rainfall rate exceeds the soil's infiltration capacity

Runoff moves downslope or causes ponding

Runoff removes nutrients, chemicals and soil

Aeration of soil is poor because of slow infiltration and ponding

Soil Infiltration: Factors that Affect It; Existing Problems; Management

Guided Notes: Soil Infiltration Laboratory

Soil Infiltration Scenario

A local farmer recently purchased some recreational ground and plans to turn the space into farm ground. One concern the farmer has is regarding the amount of vehicular traffic that has occurred on the former recreational ground. The worry is that the transportation has negatively affected the ground's ability to infiltrate water.

Laboratory Supplies

- 3-inch diameter ring
- Plastic driver (mallet)
- Small block of wood
- Plastic wrap
- Plastic bottle marked at 107 mL (for one inch of water) or graduated cylinder
- Distilled water or rainwater
- Stopwatch or timer

Laboratory Steps

Select a test site that provides at least two areas that are under different management. (As an example, in a row crop field, the two areas would be a wheel traffic row and a row without wheel traffic.) If possible, measure the bulk density of each location prior to doing this lab.

Plan to conduct multiple ring measurements since a single ring measurement is only an estimate.

Conduct the test during a time when the surface soil is not unusually dry. Add water to the surface if necessary and allow enough time for the water to soak in prior to conducting the test or conduct the test after rain or irrigation.

Infiltration Test

1. Clear all residue from the soil surface.
2. Drive the ring to a depth of three inches using a small sledge and plastic impact driver or block of wood.
3. Gently firm the soil around the inside of the ring to avoid any gaps.
4. Line the ring with plastic wrap so that it covers the inside of the ring and drapes over the side.
5. Pour 107 mL of distilled water or rainwater into the plastic-lined ring.
6. Gently pull plastic wrap away.
7. Record the time it takes for water to infiltrate soil. Stop time is when the soil is "glistening" from the water.
8. Repeat steps 2, 3 and 4 with another inch of water to estimate steady-state infiltration.
9. Record results in Table 1.
10. The ring can be removed with soil intact for use indoors in the respiration test and/or bulk density test. Consult with your teacher.

Soil Infiltration: Factors that Affect It; Existing Problems; Management

Table 1. Infiltration data sheet

Location	Soil Texture	First Inch of Water		First Infiltration Time (minutes)	Infiltration Rate (in/hr)	Second Inch of Water		Date	
		Start Time	End Time			Start Time	End Time	Second Infiltration Time (minutes)	Steady State (in/hr)

Soil Science Curriculum

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January 2018

The Scientific Method

Approximately 60 minutes

Objectives

By the end of the lesson, students will know or be able to:

- List and describe the steps and details of the scientific method
- Build an experiment using the scientific procedure
- Conduct an experiment using the scientific procedure

Preparatory Work

- Review the www.sciencebuddies.org web site to review the process students will go through to identify an experiment

Materials

- One Guided Notes packet for each student
- Projector
- One computer with internet access per student

Enroll the Participants *(Approximately 3 minutes)*

Post the following task so that it is visible to all students as they enter the classroom:

Consider your career goals. Identify which of the following six pathways best fits your ideal career.

Animal Systems
Environmental Services/Natural Resources Systems
Food Products and Processing Systems
Plant Systems
Power, Structural and Technical Systems
Social Systems

Write down your career goal, which pathway best relates to it, and a question you have about the career.

Upon student completion of the task, discuss the following information with the class:

The pathways listed are the six pathways available through the Agriculture, Food and Natural Resources Career Cluster.

The Scientific Method

The pathways are also the six categories for the FFA Agriscience Fair (if time permits, you could play the promotional video found under the Agriscience Fair tab at www.ffa.org.)

Because we are in a constant state of new information being generated in our world, students' careers will look much differently than careers in the past have looked – we will constantly be asking questions and seeking answers.

Often times we may be asked to research a topic or contribute to a larger project using researched data.

During this lesson, we will explore the scientific method and create and conduct our own experiment.

Provide the Experience – List and Describe the Steps and Details of the Scientific Method *(Approximately 30 minutes)*

Provide students with their Guided Notes packet and direct them to the web site www.sciencebuddies.org to complete their Guided Notes and to identify an experiment. Explore the web site prior to sending students to the web site so that you may provide guidance specifically around the topic selection.

Label the Information *(Times varies)*

Students complete their Guided Notes to learn the key parts of the scientific method.

Demonstrate the Relevance *(Time varies)*

Students identify their experiment topic and seek approval from the teacher. Following topic approval, students use their guided notes to design their experiment, and after approval is received from the teacher, begin conducting their experiment.

Review the Content *(Time varies)*

At the conclusion of the experiments, direct students to report their results to the class or to another pertinent group.

Celebrate Student Success *(Time varies)*

Take time throughout the duration of the experiment design and implementation to commend students for their efforts and independent work. After students share their results with their classmates, consider presenting each student with their own “Super Scientist” award.

Guided Notes

Congratulations on learning all that you have about soil science thus far in the unit. As you approach the end of the unit, you will have the chance to engage in many different experiments, depending on the time available for your class. During this lesson, we will explore the scientific method and you will design and conduct your very own short experiment in preparation for more soil science experiments. Follow these simple steps to begin:

1. Log on to www.sciencebuddies.org.
2. Click on the orange "Project Guide" tab at the top of the page.
3. Click on the "Scientific Method" link.

Use the information found on the web site to complete the following tasks and questions:

1. What type of relationships are explored by scientists during experiments and research?

2. List the six steps of the scientific method:

3. What words might start our questions about observations we make in the world around us?

4. When we identify the question we want to ask at the start of an experiment, what characteristics must we ensure the question has?

5. What six guiding questions can we use during our background research?

The Scientific Method

6. What is a model for writing a hypothesis?

7. A hypothesis must be _____, must answer the _____ and we must identify the variables. What are variables and how many variables should change at one time?

8. How do we ensure that we conduct a fair experiment?

9. If our hypothesis is proven incorrect, what is our next step?

10. If our hypothesis is proven correct once, what might we do next to ensure that the hypothesis is indeed correct?

11. List three ways we can communicate the results of an experiment.

Now that we know some basic information about the scientific method, start the process of constructing your experiment.

1. Click on the "Your Question" link under the section labeled "Ask a Question."
2. Click on "The Topic Selection Wizard" link."
3. Begin and complete the process of identifying your experiment topic by filling in the Wizard form and answering the questions that follow.
4. Identify your topic from the list provided (or come up with your own, using that list as a guide) and write it here:

5. Get your topic approved by your teacher.
6. Use the following form to construct your experiment.
7. Seek approval from your teacher of your experiment plans.
8. Begin your experiment using the scientific method.

The Scientific Method

Scientific Method Step	
What is the question?	
What sources are you using for the background research? Attach your research to this document.	
What is your hypothesis?	
How will you test your hypothesis? What supplies will you need? How much time will the experiment take? Who will be involved? What expenses might exist? Where will you conduct the experiment? How will you ensure safety during the process? Why did you choose this experiment? What are the variables? What type of environment is needed? Attach the larger plan to this document if needed.	
What data will/did you gather during the experiment? How will you organize the data? What conclusion(s) can you draw from the data?	
What are the results of your experiment?	

Soil Science Curriculum

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January 2018

Soil Science Capstone Activity

Approximately 30 minutes

Objectives

By the end of the lesson, students will know or be able to:

- Use the scientific method to conduct an experiment in one or more areas of study addressed in the unit.
- Report experiment hypothesis, procedures and results in an Agriscience Fair display and research paper.

Preparatory Work

- Review the www.sciencebuddies.org website to review the process students will go through to identify an experiment

Materials

- Specific to each student's experiment

Enroll the Participants *(Approximately 3 minutes)*

Ask students to recall what they remember from the scientific method web quest.

Ask students to recall what they remember about the introduction to the Agriscience Fair event offered through FFA.

Provide the Experience *(Approximately 5 minutes)*

Ask students to share any examples that are familiar to them in terms of completing an experiment or attending a science fair.

Soil Science Capstone Activity

Label the Information *(Approximately 13 minutes)*

Inform students that during the next several days and weeks, they will conduct a soil science experiment, using one of the unit topics as a starting point for their experiment creation.

- Soil Organic Matter
- Bulk Density
- Soil Health Measurement
- Soil Respiration
- Soil Electrical Conductivity
- Soil pH
- Soil Nitrogen
- Soil Phosphorus
- Soil Infiltration

Demonstrate the Relevance *(Time varies)*

Instruct students to use the scientific method to construct their experiment, providing guidance and approval at each phase. Use the attached resource to help you complete the assessment of each checkpoint.

Provide students with the parameters specific to your classroom in terms of the following items:

How much class time will be provided for students to conduct their experiment? How much must be completed outside of the classroom?

How much time will be provided for students to work on their Agriscience Fair display?

When is the due date on the experiment?

What resources will be provided by the school/classroom? (Make sure you make good use of the resources provided through the soil science grant!)

Will the experiments be conducted individually or as a class?

Will the students present their project to someone other than the class? If so, who?

How much will the entire activity be worth in terms of points? How much will each step be worth?

Review the Content *(Time varies)*

At the conclusion of the experiments, direct students to report their results to the class or to another pertinent group.

Soil Science Capstone Activity

Celebrate Student Success *(Time varies)*

Take time throughout the duration of the experiment design and implementation to commend students for their efforts and independent work. After students share their results with their classmates, consider presenting each student with their own “Super Scientist” award.

Soil Science Capstone Activity

Scientific Method Step	
What is the question?	
What sources are you using for the background research? Attach your research to this document.	
What is your hypothesis?	
How will you test your hypothesis? What supplies will you need? How much time will the experiment take? Who will be involved? What expenses might exist? Where will you conduct the experiment? How will you ensure safety during the process? Why did you choose this experiment? What are the variables? What type of environment is needed? Attach the larger plan to this document if needed.	

Soil Science Capstone Activity

What data will/did you gather during the experiment? How will you organize the data?
What conclusion(s) can you draw from the data?

What are the results of your experiment?

Soil Science Curriculum

January 2018

Rainfall Simulator

Approximately 270 minutes

"We know more about the movement of celestial bodies than about the soil underfoot."

- Leonardo Da Vinci, circa 1500's

"Essentially, all life depends upon the soil ... There can be no life without soil and no soil without life; they have evolved together."

- Charles E. Kellogg, USDA Yearbook of Agriculture, 1938

Desired Impact/Goal

Educational commitment and application of learning (Head). Students will understand how soil health, as affected by environmental conditions and human activity, influences the capacity of natural ecosystems to sustain plants, animals, and humans.

Life Skills

- Teamwork
- Record Keeping
- Critical Thinking
- Problem Solving
- Communication

Skill Level

Advanced; ages 15-19/grades 9-12

Time Needed

- Three hours prep time
- One 60-90 minute class period for less

Materials

- Introductory PowerPoint presentation
- Computer and projector
- Bench-top rainfall simulator and associated materials (see Directions for using the desktop expo rainfall simulator)
- Access to sites for soil sampling, including land use history information (school grounds, gardens, parks, farms)
- Copies of student Rainfall simulator demonstration and scenario worksheet



Rainfall Simulator

Next Generation Science Standards

- Human Impacts on Earth Systems (HS-ESS3-1): Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
- Human Sustainability (HS-ESS3-4): Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Key Concepts:

Soil Health

1. Soil health is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.
2. A healthy soil sustains plant, animal and human life by providing a firm foundation for plant roots and human structures, regulating water, cycling nutrients, filtering, buffering and degrading pollutants.
3. Soil health considers the integrated physical, chemical and biological components of soil ecosystems, whereas traditional soil fertility views soil as a non-living system.
4. Both environmental conditions (parent material, climate, topography) and human activities (soil disturbance, cropping, fertilization) can influence soil health.
5. In highlighting the link between functioning soil ecosystems and the productivity or resiliency of human systems, soil health represents a paradigm shift in conservation management.

Soil Minerals and Texture

1. Soil consists of four major components: mineral material (~45%), organic matter (~5%), water (~25%) and air (~25%).
2. The mineral component of soil is the remnants of weathered rocks and can be classified into three categories by particle size: sand (2.0-0.05 mm), silt (0.05-0.002 mm) and clay (<0.002mm).
3. Clay is the only chemically active texture class with the ability to adsorb plant nutrients
4. The proportion of different mineral particle sizes in a soil determines its texture, within twelve recognized classes.
5. Soil texture is important to soil health as a determinant of surface area and pore space available in a soil for holding nutrients, air and water.
6. Soil texture is primarily determined by geology and climate, and cannot be easily changed by human activity. That is except in the case of disturbed (i.e. urban) soil where large amounts of soil are imported into or removed from an area.

Soil Biology and Organic Matter

1. Soil ecosystems support a great diversity of organisms, rivaling the above-ground diversity in tropical rainforests or coral reefs.
2. Soil biota range from microscopic bacteria to vertebrates that coexist in complex food webs.
 - a. Bacteria and yeast
 - i. Microscopic colonies grow on root and organic matter surfaces
 - ii. 100 million to 1 billion per teaspoon of soil
 - iii. Biomass = 2 cows per acre
 - iv. Decomposers, nutrient cyclers, pathogens
 - b. Fungi and actinomycetes
 - i. Grow through soil as mycelium consisting of a few hyphal cells to thousands of acres in area
 - ii. Decomposers, mutualists and pathogens
 - iii. Specialize in penetrating organic matter and translocating nutrients
 - iv. Assist plant roots in accessing immobile nutrients like phosphorus
 - c. Micro and mesofauna: Protozoans, nematodes, rotifers, tardigrades, springtails and mites
 - i. Microbivores, omnivores, predators and parasites
 - ii. 500 to 1 million per square meter
 - iii. Help to regulate microbe populations through feeding
 - d. Macrofauna: Earthworms, millipedes, isopods, mollusks and insects
 - i. Size and incorporate organic matter, and also living plants as pests
 - ii. Mix and aggregate soil
 - iii. Create macropore spaces by burrowing, improve infiltration and create root channels
 - e. Megafauna: large invertebrates, vertebrates (amphibians to mammals)
 - i. Herbivores, omnivores, predators
 - ii. High level consumers
3. The organic matter component of soil is the remnants of plant and animal tissue in various states of decomposition by soil organisms, a valuable source of nutrients for all members of the soil food web, plants and megafauna, as well as a reservoir for water storage in soils.
4. Soil life is often concentrated in areas with more organic matter including near plant roots (rhizosphere exudates), close to surface litter and in sites with incorporated organic matter like crop residue, cover crops, or manure.

Soil Aggregation and Aggregate Stability

1. The four components of soil often stick together in units called aggregates that include both solid (mineral and organic) materials and pore space (air and water) held together by physical and chemical forces.
2. Several natural processes contribute to soil aggregation through the physical movement and adhesion of soil particles including:
 - a. wetting and drying
 - b. freezing and thawing
 - c. microbial activity that aids in the decay of organic matter (glomalin produced by fungi)
 - d. activity of roots and soil animals (root sugar exudates)
 - e. soil chemical charges (adsorbed cations)
3. Aggregates vary in their size, shape and stability. Patterns of soil aggregation determine soil structure within nine categories (i.e. crumb, blocky, single grain), that along with texture, is used to describe a particular soil type.
4. Soil aggregation is important to soil health as a determinant of pore space available in a soil for holding air, water and nutrients, as well as the growth of soil biology. Aggregates include micropore spaces within their structure, but also form macropores between aggregate units.
5. Soil aggregation is sensitive to environmental conditions and human activities. The impact of raindrops, tillage and wheel traffic destroy aggregates. Aggregation is encouraged by practices such as reduced tillage, and organic matter additions from crop residue, cover crops or manure.

Soil Bulk Density

1. To maximize plant root growth, a soil should ideally consist of 50% solid (mineral and organic) materials and 50% pore space (air and water).
2. Soil bulk density is a measure of soil porosity/compaction expressed as soil weight per unit volume (g/cm^3).
3. In general, low bulk density ($< 1.50 \text{ g/cm}^3$) is associated with a loose, porous soil with plenty of room for air, water and biology, while a higher bulk density ($>1.50 \text{ g/cm}^3$) can limit movement of air and water through soil and restrict root growth.
4. Practices that destroy soil aggregates, like tillage and wheel traffic, increase bulk density over time. This is somewhat counterintuitive since tillage is designed to temporarily loosen soil for planting and crop establishment. However, fractured aggregates settle and compact over time. Practices that increase aggregation, such as reduced tillage, controlled wheel traffic and organic matter additions from crop residue, cover crops or manure tend to decrease soil bulk density.

Rainfall Simulator

Life Skill Objectives:

- Teamwork
Teams of students will share responsibility for observations before and during the rainfall simulator demonstration, development and testing of hypotheses and communication of results.
- Keeping Records
Students will accurately record observations relevant to soil properties, land use/management, and their effect on the movement of water over and through soils during the demonstration.
- Critical Thinking
Students will reflect on their observations to hypothesize about the inherent soil properties and land use/management differences that may have contributed to their findings.
- Problem Solving
Teams of students will develop a plan to change land use/management on the site(s) of interest in an effort to reduce runoff/erosion and improve infiltration.
- Communication
Teams of students will present their proposed changes in land use/management to the class and test their hypotheses against those of another team using the rainfall simulator, observe and record the outcome.

Instructional Plan:

1. Background

- a. Through an introductory PowerPoint or video presented by the instructor:
 - i. Students will be introduced to the concept of soil health, its integrative definition and importance to agriculture.
 - ii. Four major components of soil and their relative abundance.
 - iii. Understand that the organic matter component of soil is the remnants of plant and animal tissue in various states of decomposition by soil microorganisms, and the mineral component of soil is the remnants of weathered rocks.
 - iv. Learn that the mineral component of soil can be classified into three categories by particle size, which determines soil texture.
 - v. Realize that the four components of soil tend to stick together in units called aggregates that include both solid (mineral and organic) materials and pore space (air and water) held together by physical and chemical forces.
 - vi. Discover that to maximize plant growth, a soil should ideally consist of 50% solid (mineral and organic) materials and 50% pore space (air and water), and become familiar with soil bulk density as a measure of soil porosity/compaction expressed as soil weight per unit volume (g/cm³).

Rainfall Simulator

2. Experience – Getting Started

- a. The instructor will assign teams of students a geographic area of interest (AOI) for the lesson, from which soil samples will be collected for analysis, plus a site description with background information on site location and land use and blank space for field observations.
- b. The instructor will introduce soil survey resources and teams of students will use Web Soil Survey or soil survey books to identify different soil types present in a given area of interest and select areas of different types/textures for sampling (or observe area where samples were collected by instructor beforehand), making predictions about soil characteristics on-site.
- c. The instructor and students will travel to a field site and use FarmLogs to locate their desired sampling area, make general site and management observations to add to their site scenario (plant cover, color, structure, moisture, slope, land use, disturbance), conduct an in-field earthworm count and collect soil samples for lab analysis of soil texture, aggregate stability, bulk density, respiration and soil (optional additional 90-minute class period).

3. Experience – Going Further

- a. In the lab, teams of students will use the hand test to estimate a soil's proportion of different mineral particle sizes by feel and identify soil texture within twelve recognized classes, indicating this on a soil texture triangle located on a lab worksheet.
- b. Teams will conduct a slake test on their unique soil as a qualitative measure of aggregate stability and record their results on a lab worksheet.
- c. Teams will measure the bulk density of their unique soil sample collected using the core method and record their results on a lab worksheet.

4. Think and Discuss

- a. Teams will research and orally report on ways that parent geology, climate, topography, biology and time may have influenced the soil types/textures found at their AOI.
- b. Students will inspect and manipulate several aggregates collected by other teams to see how they vary in their size, shape, stability and density based on texture and field histories (i.e. tilled vs. no-till).
- c. The instructor will lead the entire class in a comparison of their bulk density results by constructing a graph(s) and discussing how tillage and compaction can degrade soil aggregation and increase bulk density.
- d. Students will build on their knowledge of soil components, texture and field history to develop a brief essay/video/oral presentation theorizing about the natural and human processes that contribute to or degrade soil aggregation and bulk density including:
 - soil texture
 - wetting and drying
 - freezing and thawing
 - microbial activity that aids in the decay of organic matter (glomalin produced by fungi)
 - activity of roots and soil animals (root sugar exudates)
 - soil chemical charges (adsorbed cations)
 - mechanical disturbance (tillage)
 - mechanical compaction



Rainfall Simulator

Measurable Indicators:

Benchtop Rainfall Simulator Demonstration Student Worksheet

Before the demonstration begins...

1. What do you know about the soil samples that will be used in the rainfall simulator demonstration? Describe each one including information about use/management of the site(s) they were collected from and any known chemical, physical, or biological properties.

2. How do you expect the physical properties of each soil sample (texture, aggregation, structure, pore space) to affect how water runs-off or infiltrates through the soil? Do you think that use/management of the site(s) each sample was collected from has affected the soil's physical condition? In what ways?

3. How do you expect the biological properties of each soil sample (organic matter, cover type, biota) to affect how water runs-off or infiltrates through the soil? Do you think that use/management of the site(s) each sample was collected from has affected the soil's biological condition? In what ways?

Rainfall Simulator

During the demonstration...

4. Observe how water runs-off and/or infiltrates through the soil sample(s). Which sample(s) had the greatest volume of water run-off the soil surface? What color was the water in the run-off catch pan(s)? What does the color of the run-off water tell you about the movement of soil and nutrients with rain water?

5. Which sample(s) had the greatest volume of water infiltrate through the soil? How quickly did infiltration water accumulate in the lower catch pans compared to run-off water? Why might greater infiltration be desirable for water quality/quantity, crop production, etc.

After the demonstration...

6. Did the demonstration support your hypotheses about how water would run-off vs. infiltrate through each soil sample? If so, which physical and biological soil properties or site use/management factors seemed to have the greatest effect on the movement of water? If not, what do think led to the unexpected result?

7. Considering the sample with the greatest volume of run-off water caught in the front pan, how could use/management of the site be changed to decrease run-off and increase infiltration? Be sure to discuss use/management changes that could affect chemical, physical and biological soil properties.

Soil Science Curriculum

January 2018

Soil Microbiology - “Tighty Whities” Test

Approximately 135 minutes

Objectives

The “Tighty Whities” Test is a comparative test that shows the presence or absence of soil microbiology under different management techniques. This introduction information is compatible with the Soil Respiration lesson plan. For microbes to use energy and respire carbon dioxide (Soil Respiration lesson plan), they must uptake food. Food for these microorganisms is organic matter that comes from dead plant material. Since the cotton “tighty whities” are made from organic material (not including elastic), the soil microbiology will feed on them if microbes are present. The less “tighty white” material left, the more soil microbiological activity. The example on the bottom shows that high rotational diversity, no-till cropping systems have more material consumed than low diversity, tilled cropping system.

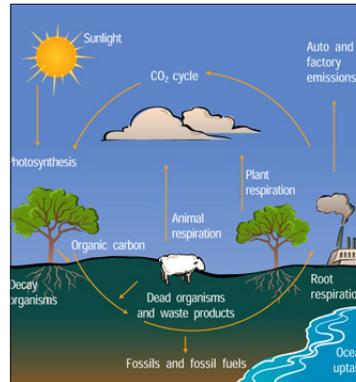
“Tighty Whities” Test

- Choose locations, field or garden, with different management techniques that you want to compare (ex. Long term no-till vs. conventional till).
- Bury “tighty white” in each field 2-inches deep, mark the location where you planted the whities.
- Dig out remains 6-8 weeks later.
- Visually compare remaining material.
- Compare weights of the “tighty whities.”

Example:



2017 SH school, tighty whities were buried for **three** weeks (during August) in a cover crop field that had been no till for seven years.



Notes

- Works best during active growing season May through June and not as well in July through August.
- Can also compare different grassland management systems.

“Tighty White” demonstration data set, 2016 Soil Health School, Aberdeen, SD

Brief Condition (Figure 1. order, left to right)	Average Brief Weight (grams/brief) 5 replications
Control -non-buried	58.5 a
No-till soil with cover crops	28.4 c
Mulch (reduced) till soybeans	48.3 b
Conventional tilled corn	50.8 b
Stats:	
F	0.001
CV	7.7
LSD (.05)	4.9

*Brief averages with different lower case letters are significantly different.

Soil Science Curriculum

Content and lab derived from the USDA-NRCS Guides for Educators. Go to <https://www.sdsoilhealthcoalition.org/soil-health-buckets/> for the Guides and additional pictures and diagrams.

July 2019

Soil Aggregates: Role in soil health and measuring stability

Approximately 60 minutes

Objectives

By the end of the lesson, students will know or be able to:

- Define soil aggregate, mycorrhizal fungi, hyphae, plant root exudates, glycoprotein
- Explain why a soil aggregate is important to soil health
- Demonstrate and/or measure soil aggregate stability
- Describe management practices that sustain or improve aggregate stability



Preparatory Work

- Print all necessary copies
- Secure permission to collect soil from the landowner(s)
- Collect surface soil from a well-managed cropland field that is not tilled, and from one that is conventionally tilled, about 2 cups of each
- Set up a table with a disposable tablecloth or paper
- Provide sheet with definitions

Materials

- 3-inch foam balls
- 1-inch or smaller foam balls
- Post-it notes or 3x5 index cards
- Slender wooden dowels, toothpicks and/or coffee stirrers
- String licorice (different colors)
- Silly string
- Roll of monofilament string (fishing line)
- Small plastic animals (farm animal set & jungle animal set - optional)
- Baby or foot powder
- Sink strainers (at least 2)
- Disposable cereal bowls
- Water (about a quart)
- Flat plastic lid or cutting board

Soil Aggregates: Role in soil health and measuring stability

Enroll the Participants *(Approximately 30 minutes)*

Hand out about 10-15, 3-4-inch-long dowels/toothpicks/stirrers, one set per student; about four to five 3-inch foam balls, about seven to none of the smaller foam balls, and two to three index cards/Post-it notes roughly torn into four pieces. Have a student with a dowel insert it into the foam ball from another student, and place on the tablecloth. Have a student with an index card piece place it on the dowel (you may have to pierce the paper with a small hole to get it started on the dowel). Add another foam ball to the other end of the dowel and insert another dowel to one of the foam balls that is already attached to the other dowel. It may help to have glue on hand and apply to the ends of the sticks as you build the aggregate. The object is to build a soil aggregate “lattice”, something like what is shown in Figure 1.

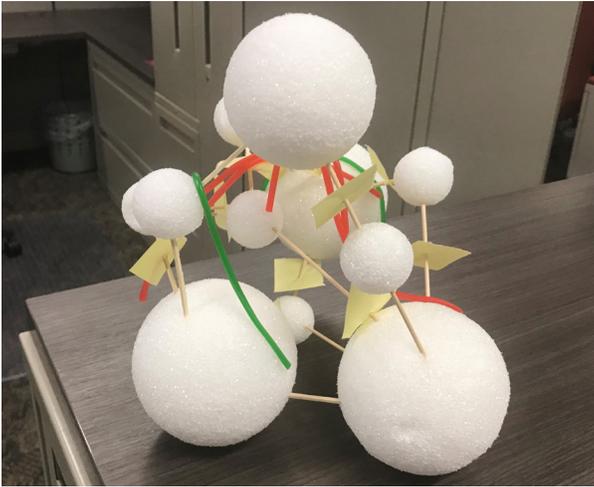


Figure 1

As you are building the soil aggregate, explain that the large foam balls represent sand particles, the smaller foam balls represent silt particles, and the Post-it note/index card pieces represent clay particles. The dowels represent weak bonds between the soil particles that would normally break very easily when the soil gets wet.

Next, hand out a few of two colors of the string licorice, and have the students lay them on/in the lattice. Explain that one color represents mycorrhizal fungi, and the other color represents plant roots.

Then give a can of the silly string to a student (or two cans, one to each of two students), and have them spray some silly string on the soil aggregate. silly string represents glycoproteins that help glue the soil aggregate together.

(Optional) Take some of the farm animals and jungle animals, and have the students place them on/in the soil aggregate. You can ask an additional question about what the animals represent. They represent soil microbes that make the aggregate their home (habitat). Some soil microbes are predators, like the lion or tiger, and some are prey, like the sheep. You can use paper cut-out animals if you don't have the plastics ones available.

Take one end of the monofilament string and tie it off to a “plant root” or just attach it to the soil aggregate, then roll the string out across the floor. This represents mycorrhizal fungi hyphae, which are basically like the roots of the fungi. They connect to the plant roots and greatly increase the area of the soil from which the plant roots can get water and nutrients. You can initially wrap the string around your arm and explain that the hyphae are like an IV that you get when you go into surgery, and acts the same way, supplying fluids and nutrients/medicines between the plants and fungi.

You can also attach a dollar bill to one of the foam balls, and when you destroy the aggregate (below), you can see the money (fertilizer, organic matter, etc.) eroding away.

Soil Aggregates: Role in soil health and measuring stability

Use the following questions to facilitate a conversation with the students:

What does the silly string represent? Answer: Plant roots give off exudates, which are basically sugars – sugar is sticky, and these act like glues that help hold the aggregate together. Mycorrhizal fungi give off glomalin, which is another “glue” that helps hold the aggregate together. Earthworms are slimy, and this slime is another glue – all these glues make the soil aggregate very strong and stable.

What do you think would happen to the aggregate if the soil is disturbed (tilled)? Answer: After you get some answers from the students, you can demonstrate what will happen by smashing the soil aggregate with your hand, and say this is a disc or plow.

What will happen to the individual soil particles with disturbance/tillage?

Answer: Erosion – you can demonstrate by taking one of the foam balls and rolling it across the floor, and say “this is like wind or water erosion”. Also, the first thing to leave during an erosion event is light organic matter particles in the air or water. You can demonstrate this with the baby/foot powder, by squeezing the bottle up into the air – it is like the carbon dioxide leaving with disturbance but you can’t see carbon dioxide.

What happens to the mycorrhizal fungi and their hyphae with disturbance/tillage? Answer: You can demonstrate the answer by showing that the hyphae are disconnected now from the plant root, and you can pull out a licorice string and break it into pieces.

There are other analogies you can draw from this demonstration, use your imagination.

Provide the Experience *(Approximately 3 minutes)*

Review the laboratory scenario with students.

A local farmer has been farming with a rotation of corn, soybeans, wheat, and sunflowers, and has been practicing no-till for 14 years. As often as possible, cover crops are incorporated into the rotation. The farmer recently decided to rent some adjacent land but found that the field cannot be entered into as early as the land currently being farmed. Water is often ponding in the rented field after a rain, and erosion is happening, even forming small gullies in some places.

Label the Information *(Approximately 3 minutes)*

Review and identify each of the supplies that will be used during the lab activity.

- Sink strainers
- Disposable cereal bowls
- Water
- Two soil samples, one from no-till and one from conventional till

Soil Aggregates: Role in soil health and measuring stability

Demonstrate the Relevance *(Approximately 25 minutes)*

Steps:

1. Fill one sink strainer level to the top with soil from the no-till field. As you are filling the sink strainer, gently break apart the soil into the naturally occurring aggregates. Do not overly work the soil sample into fine particles or crush the aggregates.
2. Repeat step 1 with the conventional tilled soil into the other sink strainer.
3. Fill the disposable cereal bowls with water to the brim.
4. Place each soil sample in the sink strainers gently into the bowls with the water. Ensure that the entire soil sample is in full contact with the water. Let the samples soak for approximately 30-60 seconds.
5. Remove each soil sample from the bowls and turn the sample over onto the flat plastic lid or plastic cutting board so that the entire sample remains on the lid/board. Place the samples several inches apart.
6. Raise one side of the board/lid slightly so the water starts to move away from the samples and observe the differences.

This is one method to test for soil aggregate stability and is also known as the slump test. The sample with good aggregate stability will “stand up” higher and the individual soil aggregates will still be visible. The sample with poor aggregate stability will ooze down the board/lid and will be “soupy”. One analogy that works is the good aggregate stability sample will look like a chocolate brownie, and the poor aggregate stability sample will look like chocolate pudding. Often times the good sample will be darker than the poorer sample, and they will often smell different (the good sample will have an earthy smell, or the smell after a rain, while the smell of the poorer sample will be variable). Figure 2 shows an example of the results of this test.



Figure 2

Definition

Glycoprotein: a sticky substance produced abundantly by hyphae and spores of mycorrhizal fungi in soils – it is an exudate of the fungi; acts as a glue holding soil particles together into aggregates.

Hyphae: long, branching filamentous structures of the mycorrhizal fungi that transport water and nutrients from the soil to the main fruiting body of the fungi and to the plant roots with which they are associated – similar to the roots of a plant.

Mycorrhizal fungi: these are fungi that form a symbiotic relationship with plants, and attach to or into the plant root and provide water and nutrients to the plant – the plant in turn supplies food to the fungi; these associations greatly increase the extension of the roots in to the soil profile area in the soil which is available to the plant.

Plant root exudates: these are polysaccharides or basically sugars produced by plant roots that are used by many soil organisms for food, and help build soil aggregates.

Soil aggregate: soil particles held together by organic matter and related substances. Well aggregated soils have higher infiltration rates and are less prone to erosion. Aggregates also provide habitat for soil microorganisms.

Soil Science Curriculum

Content and lab derived from the USDA-NRCS Guides for Educators. Go to bit.ly/SoilLessonPlan and sdsoilhealthcoalition.org/soil-health-buckets/ for the Guides and additional pictures and diagrams.

August 2019

“Edible Infiltration” Healthy Soil Activity

Objectives

Like a sponge, healthy soil holds more water in the soil profile than unhealthy soil. Because the soil profile has good structure and macro pores, precipitation soaks into the healthy soil profile while water will sit on top of or “run off” of tilled soil because the macro pores have been destroyed.

Healthy soils:

- Are more productive soils.
- Improve nutrient use efficiency.
- Allow water to infiltrate into the ground, reduce runoff pollution, and provide water to plants when they need it.
- Add nutrients to the food we eat.
- Break down or capture pesticides and other contaminants.
- Resist wind and water erosion to improve the quality of our air and water.

Each student gets either a cup of tilled or no-till soil (chocolate “crispies” cereal). They watch as it rains (milk is poured on top of the soil/cereal). Rain (milk) soaks into no-till soil (infiltrates) because it has macro pores. Rain (milk) does not soak into the tilled soil and sits on top becoming run-off which causes water erosion on soil.

Materials

- Clear/transparent cups (5 oz. or 3 oz. depending amount of cereal for the number of students.)
- Spoons
- Serving scoops (one ounce)
- Milk – In the photos on page 2, the red and yellow dispensers were used to pour the ounce of milk in the little scoop without so much splatter.
- Chocolate “crispies” cereal
- Plastic sanitary gloves for handling food

Process

Edible Infiltration Preparation: The No-till soil is used “as is” from the bag/box. The tilled soil is crushed prior to the lesson. A rolling pin can be used with cereal in a heavy-duty re-sealable baggie.



“Healthy soil” in a cup



“Plowed soil” in a cup

“Edible Infiltration” Healthy Soil Activity



Farming systems: the No-till soil is in the bowl; tilled soil is in the bag.



Staff explains the lesson and experiment.



Add Rain (milk) to the cup.



Add a little milk.



Watch what happens.

“Edible Infiltration” Healthy Soil Activity



Infiltration



No Infiltration or run-off



See the Difference!



Answer questions and eat the snack!

Students Demonstrate Knowledge

Sample Questions

1. Compare the two cups.

a. **What do you notice about how the “rain” infiltrates, or goes through the “soil”?**

b. **What do you think is the reason the “rain” infiltrates, or goes through the “no-till” sample and not the other?**

(In healthy soil, roots and soil animals create pathways, or pores, for water to go down and through the soil. When these pathways, or pores, are destroyed the water is unable to infiltrate the soil.)

2. a. **What do you think happens to the water when it cannot infiltrate the soil?**

(Stays on top, evaporates, etc.)

b. **If the ground has a slope, like a hill, and the rain/water can not infiltrate the soil, what does it do?** (It runs downhill - this is water erosion. It takes the soil away).

3. **What did you learn about soil?**

(Healthy soil holds more water in the soil profile than unhealthy soil.)

Like all living things, healthy soil needs air and water. Soil organisms need air to breathe, and they also depend on water to deliver nutrients and support the food web. Without pores through the soil, air and water would be unable to reach those living organisms.

Soils are made up of air, water decayed plant residue, organic matter from living and dead organisms, and mineral matter like sand, silt, and clay. Earthworms and dying roots create pores.

One acre of healthy soil can store more than 160,000 gallons of water in its upper foot. Soil microbes (bacteria and fungi) produce sticky substances that hold soil particles together.

Disturbances, like tillage, destroy pore structure and kill earthworms and fungi. Tillage breaks up soil structure and destroys the pores in soil that allow water to infiltrate the soil profile. Certain cropping systems, such as no-till, are better for soil—make better soil structure.

4. **What are some management activities that anyone can do to keep their soil healthy.**

- o Dig a little – then look, touch, and smell your soil. Get help if your soil doesn't appear healthy.
- o Keep it under Cover – keep the soil covered: whether in a garden, field or pasture, cover crops and mulch or residue left from plants provides soil with a protective cover that reduces erosion. It's also a source for carbon, the essential energy source for the soil food web.
- o Do not disturb – when soil is plowed or tilled, it can cause compaction or “plow pan” which restricts water infiltration and increases runoff.

“Edible Infiltration” Healthy Soil Activity

Additional Learning Resources

USDA NRCS Soil Health Information Center has soil health videos and fact sheets to help people understand infiltration: <http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/>. The website has some of America’s top soil health experts and innovative soil health farmers. From video demonstrations on soil health to videos featuring the men and women who are farming with Soil Health Management Systems, people can see why there’s a growing movement to “Unlock the Secrets in the Soil.”



Can your soil pass the “infiltration test?”



Is your soil healthy and functioning?



Have you discovered the cover?



How should healthy soils look?



How should your soil smell?



How to boost your soil’s energy.

Go to the South Dakota NRCS conservation videos for more healthy soils stories at <https://www.youtube.com/user/NRCSSouthDakota/featured>

Conservation professionals are available to help people learn about taking care of natural resources. Visit your local USDA Service Centers to find the Natural Resources Conservation Service or conservation district staff.

Appendix

July 2019

South Dakota NRCS Field Offices

Aberdeen Service Center
524 Enterprise Street S
Aberdeen, SD 57401
605-226-3360

Armour Service Center
606 1st Street
Amour, SD 57313
605-724-2846

Belle Fourche Service Center
1835 5th Ave S
Belle Fourche, SD 57717
605-892-3368

Bison Service Center
604 Coleman
Bison, SD 57620-0189
605-244-5222

Britton Service Center
505 Vanderhorck
Britton, SD 57430
604-448-5921

Brookings Service Center
205 6th
Brookings, SD 57006-1406
605-692-8003

Buffalo Service Center
107 US Hwy 85
Buffalo, SD 57720
605-375-3218

Burke Service Center
845 Main
Burke, SD 57523
605-775-9122

Canton Service Center
801 E. 5th Street
Canton, SD 57013-1920
605-987-4332

Chamberlain Service Center
200 Paul Gust RD
Chamberlain, SD 57325-1000
605-734-5413

Clark Service Center
101 Warren RD
Clark, SD 57225
605-532-3686

Clear Lake Service Center
222 4th Ave S
Clear Lake, SD 57226
605-874-8225

De Smet Service Center
202 Joliet Ave SE
De Smet, SD 57231-2425
605-854-9123

Dupree Service Center
8th Ave & Main
Dupree, SD 57623
605-365-5179

Elk Point Service Center
1101 E Main Street
Elk Point, SD 57025
605-356-3308

Faith Service Center
409 1st Street W
Faith, SD 57626
605-967-2561

Faulkton Service Center
110 8th Ave N
Faulkton, SD 57438
605-598-6237

Flandreau Service Center
105 S Crescent Street
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Gettysburg Service Center
507 E Garfield Ave
Gettysburg, SD 57442
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Hayti, SD 57241
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Highmore Service Center
218 Iowa S
Highmore, SD 57345
605-745-5716

Hot Springs Service Center
339 S Chicago Street
Hot Springs, SD 57747-2323
605-745-5716

Howard Service Center
601 W Farmer Ave
Howard, SD 57349
605-262-5642

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Huron, SD 57350-3080
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Kadoka Service Center
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Kadoka, SD 57543
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Kennebec Service Center
110 S Main Ave
Kennebec, SD 57544
605-869-2216

Lake Andes Service Center
276 Main Street
Lake Andes, SD 57356-2032
605-487-7501

Leola Service Center
709 Moulton Street
Leola, SD 57456
605-439-3336

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123 SW 2nd Street
Madison, SD 57042-2874
605-256-6674

Martin Service Center
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Milbank Service Center
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Milbank, SD 57252-2707
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118 E 2nd Street
Miller, SD 57362-1407
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Mitchell Service Center
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Mitchell, SD 573010-1114
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Mound City, SD 57646-2104
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Murdo Service Center
806 5th Street
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Onida Service Center
707 East Birch Ave
Onida, SD 57564
605-258-2613

Parker Service Center
655 E 4th Street
Parker, SD 57053
605-297-5564

Parkston Service Center
701 W Plum Street
Parkston, SD 57366-2029
605-928-7925

Philip Service Center
409 N Wray Ave
Philip, SD 57567
605-859-2186

Pierre Service Center
1717 N Lincoln Ave
Pierre, SD 57501-2398
605-224-8870

Plankton Service Center
209 N Main
Plankton, SD 57368
605-942-7719

Rapid City Service Center
414 E Stumer RD
Rapid City, SD 57701
605-342-0301

Redfield Service Center
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Redfield, SD 57469-1117
605-472-0102

Salem Service Center
340 N Nebraska Street
Salem, SD 57058-8949
605-425-2483

Selby Service Center
4307 4th Ave
Selby, SD 57472
605-649-7020

Sioux Falls Service Center
2408 E Benson RD
Sioux Falls, SD 57104-7018
605-330-4515

Sisseton Service Center
2018 E Hwy 10
Sisseton, SD 57262
605-698-7639

Sturgis Service Center
2202 Main Street
Sturgis, SD 57785-1338
605-347-4952

Timber Lake Service Center
711 Main Street
Timber Lake, SD 57656
605-865-3552

Tyndall Service Center
109 West 16th Ave
Tyndall, SD 57066
605-589-3383

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121 W Kidder Street
Vermillion, SD 57069-3033
605-624-7060

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24 Creighton RD
Wall, SD 57790-0308
605-279-2451

Watertown Service Center
1720 4th Street NE
Watertown, SD 57201
605-886-8202

Webster Service Center
600 E Hwy 12
Webster, SD 57274-1135
605-345-4661

Wessington Springs Service Center
510 Dakota Ave N
Wessington Springs, SD
57382-2044
605-539-9232

White River Service Center
123 East 6th Street
White River, SD 57579
605-259-3252

Winner Service Center
113 S Madison Street
Winner, SD 57580-1313
605-842-0603

Woonsocket Service Center
203 W 7th Street
Woonsocket, SD 57385
605-796-4476

Yankton Service Center
2914 N Broadway Ave
Yankton, SD 57078-4836
605-665-2662

South Dakota Soil & Water Conservation Districts

American Creek Conservation District
PO Box 156
Kennebec, SD 57544
605-869-2238, ext. 3

Aurora County Conservation District
PO Box 277
Plankinton SD 57368-0277
605-942-7719, ext. 3

Badlands Conservation District
706 US Hwy 18 Ste 2
Martin, SD 57551-5935
605-685-1243, ext. 3

Beadle Conservation District
1386 Lincoln Ave SW
Huron, SD 57350
605-352-2998, ext 3

Bennett County Conservation District
706 US Hwy 18, Suite 2
Martin, SD 57551-5935
605-685-1243, ext. 3

BonHomme Conservation District
PO Box 45
Tyndall, SD 57066-0045
605-589-3232, ext #3

Brookings Conservation District
205 Sixth Street
Brookings, SD 57006-1406
605-692-8003

Brown-Marshall Conservation District
PO Box 73
Hecla, SD 57446
605-994-7016

Brule-Buffalo Conservation District
200 South Paul Gust RD
Chamberlain, SD 57325
605-734-5953, ext. 3

Campbell County Conservation District
PO Box 153
Mound City, SD 57656-0153
605-955-3514, ext. 3

Charles Mix Conservation District
276 Main Street
PO Box 249
Lake Andes, SD 57356-0249
605-487-7577

Clark County Conservation District
101 Warren RD
Clark, SD 57225-5922
605-532-3797, ext. 3

Clay County Conservation District
121 W Kidder Ave, Suite 103
Vermillion, SD 57069-3033
605-624-7060, ext. 3

Clearfield-Keyapaha Conservation District
113 S Madison, Suite 100
Winner, SD 57580-1313
605-842-0603, ext. 3

Codington Conservation District
1720 4th Street NE, Suite 3
Watertown, SD 57201
605-882-4989

Corson County Conservation District
PO Box 37
McIntosh SD 57641-0037
605-273-4506, ext. 3

Custer County Conservation District
447 Crook Street, Suite 1
Custer, SD 57730
605-673-4971

Davison County Conservation District
1820 N Kimball, Suite B
Mitchell, SD 57301
605-996-1564, ext. 3

Day Conservation District
600 E Hwy 12 Suite 1
Webster, SD 57274
605-345-4661, ext. 3

Deuel Conservation District
222 4th Avenue South
PO Box 348
Clear Lake, SD 57226-0348
605-874-8225, ext. 3

Dewey County Conservation District
PO Box 133
Timber Lake, SD 57676-0133
605-865-3552, ext. 3

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PO Box 28
Armour, SD 57313-0028
605-724-2846

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605-279-2519

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605-432-6570, ext. 3

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605-775-2770, ext. 3

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605-842-0603, ext. 3

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605-239-4635

Harding County Conservation District

PO Box 265
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Hughes County Conservation District

1717 N Lincoln Ave, Suite 103
Pierre, SD 57501-7800
605-224-1694, ext. 3

Hutchinson Conservation District

415 N Access Road
Menno, SD 57045-2117
605-387-5539

Hyde County Conservation District

PO Box 484
Highmore, SD 57345-0484
605-852-2221, ext. 3

Jackson County Conservation District

PO Box 457
Kadoka, SD 57543-0457
605-837-2242, ext. 3

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510 Dakota Ave N
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PO Box 298
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PO Box 85
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Lake County Conservation District

123 SW Second Street
Madison, SD 57042
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Lawrence Conservation District

1230 North Ave, Suite 8
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605-642-3590

Lincoln Conservation District

801 E 5th Street, Suite 2
Canton, SD 57013
605-987-2624

Marshall Conservation District

PO Box 8
505 Vander Horck Ave
Britton, SD 57430-0008
605-448-2442, ext. 3

McCook County Conservation District

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605-425-2483, ext. 3

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PO Box 60
Leola, SD 57456-0060
605-439-3336, ext. 3

Miner Conservation District

601 West Farmer Ave, Suite A,
Howard, SD 57349-8734
605-772-5642, ext. 3

Minnehaha Conservation District

2408 E Benson RD
Sioux Falls, SD 57104
605-370-3480

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202 East 3rd Ave
Flandreau, SD 57028
605-997-2949 ext. 3

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414 E Stumer RD, Suite 300
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605-342-0301, ext. 3

Perkins County Conservation District

PO Box 189
Bison, SD 57620-0189
605-244-7160, ext. 3

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Gettysburg, SD 57442-1233
605-765-2575, ext. 107

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2018 SD Hwy 10
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605-698-3923

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203 W Seventh Street, Suite 200
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605-796-4476, ext. 3

South Brown Conservation District

524 S. Enterprise Street, Suite 300
Aberdeen, SD 57401
605-226-3360, ext. 3

Spink Conservation District

PO Box 146
25 1/2 Sixth Ave West
Redfield, SD 57469
605-472-1437, ext. 3

Stanley County Conservation District

1717 N Lincoln Ave, Suite 103
Pierre, SD 57501
605-224-1694, ext. 2

Sully County Conservation District

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Onida, SD 57564-0203
605-258-2571

Todd County Conservation District

PO Box 268
Mission, SD 57555-0268
605-856-4440

Tri-County Conservation District

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Faith, SD 57626-0399
605-967-2561, ext. 3

Turner County Conservation District

PO Box 416
Parker, SD 57053-0416
605-297-5564, ext. 3

Union County Conservation District

PO Box 458
Elk Point, SD 57025-0458
605-356-3308, ext. 3

Walworth County Conservation District

PO Box 139
Selby, SD 57472-0139
605-649-7020, ext 3

Yankton County Conservation District

2914 Broadway Street
Yankton, SD 57078-1202
605-665-6704, ext. 3

Ziebach County Conservation District

PO Box 246
Dupree, SD 57623-0246
605-365-5185, ext. 3

Additional sources of information and assistance in soil health**South Dakota Grassland Coalition**

The SD Grassland Coalition was created to serve as a voice for grassland managers. We are a unified voice for managing grasslands.

www.sdgrass.org/

South Dakota Soil Health Coalition

A collective effort to increase sustainable ag production through diversification and improved soil health. With our vision, we have a united and experienced coalition of farmers and ranchers that depend on generations of knowledge to make that vision happen.

www.sdsoilhealthcoalition.org/

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South Dakota Envirothon

Kim Smeenk

Coordinator

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Newell, SD 57760

605-892-5699

SD Envirothon Website:

www.sdenvirothon.org

NCF Envirothon Website:

www.envirothon.org

South Dakota Land Judging**South Dakota Range Judging**

Lance Howe, Soil Scientist

Redfield Soil Survey Office

PO BOX 146

Redfield, SD 57469

605-472-0102, ext. 4

USDA-NRCS Soil Health

<https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/>

Soil Science Society of America

<http://www.soils4teachers.org/lessons-and-activities>

Discovery Education

<https://school.discoveryeducation.com/schooladventures/soil/>

National Agriculture in the Classroom

<https://agclassroom.org/>

Iowa Agriculture Literacy Foundation

<http://www.iowaagliteracy.org/>

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