Kansas Corn: Just Dirt?

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Grade Level: High School

Overview

No other resources are more precious to a farmer than water and soil. This lesson looks at one in much more detail than students have probably considered before. Soil is not just an inert receptacle where we place plants and hope they grow. It is a diverse and dynamic ecosystem of biotic and abiotic forces than can shape the productivity of every square inch of our land. During the activity, students will learn about abiotic (non-living) components of soil such as the three major particles sand, silt and clay, and how those factors affect the overall texture of soil, which is utilized in multiple areas of agriculture and crop management. Special attention will also be paid to the biotic features of the soil. Microorganisms, such as bacteria and fungi, have a major impact on soil productivity as well as the stability of the soil itself. Students will be sampling different soils and culturing microorganisms for identification from the soils collected. Additionally, students will learn how the presence of these microorganisms can influence crops as well.

Kansas College and Career Ready Standards

Science

- **HS-LS2-2.** Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
- **HS-LS2-6.** Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- **HS-LS2-7.** Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- **HS-ESS2-2.** Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
- **HS-ESS3-3.** Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity

Language Arts

- **W.9-10.1.** Write arguments to support claims in an analysis of substantive topics or texts, using valid reason and relevant and sufficient evidence.
- **W.9-10.2.** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
- **W.9-10.7.** Conduct short research projects to answer a question, drawing on several sources and generating additional related focused questions that allow for multiple avenues of exploration.
- **R1.11-12.4.** Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze how an author uses and refines the meaning of a key term or terms.

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- **R1.11-12.7.** Integrate and evaluate multiple sources of information presented in media or formats as well as in words in order to address a question or solve a problem.

Math

- **N.Q.1.** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (N.Q.1)
- **N.Q.2.** Define appropriate quantities for the purpose of descriptive modeling. (N.Q.2)

Learning Objectives

- Students will be able to identify the abiotic components of soil as they relate to the makeup of soil and classification into soil textures.
- Students will be able to identify different types of microorganisms that live in soil and their importance to the productivity of the soil.
- Students will be sampling, culturing, and identifying soil microorganisms from collected soil samples.
- Students will be able to analyze a soil's overall productivity based on both biotic and abiotic factors of a collected soil sample.
- Students will be able to describe the importance of microorganisms to the overall productivity of soil and the health of the soil ecosystem.

Materials

- Kansas Corn: Just Dirt PowerPoint (available at www.kscorn.com)
- Soil: What is it? Discussion Reflection Worksheet (pg. S1-2 or available at www.kscorn.com)
- 6 Mason jars or other clear containers with water tight lid
- Hand lenses
- Collected soil samples
- Dish soap
- 100 mL beakers
- 70% isopropyl alcohol
- Scale or sterilized spoons for measuring soil
- Distilled water
- Incubator (optional)
- LaMotte Microbe Hunter Kit
    - TSA/RB biopaddles
    - Teacher and student resource documents located on CD provided with kit

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Safety Considerations
As with any lab situation, appropriate protective clothing should be utilized.
Know where emergency equipment is located in the room and how to operate them as well.
Washing hands before and after any bacterial sampling can prevent cross contamination. Special attention should be paid to keeping any cultured bacteria sealed after the incubation process. All surfaces can be host to potentially pathogenic strains of microbes, and thus, student exposure to the cultured microbes should be eliminated. Teachers and trained safety staff should deal with clean up and disposal of cultured bacterial samples.

For more detailed information, please reference the Teacher Guide on page 8, and the MSDS Sheet provided on the Resource Document CD provided with LaMotte Microbe Hunter Kit.

Procedures for Instruction
Length of Time for Preparation: 15-20 minutes for each activity
Length of Time for Classroom Teaching: 30-45 minutes

Preparation Procedure
Acquire local soil samples, one to two shovels full of soil. Distribute into small plastic cups for each group of students. Paper towels or bins should be made available for students to place their soil in while examining. A small dust pan and broom will also be helpful.

Prepare a demo texture jar. Fill one mason jar or comparable vessel approximately 2/3-full of soil sample, then pour in water to the top of the jar, adding a few drops of clear liquid dish soap. Close the lid on the jar, and shake the jar vigorously. By making sure that the jar is full of water, you will eliminate issues due to bubbles. Then, let the jar settle at least overnight.

Background Information
Soil is primarily made up of minerals, air, water, and organic material. Approximately 45 percent, overall, is made up of particulate minerals in the form of sand, silt, and clay. Sand is the largest of these particles, followed by silt and clay, respectively. The proportions of these mineral particles help to determine some of the physical properties of soil and allow us to separate soil into different categories based on their texture. But soil is not merely a conglomeration of minerals. An additional 25 percent of soil is made up by water and another 25 percent by air. That leaves only 5 percent for organic material.

Some of that material is dead and decaying matter of previously living organisms or parts of organisms, such as decaying leaves or grass and the occasional decomposing body or pile of excrement. Yet, some of that material is still actively living. Their contribution is small but yet very mighty. Macroorganisms, such as earthworms and arthropods, are also found in the soil but we also have microorganisms, such as bacteria, fungi, and actinomycetes, that all call the soil their home. Each play a part in the overall ecosystem that is the soil. Some aid in the fixation of nitrogen for plants; others help to protect plants by outcompeting potential plant pathogens; and still others form symbiotic relationships based on mutually beneficial interactions between plant roots and microbes. More detailed and in-depth information in regards to species specific benefits can be found in both the teacher and student guides which are located on the Resource Document CD provided with the LaMotte Microbe Hunter Kit.

Classroom Discussion

Activity 1: What is in Soil?

Introduce the topic and assess students for prior understanding.

- In groups or as individuals, have students create a list all of the things they think are in soil. This can be recorded on a blank sheet of paper or on a white board.
- Facilitate students as they share what was on their lists, and compile a single classroom list. Post this in a location for all to see.
- Have students obtain and examine the soil sample to see what on their lists were actually identified. Small hand lenses can be utilized. Place a check mark next to the items that could be identified in their soil sample and separate out one or two exemplars of that characteristic onto a piece of paper towel.
- After their visual inspection, generally, students will be able to list and identify things such as, small rocks, particles of "dirt," dead or decaying matter, such as grass or leaves, as well as the occasional insect or worm. Discuss the major components of soil (sand, silt, and clay) as well as water and air, paying special attention to the distinguishing differences between particle sizes. This should also include any organic matter present.
- Come back together as a class and review the list of items students were able to actually distinguish from their soil sample, making sure all students have seen the examples pulled from the sample, since each group will have a different sample of soil.
- Pose the question to students: How could we separate out the different parts of what is in this soil? Manually? What are the other options?
- Generally, students will come up with the following choices: 1) Manually try to separate using their hands or tweezers, and 2) Using some type of screen or sieve to separate larger particles from smaller particles. Compile a list of ideas on the board to track students' ideas.

- Narrow down students' options by providing them with a hint. Place a small water bottle, mason jar, or other closeable clear vessel in front of the students. Ask students: Can we use this to separate different parts of the soil? Allow students to work together in pairs or groups to brainstorm possible options.
- Walk through the procedure for soil separation with students (same procedure as was utilized to create the demo jar, a more specific procedure can be found on pages 2 and 3 of the Soil Classification and Sampling Procedure Document which is located on the Resource Document CD provided with the LaMotte Microbe Hunter Kit), allowing them to make their own jars of separated soil. Allow jars to sit undisturbed for at least 24 hours before analyzing.
- Have students mark on the jars with Expo marker where they believe the separation lines would be for sand, silt, and clay. Remind students to sketch their results on the discussion sheet. Figure the percentages of each particle.
- Use the Soil Texture Triangle to determine the overall texture of the given soil sample. Hint: Allow students to use a ruler and bright highlighter or marker to indicate where on each side of the triangle their sample would fall. Make sure you follow the lines provided and are not drawing lines perpendicular to that particular side of the triangle.
- Once students determine the overall texture of the soil, discard the soil and wash the jars for future use.
- Finally, have students think about the conclusion question: Are these three particles, along with air and water, all that truly make up soil? Is our class list really complete? How would be we able to tell? What tools would be necessary to complete that investigation.

Procedure for Lab

Activity 2: The Millions We Cannot See!

- In this activity, students will be sampling soil from different locations around the school or home and utilizing that soil to inoculate nutrient rich growth medium for the purposes of growing soil microbes.
- Pre-Lab Activity: Could be done as homework. Provide each student with a copy (paper or digital) of pages 9-12 of the LaMotte Student Guide, which is located on the Resource Document CD provided with LaMotte Microbe Hunter Kit. Have students complete a mind map or graphic organizer, showing how all of the elements of the soil microbiome interact with one another and paying special attention to the potential benefits each microorganism can provide.
- Utilizing the collected soil samples, inoculate the paddles using the technique you desire. Either a contact technique or serial dilution technique can be utilized. Both are laid out in detail on pages 4 and 5 of the Soil Sampling and Classification Procedures Document which is located on the Resource Document CD provided with LaMotte Microbe Hunter Kit.
- Allow the paddle to incubate in an incubator at 20°C for 24-48 hours, or if no incubator is available, store the paddles in a warm location in the room out of direct sunlight for 5-7 days.

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Lab Analysis

- After incubation, analyze the paddle results by utilizing the provided Identification Guide which is located on the Resource Document CD provided with the LaMotte Microbe Hunter Kit. Color pictures from the guide are very important when identifying the microbes. Digital copies can be distributed to students if one to one devices are available. Alternatively, LaMotte also offers an iPad or iPhone app that allows students to take picture and create reports of their findings that can be emailed directly to you or your students.
- Analysis student sheets are provided on page 28 of the Student Guide which is located on the Resource Document CD provided with the LaMotte Microbe Hunter Kit. It is our recommendation that unless multiple soil horizons were tested the additional questions on page 29 would not be applicable.

Teachers Tips

- Colony identification can be a difficult job even for the highest trained individuals, especially when diverse areas are being sampled. Providing students with full color images via the Soil Microbes Identification Guide, which is located on the Resource Document CD provided with LaMotte Microbe Hunter Kit, is vitally important in order to not frustrate students during the analysis process.
- Some frustrations can be eliminated by going through the practice images provided on pages 23-27 of the Student Guide, which is located on the Resource Document CD provided with LaMotte Microbe Hunter Kit, prior to the actual sample analysis. This allows students to have the opportunity to brush up on any skills that may need additional practice or to learn identifying features that will provide more guidance during identification. Additional documents are provided that help describe some of the properties of bacteria and colony formation. The following documents will prove useful: Colony Characteristics, Estimating Colony Size, and Microbe Motility. These are located on the Resource Document CD provided with LaMotte Microbe Hunter Kit. All documents are provided on the disk are included in the initial kit.
- Incubators are expensive and sometimes hard to come by. If no incubator is available, consider placing the vials on top of a refrigerator. The warm air moving around the coils on the back of the refrigerator will help to provide a nice fairly regulated environment for your microbes to grow in.

Reflection and Conclusion

- Pose the following questions to students as a guide for their reflection in conclusion of the lab activities.
  - Based on your initial observations of the soil, did you think there was much living material in the soil?
  - Was your soil sample an example of a "diverse and healthy living soil?"
  - What data do you have to support this claim?
  - Reflect on this quote: "To be a successful farmer one must first know the nature of the soil."
    - Xenophon, Oeconomicus, 400 B.C.

- Describe how you now see soil differently and how that will be important to understanding agriculture and its future innovations.
- These questions can be addressed via a short answer or essay format, whichever meets the needs of your students and their overall abilities.

Assessment

- As identification of bacteria is new to most high school students, it is not our recommendation that students be assessed on the accuracy of their microbe identification, but rather on their understanding of the overall necessity of microbes as a part of the overall soil ecosystem.
- This can be assessed through the students answers to the reflection questions on the Soil: What is it? Discussion Reflection Sheet after the lab has been completed.

Science and Agriculture Careers

Soil scientists work for federal and state governments, universities, and the private sector. The job of a soil scientist includes collection of soil data, consultation, investigation, evaluation, interpretation, planning or inspection relating to soil science. This career includes many different assignments and involves making recommendations about many resource areas. Well-trained soil scientists are in high demand for a wide array of professional positions. Individuals with soil science training can potentially work in the following career fields: watershed and wetland conservation positions, environmental technicians, state soil and water quality testing staff, soil conservationist, agricultural agents, crop consultants, landscaping consulting or business operator, crop production specialist and research scientist for both public and private sector positions.

To learn more about agriculture careers, visit www.agexplorer.com. You can also find career profiles at www.kscorn.com.

Sources

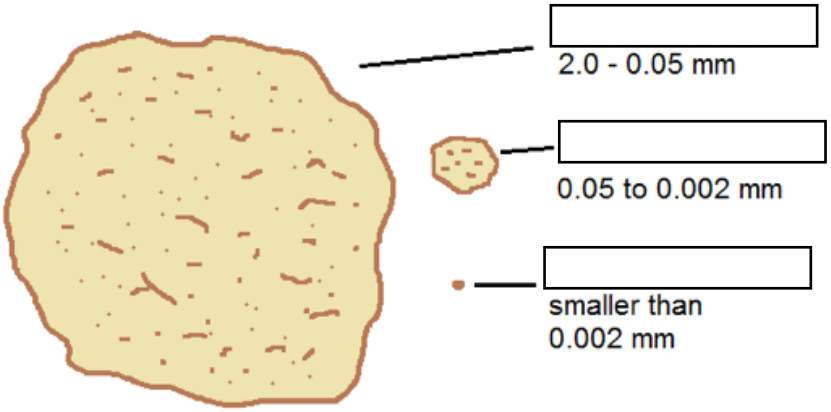
- https://www.nrcs.usda.gov/wps/portal/nrcs/site/soils/home/
- LaMotte Company, 802 Washington Ave. Chestertown, MD 21620, www.lamotte.com; LaMotte product #5563 Soil Microbe Hunter

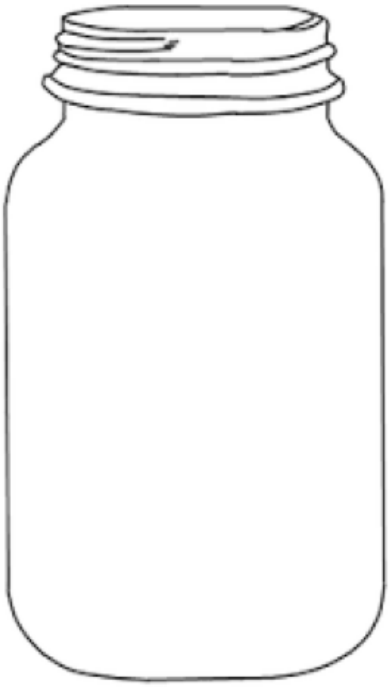
Any educator electing to perform demonstrations is expected to follow *NSTA Minimum Safety Practices and Regulations for Demonstrations, Experiments, and Workshops*, which are available at http://static.nsta.org/pdfs/MinimumSafetyPracticesAndRegulations.pdf, as well as all school policies and rules and all state and federal laws, regulations, codes and professional standards. Educators are under a duty of care to make laboratories and demonstrations in and out of the classroom as safe as possible. If in doubt, do not perform the demonstrations.

Soil: What is it?

Name _____

Major Features:	Observed?





Draw you soil layers here...

Make sure you provide measurements!

Sand: _____ mm / _____mm = _____%

Silt: _____ mm / _____mm = _____%

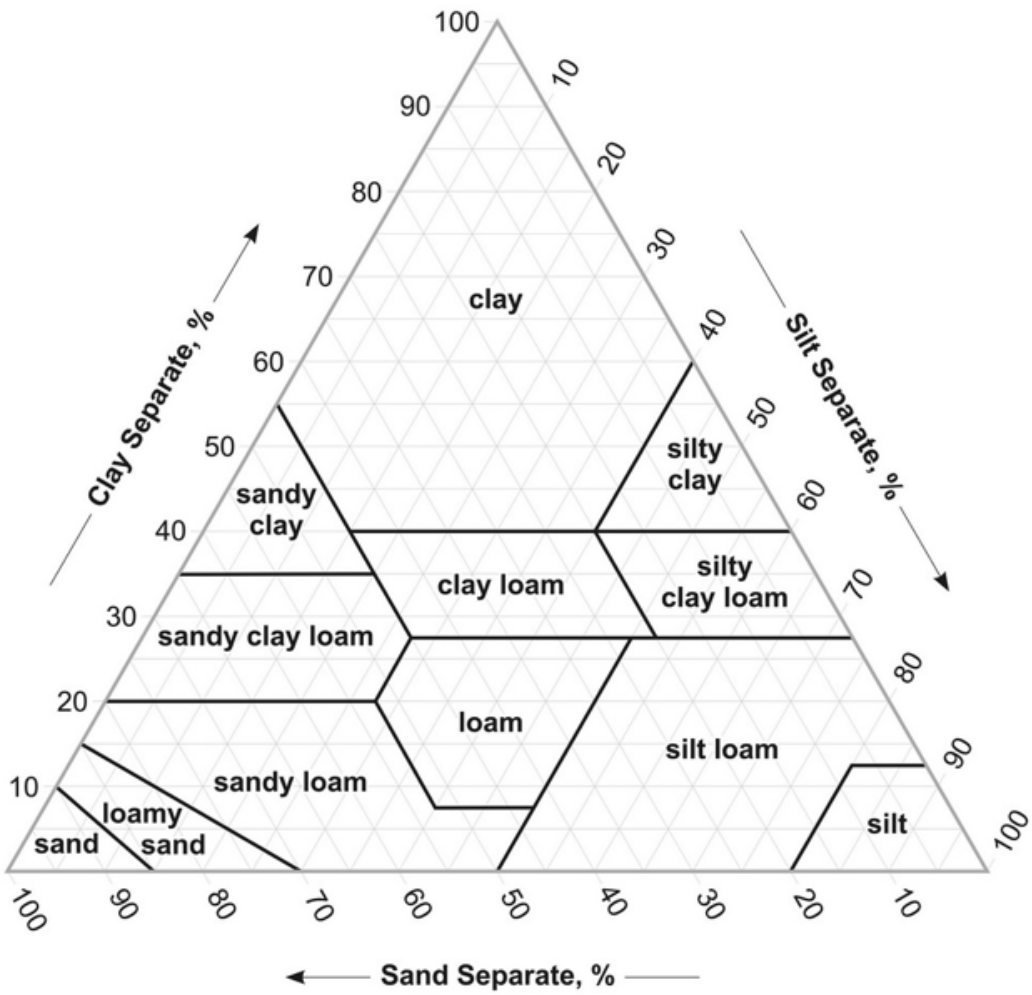
Clay: _____ mm / _____mm = _____%

Make sure you are following the lines provided, do not draw perpendicular lines to the sides of the triangle!

- Use a red pen/pencil: Draw your line for the percentage of clay you measure in your jar.
- Use a blue pen/pencil: Draw your line for the percentage of silt you measure in your jar.
- Use a green pen/pencil: Draw your line for the percentage of sand you measure in your jar.

The point where all of your lines intersect is your soil's texture!

Soil Textural Triangle



What is the texture of your soil?

Do sand, silt, and clay really represent everything found in soil?

What else has not yet been discussed in soil?