Teacher Guide: Soil Quality

Desired Results

National Learning Standards

MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

CCSS.MATH.CONTENT.8.G.C.9: Know the formulas for the volumes of cones, cylinders and spheres and use them to solve real-world and mathematical problems.

CCSS.MATH.CONTENT.6.RP.A.3: Use ratio and rate reasoning to solve real-world and mathematical problems (e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams or equations).

CCSS.ELA-LITERACY.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements or performing technical tasks.

CCSS.ELA-LITERACY.RI.6-8.1: Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

Understandings

Students will understand that:

- Healthy soil is well structured.
- Evaluating bulk density is one way to assess soil structure.
- Farmers can implement techniques to improve soil structure.

Essential Questions

- What qualities increase soil function?
- How can soil quality be measured?
- What can farmers do to improve soil quality?
- Why do farmers care about soil quality?

Students will know:

- Compaction describes bulk density that is too high.
- Compaction causes problems both on the farm and in the environment.

Students will be able to:

- Take a core sample and determine the bulk density.
- Identify human activities that affect bulk density.
- Identify techniques that improve soil structure.

Assessment Evidence

Performance Tasks

- Students will evaluate bulk density and assess soil structure.

Other Evidence

- Students will respond to specific questions with detail.
- Students will use geometric and ratio formulas to solve real-world mathematical problems.

Learning Plan

Learning Activities

- Students will read an informational text about soil quality.
- Students will answer questions about the text.
- Students will take a core sample and determine the bulk density.
- Students will analyze the meaning of their results.
- Students will plot their results on a map and pinpoint areas of high compaction.
- Students will identify practical ways that compaction could be minimized within the sampling area.

Background: Soil Quality

Soft and crumbly — like cottage cheese.
Loose and full of holes — like a sponge.

These are descriptions of a soil that has proper structure. Soil structure is the arrangement of the solid parts of the soil and the space between them. When the solid parts — sand, silt and clay particles — cling together as coarse, granular aggregates, the soil has a good balance of solid parts and pore space.

Healthy soil is well-structured. One way we measure the structure of soil is by evaluating bulk density. Bulk density is calculated as the dry weight of soil divided by its volume. This volume includes the volume of soil particles and the volume of pores among soil particles. Bulk density is typically expressed in g/cm^{3}.

Bulk density is important. Compaction is a term that describes bulk density that is too high. Compaction can restrict root growth and cause poor plant growth reducing crop yield. Compaction causes poor movement of air and water through the soil. It can lead to increased runoff and erosion on sloping land or waterlogged soils in flatter areas.

There are practices farmers can avoid to reduce the likelihood of compaction:

- Minimize soil disturbance and production activities when soils are wet
- Use designated field roads or rows for equipment traffic
- Reduce the number of trips across an area

Long-term solutions to bulk density and soil compaction problems revolve around decreasing soil disturbance and increasing soil organic matter. Farmers can use techniques such as cover crops (plants grown for the enrichment of the soil) and reduced tillage (limiting how much the ground is broken up at the beginning of a planting season). Using these techniques results in increased soil organic matter, less disturbance and reduced bulk density.

Soil structure is critical to how soil functions. As world population and food production demands rise, keeping our soil healthy and productive is of paramount importance. As a result of using techniques that promote proper soil structure, farmers are preventing unnecessary erosion, increasing water infiltration and improving microbial populations — all while harvesting better profits and often better yields.

Questions for discussion:

1. Why is measuring bulk density important?
2. What practices promote well-structured soil?
3. Why should a farmer care about soil quality?

Engagement: Soil Quality

Name Date Class

Materials:

Empty tin can with height of approximately 2–3 inches, can opener, cm ruler, wood block, mallet, garden trowel, butter knife, paper food tray, microwave oven, scientific scale

Procedure:

1. Read the background information on soil quality. Answer the questions at the bottom of the page.
2. Remove the bottom of the tin can to create a metal ring. To complete this exploration, you will need to know the soil volume, which will be the same as the volume of the ring. Complete the table to calculate the volume of the soil.

Height of ring (in cm to the nearest mm)	Diameter of ring (in cm to the nearest mm)	Radius of ring (half the diameter)

Soil volume (cm^3) = 3.14 x r^2 x ring height
Soil volume (cm^3) = __________

3. Determine a suitable location to take a soil sample to measure bulk density. Avoid areas that are rocky, sandy, extremely dry or muddy.
4. After arriving at your location, place the ring on the soil surface. Place the wood block over the can and tap the wood with a mallet. Continue until the top of the can is even with the soil's surface.
5. Dig around the ring, and with the trowel underneath it, carefully lift the ring out to prevent any loss of soil.
6. Remove excess soil from the top and bottom of the sample with a butter knife. The top and bottom of the sample should be flat and even with the edges of the ring.
7. Calculate the dry weight of the soil by removing all moisture. Use the butter knife to gently knock the soil out of the metal ring and into a paper food tray. Use the butter knife to break the soil into small clumps.
8. Place the paper tray containing the soil in a microwave and dry for four-minute cycles at full power. To determine if the soil is dry, weigh the sample and record its weight after each cycle. When its weight does not change after a drying cycle, then it is dry. Open the microwave door for one minute between cycles to allow venting.
9. Weigh the dry soil on its paper tray. Weigh an empty paper tray. Determine the weight of the dry soil by finding the difference.

Weight of dry soil and tray	Weight of empty tray	Weight of dry soil

Complete this equation to calculate bulk density:
Bulk density (g/cm^3) = Weight of dry soil (g) / Soil volume (cm^3)
Bulk density (g/cm^3) = ___________

11. Bulk density greater than 1.6 g/cm^3 tends to restrict root growth. Healthy soils rich in organic matter can have densities of less than 0.5 g/cm^3. Write a sentence to summarize the bulk density of your soil sample:
____
12. Compare your results with the class. Using a map of the sample area, identify locations with the highest compaction (greatest bulk density) and the areas with the lowest bulk density. Discuss practical ways that compaction could be minimized within the sampling area.
13. Reflect on these questions; your teacher may ask you to write or discuss:
    a. Give two examples of human activity that affect bulk density within your sampling area.
    b. What practices could be implemented to improve bulk density within your sampling area?
    c. Apply what you've learned to an agricultural setting.
    d. How would the bulk density of your soil sample affect plant growth?
    e. As a farmer, how would the sampling results influence your agricultural practices?