Soil Erosion Demonstration

Age: 8-10 years old (grades 3-4), but easily adapted for all youth 5-19 (grades K-12)

Objectives:

1. Members/students will learn about soil erosion and understand how the amount of soil erosion can be impacted by several factors.
2. Members/students will analyze three (or more) realistic field (location, etc.) situation to predict/theorize which situation will result in the most soil erosion and which will have the fastest runoff time.
3. Members/students will test their erosion and runoff theories to make valid explanations and conclusions based on the results.
4. Members/students will analyze the factors that impact soil erosion and recommend strategies to reduce or limit soil loss.

Preparation:

Supplies Needed for Demonstration:

- 3 soil erosion demonstration set-ups constructed as described below
- 2 different soil types – about 6 cups of 1 type and 3 cups of the other, air dried and broke into very small pieces
- empty 5 gallon bucket for clean-up
- spoon or stirring rod
- water container full of water (either extra 2-liter bottles or a water pitcher)
- crop residue (grass clippings, small pieces of corn stalks and leaves, etc.)
- student/member worksheet

Construction of Soil Erosion Demonstration Set-up
Materials Needed for 1 set-up – Three (or more) set-ups are recommended.
Estimated time: 1 hour

- 3 clear 2-liter bottles with labels removed
- 1 bottle cap for a 2-liter bottle
- 1 clear 1-liter bottle (tonic water or club soda often sold in this size with the perfect shape)
- small nail (finishing or picture hanging size)
- candle (lit)
- pliers, needle nose
- scissors
- packing knife or razor blade

Tip: Empty bottles are often available for youth activities free of charge at local recycling facilities.

Directions:

1. Cut the top neck off one of the 2-liter bottles. Cut where the bottle begins to bend, leaving just the beginning of the curve with the rest of the bottle. It may be easiest to pierce the bottle with the packing knife or razor blade but use scissors to make the smooth cut around the top.

2. Working with the same 2-liter bottle with the top cut off, cut two approximately circular holes a little more than halfway up the existing bottle. The diameter of the circles should roughly be the diameter of the 1-liter bottle. When completed, the 1-liter bottle should be balanced horizontally resting within the 2-liter bottle. Again, it may be easiest to pierce with the knife, but cut with scissors. Remember to start your circles on the small side as more area can easily be cut away. Keep cutting and test fitting the 1-liter bottle until the 1-liter slides into the 2-liter fairly easily and rests horizontally balanced. Once you get this adjustment right, you may want to rough trace the shape and location onto 2-liter bottles you are using to make additional set-ups using a marker. This can make this step less tedious for additional/future set-ups.

Two-liter bottle with top cut off and holes through the side.

One-liter bottle resting between side holes of two-liter bottle.

3. With the 1-liter bottle on its side, cut away about 1/3 of the surface in a rectangle, leaving the neck and base for structural stability. This bottle is the tray where soil is placed for the demonstration. Again, test fit the 1-liter bottle horizontally in the 2-liter. Enough of the 1-liter bottle should be cut away so the cut edge is not a barrier to water easily reaching soil in the tray, but so the 1-liter bottle still retains its bottle shape.

One-liter bottle with rectangular approximately 1/3 section cut out.

4. Cut another 2-liter bottle around the circumference so the bottom 1/3 makes a runoff collection cup and the top 2/3 makes a funnel. The collection cup must slip just underneath the 1-liter bottle mouth, so use this reference to make both the collection cup and funnel as tall as practical.

Funnel (top 2/3 of bottle)

Collection cup (bottom 1/3 of bottle)

5. Hold the small nail with needle nose pliers so that you can heat the nail with the lit candle. Once heated, carefully use it to pierce a small hole in the end of the bottle cap. The water flow through the funnel will be controlled by this hole. Screw the bottle cap on the end of the funnel.
6. Cut the top and the bottom off the remaining 2-liter bottle. The bottom edge should be even with the bottle sides and the top should leave just a little of the curved neck edge as in step 1. This bottle will be used as a spacer so there is more distance between the base of the funnel and soil in the tray.
7. Test fit the entire assembly. 1-liter bottle should rest horizontally in 2-liter without a top and with circular holes cut through the sides. Collection cup should slip under the mouth of the 1-liter bottle. Spacer bottle should rest on top the described assembly with the bottom edge down. Funnel bottle with cap should rest on top of the spacer bottle.
8. Although the set-up takes some time to construct, the good news is it can be rinsed after use and be used again and again for years to come.

Spacer bottle with top and bottom cut off

Spacer, one-liter and two-liter with side holes set-up

Complete assembly includes 3 two-liter bottles and 1 one-liter bottle.

Tips: I like to use a "natural" soil that in my area has a high clay content and a "manufactured" soil where I add a lot of sand to a "natural" soil. I usually use the "soil" from our rodeo arena where a lot of sand has been added. The more difference between the 2 soil types, the better. Note that adding a little sand to a high clay content soil makes concrete. If you live where sandy soils predominate, you can "manufacture" a soil by adding bentonite clay (or similar) to your "natural" soil. Because I never know how much notice I will have prior to a presentation and weather can be unpredictable, I collect plenty of soil in advance and store it in buckets in my office. To evaluate the impact of a growing grass crop, you could add soil and plant grass seed in one of your 1-liter bottles about 2-3 weeks prior to your demonstration. This could simulate a grass waterway used with terraces, a buffer strip or even a lawn.

Directions for Demonstration Set-up:

1. Fill 1-liter bottles lying on their sides (cut side up) with soil so that the soil level is about even with the bottom edge of the bottle mouth. Two bottles should be filled with the same soil type, while one is filled with the other type.
2. Add crop residue to one of the two bottles containing the same soil type. Keep in mind the size limitations of this model. I usually tear small pieces of stalk and leaves. If you want to "plant" a stalk, you may need to do it once the 1-liter bottle is resting inside the cut 2-liter.
3. Assemble the soil erosion demonstration set-ups so that the 1-liter bottle containing soil rests horizontally in 2-liter without a top and with circular holes cut through the sides. Collection cup should slip under the mouth of the 1-liter bottle. Spacer bottle should rest on top the described assembly with the bottom edge down. Funnel bottle with cap should rest on top of the spacer bottle. Line them up so each is easily visible to your audience. You may want to label set-ups with masking tape or organize them in a logical order.

4. Place the spoon or stirring rod within reach. It may be needed to make a "fair" evaluation of the soil erosion run-off in the collection cup.

Interest Approach:

- Have the demonstration set up prior to the project meeting or class beginning as it alone will gain student/member attention and questions.
- Share erosion facts including:
    - Did you know that 6.4 billion tons of soil is eroded from U.S. land each year? This amount of soil would fill 320 million dump trucks if each carried 20 tons of soil. If these trucks were parked end to end and were 25 ft long, they would extend to the moon and three-quarters of the way back.
    - Also, erosion is a selective process by which the finer and more fertile soil elements are lost first. The soil surface is generally the richest part of the soil.
- Ask the group if they have seen a farmer's field after harvest with all the left over stems and pieces of the plants lying all over the ground. He/she left it that way over the winter and didn't clean it up. Have any of you thought the farmer was just being lazy? (raise hands) In our activity today we will experiment with this practice and try to figure out if there is a reason farmers do it.

Content:

- Explain the set-up to the members/students. We are modeling soil erosion due to water in 3 different situations. The first set-up contains a bare soil common to this area (Explain and tell them the soil texture/type).The second set-up also contains a bare soil, but it is much different (Discuss the soil texture/type, including how the soil mix was made, if applicable. The third set-up contains the same soil texture/type as the first, but it is covered with crop residue – pieces of plants left over after harvest.
- Hand out the member/student worksheet. If time allows, give participants a few minutes to work on their drawing of the experiment set-up. Explain that the most important part of their drawing is the bottles containing the soil. Emphasize the importance of the labels including which texture/type of soil and if residue is present.
- Experience: Pour water into each set-up funnel. Begin by adding a small amount of water to each so that the beginning of runoff time will be approximately the same. Go back and add water as needed to each funnel. You may even select 3 students and give each a water bottle so the pour can start at the "exact" same time.
- Wait as it "rains" on each soil. Tell the students that they are looking to see which situation results in water in the collection cup the fastest (i.e. runoff time) and which will have the most soil erosion observed by the amount of soil in the collection cup.
- As the runoff and erosion begin to occur, pay particular attention to the amount of water in the collection cup. You may have to remove the set-up funnel and place it in your clean-up bucket relatively quickly to avoid a mess.
- Define erosion: loss of soil from the surface. Since most soil nutrients and organic matter is near or at the surface, erosion results in their loss as well.
- Share: After you have removed all the funnels and the runoff and erosion has (almost) stopped, have the students evaluate the amount of soil in each collection cup (erosion) in relation to the others. If the sandy soil settles quickly, but the clay soil

remains in suspension, you may want to quickly stir each with your spoon or stirring rod so they can make the most accurate evaluation.

- Process: Have each member/student complete the "Experiment" portion of their worksheet. Discuss the results as a group. Remember, this can be modified to be age appropriate for a wide range of students/members. For older students, one of my favorite things to include is a chance for them to think about/detect sources of experimental error.
- Give each student/member a few minutes to work on the evaluation/application portion of the worksheet. This could be done individually or in small groups of 2-3. Then, discuss the answers as an entire group.
- Generalize: For this age level or younger, you may want to briefly discuss some of the other factors in the universal soil loss equation (USLE) such as amount of rainfall, length and steepness of slope, practices like contour farming, no-till and terraces. Higher rainfall areas have more erosion, the longer the slope and the steeper the slope of the land increases erosion potential, and practices such as contour farming and terraces are ways we try to limit erosion.

  Two other factors, soil texture/type and cover (by residue), were covered in this experiment, but other situations could be discussed such as growing plants (planted in rows versus drilled/broadcast) or other soil textures/types. Growing plants, especially those that are drilled or broadcasted reduce erosion since the roots are actively "holding" the soil. This is why we plant grass buffer strips near streams, plant grass in waterways of terraces and why a good, healthy lawn can reduce erosion. Common soil types will likely have properties that cause them to fall between the two used today. Remind the students that the size and even the shape of the texture particles make the difference (i.e. sand is big and heavy; clay is small, light, but flat and often attached to other clay particles; and silt is in between the size of sand and clay).
- Higher level students/members should be ready for the USLE (Universal Soil Loss Equation) activity included in this lesson group.
- Apply: Discuss that some of the factors that influence erosion can be influenced or affected by us, but others just are natural and cannot be changed. Can we make it rain less so there will be less erosion? No, we cannot, but if we live and work in a high rainfall area, other things that we can do or change can be even more important. We cannot change the soil texture/type over a large area, but if we know the type, we can use the information to make choices for the use of the land so erosion is limited. For example, if we have a high clay soil which also has long slope lengths and is very steep, we may need to plant it to grass instead of farming it in row crops. If we need to farm it in row crops, terraces, no-till and contour farming can make a big difference. Erosion occurs outside of agriculture, too.

  Think about the things done to limit or slow erosion at a construction site. Have you seen hay bales placed to act like terraces? When building on a very steep slope, the time of year when the soil will be bare will often be considered. Contractors may pick a low rainfall time for construction followed by a time when grass establishment is possible so the bare soil will be covered quickly.

Summary:

- Erosion is the loss of soil from the surface, including soil nutrients and organic matter.
- There are five factors that affect soil erosion due to water:
    - Rainfall
    - Soil Texture/Type
    - Slope Length and Steepness
    - Cover (like residues or growing crops)
    - Practices (like terraces and contour farming)

Erosion is a natural process, but there are some things we can do to limit erosion so it does not hurt the ability of plants and animals, including us, to survive on Earth.

Assessment:

1. In our experiment, which soil type had the least erosion? Why?

   A: Between a clay soil and a sand soil, the sand soil should have the least erosion. The particle size of clay is much smaller and therefore easier to move/remove. Erosion is selective in the small particle sizes are lost first.

2. In our experiment, which situation resulted in the slowest runoff time? How does this impact erosion, especially in the "real" world?

   A: With bare clay soil, bare sand soil and covered (residue) clay soil, the slowest runoff time should be the covered clay soil. A slower runoff time should result in less erosion, which should be seen when comparing bare clay soil and covered clay soil. Cover helps "hold" the soil in place and makes it more difficult for it to be lost as a result of erosion.

3. Explain how we can use our knowledge of soil texture/type to make decisions so we can conserve soil. Give an example.

   A: Although we cannot practically change soil texture/type, we can use that knowledge to make good management decisions. Soil texture/type can be one factor that leads to a decision to grow a perennial, densely planted crop, such as grass instead of row crops. The importance of soil conservation practices such as no-till, terraces and contour farming are intensified for some soil textures/types (i.e. silt- and clay-based soils versus sand-based soils).

4. Would we expect more water-based erosion in Eastern Kansas or Western Kansas? Why?

   A: More water-based erosion in Eastern Kansas since it rains more. Eastern Kansas also has higher percentage clay and silt soils and often more slope length and steepness.

5. What practices can help reduce high erosion levels caused by long, steep slopes?

A: Terraces can reduce the length of a slope by breaking it up into shorter "runs." Contour farming can also slow the flow of water down a slope. Finally, planting a dense perennial crop such as grass reduces the surface area available for soil loss.

References:

"Soil Erosion Demonstration."
http://soils.usda.gov/education/resources/lessons/experiments/erosion/

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