Collecting Soil Aggregates and Measuring Aggregate Stability
(Non-Technical Protocol)

Introduction

Soil aggregates are generally divided into two groups: **1.** microaggregates (< 250 µm) and **2.** macroaggregates (>250 µm). Microaggregates consist of clay, silt, and sand bound together primarily by clay mineral interactions, humified organic matter, and plant and microbial debris encrusted with iron and aluminum amorphous oxides. Macroaggregates are primarily bound together by fungal hyphae, fibrous roots, and polysaccharides. Studies have targeted the stability of 1-2 mm aggregates as indicators of soil health.

Aggregate stability measures the amount of stable aggregates against flowing water or aggregates that survive wet-dry cycles/precipitation. It is recommended that aggregate stability be determined on the top 0-2 inches (0-5 cm) up to 0-6 inches (0-15 cm) of surface soil. The soil sample should be air-dried before determining aggregate stability. Soil aggregates protect organic matter within their structure from microbial attack allowing organic matter to be preserved in the soil. Table 8 contains suitable values for aggregate stability based on soil organic matter and clay content. A suitable range of values could be developed for a soil using the aggregate stability values for the organic matter content and clay content as end members to the range. For example, for a soil with 2% organic matter and 10% clay, the suitable aggregate stability range is likely to have 65 to 75% of the 1-2 mm aggregates as water stable.

Materials

- Aluminum foil or wax paper
- Liquid soap
- Mesh screen, plastic (2 mm opening, standard window screen)
- Mesh screen, plastic (1 mm opening, small insect screen or no see ums screen)
  Muffin tin (optional)
- Newspaper/Kraft paper/butcher paper
- Permanent marker
- PVC pipe (1-2” outer diameter, 0.9-1.9” inner diameter)
- Saw or pipe cutter
- Scale or balance, kitchen or food scale may be used
- Water-insoluble glue
- Oven

Methods

Air-drying the soil:

1. Take soil sample and spread it out on newspaper or Kraft paper to air dry.
2. Spread the soil out in a layer that is about 2 cm or 0.5 inch.
3. Manually break apart any large clods by gently kneading or massaging with your fingers.

4. Repeat step 3 daily for 5 to 10 days until the soil is dry.
5. To determine if the soil is dry, weigh the soil or a subsample of soil using a scale, record the weight, dry for 24 hours, and weigh again. If the weight does not change, then the soil is dry. Dry longer if needed.

Making the sieves:

1. Take the PVC pipe and cut it into 5-7.5-cm or 2-3-inch sections.
2. Cut the screens into 6-cm or 2.5-inch squares (Figures 1-2).
3. Lay out a strip of foil or wax paper big enough to hold mesh squares equal to the number of sieves you wish to make with a little extra for about a 1-inch circle of glue.
4. Place the glue on the foil or wax paper.
5. Lay out the squares of mesh on the foil or wax paper. An equal number of squares for both sizes of mesh should be laid out.
6. Generously coat the bottom edge of each PVC piece with the glue.
7. Place the glue coated edge down on the mesh - one PVC per each mesh (Figure 3).
8. Place a book or weight on top of the PVC pieces to allow the glue to make a good seal (Figure 4).
9. Allow the glue to dry overnight, remove the weight and carefully remove the mesh screens from the foil or wax paper. You now have two sieves – one with the large mesh openings (about 2 mm) and one with smaller mesh openings (about 1 mm). Label the sieves with permanent marker as 2 mm or 1 mm, respectively (Figure 5).
10. Weigh each of the sieves and write the weights with a permanent marker on the side of each sieve.

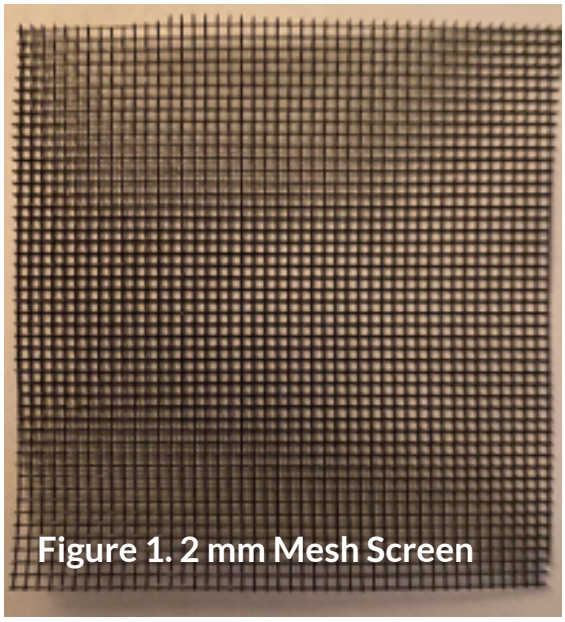

Figure 1. 2 mm Mesh Screen

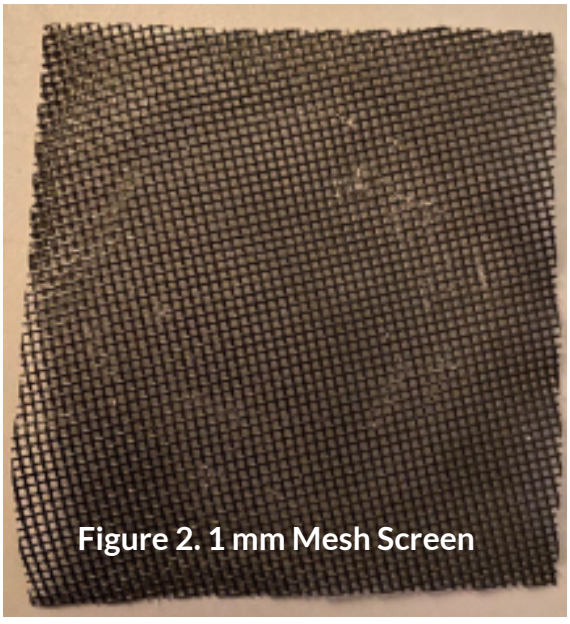

Figure 2. 1 mm Mesh Screen

Figure 3. Gluing Mesh to PVC Pipe on Foil

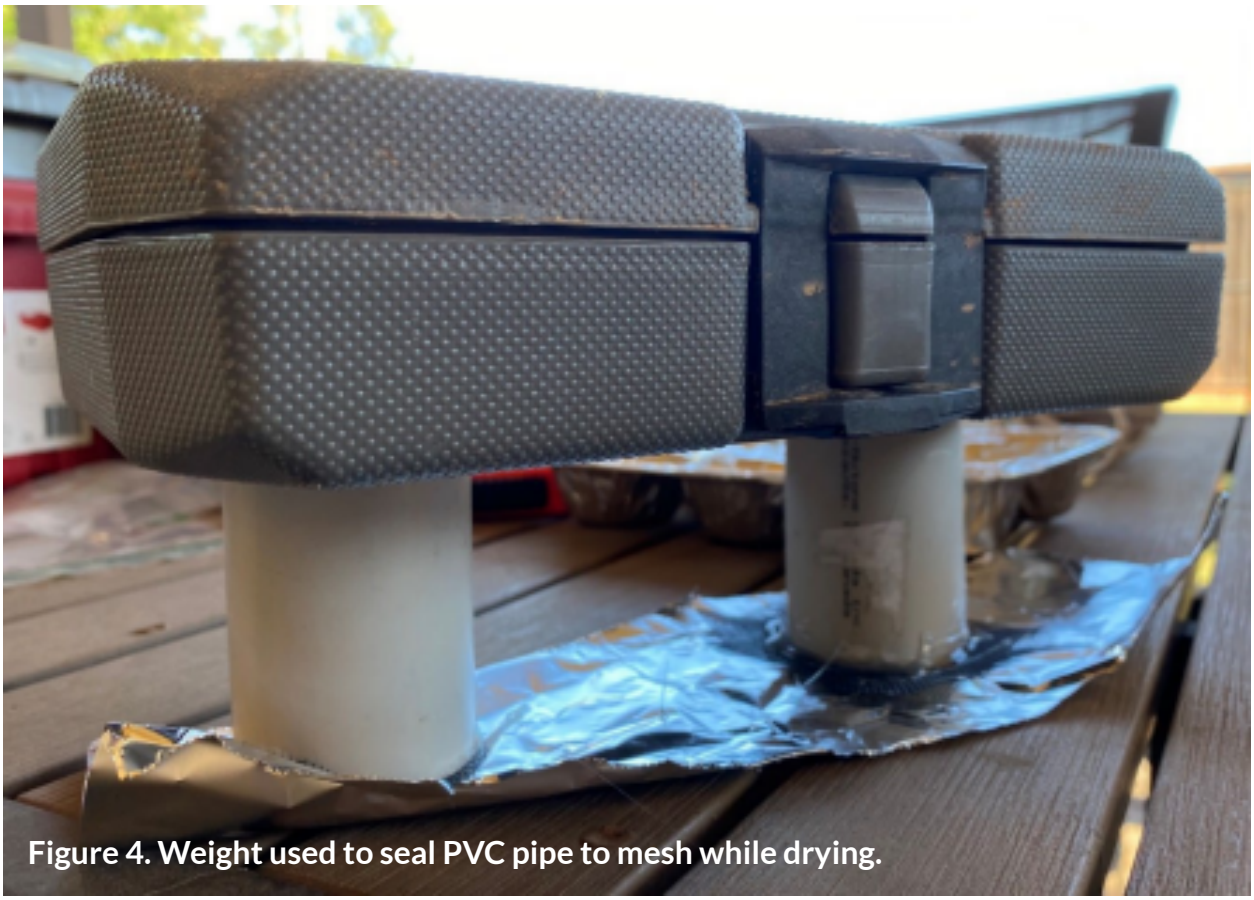

Figure 4. Weight used to seal PVC pipe to mesh while drying.

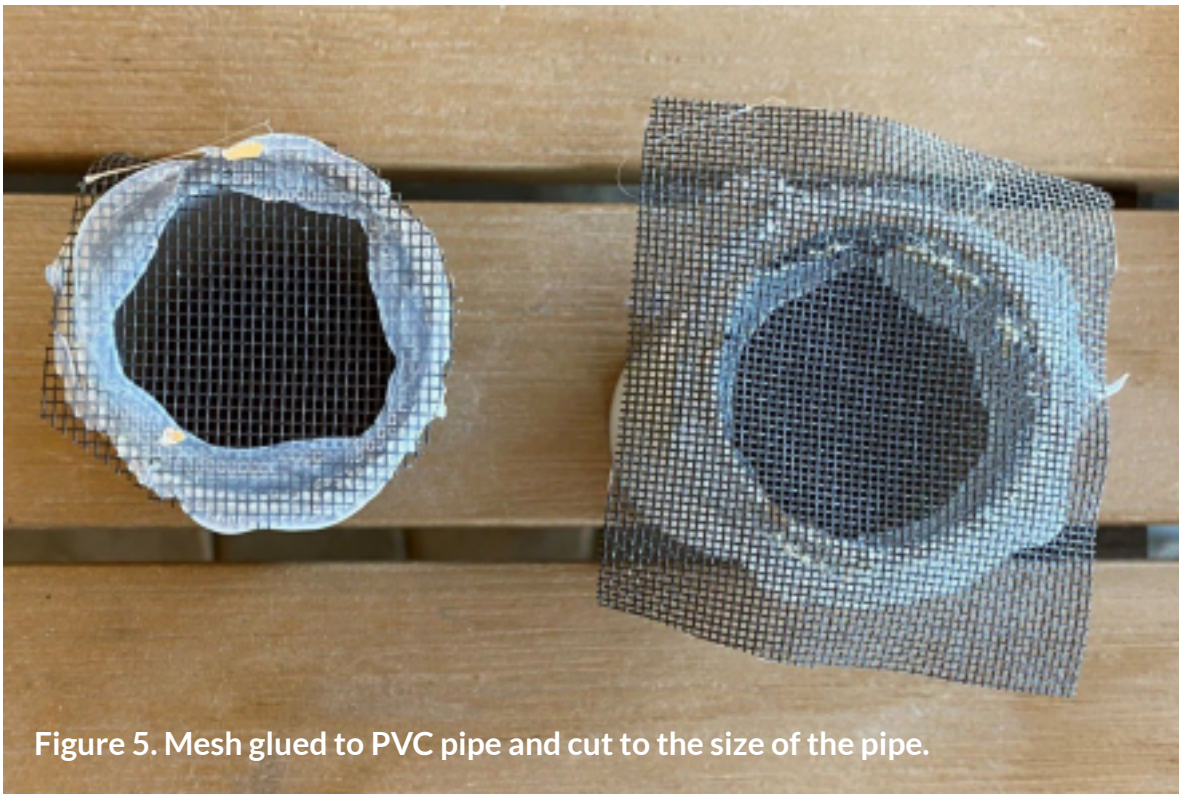

Figure 5. Mesh glued to PVC pipe and cut to the size of the pipe.

Dry sieving the soil:

1. Weigh out about 2-5 ounces or 5-10 grams of soil. The amount of soil may vary based on the sand content and the internal diameter of the sieve. There should be enough soil to have about a 3-5 mm or about 1/8th inch layer of soil on top of the mesh screen.
2. Place soil in the 2mm sieve (Figure 6).
3. Gently shake the sieve to pass soil aggregates and particles smaller than the openings on the large mesh (approx. 2 mm). This may be done by tapping on the side of the sieve. Typically, tapping 25-50 times will be adequate (Figure 7).
4. Collect the soil aggregates and particles that pass through on a paper or container (Figure 8).
5. Gently pour the collected soil into the 1 mm sieve (Figure 9).
6. Gently shake the sieve to pass soil aggregates and particles smaller than 1 mm through mesh as was done in step 3. Typically, tapping 25-50 times will be adequate.
7. Weigh soil collected on the 2- and 1-mm screens separately and record the weights. This may be done by weighing the soil in the sieves and subtracting the sieve weight.
8. The weight of the aggregates on the 2 mm screen indicates the weight of dry aggregates >2 mm while the weight of the aggregates on the 1 mm screen is the weight of 1-2 mm aggregates.

Figure 6. Soil placed on 2mm sieve

Figure 7. Soil left in 2mm sieve after shaking

Figure 8. Soil passed through 2mm screen

Figure 9. Soil passed through 2mm screen was placed on 1mm screen

Observing aggregate stability:

1. If you do not want to quantify aggregate stability and/or wish to immediately demonstrate aggregate stability, then follow the procedure below:
    a. Take about 10-15 of the dry sieved 1-2 mm aggregates from the 1 mm sieve, and place them in a small clean plastic container or cup.
    b. Gently add water by pouring it down the side of the container to cover the aggregates.
    c. Observe if the aggregates remain intact and how clear the water is.
    d. Estimate the amount of aggregates that remain intact by observing the aggregates through the bottom of the cup/container.

Measuring the percentage of water-stable aggregates:

1. If you removed the dry 1-2 mm aggregates from the 1 mm sieve, gently pour them back into the sieve. If you didn't remove them, then proceed to step 2. You can also test the stability of the >2 mm aggregates by following the same steps.
2. Weigh the aggregates on the screen.
3. Place the 1-mm sieve in a muffin cup in a muffin tin or some other leak-proof container where the bottom of the sieve will sit flat.
4. Add water (preferably distilled water) around the outside of the sieve so the water will wick under the sieve and into the aggregates by capillary action. If the water does not wick under the sieve, then lift one side of the sieve gently just to start the water wicking. Let it incubate for 5 minutes (Figure 10-11).
5. After the incubation in Step 4, transfer the sieve into another muffin cup filled ¾ full with water (preferably distilled water) or about 1-2 cm or 0.5 inch above the aggregates on the screen (Figure 12).
6. Gently move the sieve up and down while keeping the aggregates and screen submerged in water and repeat this process 50 times over a two-minute period. (Hint: Use the beat from the song "Staying Alive" or "Another One Bites the Dust" to establish the perfect rhythm.)
7. Unstable aggregates will break up as the sieve is moved up and down and the soil particles that were inside these unstable aggregates will pass through the mesh screen and collect on the bottom of the muffin cup or container (Figure 13).
8. Remove the sieve from the water. The aggregates that stay on the screen are water stable but there might also be sand or other debris (i.e. coarse material) on the screen which are not aggregates.
9. Add water (either tap or distilled water) plus a small drop of liquid soap to another muffin cup or leak-proof, oven-safe container to be just above the aggregates and coarse material on the screen.
10. Place the sieve in the muffin cup or container from Step 9 and shake and move the sieve up and down to break up the aggregates for five minutes. If needed, you may gently use a butter knife to break up the aggregates on the screen while the screen is submerged. In this step, the stable aggregates from Step 9 should break apart with the soil particles that were inside these aggregate passing through the mesh screen and the coarse material staying on the screen (Figure 14).
11. Place the muffin pan or containers from Steps 6-9 and 11-12 into an oven at 200-250°F to evaporate the water and oven-dry the soil particles from the unstable aggregates in Step 9 and the stable aggregates in Step 12. Cook/incubate

in the oven for 12-24 hours depending upon the size of the containers and the amount of water in the container (Figure 15).

12. Weigh the material in each muffin tin or container separately.
13. To calculate the percentage of water-stable aggregates, take the oven-dried weight of the soil particles collected in Step 12, divide by the weight of aggregates from Step 2 and multiply by 100.
14. If you wish to check the data, the weight of the aggregates from Step 2 should be equivalent to the combined value of the following four weights - **1.** any soil particles or debris in the muffin cup or container in Step 5, **2.** soil particles from unstable aggregates (Step 9), **3.** soil particles from the stable aggregates (Step 12), and **4.** coarse material from Step 12. **Note:** These four weights are on oven-dried material so Step 5 should be performed in a leak-proof, oven-safe container and the coarse material from Step 12 needs to be rinsed it off the screen into a leak-proof, oven-safe container. Both of these will be oven-dried by cooking/incubating in an oven as discussed in Step 13

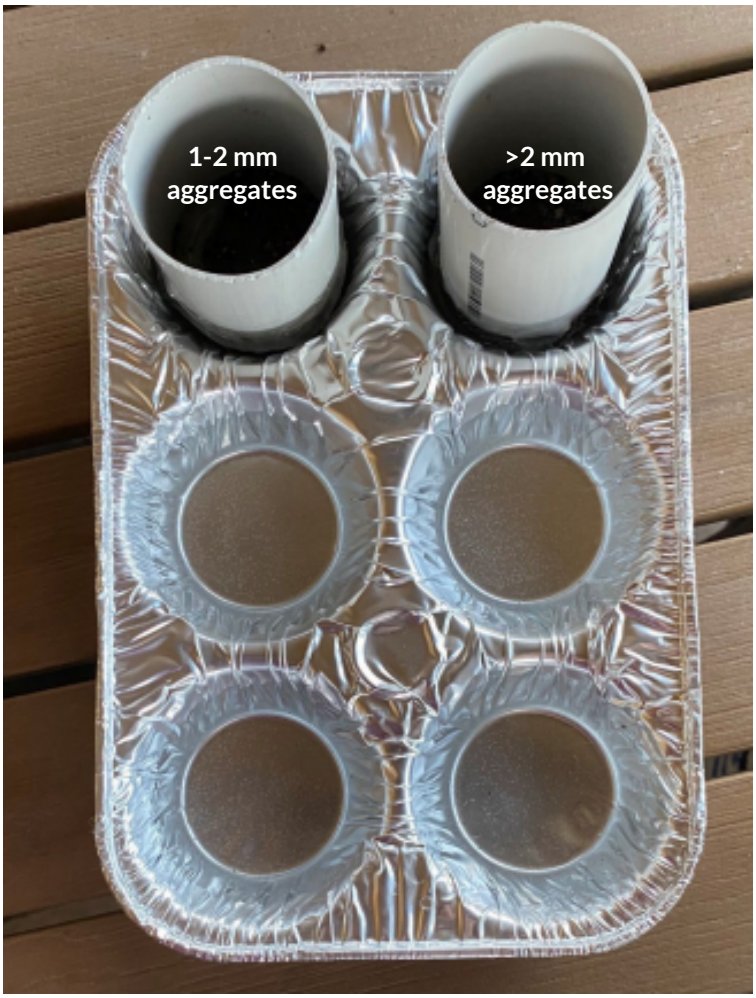

Figure 10. Water added around the sieve in the muffin cup to wet aggregates by capillary action.

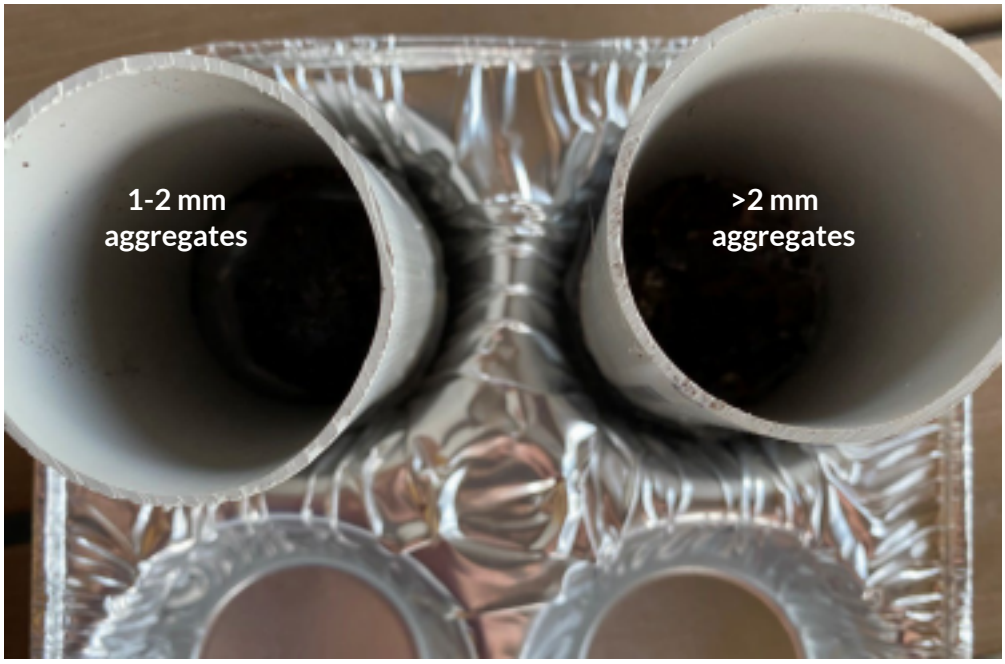

Figure 11. Aggregates wet in sieves

Figure 12. Aggregates stability tested

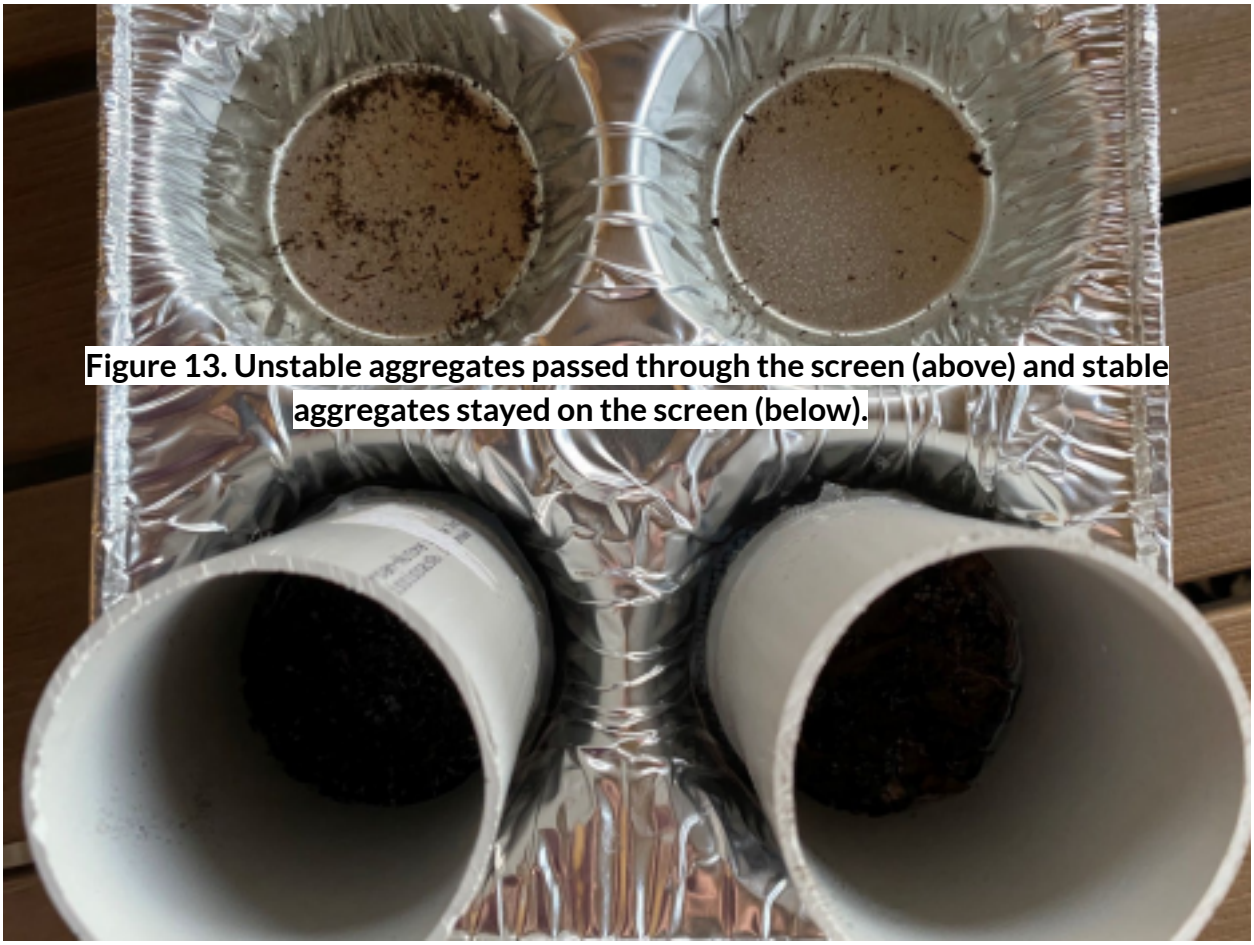

Figure 13. Unstable aggregates passed through the screen (above) and stable aggregates stayed on the screen (below).

Figure 14. The soil particles in the top muffin cups are particles that passed through the screen during the capillary rewetting process. In the middle cups, the unstable aggregates that passed through the screen during wet sieving. The bottom cups contain stable aggregates that were collected after treating the aggregates with dish soap and breaking up the stable aggregates.

Figure 15. After oven drying to evaporate the water, the soil particles remaining in each muffin cup are weighed to calculate the percentage of stable aggregates. In the pictures to the left, the top cups contain particles that passed through the screen during the capillary wetting step. In the middle are the unstable aggregates while the stable aggregates are in the bottom. The coarse material was collected in the cups in the bottom image.

Observations

- Note the amount of soil which is at the bottom of the cup after capillary rewetting and after sieving.
- Note the clarity of the water during the capillary rewetting and sieving steps.

What's Happening

- The 1-2 mm aggregate size class is targeted because research indicates this size class is most impacted by biological processes.
- Soil aggregates are formed and stabilized by biological, physical, chemical and geological processes.
- Soil aggregation defines soil porosity and the maintenance of soil pores with water-stable soil aggregates.

Tips & Tricks

- You may stop at or not perform the 'Observing Aggregate Stability' step.
- Compare aggregate stability to the dry aggregate weight/percentage.
- If there is a lot of organic matter or sand, the coarse material correction step needs to be performed.
- If a more quantitative measurement is desired for the entire soil, refer to the technical method.

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