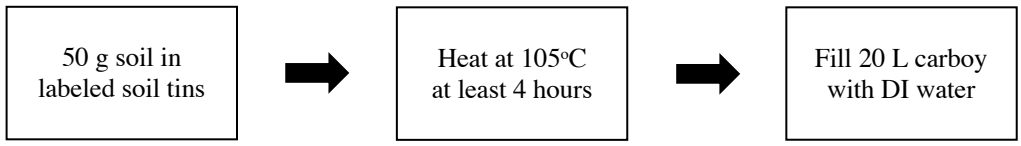
Procedure for Soil Particle Size (Texture): 2-Hour Hydrometer Method

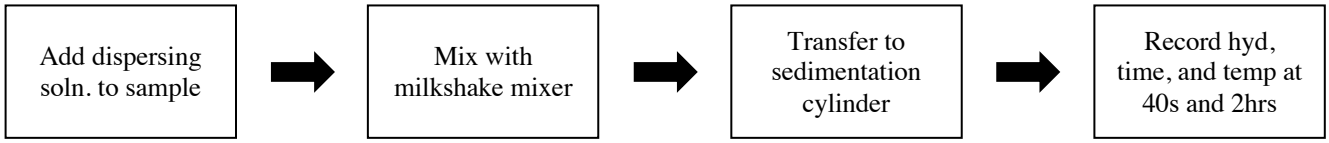
Procedure Overview

This procedure describes a technique for determining soil particle size (percent sand, silt, and clay) along with the soil textural class. Separation of soil into the sand, silt, and clay fractions is based on their differences in settling rates as described by Stokes' Law. A hydrometer is used to measure the density of soil particles in suspension at specific periods of time. Soils that are air-dried and ground to <2 mm are typically used.

Preparation



Quantification



Instrumentation and Materials:

Sodium Hexametaphosphate [$(NaPO_3)_6$] Dispersing Solution Preparation

- Sodium hexametaphosphate ($(NaPO_3)_6$; FW=611.77 g mol^{-1})
- 1 L volumetric flask
- Stir bar

Sample Preparation and Analysis

- Soil tins capable of holding at least 50 g of soil
- Analytical balance with a readability of at least two decimal places
- 20 L carboy
- Wash bottles with DI water
- Adjustable bottle-top dispenser fitted to bottle of sodium hexametaphosphate and calibrated to deliver 25.0 mL
- 250 mL glass beakers
- Electric mixer (malted-milk-mixer type with 10,000 rpm motor)
- Metal dispersing cups for mixer
- Graduated 1000 mL sedimentation cylinders and plunger
- iso-Amyl alcohol
- Stopwatch
- Standard hydrometer, ASTM no. 152 H with Bouyoucos scale in g L^{-1}
- Thermometer

Detailed Procedure

I. 0.5% Sodium Hexametaphosphate [$(NaPO_3)_6$] Dispersing Solution Preparation (makes 1 liter, enough for 40 samples):

1. Weigh 25 g of $(NaPO_3)_6$ and add to a 1 L volumetric flask.
2. Carefully place a stir bar in the same volumetric flask and add 500 mL of deionized water.
3. Stir at moderate speed until completely dissolved.
4. Bring volume to 1 L.
5. Transfer to bottle with 25 mL bottle-top dispenser.
6. Solution can be sealed and stored at room temperature.

II. Sample Preparation

1. Soil checks should be prepared in the same manner as the soil samples and serve as laboratory reference samples. It is recommended to pulverize and homogenize a large batch of air-dried soil for long-term use. The soil checks allow for a quality control check across texture analyses performed on different batches, over multiple days, and with different reagents. Note: If analysis is expected to be performed over multiple days, prepare one soil check and blank per day.
2. Label soil tins with sample ID's.
3. Weigh 60 grams of sample in respective tins and place in an oven at 105°C for at least four hours. Include at least one soil check.
4. Fill a carboy and several wash bottles with DI water then set aside to bring to room temperature. Use these throughout analysis when DI water is needed.

III. Sample Analysis

1. Using heat protective gloves, remove soil samples from oven and allow to cool to room temperature.
2. Tare labeled, 250 mL beakers on analytical balance and weigh 50 grams (± 0.05 g) of soil from each tin directly into respective 250 mL beaker. Record initial weight.
3. Add 25.0 mL of sodium hexametaphosphate dispersing solution to each beaker with soil. Add dispersing solution to an empty beaker to be used as a blank.
4. Bring beakers to a total volume of ~200 mL with deionized water.
5. Stir with glass rod at a moderate speed for 10 seconds, rinsing rod with deionized water into waste beaker between each sample. Let sit for 30 minutes.
6. Pour sample mixture from beaker into dispersion cup. Use a wash bottle of DI water to ensure that all soil particles are rinsed from beaker. Add DI water to dispersion cup until it is no more than ¾ full.
7. Mix for 10 minutes with the electric mixer set to "M" (medium).
8. Transfer sample mixture to a 1000 mL graduated sedimentation cylinder. Use a wash bottle of DI water to ensure all soil particles are rinsed from metal dispersion cup into graduated cylinder.
9. Using DI water, bring cylinder to a total volume of 1000 mL.
10. Insert plunger into cylinder and mix the contents thoroughly with rapid but controlled vertical strokes. Add a drop of amyl alcohol if the surface is covered with foam.

11. As soon as mixing is completed, start a timer (counting up), lower the hydrometer gently into the solution mixture and allow to stabilize, take a reading at 40 seconds, then record. Remove the hydrometer and rinse completely into a waste beaker with a wash bottle of DI water.
12. Record the temperature of the solution mixture.
13. Let the cylinder stand undisturbed for 2 hours. At the 2 hour mark, measure and record the hydrometer and temperature readings of the sample mixture as described in Step 11.
14. If a Fahrenheit thermometer was used during the procedure, convert all temperature readings to Celsius.

IV. Calculating Sand, Silt, and Clay

1. **Correct hydrometer readings for temperature:**
   a. Recall sample hydrometer and temperature readings. For each degree above 20 ^{o}C add 0.36 g L^{-1} to the hydrometer reading; for each degree below 20 ^{o}C subtract 0.36 g L^{-1} from the hydrometer reading (e.g. If hydrometer reads 35 g L^{-1} at 22 ^{o}C, the corrected hydrometer reading is 35.72 g L^{-1}). This should be done for each sample (soil checks and blanks included) at both time intervals.

2. **Calculate Silt+Clay Fraction:**
   a. Subtract the corrected blank hydrometer reading at 40 seconds from the corrected sample hydrometer reading at 40 seconds. This step accounts for any effect the dispersing solution may have had on the density of the solution mixture. Note: The values should be calculated using the blank ran on the corresponding day of the unknown samples.
   b. Divide the value calculated in step 2a by the sample weight then multiply by 100 to determine (%) silt+clay per liter of sample mixture.

3. **Calculate Clay Fraction**
   a. Subtract the corrected blank hydrometer reading at 2 hours from the corrected sample hydrometer reading at 2 hours.
   b. Divide the value calculated in step 3a by the sample weight then multiply by 100 to determine (%) clay per liter of sample mixture.

4. **Calculate Silt Fraction**
   a. Subtract percent clay from percent silt+clay.

5. **Calculate Sand Fraction**
   a. Subtract percent silt+clay from 100.

Example Calculation

Unknown sample weight: 50.00 grams
Corrected sample hydrometer reading at 40 seconds: 37.08 g L^{-1}
Corrected blank hydrometer reading at 40 seconds: $^{-}$0.28 g L^{-1}
Corrected sample hydrometer reading at 2 hours: 14.86 g L^{-1}
Corrected blank hydrometer reading at 2 hours: $^{-}$0.14 g L^{-1}

Silt + Clay = $\frac{37.08\ g/L - {}^{-}0.28\ g/L}{50.00\ g} \times 100 = 75\%$

Clay = $\frac{14.86\ g/L - {}^{-}0.14\ g/L}{50.00\ g} \times 100 =$ **30%**

Silt = 75% – 30% = **45%**

Sand = 100% – (30% + 45%) = **25%**

Textural Class: **Clay Loam**

Clean-up and Disposal

1. After recording values, dispose of all solution mixtures appropriately, by pouring into a settling bucket or a sink with a soil trap.
2. Rinse equipment thoroughly with DI water and allow to air-dry.

References

Gee, G.W and J.W. Bauder. 1986. Particle Size Analysis. In Methods of Soil Analysis, Part 1, Physical and Mineralogical Methods. Agronomy Monograph No. 9 (second edition). Soil Science Society of America, Madison, WI

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