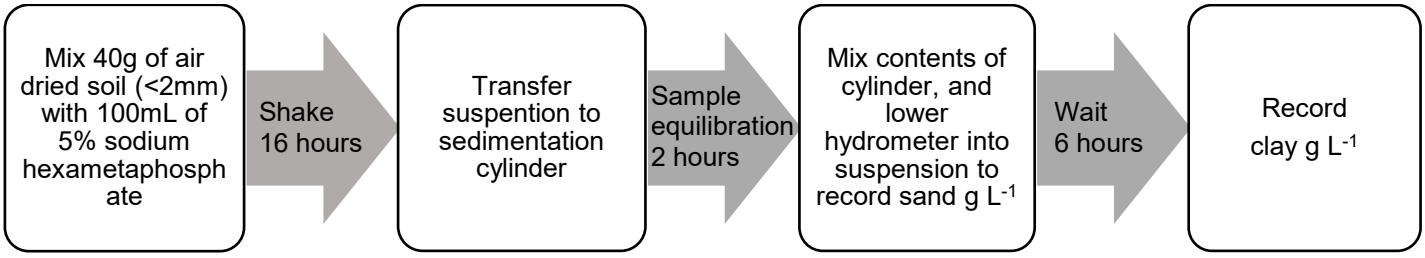
SOP: Particle Size Analysis for Soil Texture (Hydrometer Method)

Overview:

This standard operating procedure (SOP) describes a protocol for determining the relative proportion of sand, silt, and clay of a soil sample. The hydrometer method for particle size analysis calculates the proportion of the three size classes: sand (2000 – 50 µm), silt (50 – 2.0 µm) and clay (<2.0 µm) based on the particle's settling rates in an aqueous solution. The settling rates of particles are based on the principle of sedimentation described by Stokes Law. This method uses an ASTM standard E126 hydrometer (Figure 1), and it is based upon a standard temperature of 20 °C and a particle density of 2.64 g cm^{-3}. The final units are expressed as grams of soil per liter and can be converted to particle size percent (%). This method does not use H_2O_2 to remove organics in soil sample before analysis.



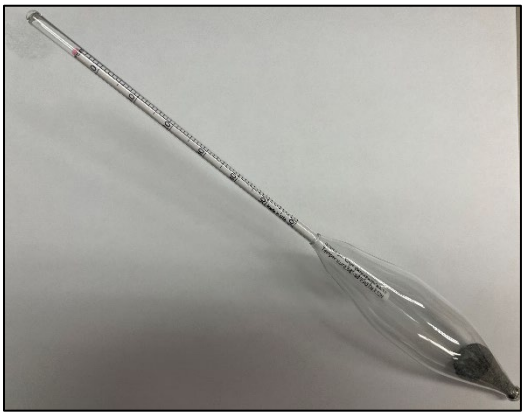


Figure 1. ASTM standard E126 hydrometer with Bouyoucos scale (g L^{-1})

Safety:

All standard safety protocols and online safety training via UIUC Division of Research Safety (DRS) are required.

Instrumentation & Consumables:

Hydrometer
- ASTM standard
- Bouyoucos scale (g L^{-1})

Sedimentation cylinder
- 1.0 L mark

Analytical scale
- Resolution ± 0.01

Reciprocating horizontal shaker

Shaker bottle
- Nalgene, polypropylene, glass
- 250 mL

Parafilm

Stopwatch

Reagents
- Alcohol
- 5% Sodium Hexametaphosphate (should be stable in solution at room temperature)
  - 1 L volumetric flask
  - Sodium hexametaphosphate $(NaPO_3)_6$
  - DI water

Detailed Procedure:

I. 5% $(NaPO_3)_6$
1. Calculate in advance how much 5% $(NaPO_3)_6$ reagent you will need for all samples.
   a. Each sample will require 100 mL of 5% $(NaPO_3)_6$
2. In a 1L volumetric flask, dissolve 50g $(NaPO_3)_6$ into 1L RO water.

II. Soil samples
1. Weigh 40 g of air-dried soil (>2mm) into 250mL shaker bottles.
2. Label sample shaker bottles using tape to identify after shaking.

III. Sample preparation
1. Add 100 mL of 5% $(NaPO_3)_6$ reagent to shaker bottles containing soil and firmly place cap.
2. Shake soil samples for 16 hours in a reciprocating horizontal shaker at 120 rpm (low).
3. Transfer the sample suspensions to sedimentation cylinders. Make sure the label on the sample matches the label on the cylinder.
4. Add RO water to cylinders with samples until the 1L mark.
5. Allow the suspension to equilibrate to room temperature for 2 hours.

IV. Hydrometer calibration

1. Add 100 mL of 5% $(NaPO_3)_6$ to a sedimentation cylinder.
2. Add RO water to 1L mark.
3. Carefully lower the hydrometer into the liquid and wait until it stops moving.
4. Record to the nearest ±0.5 g L^{-1} as “Control”.

V. Measurement with hydrometer

1. Cover top of cylinder with parafilm. Make sure the seal is tight. Use square piece of Styrofoam that covers the top of the cylinder as aid (See supporting information for reference pictures). Use plunger if available. Any method that prevents spilling is acceptable.
2. Hold the Styrofoam at the top of the cylinder with one hand and place other hand at the base of cylinder. Press Styrofoam to avoid leaks.
3. Shake the cylinder “end over end” until the sediment at the bottom of the cylinder is dislodged.
4. Place the cylinder on a flat surface and remove the parafilm seal.
5. If the suspension has foam, use a wash bottle to add alcohol until foam disappears.
6. Carefully lower the hydrometer into the suspension. After 30 seconds record to the nearest ±0.5 g L^{-1} as “MSand”.
7. Remove the hydrometer from the suspension. Rinse with water and pat dry with a kimwipe.
8. After 6 hours, measure the temperature of the suspension. Refer to Table 1 to determine the settling time for the <2.0 µm size fraction.
   NOTE: The settling time for clay in Table 1 includes the 6 hour wait. Use the table to estimate the additional time needed (or total time) for clay determination.
9. Carefully lower the hydrometer into the suspension. After 30 seconds record to the nearest ±0.5 g L^{-1} as “MClay”.
   Preferably use the same hydrometer that was calibrated before measuring “MSand”. If not, do a hydrometer calibration before measuring “MClay”
10. See section “VI. Calculation” to determine percent sand, silt, and clay and texture classification.

Table 1: Temperature of soil and 5%$(NaPO_3)_6$ and settling time for clay size fraction (<2.0 µm)

Suspension temperature (°C)	**Settling time for clay (<2.0 µm) (Hours and minutes)**
18	8:09
19	7:57
20	7:45
21	7:35
22	7:24
23	7:13

24	7:03
25	6:53
26	6:44
27	6:35
28	6:27

VI. Calculation

1. Sand (%)

$$\frac{Soil\ mass\ (g) - (MSand - Control)}{Soil\ mass\ (g)} \times 100$$

2. Clay (%)

$$\frac{MClay - Control}{Soil\ mass\ (g)} \times 100$$

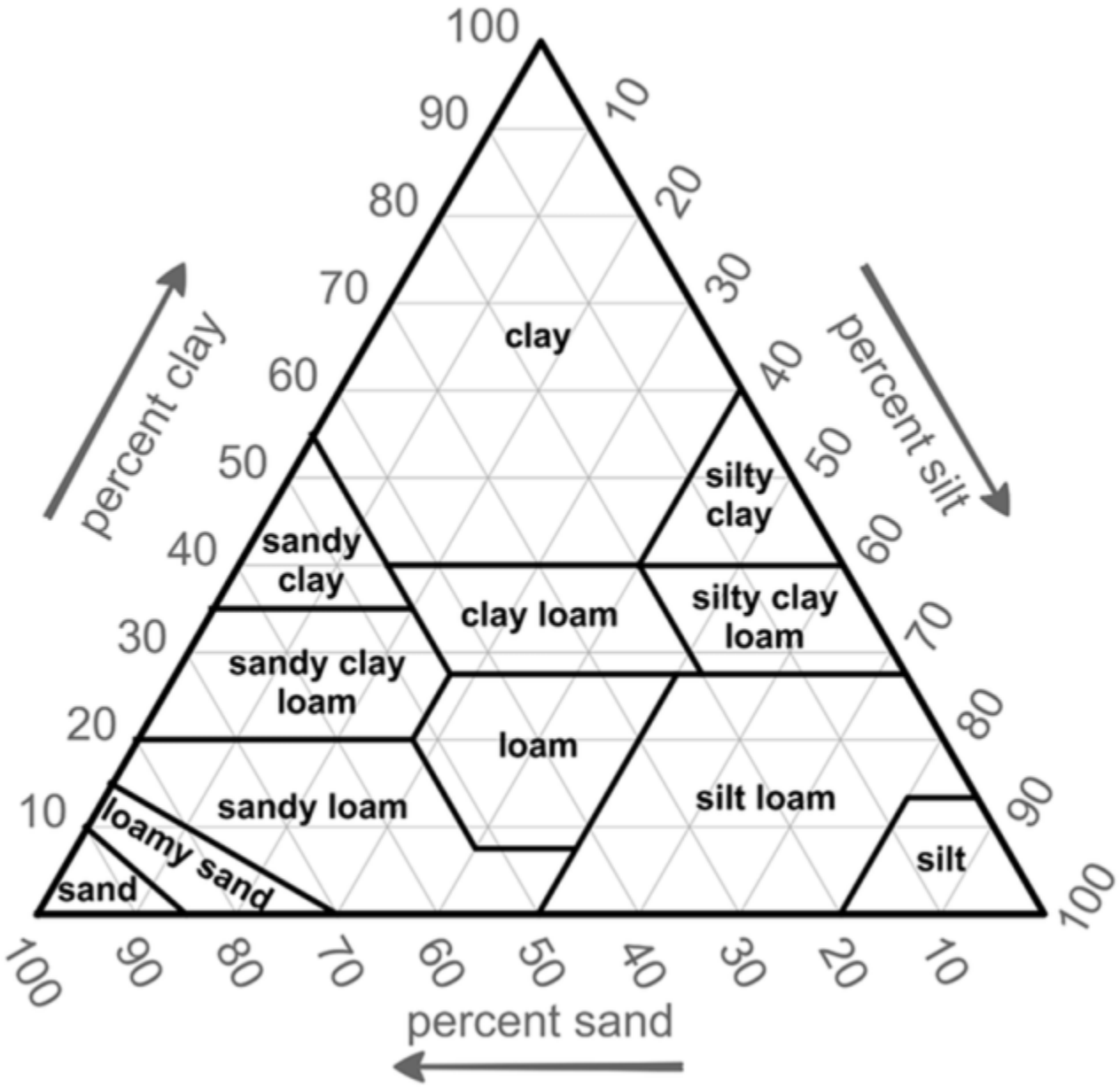
3. Silt (%)

$$100 - (Sand(\%) + Clay(\%))$$

VII. Clean up

1. Make sure to rinse the hydrometer after use and before storing it.
2. Suspension can be disposed in the drain.

After estimating the proportion of sand, silt and clay in a soil sample, the texture class can be determined using the NRCS Soil Texture Calculator or Soil Textural Triangle https://www.nrcs.usda.gov/resources/education-and-teaching-materials/soil-texture-calculator



References

Gavlak, R., D. Horneck, and R. Miller. 2005. Plant, soil and water reference methods for the Western Region. Western Regional Extension Publication (WREP) 125, WERA-103 Technical Committee, http://www.naptprogram.org/files/napt/western-states-method-manual-2005.pdf.

Citation:

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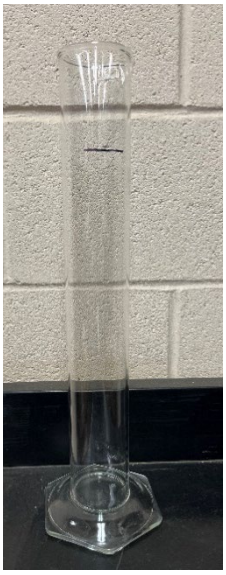
Supporting information

Supporting Figure 1.
Example of 250 mL Nalgene shaker bottle.



Supporting Figure 2.
Example of a sedimentation cylinder with a 1L mark.

Supporting Figure 3.
Example of parafilm wrap on sedimentation cylinder.

Supporting Figure 4.
Example of parafilm wrap and Styrofoam.