On-Site Wastewater Treatment Systems

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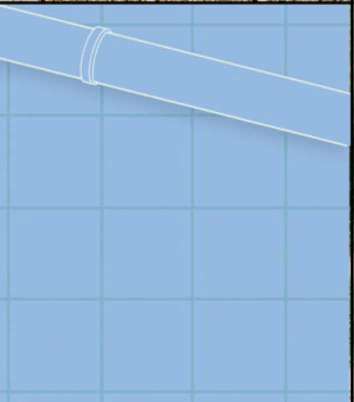
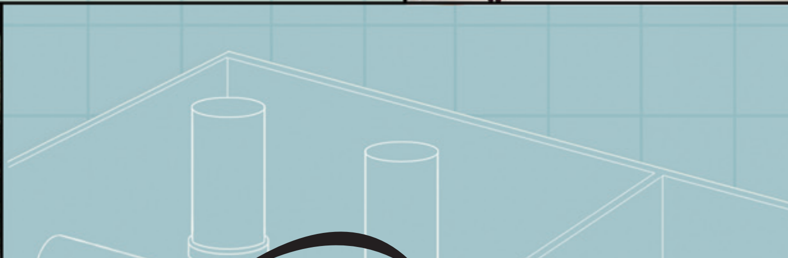
Soil Particle Analysis Procedure





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On-Site Wastewater Treatment Systems: Soil Particle Analysis Procedure

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Contents

Soil is an important component of an on-site wastewater treatment system. The soil makes the final treatment of the wastewater. Treatment is effective when the soil holds the wastewater long enough for microbes to remove contaminants. Aerobic microbes need air to survive. The amount of air in soil depends on the size of soil particles. Soil particle analysis determines the size of soil particles and can be used to estimate the soil's ability to hold and treat wastewater.

The Composition of Soils

A soil suitable for wastewater treatment will have four components: inorganic material, organic material, air and water (Fig. 1). The soil will also contain microbes.

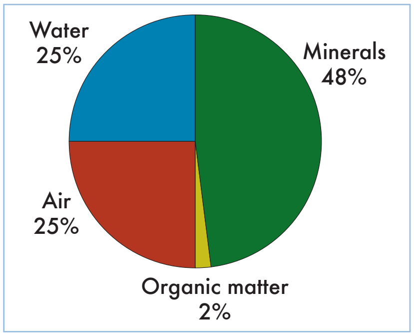


Figure 1. Components of soil.

Inorganic materials

Most soils in Texas are dominated by inorganic or mineral materials such as clays, sands and silts. Silicon, oxygen and aluminum are the main elements in the "aluminosilicate" minerals that make up most of the inorganic material of soils. Quartz, which is mainly silicon and oxygen, is also a very common mineral. The particle size of the minerals is an important soil characteristic with respect to wastewater treatment.

Organic materials

Purely organic soils are rare in Texas. Most soils contain less than 2 percent organic matter. It is concentrated in the topsoil, mostly in the form of humus (fully decayed plant and animal matter). Although most soils do not contain much humus, it has a very large effect on many soil properties.

Air and water

These can account for up to 50 percent of the volume of soils. The amounts of air and water in a soil depend on the "porosity" or amount of pore space in that soil. Soil pore space relates to the size of soil particles. Soils with mostly clay-size particles have greater porosity (up to 50 percent), while soils dominated by large particles such as sand and gravel have a lower porosity (closer to 35 percent). The distribution of air and water in the soil pores also relates to the soil particle size. Soils with mostly clay-size particles have smaller pores that hold more water than air. Soils with larger particles have larger pores that do not hold water as well and, thus, have a greater volume of air than water.

Microbes

Microbes may make up a very small part of the soil on a weight basis, but they are a very active part. A single gram of soil may easily contain hundreds of millions of live bacterial cells, a million fungal spores, and a host of other microbes such as algae and protozoa. Microbes are a key component of a soil's ability to treat waste.

Particles in the Soil

Soil particles of the inorganic materials are categorized by size. The finer sizes are less than 2 mm, while the rock fragments or gravel are larger than 2 mm (Table 1).

Table 1. Soil particle sizes (USDA, 1993).

Soil particle	Particle diameter
Gravel	> 2.0 mm
Sand	0.05 – 2.0 mm
Silt	0.002 – 0.05 mm
Clay	> 0.002 mm

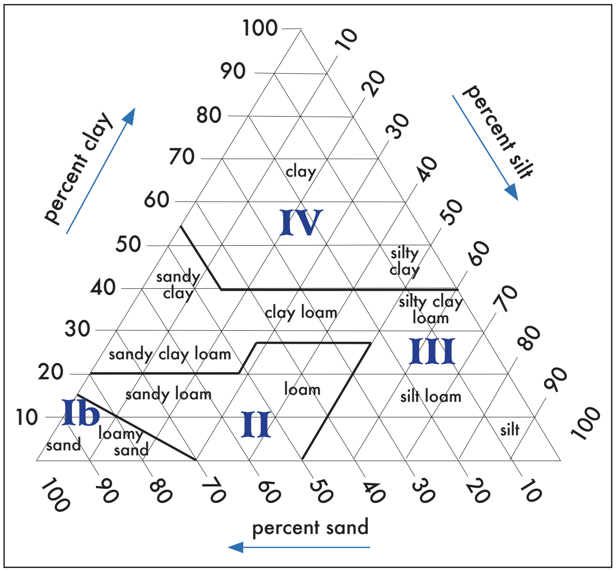


Figure 2. Soil textural classification. (Source: Texas Commission on Environmental Quality, 2005.)

Soil texture

The finer particle sizes are divided into sand (0.05 to 2.0 mm), silt (0.002 to 0.05 mm) and clay (less than 0.002 mm). Soil texture is determined by the relative quantities of these materials, and only these materials. There are 12 textural classifications as described in the textural triangle (Fig. 2). Note that gravel (larger than 2.0 mm) is not included in the definitions of soil texture.

A soil's ability to hold and treat wastewater relates to its texture. The textural triangle is divided into four different on-site wastewater treatment system (OWTS) classes (Ib, II, III, IV). These classes are defined in wastewater regulations. They determine the wastewater loading rate to soils and the type of pretreatment and distribution system required.

Rock fragments or gravel

Rock fragments are pieces of rock more than 2 mm in diameter. Rock fragments are described by their shape, size and the material from which they were formed. The classes of rock fragments include pebbles, cobbles, stones, boulders, channers and flagstones (Table 2). The first way to separate rocks is by shape—round or flat. The round rocks are divided into pebbles, cobbles, stones and boulders. The pebbles category is further divided into fine, medium and coarse based on the diameter of the pebbles. Regulations for on-site wastewater treatment systems (Texas Commission on Environmental Quality, Chapter 285) set the differentiation point for gravel as fine pebbles, or gravel with a diameter of 2 to 5 mm. A 2-mm particle is separated with a "number 10" sieve having a 2-mm opening, while a 5-mm particle is separated with a "number 4" sieve having a 4.76-mm opening (Table 3) (Fig. 3).

Table 2. Terms for rock fragments.

Shape[1] and size	Noun	Adjective
Spherical, cubelike or equiaxial:		
2 to 75 mm diameter	Pebbles	Gravelly
2 to 55 mm diameter	Fine	Fine gravelly
5 to 20 mm diameter	Medium	Medium gravelly
20 to 75 mm diameter	Coarse	Coarse gravelly
75 to 250 mm diameter	Cobbles	Cobbly
250 to 600 mm diameter	Stones	Stony
≥600 mm diameter	Boulders	Bouldery
Flat:		
2 to 150 mm long	Channers	Channery
150 to 380 mm long	Flagstones	Flaggy
380 to 600 mm long	Stones	Stony
≥600 mm long	Boulders	Bouldery

[1] The roundness of fragments may be indicated as angular (has strongly developed faces with sharp edges), irregular (has prominent flat faces with some rounding of corners), subrounded (has detectable flat faces with well-rounded corners), and rounded (has no or almost no flat faces or corners). (Source: USDA, 1993.)

Table 3. Standard sieve size associated with gravel particle size analysis.

Sieve number	Size of opening (mm)
4	4.76*
10	2

*This standard sieve opening represents 5-mm gravel.

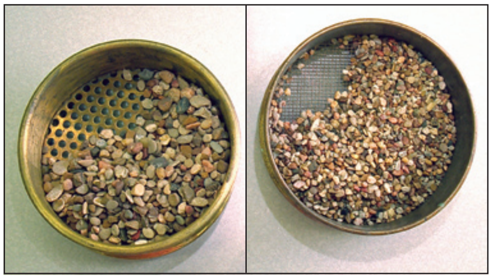


Figure 3. Number 4 sieve (left) with particles larger than 5 mm and number 10 sieve (right) with particles larger than 2 mm but smaller than 5 mm.

Soil and the On-Site Wastewater Treatment System

The suitability of a soil for a standard subsurface disposal system in Texas is based on the total volume and size of the gravel present and the soil texture (Table 4). In determining the volume of gravel, two specific size ranges are evaluated: gravel 2 to 5 mm in diameter (Fig. 4) and gravel larger than 5 mm in diameter (Fig. 5). The suitability of different soil textures is described in Table 4.

Table 4. Criteria for standard subsurface soil absorption systems.

Factors	Suitable (S)	Unsuitable (U)
Gravel analysis (% gravel by volume)	In Class II or III soils, only: soil contains less than 30% gravel; or soil contains more than 30% gravel and 80% of the gravel is smaller than 5.0 mm.	All other Class II or III soils that contain more gravel than is described as suitable. All other soils with more than 30% gravel.
Soil texture	Class Ib, II or III soils along the sidewall and 2 feet below the bottom of the excavation.	Class Ia* soils along the sidewall or within 2 feet below the bottom of the excavation. Class IV soils along the sidewall or within 2 feet below the bottom of the excavation.

*Class Ia soil is a class I soil containing more than 30 percent gravel. (Source: Texas Commission on Environmental Quality, 2005).

Soil Texture Analysis

Soil texture can be determined fairly accurately in the field by the "feel" method (see Worksheet A). To learn to do this, one can use soil samples whose texture has been measured in a laboratory. The "feel" of a soil texture varies with mineralogy, so laboratory-measured samples can help one learn the feel of soils in a particular region.

One laboratory analysis method of determining the quantity of sand, silt and clay in soil is called the Bouyoucos Hydrometer method (see Worksheet B). This procedure requires more time than the field method but is more accurate. This laboratory method can be used in combination with the field technique to calibrate one's fingers for soils local to your area.

The way a soil sample is collected affects the accuracy of the test. Soil samples should be collected from each soil horizon to determine the soil profile.

Figure 4. Separation of particles larger than 2 mm but smaller than 5 mm.

Figure 5. Gravel particles larger than 5 mm from soil sample.

Gravel Analysis

The first step in determining the quantity of gravel in soil is separating the sample into material less than and greater than 2 mm (Fig. 6). The sample is passed through a 2-mm sieve and the volume or percent of fine material is determined. If the volume of gravel is more than 30 percent of the total sample, an additional evaluation is required for Type II and III soils to determine the volume of gravel greater than 5 mm in diameter.

Figure 6. Particle size separation using a number 4 sieve on top of a number 10 sieve.

Three different approaches can then be used to determine the relative volume of the sample that is less than and greater than 5 mm in diameter:

- volume;
- water displaced by gravel; and
- weight.

Volume measurement

Volume measurement is used when the rock fragments are relatively small. The sample is placed in a container with volumetric marks and the volume of gravel is read from the graduated markings. The pore spaces between the gravel must be small to allow for an accurate reading.

Water displaced by gravel

This method can be used on rock fragments that do not dissolve or slake. The gravel is placed in a volumetric container that is then filled with water to a predetermined level. The water is then poured into another container and its volume measured. The volume of water is subtracted from the total volume to get the volume of gravel.

Weight

The sieved portions of the gravel are weighed separately to determine the relative percent of gravel less than 5 mm in diameter. The weight method assumes that all the gravel in the system has the same density. Therefore, if your sample has different types of rocks of different densities, measuring the volume of the gravel this way may not be accurate.

Professional judgement is needed to select the most appropriate of these methods for each site. Each method has limitations. Because gravel size can vary considerably, the main limitation is the quantity of gravel to be evaluated. If the rock fragments are fairly large, the sample size may need to be as much as 110 to 130 pounds of material (USDA, 1993).

Summary

The soil is an essential component of an on-site wastewater treatment system. Properly analyzing the soil particle sizes is key to determining the suitability of a site for wastewater treatment. The criteria for determining the size of a treatment system also are tied to soil particle size distribution.

The worksheets that follow give examples of conducting various kinds of soil analysis.

References

Milford, Murray H. 1997. Introduction to Soils and Soil Science Laboratory Exercises. Kendall/Hunt Publishing Company, Dubuque, Iowa.

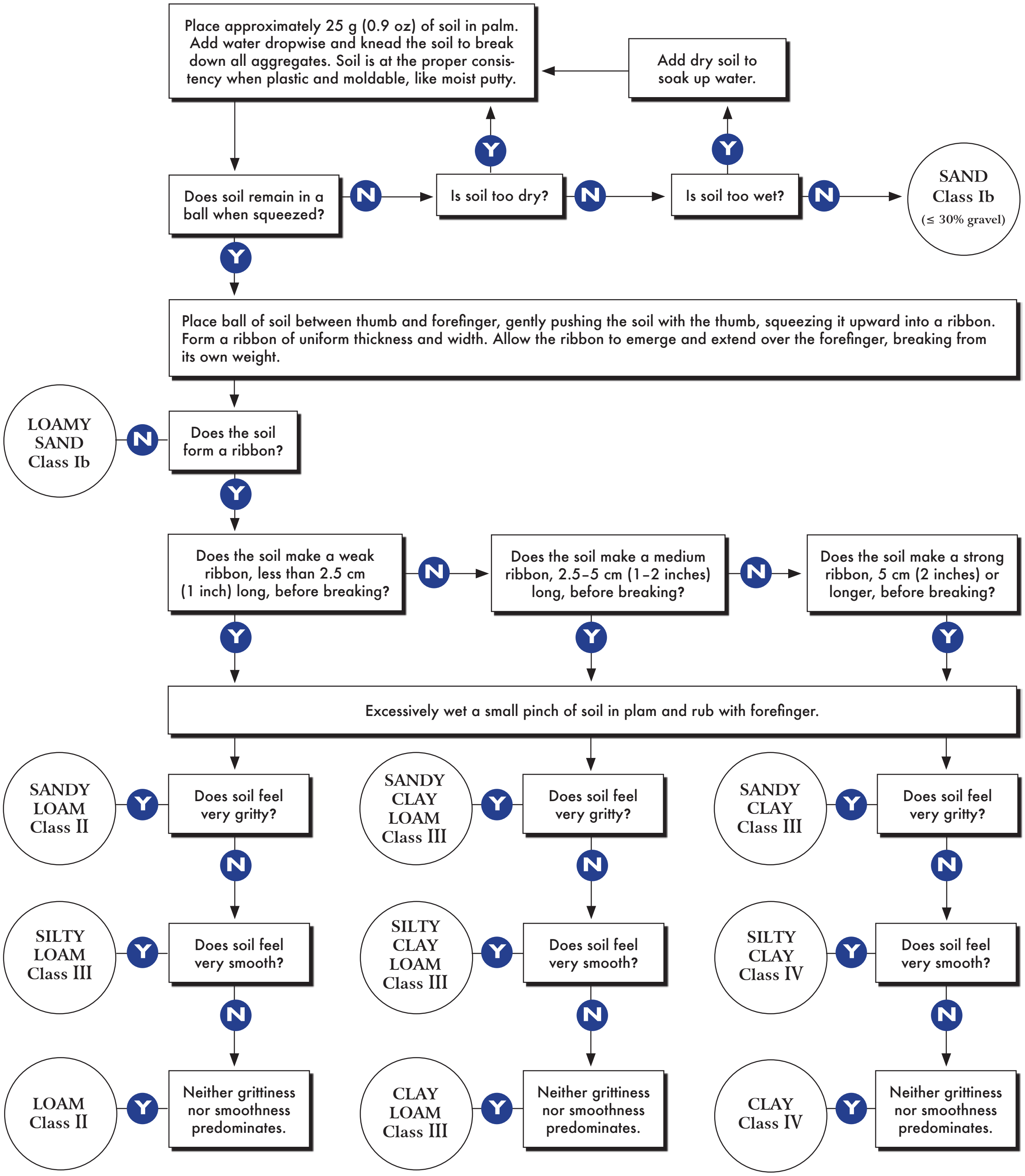
Texas Commission on Environmental Quality. 2005. On-site sewage facilities. 30 TAC Chapter 285. January 6, 2005.

Thein, S.J. 1979. A Flow Diagram for Teaching Texture-by-feel Analysis. *Journal of Agronomic Education*. 8:54-55.

U.S. Department of Agriculture. 1993. Soil Survey Manual. Handbook No. 18. Washington, D.C.

Worksheet A: Determining Texture by the “Feel” Method (modified from Thein, 1979).

Soil Texture



Texture by Feel

To prepare a sample for texturing, place 1 heaping tablespoon of soil in the palm of one hand. Use the other hand to crush large aggregates; remove rocks, roots and other debris from the sample; and apply water to the sample. Do not attempt to determine texture on dry soil material. Enough water should be added to the sample to make it very wet, but not soupy. To estimate the texture, rub the wet sample between the thumb and fingers while feeling the stickiness, grittiness, smoothness and other characteristics. Also determine how well the sample holds together.

Continue to rub the sample between the fingers until it becomes too dry to manipulate easily. This requires only a few minutes and is necessary for accurate texture estimation. While the sample is being rubbed, first estimate the clay content and then the silt and sand content.

For sandy soils, a "cast" or "mold" can be made by grasping the sample with the thumb and index and middle fingers (Fig. A1). Then raise the cast about 10 to 12 inches in one hand and drop it into the palm of the other hand (Fig. A2). The ability of the sample to retain its shape is related to its clay content. The higher the clay content, the more resistant the cast is to shattering.

Figure A1. Class Ib soil (Loamy sand—2 percent clay, 85 percent sand, 13 percent silt) forming a cast.

Figure A2. Dropped cast of Class Ib soil (Loamy sand—2 percent clay, 85 percent sand, 13 percent silt).

For finer textures, force the soil material into a "ribbon" by applying pressure and sliding the material between the thumb and index finger (Figs. A3-A7). In general, the finer the texture, the longer, thinner and stronger the "ribbon" will be before it breaks.

Other techniques may be used in conjunction with these to help determine texture. Use the combination of practices that works best for you. There is no substitute for practicing these techniques on samples of known texture to become proficient at estimating soil texture in the field.

Verbal descriptions of soil textures are always inadequate because it is primarily the individual's sense of "feel" that must be educated. However, the following descriptions of general characteristics may be helpful.

OWTS Class Ib: Class Ib soil is loose and single-grained. The individual sand grains are easily seen, and the feel is gritty. Squeezed when dry, aggregates readily fall apart into single-grained particles. Squeezed when moist, the soil will form a cast (Fig. A1), but the cast will crumble when touched or when dropped from one hand into the palm of the other hand (Fig. A2).

OWTS Class II: Class II soils cover a wide range. Some contain large amounts of sand but also have enough silt and clay to form clods when dry and hold together when moist. Some are a fairly equal mixture of sand, silt and clay. Squeezed when dry, the aggregates will fall apart; squeezed when moist, a cast can be formed that will bear careful handling without breaking. A dropped cast shows more stability than with sands. The soil will be soft but not sticky or shiny. Rubbed between the thumb and finger, the sample holds together and will either feel gritty and will not ribbon well, or will feel neither gritty nor smooth and will make a weak ribbon before breaking (Fig. A3). In the case of the latter, the soil will have some sand, but not a lot.

OWTS Class III: Soils of this class range from a relatively even mixture of sand and clay to a mixture that seems soft, smooth, non-gritty and slightly plastic. Squeezed when relatively moist, it will form a cast that can be handled quite freely without breaking. When the moist sample is kneaded in the hand, it does not crumble readily. When moist soil is squeezed between thumb and finger, the ribbon formed can either be a weak ribbon that will have a broken, almost "scaly" appearance (Fig. A4) or a medium-length ribbon that will break readily, barely sustaining its own weight (Fig. A5). The ribbon will have a smooth, doughy or slightly slick feel. When dry, it may appear cloddy and may break into hard lumps. When pulverized, it feels soft and floury.

OWTS Class IV: Class IV soils usually form hard lumps or clods when dry and are plastic and very sticky when wet. When the moist soil is pressed out between the thumb and fingers, it will generally form a long, thin, flexible ribbon (Figs. A6 and A7). The ribbon is durable and its surface may appear slick and shiny.

Other Considerations

Kinds of clay: Certain types of clay tend to be stickier than others. To be as accurate as possible in field determinations, become familiar with the types and feel of the clay minerals in the soils of the area being studied.

Organic matter: Organic matter, which is especially prevalent in surface soil horizons, tends to cause errors in estimating the clay content of samples. Organic matter gives a soil sample a smooth, slick, non-sticky feel. In sandy soils, organic matter leads to an overestimation of clay content because it binds the sand particles together. If the presence of organic matter is suspected (it imparts a dark color to the soil), make appropriate adjustments when estimating clay content.

Amorphous material: Soils formed from volcanic ash or pumice frequently contain large amounts of amorphous materials. These are rare in Texas. These materials cause difficulty in texturing because the particles contained in the sample continually break down as the sample is rubbed. Therefore, the estimated texture depends on how long and how hard a sample is rubbed. Amorphous materials impart a "greasy" feel to samples and make them seem to become wetter the longer they are rubbed or kneaded in the hand.

Figure A3. Class II soil (Sandy loam—17 percent clay, 64 percent sand, 19 percent silt).

Figure A4. Class III soil (Silt loam—16 percent clay, 19 percent sand, 65 percent silt).

Figure A5. Class III soil (Silty clay loam—31 percent clay, 18 percent sand, 51 percent silt).

Figure A6. Dark Class IV soil (Clay—52 percent clay, 11 percent sand, 37 percent silt).

Figure A7. Red Class IV soil (Silty clay—48 percent clay, 6 percent sand, 46 percent silt).

Excessive salts: Large amounts of calcium carbonate, gypsum or other salts tend to cause problems in determining soil textures. Some salts lead to an underestimation of clay content because they reduce the stickiness of clays and dilute the volume of silicate mineral matter. However, in some cases, the calcium carbonate crystals are clay-sized and cannot be distinguished by feel from clay particles. This leads to an overestimation of clay content. Sodium salts tend to make soil particles disperse, which also can lead to a higher estimate of clay content. For maximum accuracy, become familiar with the particular salt present in a sample and its effect on texture estimation. Comparing field determinations of texture with laboratory analyses of the same samples is an excellent approach.

Worksheet B: The Bouyoucos Hydrometer Method for Particle Size Analysis.

This method is one of the simplest and fastest for analyzing the particle size of soils. A dispersed sample of soil is thoroughly mixed with water in a tall glass cylinder and allowed to settle. After selected settling times, the density of the suspension is measured with a hydrometer. To understand the basis for the method, consider an imaginary plane some distance below the surface of the soil-water mixture. The time required for a given size of particle, say 0.05 mm in diameter, to fall from the surface of the water to this plane can be calculated. When this time has elapsed all particles 0.05 mm in diameter and larger (because these will fall faster) will be below the plane. Immediately above the plane the concentration of particles smaller than 0.05 mm will be the *same as the concentration of these particles in the entire suspension before sedimentation began.* Measuring the concentration in this plane makes it possible to calculate the total mass of particles smaller than 0.05 mm, assuming that the volume of water in the cylinder is known. By selecting appropriate time periods, the weight of particles smaller than any desired size limit can be determined. Bouyoucos hydrometers are calibrated to measure grams of particles per liter of soil suspension. After a settling time of 40 seconds, the buoyant force on the hydrometer is due to a concentration of clay and silt equal to that in the imaginary plane as described above. Because sand particles are the largest, any sand in the soil sample has settled below the plane after 40 seconds. This leaves only clay and silt suspended in the water. Since silt particles settle below the plane after 2 hours, the buoyancy on the hydrometer is determined by a concentration of particles equal to that of the clay particles throughout the suspension at time zero.

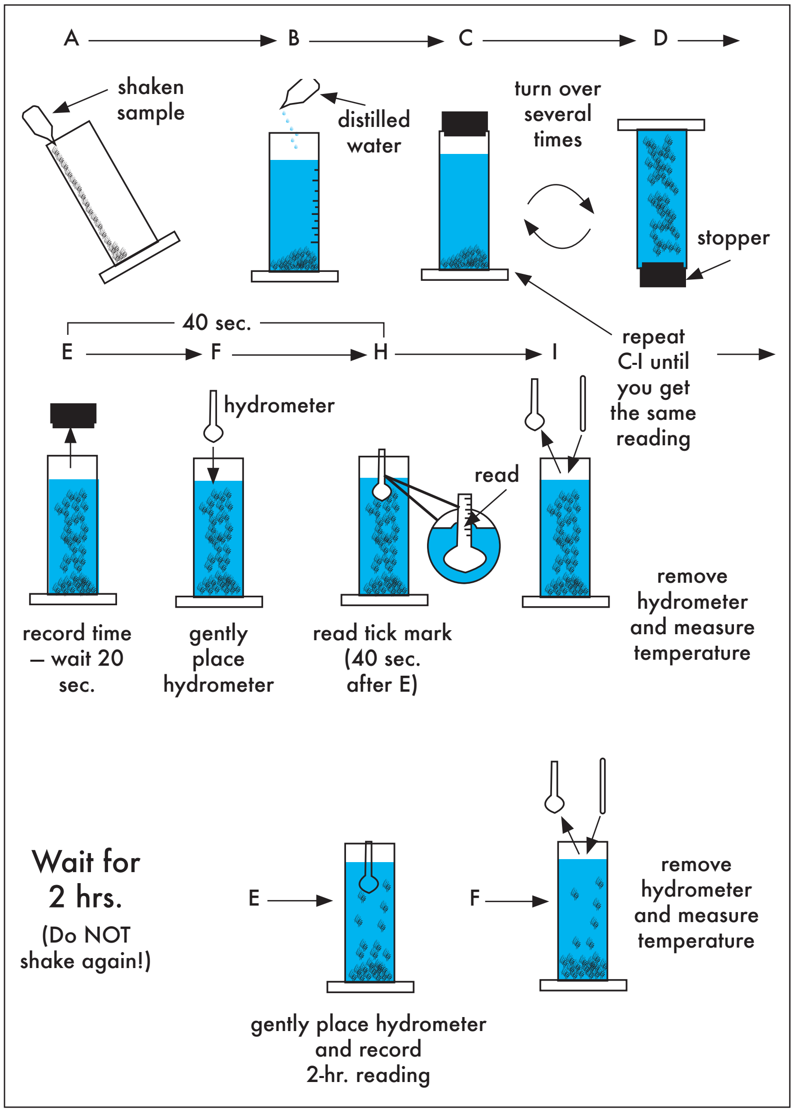


Figure B1. Bouyoucos hydrometer method.

The hydrometer is calibrated at 20 degrees C (68 degrees F). Hydrometer readings must be corrected for variations in temperature because the viscosity of water and, to a lesser extent, the density of water change as the temperature changes.

Materials List

Standard soil analysis equipment required for the determination of soil texture.

Dispersant
Graduated cylinder
Hydrometer
Mixer
Mortar and pestle
Oven
Scale
Shaker bottles
Sieve
Stopper
Thermometer
Wash bottle
Weighing dish

Procedure

The hydrometer method is a fairly accurate method for determining the particle size distribution of a soil sample. The following step-by-step procedure assumes you have already collected your soil samples and are ready to analyze them.

1. Place an air-dry sample of soil in a shaker bottle (a glass or plastic 8- or 12-ounce bottle). Weigh sample and record weight before placing sample in the bottle. Use 100 grams of soil if the sample is a sand. Use 50 grams of soil for all other soil types.
2. Add 2.0 grams of sodium metaphosphate (or sodium hexametaphosphate), which is a dispersant. Adding it will break up any aggregates in the soil sample. This ensures that smaller silt and clay particles will not bind to each other, which would allow them to settle as if they were sand particles.
3. Add **distilled** water until the bottle is two-thirds full.
4. Cap the bottle and shake in a mechanical shaker for at least 4 hours. Alternately, agitate for 5 minutes using a stirrer (Malt Mixer type). If a shaker or mixer is not available, the sample may be shaken by hand every few hours over a 2-day period.
5. Soil moisture correction:
   Weigh 10 grams of soil. Oven dry for 24 hours at a temperature of 105 degrees C. Re-weigh soil when slightly cooled and use the following relationship for correcting the weight of soil added to the system:

   $$MCF = 1 - [(AD - OD) \div AD]$$

   Where: MCF = Moisture Correction Factor
   AD = air-dry weight
   OD = oven-dry weight
6. Transfer soil from the bottle into a settling cylinder. To do this, thoroughly mix contents of bottle by shaking; quickly invert bottle at an angle over the mouth of the cylinder and remove the cap. Rinse remaining soil from bottle and cap into cylinder using distilled water from a wash bottle. Take care to remove all particles from the bottle with no loss.
7. For cylinders marked at 1130 ml and 1205 ml, respectively, add distilled water to within 3 inches of the lower graduation on the cylinder. Insert the hydrometer, bulb end down, and fill the cylinder to the lower graduation (1130-ml line) if a 50-gram sample is being used, or to the upper graduation (1205-ml line) if a 100-gram sample is being used. (Always hold the bulb end of the hydrometer except when it is held vertically for inserting or removing from the cylinder.) After filling to the desired mark, remove the hydrometer from the cylinder.
8. For cylinders marked at 1000 ml only, fill the cylinder to the mark with distilled water without inserting the hydrometer.
9. Stopper the cylinder, turn end-over-end several times, return to upright position, record the time, and place gently in a selected place. It must remain in the location for at least 2 hours undisturbed so avoid places where the cylinder might get bumped or tipped over, or where the temperature may fluctuate greatly.

10. Wait about 20 seconds after end-over-end shaking is complete, then insert the hydrometer into the suspension gently. If a foam persists on the surface of the suspension, add one or two drops of iso-amyl alcohol to break the surface tension. *Read the hydrometer exactly 40 seconds after the cylinder is returned to an upright position.* Remove the hydrometer and repeat steps 9 and 10 until a consistent hydrometer reading is obtained. Record the 40-second hydrometer reading in the data table.
11. Remove the hydrometer. Use a thermometer to measure the temperature of the suspension. Record the temperature. Let the cylinder sit undisturbed for 2 hours.
12. Obtain hydrometer reading after a settling period of 2 hours. Be careful not to resuspend the soil by shaking the cylinder again. Measure the temperature. Record temperature and hydrometer reading in the data table.

(Procedure adapted from Milford, 1997.)

Calculations

The calculations required to determine the textural classification can be divided into two separate sections: soil sample weight and particle size analysis. The soil sample weight is determined by using the air-dry soil weight and the moisture correction factor.

Determining Soil Moisture Correction Factor

1. Pan weight ____________
2. Weight of pan plus air-dry soil ____________
3. Weight of pan plus oven-dry soil ____________
4. Determine weight of air-dry soil (AD)
   AD = Weight of pan plus air-dry soil – pan weight
   AD = ________ – ________ = ________
5. Determine weight of oven-dry soil (OD)
   OD = Weight of pan plus oven-dry soil – pan weight
   OD = ________ – ________ = ________
6. Determine soil moisture correction factor (MCF)
   MCF = 1 – [(AD – OD) ÷ AD)]
   MCF = 1 – [(____ – ____)÷____)]
   MCF = _______

Determining Weight of Dry Soil

The weight of dry soil is determined by multiplying the air-dry weight by the moisture correction factor (MCF).

Weight of Dry Soil = Air-dry Soil x MCF

Correcting Hydrometer Reading

For temperatures above 20 degrees C:
Hydrometer reading =
Measured reading g/l + [(measured temperature – 20) x 0.36 g/l]

For temperatures below 20 degrees C:
Hydrometer reading =
Measured reading g/l – [20 – (measured temperature) x 0.36 g/l]

To correct the hydrometer readings for temperature, add 0.36 gram/liter for every 1 degree C above 20 degrees C; subtract 0.36 gram/liter for every 1 degree C below 20 degrees C.

Determining Percent Sand, Silt and Clay

$$\% \text{ clay} = \frac{\text{Corrected 2-hour hydrometer reading x 100}}{\text{Oven-dry Weight of Soil}}$$

$$\% \text{ silt plus clay} = \frac{\text{Corrected 40-second hydrometer reading x 100}}{\text{Oven-dry Weight of Soil}}$$

$$\% \text{ sand} = 100 - \% \text{ silt plus clay}$$

Hydrometer Texture Analysis Data Table

Sample number	*Example 1*	*Example 2*
Air-dry weight of sample (g)	50 g	50 g
Weight of dry sample (g)	48 g	46 g
40-second hydrometer reading (g/1)	11 g/1	13 g/1
Temperature	26 degrees C	25 degrees C
Corrected 40-second reading (g/1)	13.16 g/1	14.8 g/1
Percent sand	72	68
2-hour hydrometer reading (g/1)	9 g/1	4 g/1
Temperature	21 degrees C	23 degrees C
Corrected 2-hour reading (g/1)	9.36 g/1	5.08 g/1
Percent clay	20	11
Percent silt	8	21
Textural class name	sandy clay loam	sandy loam

Hydrometer Texture Analysis Data Table

Sample number		
Air-dry weight of sample (g)		
Weight of dry sample (g)		
40-second hydrometer reading (g/1)		
Temperature		
Corrected 40-second reading (g/1)		
Percent sand		
2-hour hydrometer reading (g/1)		
Temperature		
Corrected 2-hour reading (g/1)		
Percent clay		
Percent silt		
Textural class name		

Calculations (Example 1)

To correct the hydrometer readings for temperature, add 0.36 gram/liter for every 1 degree C above 20 degrees C; subtract 0.36 gram/liter for every 1 degreee C below 20 degrees C.

40-second hydrometer reading = 11 g/l + (6 x 0.36 g/l) = 11 + 2.16 = 13.16

$$\% \text{ silt plus clay} = \frac{13.16 \text{ x } 100}{48} = 28$$

2-hour hydrometer reading = 9 g/l + (1 x 0.36 g/l) = 9 + 0.36 = 9.36

$$\% \text{ clay} = \frac{9.36 \text{ x } 100}{48} = 20$$

% sand = 100 – 28 = 72

% silt = 28 – 20 = 8

Textural class = Sandy Clay Loam
Onsite Class III Soil

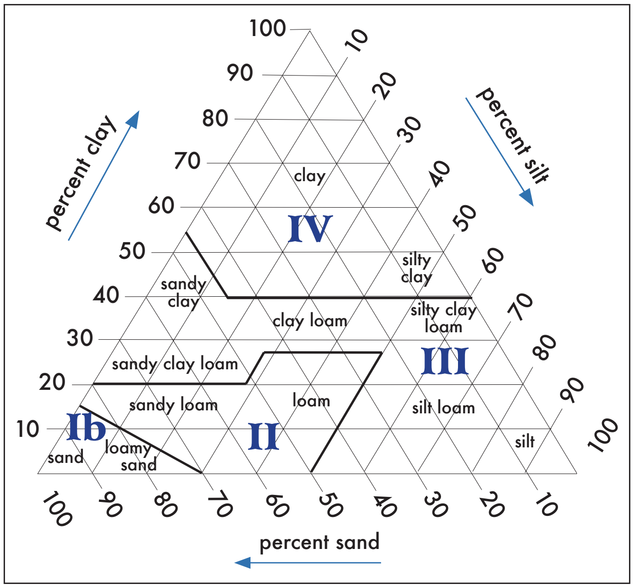


Figure B2. Soil textural classification with on-site classes.

Calculations (Example 2)

To correct the hydrometer readings for temperature, add 0.36 gram/liter for every 1 degree C above 20 degrees C; subtract 0.36 gram/liter for every 1 degree C below 20 degrees C.

40-second hydrometer reading = 13 g/l + (5 x 0.36 g/l) = 13 + 1.80 = 14.8

$$\% \text{ silt plus clay} = \frac{14.8 \text{ x } 100}{46} = 32$$

2-hour hydrometer reading = 4 g/l + (3 x 0.36 g/l) = 4 + 1.08 = 5.08

$$\% \text{ clay} = \frac{5.08 \text{ x } 100}{46} = 11$$

% sand = 100 – 32 = 68

% silt = 32 – 11 = 21

Textural class = Sandy Loam
On-Site Class II Soil

Worksheet C: Gravel Analysis Procedure

The gravel criteria in the on-site wastewater treatment regulations are based on the percentage of soil volume filled with gravel. A sieve analysis method can be used to evaluate the volume of gravel in the soil. This is accomplished indirectly by measuring the volume of sample less than 2 mm.

1. Collect a soil sample and thoroughly mix it to allow the finer material to freely flow through a sieve.

2. Pour a specific quantity of soil into a container. A container with graduated marks will make measurements easy to record.

3. Separate the soil into fine material and gravel by passing the soil sample through a 2-mm sieve.

4. Pour the fine material (less than 2 mm) back into the graduated container to determine the volume of fine material.

5. Separate the fine gravel from the larger gravel by pouring the material greater than 2 mm through a 5-mm sieve.

6. Determine the percent of gravel less than 5 mm in diameter using the volume, water displacement or weight method.

    6a. Using volume to determine percent gravel: Pour the fine gravel into the volumetric container and read the volume of gravel directly. Then calculate the volume of gravel greater than 5 mm and the percent gravel less than 5 mm.

    6b. Using water displacement to determine percent gravel: Pass all the gravel through the 5-mm sieve. Pour the gravel less than 5 mm into a graduated container and then cover the gravel with water. Record the total volume of water and gravel. Pour the water into another graduated container and record the volume of water. Subtract the volume of water from the volume of water and rock to obtain the volume of rock. Repeat the steps above for the rock greater than 5 mm. Then divide the volume of rock less than 5 mm by the sum of the rock less than 5 mm and greater than 5 mm and multiply this value by 100 to get the percent rock less than 5 mm.

    6c. Using weight to determine percent gravel: Weigh all the gravel retained on the 2-mm sieve and weigh the quantity of fine gravel (2 to 5 mm). Divide the weight of fine gravel by the total weight of gravel.

Gravel Analysis Data Sheet, Volume

Job number: ______________________ Sample no: ______________________

Customer name: ______________________ Date: ______________________

Address: ______________________

____

Sample location: ______________________

____

____

Sample description: ______________________

____

____

Sample name	1	2	3
Sample volume, ml			
Volume passing 2-mm sieve, ml			
Volume retained on 2-mm sieve, ml[1]			
Volume between 2 and 5 mm, ml			
% gravel in sample[2]			
% gravel less than 5 mm[3]			

[1] (Sample volume – Volume passing 2-mm sieve)

[2] [(Sample volume – Volume passing 2-mm sieve) ÷ Sample volume] x 100

[3] [(Volume between 2 and 5 mm ÷ (Sample volume – Volume passing 2-mm sieve)] x 100

Gravel Analysis Data Sheet, Water Displacement

Job number: ______________________ Sample no: ______________________

Customer name: ______________________ Date: ______________________

Address: ______________________

____

Sample location: ______________________

____

____

Sample description: ______________________

____

____

Sample name	1	2	3
Sample volume, ml			
Volume passing 2-mm sieve, ml			
Volume retained on 2-mm sieve, ml[1]			
Fine gravel total: Volume of water and rock (2 to 5 mm), ml			
Large gravel total: Volume of water and rock (greater than 5 mm), ml			
Large gravel water: Volume water contained in sample (greater than 5 mm), ml			
% gravel in sample[2]			
% gravel less than 5 mm[3]			

[1] (Sample volume – Volume passing 2-mm sieve)

[2] [(Sample volume – Volume passing 2-mm sieve) ÷ Sample volume] x 100

[3] {(Fine gravel total – Fine gravel water) ÷ [(Fine gravel total – Fine gravel water) + (Large gravel total – Large gravel water)]} x 100

Gravel Analysis Data Sheet, Weight

Job number: ______________________ Sample no: ______________________

Customer name: ______________________ Date: ______________________

Address: ______________________

____

Sample location: ____

____

____

Sample description: ____

____

____

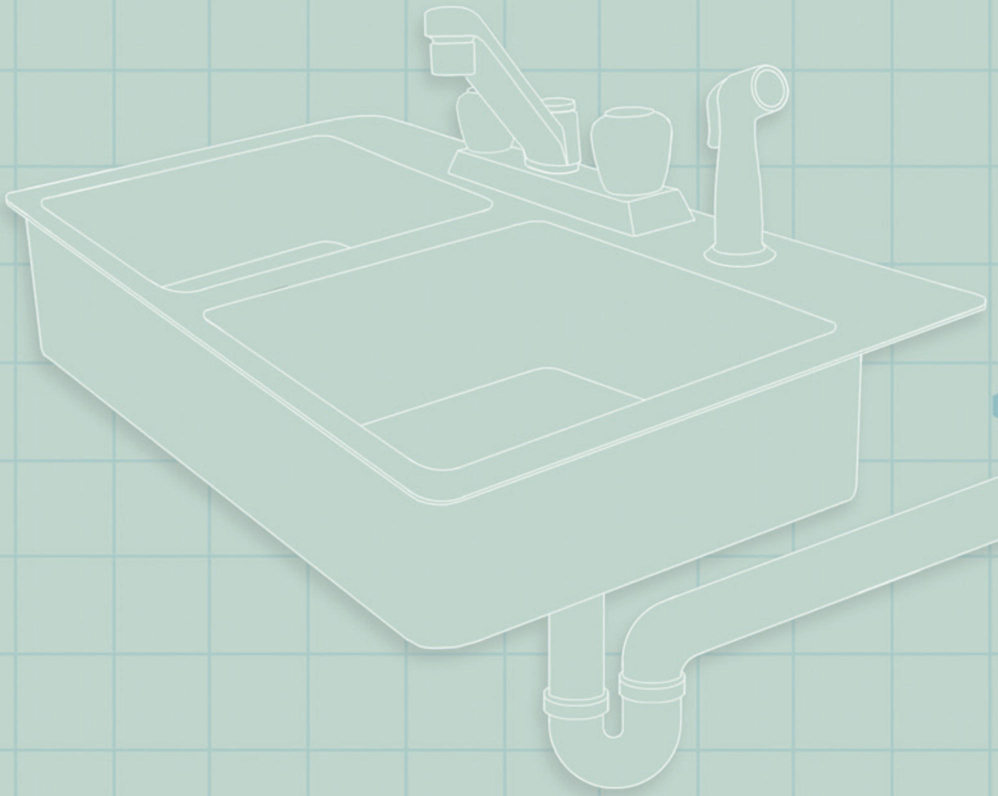
Sample name	1	2	3
Sample volume, ml			
Volume passing 2-mm sieve, ml			
Volume retained on 2-mm sieve, ml[1]			
Weight retained on 2-mm sieve, lbs			
Weight between 2 and 5 mm, lbs			
% gravel in sample[2]			
% gravel less than 5 mm[3]			

[1] (Sample volume – Volume passing 2-mm sieve)

[2] [(Sample volume – Volume passing 2-mm sieve) ÷ Sample volume] x 100

[3] (Weight between 2 and 5 mm ÷ Weight retained on 2-mm sieve) x 100

On-Site Wastewater Treatmen



Texas Water Resources Institute
make every drop count

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