Tutorial
SOIL OR SEDIMENT TESTING PROTOCOL

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1) Laboratory analysis

A. Soil/Sediment sample preparation
   i) Dry the Soil/Sediment sample. According to the nature of the test, you can prepare air dried
   and oven dried sample (For soil fertility test – Nitrogen, etc. - never use oven dried sample).
   ii) Sieve the sample using #10 Sieve (2 mm mesh openings)
   iii) For coarse fragment test do not use sieved sample. The separation of the fragment will take place during the bulk density test.
B. Perform the following tests for physical properties:
   i) Existence of coarse fragments
   ii) Bulk density test
   iii) Particle density test
   iv) Porosity test
   v) Moisture test
   vi) Soil/Sediment texture test (If you did not perform this test on the field)
C. Soil sample preparation for fertility test
   i) Aqueous extraction
   ii) Calcium Sulfate extraction
   iii) Mehlich 2 extraction
D. Perform the following tests for chemical properties:
   i) pH test
   ii) Nitrate-Nitrogen test
   iii) Phosphorus test
   iv) Potassium, Exchangeable test
   v) Electrical conductivity test
   vi) Salinity test
E. Interpretation of Soil/Sediment test results and recommendations: Use the manual

Testing Soil/Sediment Physical Properties

Soil/Sediment Colour Test

Test. The first test that we have to make is to register the color of the Soil/Sediment. This process does not require any sophisticated technique. It is usually described from the Munsell color chart. For our purposes, the simple identification of the main color of the Soil/Sediment is sufficient. Notice that wet Soil/Sediment looks darker than when it is dry.

Step 1: Take some Soil/Sediment ped from each soil horizon

Step 2: Break the ped

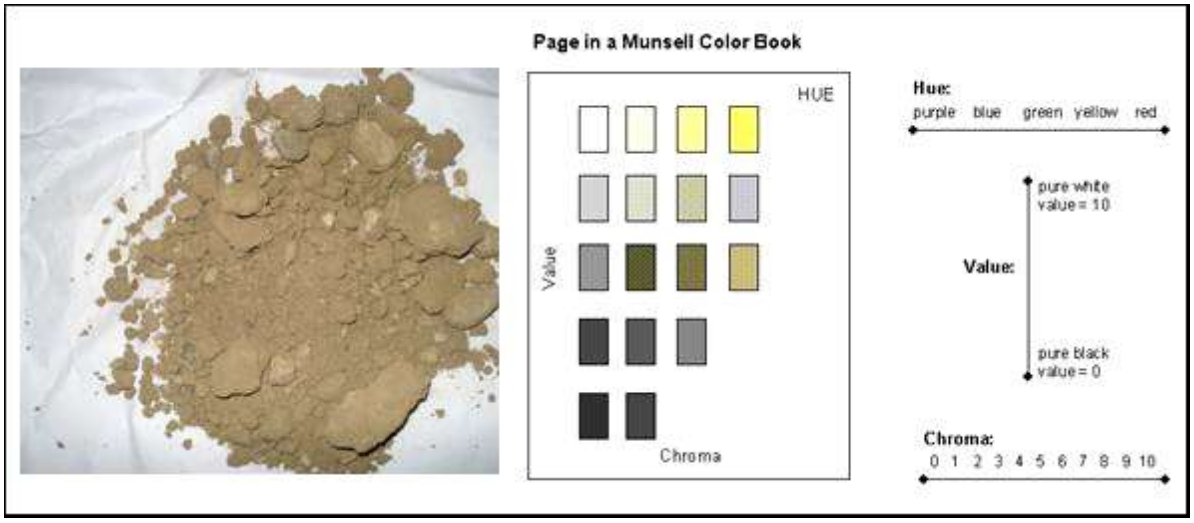
Step 3: Check the color of the ped according to the Munsell color chart. If the ped shows more than one type of color, indicate the dominant and the sub-dominant color.

Key to use the Munsell Color Chart:

- The Munsell Color Chart shows the different colors and a code
- The code below each color indicates the Hue, Value and Chroma, which belong to each color.
- The Hue is the first set of numbers and the letter indicates the position of the color on the color wheel. The symbol indicates the following:
  - Y=Yellow
  - R=Red

- G=Green
- B=Blue
- YR=Yellow Red
- RY=Red Yellow

- The number of Value indicates the lightness of the color (ranging from 0 to 10).
- Chroma indicates the intensity of the color from 0 on upwards. There is no arbitrary end on the scale to determine the maximum value.
- *Data analysis.* Soil can be categorized in six groups according to the color and tone of the sample.
  - Brown to Dark Black
  - Black for surface horizon
  - Dark Grey to Bluish
  - White to Grey
  - Dark Red
  - Yellow to Reddish



Source: Photograph by Ferenc Sandor, Charts by K. McSweeney, S. Grunwald., 1999. Soil/Sediment Morphology, Classification and Mapping. University of Wisconsin-Madison, Department of Soil Science

Soil/Sediment Texture Analysis

Soil/Sediment texture is one of the most important physical properties of Soil/Sediment. It refers to the basic composition of the Soil/Sediment, which consists of sand, silt and clay contents. The Soil/Sediment texture directly or indirectly affects almost every single characteristic of the Soil/Sediment. The classifications of particle sizes are as following (units: mm):

- clay: < 0.002 (It is recognizable by its stickiness. It is hard and cloddy when dry)
- silt: 0.002 - 0.05 (Particles cannot be detected, but their presence makes the Soil/Sediment feel smooth and soapy and only very slightly sticky.)
- fine sand: 0.05 - 0.1 (Sand particles grate against each other and they can be detected by sight. Sand shows no stickiness or plasticity when wet.
- medium sand: 0.1 - 0.5
- coarse sand: 0.5 - 1.0
- very coarse sand: 1.0 - 2.0

There are different methods to establish the Soil/Sediment sample's textural class.

Test - Method 1

1. Collect about 500 ml (2 cups) of Soil/Sediment and remove the bulk of organic matter from the top.
2. Let the sample dry.
3. Break up any clumps with a hammer.
4. Take a litre glass jar and put in 200 ml of Soil/Sediment sample (3/4 of a cup).

5. Fill up the jar with water and shake it for five minutes.
6. Wait 24 hours and measure the depth of the settled Soil/Sediment with a ruler.
7. Shake the jar again for 5 minutes, wait 40 seconds and measure the settled Soil/Sediment again.
8. Wait a further 25 minutes (total 30 minutes) and measure again.

Data analysis

After 24 hours the depth of the settled Soil/Sediment gives us the total amount of Soil/Sediment particles in the sample. The depth of the settled Soil/Sediment particles after 40 seconds gives the total sand content of the sample. Further 25 minutes of waiting enables the measuring of the sand and silting contents together in the sample.

Figure 7 Soil/Sediment Particle Content Test. Source: Photos by Ferenc Sandor

Equations

Silt content = [(Total silt + sand – Total sand) / Total Soil/Sediment] * 100
Clay content = [Total Soil/Sediment – (Total silt + sand)] / Total Soil/Sediment] * 100
Sand content = (Total sand / Total Soil/Sediment) * 100
Measuring unit: %

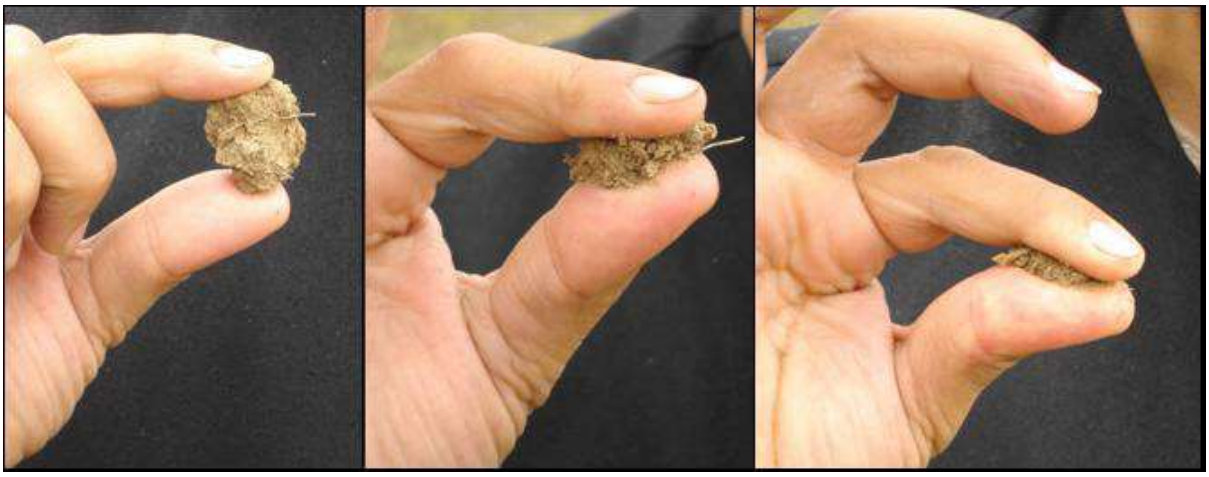
Soil/Sediment Consistence Test

Test. This is a very simple test. Take a Soil/Sediment ped between your thumb and forefinger and squeeze it until it pops or fall apart. If the Soil/Sediment is too dry squirt a small quantity of water on it.

Data analysis

There are four categories for the result of the test:

- Loose: The Soil/Sediment structure falls apart before you handle it
- Friable: The ped breaks under small pressure
- Firm: The ped breaks under strong pressure
- Extremely firm: The ped does not break at all



Source: Photos by Ferenc Sandor

Bulk Density Test

There are several methods, from the simple to the sophisticated, to measure the bulk density of the Soil/Sediment. Bulk density indicates how dense the Soil/Sediment is and how tightly it is packed according to the shape of the Soil/Sediment peds and the percentage of air space or pores. It is directly related to the compaction level of the Soil/Sediment. The bulk density indicator is measured with the dry mass per volume in g/cm3 or g/ml.

Test – Method 1

The volumetric displacement procedure uses a ring with a hook gage and plastic sheet. First, fix the ring on the Soil/Sediment and place a plastic sheet inside the ring. With a graduated cylinder, fill up the ring to measure the background volume. After removing the plastic, take the Soil/Sediment sample to a specified depth. Place the plastic sheet back in the ring and fill it up again from the graduated cylinder (thus measuring the total quantity of water). After that, dry the Soil/Sediment in the oven (110 Cº) and measure its weight.

Data analysis

The method provides representative values, therefore it can be used for fields are not sampled.

Equations:

Step 1: Soil/Sediment sample volume = Total volume of water – Volume of background water

Step 2: Bulk density = Dry Soil/Sediment weight / Soil/Sediment sample volume (g/cm3 or g/ml)

Test – Method 2

Take a graduated cylinder and measure its weight. Fill up the cylinder with a dry Soil/Sediment sample. After that, record the marking indicated on the cylinder. Measure the weight of the Soil/Sediment and cylinder together. This test is accurate for single grained sandy Soil/Sediments.

Equation:

Bulk density = Weight of cylinder and Soil/Sediment – weight of cylinder (Soil/Sediment mass)
Volume of Soil/Sediment Measuring unit: g/cm3 or g/ml

Data analysis

This method cannot compete with other more accurate laboratory measurements, but it is simple and can be used to analyze Soil/Sediment properties. It is mostly applicable for sandy Soil/Sediments.

Test – Method 3

This method uses samples collected in a metal can with a specific volume. Instead of collecting Soil/Sediment samples to fill up the can, the can is pushed into the Soil/Sediment horizon to obtain the sample. The Soil/Sediment must be removed, dried and finally measured for weight. After recording its weight, the Soil/Sediment sample should be sieved and particles larger than 2 mm (rock content) should be removed, measured for weight and kept separately. The empty and cleaned can will then be filled with water. After that, the volume of the water will be measured in a graduated cylinder. Take a graduated cylinder and fill it with water to a specific volume (e.g. 100 ml). The last part of the testing process is to take the larger particles (more than 2 mm) and place them in the graduated cylinder, which contains the specific volume of water. After this, measure and register the value shown on the scale of the cylinder.

Data analysis

The weight of the dry Soil/Sediment sample gives the mass of the Soil/Sediment. The measured water volume, which needs to be filled up in the metal can, is equal to the volume of the Soil/Sediment sample.

Source: Photos by Ferenc Sandor.

Equations:
Total Bulk density = Dry Soil/Sediment sample / Volume of can (g/cm3 or g/ml)
Volume of rock content = Rock and water volume – water volume (cm3 or ml)
Soil/Sediment Bulk density = Dry Soil/Sediment weight – Rock content weight
Can volume – Rock content volume
Measuring unit: g/cm3 or g/ml

Source: Photos by Ferenc Sandor.

Particle Density (Real density) Test
The particle density test measures the mass of the Soil/Sediment in a specific volume, which is very similar to the bulk density test. The main difference is that the particle density only measures the density of the Soil/Sediment particle component and excludes the volume of pore spaces, which contains air and water.
Test. First we take a graduated glass container and measure its weight. Then place 25 g of a Soil/Sediment sample inside the container. Measure and register the weight of the Soil/Sediment together with the container. With some water added, boil the mixture for 10 minutes to remove all air bubbles. Once the container has cooled, place it in a cup and let it sit for 24 hours. After 24 hours, fill up the container with water to a total volume of 100 ml and measure the weight and temperature of the mixture.

Data analysis

The particle density is calculated from the mass of the solid particles in a specific volume.

Equations

Mass of Soil/Sediment = Mass of Soil/Sediment and container – Mass of empty container (g)
Mass of water = Mass of water, Soil/Sediment and container - Mass of Soil/Sediment and container (g)
Volume of water = Mass of water / Density of water (cm3 or ml), where the density of water equal to 1.0 g/cm3 or g/ml
Volume of Soil/Sediment = Given volume of mixture (100 ml) – Volume of water (cm3 or ml)
Soil/Sediment particle density = Mass of Soil/Sediment / Volume of Soil/Sediment (g/cm3 or g/ml)

Source: Photos by Ferenc Sandor.

Soil/Sediment Porosity Test

The fraction of pore space in the Soil/Sediment is called Soil/Sediment porosity and it measured in percentage.

Test – Method 1

The measurement procedures include two test:

- Bulk density test
- Particle density test

Data analysis. The porosity value always will be less or equal than 1. This value multiplied by 100 gives the percentage of porosity.

Equation: Porosity = [1 – (Bulk density / Particle density)] x 100 (%)

Test – Method 2

This method directly calculates the porosity from the volume of air and volume of Soil/Sediment of the sample. The method is accurate for testing sandy Soil/Sediments. It is simpler and less accurate then that the previous method, which is used to calculate the two density indicators and establishes the Soil/Sediment porosity value. However, it is a sufficient representative for the description of the Soil/Sediments main physical properties.

Step 1. Weight an empty graduated cylinder and record the value. Then pour a sample of dry Soil/Sediment into it and measure the weight again.

Step 2. Measure also the volume of dry Soil/Sediment in the cylinder alone and record it.

Step 3. Measure a specific volume of water in another graduated cylinder and record the value. Once finished, add the water to the Soil/Sediment and then place it in the other cylinder. Stir the mixture until the water can completely penetrate the Soil/Sediment. (It not will be entirely as accurate as the procedure described in the particle density test due to the fact that, without heating the sample, some microscopic volumes of air will remain between the Soil/Sediment particles.)

Step 4. Measure and record the volume of the Soil/Sediment and water mixture.

Data analysis Use the recorded values to calculate the total porosity of the Soil/Sediment.

Equations:

Mass of the Soil/Sediment = Mass of cylinder and Soil/Sediment – Mass of cylinder alone (g)
Bulk density = Mass of the Soil/Sediment / Volume of the Soil/Sediment (g/cm3 or g/ml)

Pore space volume = Volume of Soil/Sediment + Volume of water – volume of Soil/Sediment and water (cm3 or ml)
Porosity = Pore space volume / Volume of Soil/Sediment x 100

Source: Photos by Ferenc Sandor.

Soil/Sediment Moisture Tests
The water holding capacity of a specific Soil/Sediment type is very important to calculate the necessary volume and frequency for irrigation during production.
Test 1. – "0" Bar Water Holding Capacity. Take a Gooch Crucible or make one (small pot with sufficient small holes to retain Soil/Sediment samples in the pot). Record its weight. Fill up to ¾ of the pot with Soil/Sediment sample, record the weight and place the pot in a small dish, which is half filled with water. Leave it for 20 minutes in the water and measure its weight again.
Data analysis
The water holding capacity will be the relationship between the weight of wet Soil/Sediment and dry Soil/Sediment in percentage.

Source: Photos by Ferenc Sandor.

Equations
Weight of the dry Soil/Sediment = Weight of dry Soil/Sediment and pot – Weight of the pot (g)
Weight of wet Soil/Sediment = Weight of wet Soil/Sediment and pot – Weight of the pot (g)
Weight of water = Weight of wet Soil/Sediment – Weight of dry Soil/Sediment
Water holding capacity by mass = (Weight of water / Weight of the wet Soil/Sediment) x 100
Volume of water = Weight of water / Density of water (1g/cm3 or ml)
Water holding capacity by volume = (Volume of water / Volume of Gooch Crucible) x 100

METHODS OF ANALYSIS

I. pH - 1:1 Soil/Sediment water paste
A. Reagents
1. Standard buffer solutions to standardize pH meter
B. Procedure
1. Weigh 10 grams of Soil/Sediment into a 50 ml beaker or No. 250 C.R. souffle cup. Add 10 ml of distilled water. Stir thoroughly.
2. Let stand for at least 30 minutes, stirring two or three times.
3. Read with a pH meter using a glass electrode.
II. LIME REWIREMENT - Woodruff method (12)
A. Reagents
1. Buffer solution - Weigh out 800 grams calcium acetate, 160 grams

p-nitrophenol, and 12 grams magnesium oxide. Dissolve in about 18 liters distilled water. Make up to 20 liters. Let settle for a week then adjust to pH 7.0 with HC1 or NaOH - 2

2. Standard buffer solution for pH meter.

B. Procedure

1. Weigh 10 grams of Soil/Sediment into a 50 **ml** beaker or No. 250 C.R. souffle cup. Add 10 ml of distilled water, stir and let stand for at least 15 minutes.

2. Add 20 ml of the buffered solution, mix well, and let stand for at least 20 minutes, stirring two or three times.

3. Read on glass electrode pH meter. East 0.1 drop from pH 7.0 is equivalent to 1000 lbs. $CaCO_3$.

The buffer solution could be added afer the Soil/Sediment pH is determined in Part I.

References:

February 8, 2008. Soil Testing, Perennial Crop Support Series Jalalabad, Afghanistan Publication No. 2008-001-AFG.pp.1-100.