Basic Soil Science

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Today’s Objectives:

• Elements of soil formation
• Describe important soil physical & chemical properties
• Describe the ability to use and interpret soil survey information (printed and digital)
• List some site specific control practices for soil conservation.
Why do soils differ across the landscape?
Why do soils differ across a landscape?

• Parent material
  – rocks (and minerals)
• Landscape position (topography)
• Biotic factors
• Climate
  – temperature and rainfall
• Time
Soil Horizons

- O – organic material
- A – mineral and organic components mixed
- E – eluviated horizon – loss of clays, Fe, Al
- B – illuvial accumulation of clays, Fe, Al, OM
- C – unconsolidated bedrock
- R – hard bedrock
What horizons can you see in this soil?
What are Soils?

• Dynamic, reactive, three-phase ecosystems composed of solids, liquids and gases

![Pie chart showing the composition of topsoil: 49% Minerals, 25% Water, 25% Air, 1% Organic Matter.]

topsoil several days after rainfall or irrigation
Soil Solids

• Mineral or inorganic solids
  – often classified based on particle size

• Organic solids a.k.a. “organic matter”
## Major Mineral Classes in a Soil

<table>
<thead>
<tr>
<th>Mineral Class</th>
<th>Size of Mineral Particles</th>
<th>Feel of Particles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sands</td>
<td>0.05 – 2 millimeters (mm)</td>
<td>Gritty</td>
</tr>
<tr>
<td>Silts</td>
<td>0.002 – 0.05 millimeters (mm)</td>
<td>Like flour, cornstarch or talcum powder</td>
</tr>
<tr>
<td>Clays</td>
<td>Less than 0.002 millimeters (mm)</td>
<td>Sticky when wet</td>
</tr>
</tbody>
</table>
What is the texture of a soil with 30% clay and 50% sand?
FIGURE 3-8  The soil triangle is redrawn to show fine-, medium-, and coarse-textured soils. An exception is very fine sandy loam, which is considered medium textured.
<table>
<thead>
<tr>
<th>Property</th>
<th>Coarse Textured</th>
<th>Medium Textured</th>
<th>Fine Textured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-holding capacity</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Nutrient retention capacity</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Leaching potential</td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Susceptibility to erosion</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
Review Question #1

The soil physical property that describes the proportion of sand, silt, and clay-sized particles in a soil is called

a) structure
b) texture
c) bulk density
d) porosity
Two questions to ponder:

• How does organic matter affect soil texture?

• How does organic matter affect soil structure?
Clay in suspension →
Silt →
Fine sand →
Coarse sand →

Photo: Brady & Weil, 14th ed.
Organic Matter

- Humus: 75%
- Biomass: 10%
- Residues & By-Products: 15%

Department of Environmental Science and Technology
Humus: What It Is

• Stable end product of residue decomposition
• Composes the majority of organic matter
• Resists further decomposition (1% per year)
• It is not a good nutrient or energy source for soil creatures
Humus: What It Does

- Very small in particle size
- High surface area
- Charged sites at many locations on the surface
- Effective at holding water and nutrients

Figure: Brady & Weil, 14th ed.
Biomass: What Is It?

• The living component of the soil
• Consists of a range of creatures
  – microscopic viruses & bacteria
  – worms and other creatures that are visible to the unaided eye
  – everything in-between
Biomass: What It Does

• Participates in nutrient cycling
  – digest plant and animal materials (residues), using what they need and leaving behind what they don’t

• \textit{immobilization} \& \textit{mineralization}
Biomass: What It Does (cont.)

• Creation of biopores
  – larger organisms move through soil creating channels
  – channels promote water infiltration and create a healthy balance between large and small pores

Photo: R. Weil
Residues and By-Products: What are They?

• Dead stuff - crop residues, dead roots and bodies of soil creatures

• By-products - materials that plant roots and soil creatures release or exude into the soil
Residues and By-products: What They Do

- Fuel and nutrients for soil organisms
  - energy and nutrient source for most of the soil creatures
- Formation and maintenance of soil aggregates (structure)
  - sticky by-products of residue decomposition hold soil particles together in clumps or aggregates

Photo: Brady & Weil, 14th ed.
Figure: Brady & Weil, 14th ed.
Review Question #2

The property that describes how particles are arranged into aggregates is called
a) texture
b) porosity
c) structure
d) particle density
Soil Aeration

• The exchange of $O_2$ and $CO_2$ between the soil pores and the ambient atmosphere
Balance Between Water and Air

• Macropores (large pores)
  – drain quickly after rain or irrigation
  – allow rapid infiltration of rainfall and replenishment of oxygen in the root zone

• Mesopores (medium-sized pores)
  – “storage pores”
  – hold water in form most plants can use

• Micropores (very small pores)
  – water is held too tightly to be use to most plants
Texture and Porosity

AMOUNT OF PORE SPACE

TOTAL PORE SPACE

VOLUME OF SMALL PORES

VOLUME OF LARGE PORES

Small Amount

Large Amount

Sand

Loam

Clay

TEXTURE
What makes the wetting front wavy/not uniform?

Wetting front 24 hours after 5 cm rainfall

Photo: Brady & Weil, 14th ed.
How much does soil weigh?

• Expressing soil weight as density
  – English units – pounds/cubic foot (#/ft³)
  – Metric units – grams/cubic centimeter (g/cm³)

1 acre of soil to a depth of 6 inches weighs approximately 2 million pounds!
What is its density?

• 2 kinds of density in soil
  – bulk density
    • density of whole soil
  – particle density
    • density of soil solids only
<table>
<thead>
<tr>
<th>Soil</th>
<th>Typical Bulk Density (g/cm(^3))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Soil</td>
<td>0.1 - 0.6</td>
</tr>
<tr>
<td>Volcanic</td>
<td>0.6 – 0.8</td>
</tr>
<tr>
<td>Forest &amp; Native Grassland</td>
<td>0.8 – 1.1</td>
</tr>
<tr>
<td>Cultivated Silt Loams</td>
<td>0.9 – 1.5</td>
</tr>
<tr>
<td>Cultivated Sandy Loams</td>
<td>1.2 – 1.7</td>
</tr>
<tr>
<td>Plow Pans</td>
<td>1.7 – 2.0</td>
</tr>
</tbody>
</table>

*BDB through which roots cannot penetrate: 1.6 g/cm\(^3\)*
If a soil ped has a volume of $124 \text{ cm}^3$ and a dry weight of 138 grams, what is its bulk density?

- $BD = \frac{\text{dry weight}}{\text{volume}}$
  - $\#/\text{ft}^3$
  - grams/cm$^3$

- $BD = 138 \text{ grams} / 124 \text{ cm}^3$
  - $1.11 \text{ grams/cm}^3$
Formula for porosity

% PORE SPACE = 100 - % SOLID SPACE

OR

% PORE SPACE = 100 - (BD/PD X 100)
A very compacted plow pan has a bulk density of $1.74 \text{ g/cm}^3$ and a particle density of $2.68 \text{ g/cm}^3$. What is the percent porosity?

\[
\%PS = 100 - \left[ \frac{1.74}{2.68} \right] \times 100
\]

\[
\%PS = 100 - 65 = 35\%
\]
Formula for soil moisture

\[
\text{%moisture} = \left( \frac{\text{weight of water/oven dry soil weight}}{\text{wet weight} - \text{oven dry weight}} \right) \times 100
\]
Biological Classes of Water

Saturation
Saturated Soil
100 g
40 ml
Water
Solid

Field Capacity
Field Capacity
100 g
20 ml
Air

Wilting Point
Wilting Coefficient
100 g
10 ml
Air

Hygroscopic Coefficient
100 g
8 ml
Air

Solid
Pore Space
Biological Classes of Soil Water

- Gravitational water
- Field capacity
- Available water
- Wilting point
- Unavailable water—tightly held

Percentage water by weight

Percentage clay in the soil

- Sandy soil
- Loamy soil
- Clay soil
Soils are Biochemical Reactors

• The various phases (soil air, soil water, soil minerals and organic matter) interact

• A wide array of chemical and biochemical processes occur
From this ... to this.
• Map units
• Roads
• Hydric soils
• Slopes

• Drainage
• Profile
• Uses and Suitability
• Permeability
58B—Sassafras loam, 3 to 8 percent slopes. This soil is very deep and well drained. It is on broad ridgetops. Slopes generally are smooth, but a few are dissected by small drainageways. Areas range from 5 to 10 acres in size.

The typical sequence, depth, and composition of the layers in this soil are as follows—

**Surface layer:**
- 0 to 8 inches, dark yellowish brown loam

**Subsoil:**
- 8 to 13 inches, dark yellowish brown loam
- 13 to 17 inches, yellowish brown and dark yellowish brown sandy clay loam
- 17 to 22 inches, yellowish brown and dark yellowish brown sandy loam

**Substratum:**
- 22 to 35 inches, strong brown sandy loam
- 35 to 65 inches, brownish yellow loamy sand

Included with this soil in mapping are small areas of Croom and Evesboro soils. Also included are moderately well drained or somewhat poorly drained soils in low areas. Included soils make up as much as 15 percent of the unit.

**Soil properties—**

**Permeability:** Moderate  
**Available water capacity:** Moderate  
**Potential for frost action:** Moderate

Most areas are used for cultivated crops. A few areas are used for hay or pasture or for urban development. This soil is well suited to cultivated crops. The moderate available water capacity is the main management concern. The soil tends to be droughty during long dry periods. A cropping system that includes cover crops and grasses and legumes and a conservation tillage system that leaves some or all of the crop residue on the surface minimize crusting, maintain or increase the content of organic matter in the surface layer, and conserve moisture.

This soil is well suited to hay and pasture. Forage production is somewhat limited because of the moderate available water capacity. Overgrazing reduces the quantity and quality of the forage. Deferring and rotating grazing as needed, applying lime and fertilizer, harvesting at the proper stage of plant growth, and controlling weeds and brush increase the quantity and quality of feed and forage.

The potential productivity for trees on this soil is moderately high.

This soil is well suited to dwellings.

The potential for frost action is the main limitation on sites for local roads and streets. Providing coarse grained subgrade or base material to frost depth helps to prevent the damage to pavement caused by frost action.

The moderate permeability is the main limitation on sites for septic tank absorption fields. This limitation can be overcome by an alternative design that meets the requirements of State and local regulations.

The capability subclass is I11e.
- physical and chemical properties
- vegetative productivity
- water management
- land management
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The End

Questions?