MASTER GARDENER
COLORADO STATE UNIVERSITY
EXTENSION

CMG GardenNotes #211

Introduction to Soils

Outline:

Soil Attributes

What is soil? Gardeners know that soil is more than simply broken up rocks. Rather than being an inert unchanging material, soil is a dynamic living substance in which complex chemical and biological reactions are constantly occurring.

According to the Soil Science Society of America, soil is defined as, "…the unconsolidated mineral or organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants..." **Unconsolidated** materials are loose materials composed of multiple units (e.g. sand, gravel, etc.) unlike hard, massive materials like rock. Effective gardeners manage soils to produce healthy and resilient plants.

Soil contains a variety of substances. In a well-managed western soil, usually around 50% percent of the soil's volume is composed of solid particles, while the other 50% is empty space. Soil scientists refer to these empty spaces as "pores." [Figure 1]

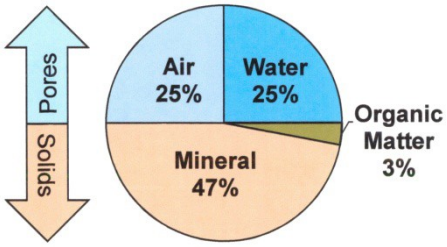

Figure 1: A well-managed Western soil has 25% air, 25% water, 1-5% organic matter and 45-49% mineral solids.

Most of the solid particles are derived from mineral sources such as decomposed rocks or sediments. Roughly 1 to 5% of the soil's volume is organic matter—plant, animal and microbial residues in various stages of decomposition. [Figure 1]

The empty space between the solid particles can be occupied by water, air, or a combination of both. In a well-managed soil, about 25% of the soil's volume is air, while the remaining 25% is occupied by water. This combination of components provides a healthy environment for roots to grow.

Soil-Forming Factors

Soils vary across the landscape. A Colorado gardener may have noticed substantial differences between the soil in his or her yard compared to their neighbor's soil. In Colorado, there are many different types of soils ranging from heavy clays to sands or decomposed granite.

The factors that cause variation in soils in different locations are referred to as soil-forming factors. Soil scientists recognize five soil-forming factors, including:

- Parent material
- Climate (precipitation, temperature, wind)
- Topography
- Biological organisms
- Time

These factors differ in subtle and complex ways over the surface of the earth to create an infinite array of soils.

The term **parent material** refers to the starting material for a soil. It consists of specific minerals (or organic materials) from which a soil is formed. The mineralogy of the parent material has a great effect on the mineralogy and properties of the soil.

Climatic factors influence soil formation in several ways. First, precipitation and temperature cause weathering of rocks. In dry climates like Colorado (unlike warm, moist climates), wind is often more important than water in weathering rocks and transporting parent materials. Second, climatic factors often transport parent materials over long distances. Sometimes the parent material for a soil is **residual**, meaning it disintegrated in place to form soil. In other cases, the parent material is **transported** by water (rivers and streams), wind, gravity, or glaciers. As with weathering, wind is the primary means of transport in Colorado. Once the parent materials land on a stable surface, the process of soil formation can begin. The characteristics of the resulting soil will depend on the interaction of the remaining four soil forming factors on the parent material. Together, these factors act over thousands of years to form soil.

Soil Variation

Soils are three-dimensional entities. Soil not only varies across the landscape, but also varies vertically with depth. Gardeners will notice changes in soil color, physical properties, and chemical properties as they dig deeper. Over time, the soil-forming factors change the undifferentiated parent material into a vertically differentiated soil. Soil scientists recognize **horizons**, or horizontal layers within a soil. Horizons are identified by letter codes. They may blend together gradually or have abrupt borders between layers. [Figure 2]

A Horizon (also referred to as "topsoil")

The A horizon is usually the surface horizon. This is an area of high biological activity with the greatest organic matter content. It is also a zone of leaching. As precipitation enters the A horizon, it dissolves soluble soil organic compounds and minerals. These dissolved compounds are then moved downward through the soil profile. Most plant roots are found in the A horizon.

B Horizon (also referred to as "subsoil")

The B horizon lies underneath the A horizon. This layer usually contains less organic matter than the surface layer, but accumulates the dissolved materials leached from the A horizon (clays, iron oxides, aluminum, and dissolved organic compounds). For this reason, the B horizon typically contains more clay than the surface layer. The accumulated products in the B horizon increase over time as the soil forms.

C Horizon

The C horizon contains unconsolidated material that has been minimally affected by the soil forming factors. It lies beneath the B horizon, and may or may not be the same as the parent material from which the soil formed.

Figure 2. Soil Profile

Landscape Soils

Landscape soils differ significantly from agricultural or native soils. **Landscape soils** are soils that are found in a typical neighborhood community around homes, parks, schools, offices, parking lots, and buildings. Soil scientists often refer to landscape soils as "urban" soils.

During the construction process, soils in communities are often graded by moving large volumes of soil. This process often removes the A horizon, taking with it the vast majority of organic matter. Furthermore, when construction workers drive large pieces of equipment over soil it becomes compacted. Thousands of years of soil development can be destroyed in minutes with a bulldozer and other soil moving equipment in a construction site.

Sometimes construction debris, such as wood, trash, drywall, bricks, asphalt, or concrete, is buried in the soil during construction. Other possible landscape soil changes include increased variability, increased surface crusting, increased pH, decreased drainage, decreased soil microbial activity, and increased soil temperature. All of these factors can cause problems when managing soils around buildings.

Native, undisturbed soils typically have well defined A, B and C horizons. In compacted landscape soils, the horizons are scrambled and not defined, organic content is low, and air and water movement is reduced.

In comparison, the compacted unamended landscape soil typically has 10% air, 20% water, 1% organic matter and 69% mineral solids. The most significant aspect of the compacted landscape soil is the reduction in air. Low soil oxygen is the most common limiting factor of plant (root) growth. [Figure 3]

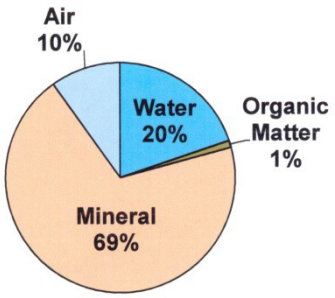

Figure 3: A typical compacted, unamended landscape soil has 10% air, water, 1% organic matter, and 69% mineral solids.

20%

Soil conditions contribute to a large number of plant problems. What can the gardener do?

1. Understand soils as a living ecosystem. Nurture soil organisms by providing their food source (organic matter) and improving aeration and drainage (oxygen and water). For additional information, refer to CMG GardenNotes #212, *The Living Soils*.

2. Understand the soil physical properties of *texture*, *structure*, and *pore space* as they relate to soil *tilth*. Compaction is a reduction in total pore space, but more importantly, compaction is a major reduction in large pore space where the air is located. Gardeners will be more successful in soil management by understanding what properties can be changed and what properties cannot be changed. For additional information, refer to CMG GardenNotes #213, *Managing Soil Tilth.*

In summary, soils are important to gardeners because they strongly influence plant growth. In Colorado, soils vary substantially horizontally across the landscape and vertically with depth. In addition, landscape soils may vary considerably from agricultural or native soils. Landscapers and gardeners must take these changes into account when developing a soil management plan.

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