

# SOIL

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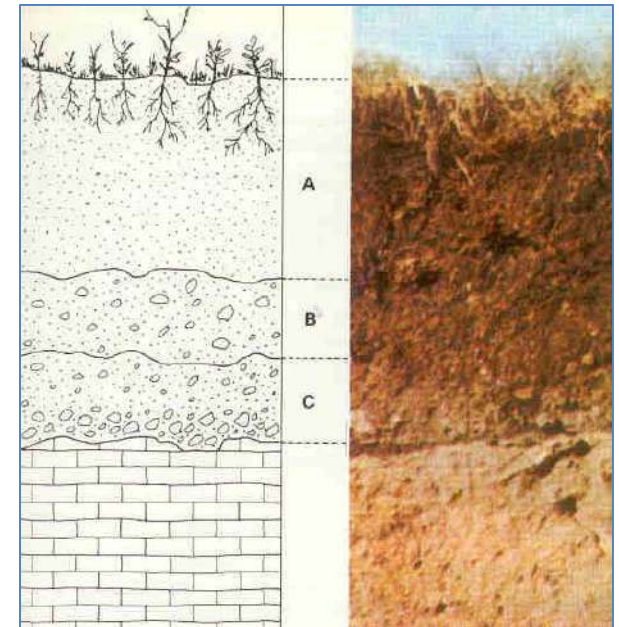
**Soil** is a mixture of organic matter, minerals, gases, liquids, and organisms that together support life. Earth's body of soil, called the pedosphere, has four important functions:

- as a medium for plant growth
- as a means of water storage, supply and purification
- as a modifier of Earth's atmosphere
- as a habitat for organisms

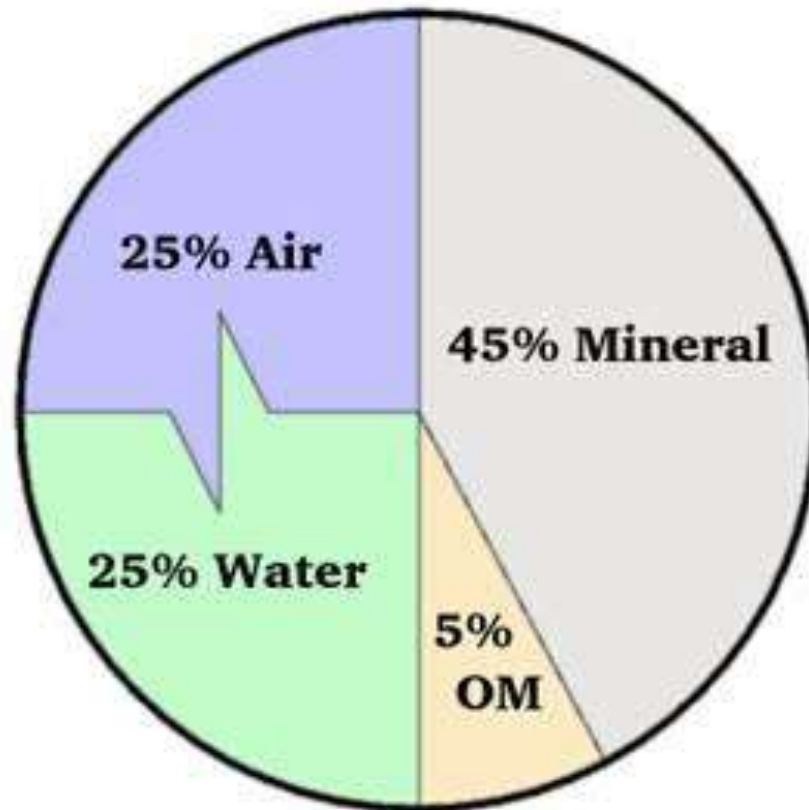
All of these functions, in their turn, modify the soil and its properties.

Soil is also commonly referred to as **earth** or dirt; some scientific definitions distinguish *dirt* from *soil* by restricting the former term specifically to displaced soil.

The pedosphere interfaces with the lithosphere, the hydrosphere, the atmosphere, and the biosphere.<sup>1</sup>



## Soil Composition



Soil is one of the most important elements of an ecosystem, and it contains both biotic and abiotic factors.

Biotic – It includes the living things like plants and insects.

Abiotic - – It includes the non-living things like minerals, water, and air.

The most common minerals found in soil that support plant growth are phosphorus, and potassium and also, nitrogen gas. Other, less common minerals include calcium, magnesium, and sulfur.

**The biotic and abiotic factors in the soil are what make up the soil's composition.**

**Soil composition is a mix of soil ingredients that varies from place to place and it is an important aspect of nutrient management.**

Soil scientists conduct various tests on soils to learn about their composition. Soil testing can identify the amounts of biotic and abiotic factors in the soil. The results of these tests can also reveal if the soil has too much of a specific mineral or if it needs more nutrients to support plants. Scientists also measure other factors, such as the amount of water in the soil and how it varies over time—for instance, is the soil unusually wet or dry? The tests can also identify contaminants and heavy metal in the soil and determine the soil's nitrogen content and pH level (acidity or alkalinity). All of these measurements can be used to determine the soil's health.

## COMPOSITION OF SOIL

Soil is a complex body composed of five major components (Fig. 1.3 namely:

- a) mineral matter obtained by the disintegration and decomposition of rocks;
- b) organic matter, obtained by the decay of plant residues, animal remains and microbial tissues;
- c) water, obtained from the atmosphere and the reactions in soil (chemical, physical and microbial);
- d) air or gases, from atmosphere, reactions of roots, microbes and chemicals in the soil
- e) organisms, both big (worms, insects) and small (microbes)

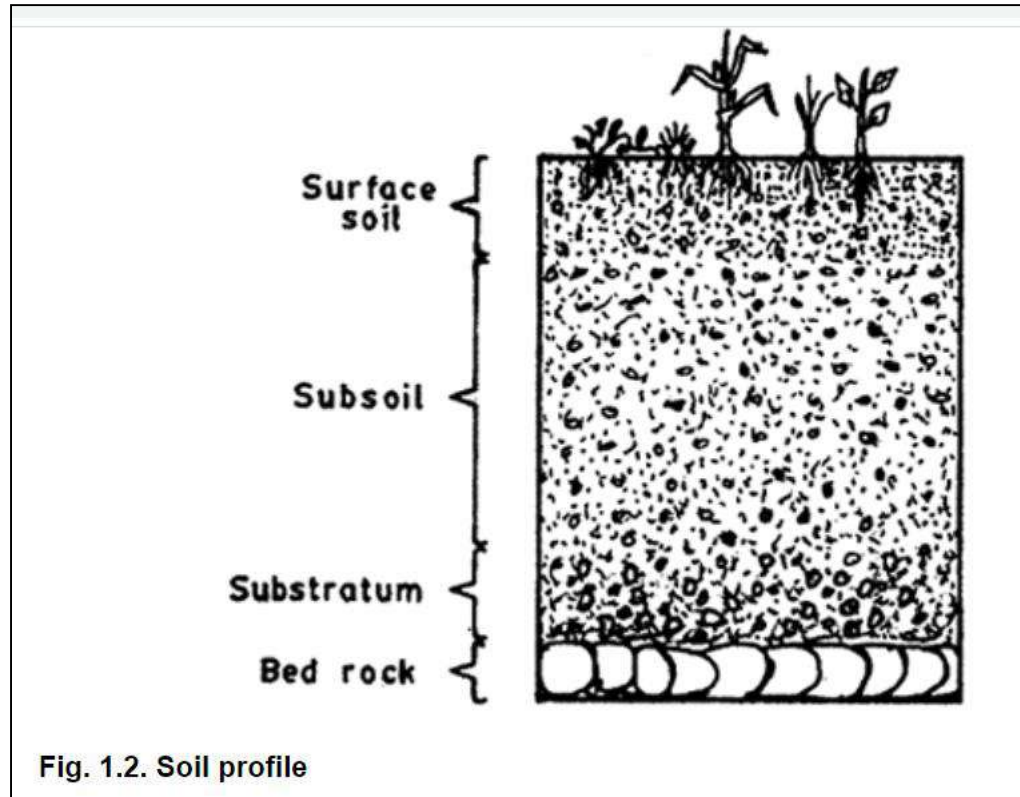


Table I.: Classification of soil particles according to two systems (U.S.D.A and International)

Soil separates	U.S. Dept. of Agric. system Diameter (mm)	International system Diameter (mm)	Number of particles per g
Very coarse sand	2.00 - 1.00	)	90
Coarse sand	1.00 - 0.50	) 2.00 - 0.20	720
Medium sand	0.50 - 0.25	)	5,700
Fine sand	0.25 - 0.10	)	46,000
Very fine sand	0.10 - 0.05	) 0.20 - 0.02	722,000
Silt	0.05 - 0.002	0.02 - 0.002	5,776,000
Clay	below 0.002	below 0.002	90,260,853,000

The basic components of soil are minerals, organic matter, water and air. The typical soil consists of approximately 45% mineral, 5% organic matter, 20-30% water, and 20-30% air. These percentages are only generalizations at best. In reality, the soil is very complex and dynamic. The composition of the soil can fluctuate on a daily basis, depending on numerous factors such as water supply, cultivation practices, and/or soil type.

The solid phase of soil, which includes minerals and organic matter, are generally stable in nature. Yet, if organic matter is not properly managed, it may be depleted from the soil. The liquid and gas phases of the soil, which are water and air respectively, are the most dynamic properties of the soil. The relative amounts of water and air in the soil are constantly changing as the soil wets or dries.



## **Soil Minerals**

Soil minerals play a vital role in soil fertility since mineral surfaces serve as potential sites for nutrient storage. However, different types of soil minerals hold and retain differing amounts of nutrients. Therefore, it is helpful to know the types of minerals that make up your soil so that you can predict the degree to which the soil can retain and supply nutrients to plants.

There are numerous types of minerals found in the soil. These minerals vary greatly in size and chemical composition.

### **Soil Mineral Particle Size**

Particle size is an important property that allows us to make distinctions among the different soil minerals. Soils contain particles that range from very large boulders to minute particles which are invisible to the naked eye. To further distinguish particles based upon size, particles are separated into the two categories: the coarse fraction and the fine earth fraction.

### **FINE EARTH FRACTION**

When we refer to most soils of Maui, we are generally referring to the second category of particle size: the fine earth fraction. This is because the soils of Maui are almost exclusively finely textured. The fine earth fraction includes any particle less than 2.0 mm (.078 inches) and is divided into three classes of size: sand, silt, or clay. To put this into perspective, the width of the lead in a No. 2 pencil is approximately 2.0 mm. **Table 1** provides descriptions of each class in the fine earth fraction.

## **Soil Organic Matter**

Soil organic matter not only stores nutrients in the soil, but is also a direct source of nutrients. Some of the world's most fertile soils tend to contain high amounts of organic matter.

Soil organic matter includes all organic (or carbon-containing) substances within the soil.

Soil organic matter includes:

- Living organisms (soil biomass)

- The remains of microorganisms that once inhabited the soil

- The remains of plants and animals

- Organic compounds that have been decomposed within the soil and, over thousands of years, reduced to complex and relatively stable substances commonly called humus.

As organic matter decomposes in the soil, it may be lost through several avenues. Since organic matter performs many functions in the soil, it is important to maintain soil organic matter by adding fresh sources of animal and plant residues, especially in the tropics where the decomposition of organic residues is continuous throughout the year.

## **Important Functions of Organic Matter**

Although surface soils usually contain only 1-6 % organic matter, soil organic matter performs very important functions in the soil. Soil organic matter:

- Acts as a binding agent for mineral particles.

  - This is responsible for producing friable (easily crumbled) surface soils.

- Increases the amount of water that a soil may hold.

- Provides food for organisms that inhabit the soil.

Humus is an integral component of organic matter because it is fairly stable and resistant to further decomposition.

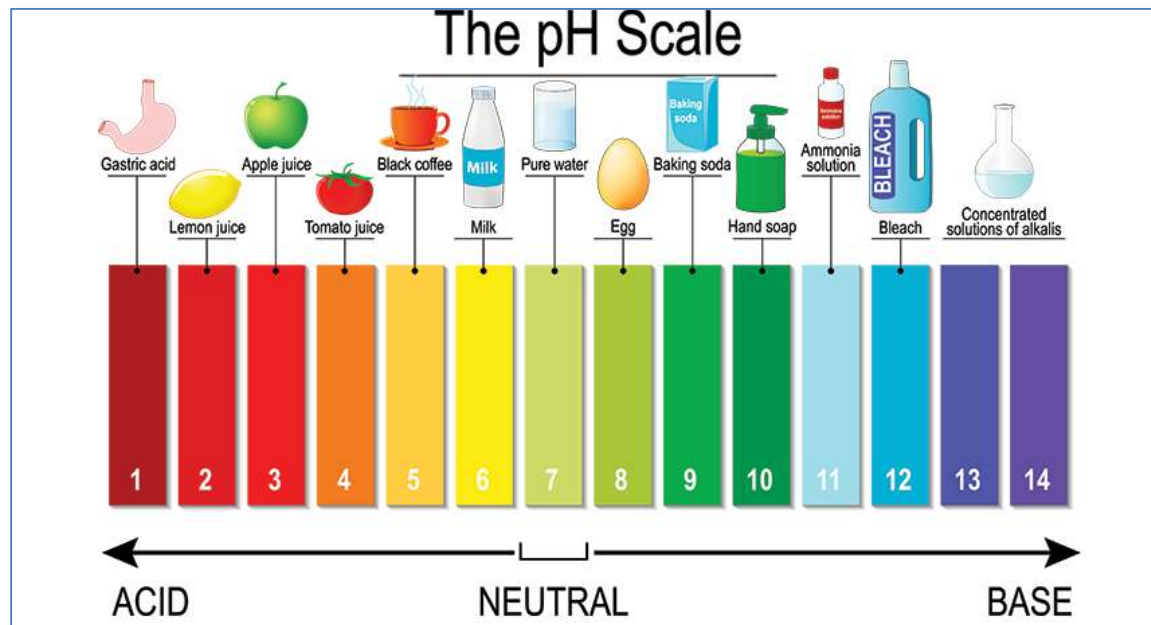
  - Humus is brown or black and gives soils its dark color.

  - Like clay particles, humus is an important source of plant nutrients.

## **Texture:**

Texture refers to the relative proportions of particles of various sizes such as sand, silt and clay in the soil. The proportions of the separates in classes commonly used in describing soils are given in the textural triangle shown in Fig.1.5. In using the diagram, the points corresponding to the percentages of silt and clay present in the soil under consideration are located on the silt and clay lines respectively. Lines are then projected inward, parallel in the first case to the clay side of the triangle and in the second case parallel to the sand side. The name of the compartment in which the two lines intersect is the class name of the soil in question. For examples a soil containing 15% clay, 20% silt and 65% sand is sandy loam and a soil containing equal amounts of sand, silt and clay is clay loam.

The percentages of sand, silt and clay in a soil could be determined in a soil laboratory by two standard methods - hydrometer method and pipette method (Black et al., 1965a). Both methods depend on the fact that at any given depth in a settling suspension the concentration of the particles varies with time, as the coarser fractions settle at a faster rate than the finer (Fig. 1.6).



A figure expressing the acidity or alkalinity of a solution on a logarithmic scale on which 7 is neutral, lower values are more acid and higher values more alkaline. The range of pH scale is from 0 to 14

$$\text{pH} = -\log a\text{H}^+$$

## Soil pH: What it Means

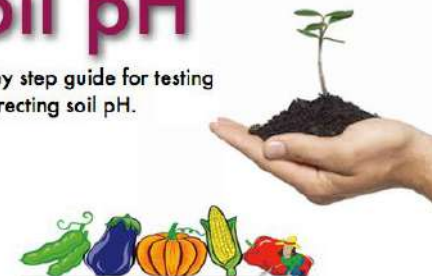
Soil pH or soil reaction is an indication of the acidity or alkalinity of soil and is measured in pH units. Soil pH is defined as the negative logarithm of the hydrogen ion concentration. The pH scale goes from 0 to 14 with pH 7 as the neutral point. As the amount of hydrogen ions in the soil increases the soil pH decreases thus becoming more acidic. From pH 7 to 0 the soil is increasingly more acidic and from pH 7 to 14 the soil is increasingly more alkaline or basic.

Descriptive terms commonly associated with certain ranges in soil pH are:

- **Extremely acid:** < than 4.5; lemon=2.5; vinegar=3.0; stomach acid=2.0; soda=2–4
- **Very strongly acid:** 4.5–5.0; beer=4.5–5.0; tomatoes=4.5
- **Strongly acid:** 5.1–5.5; carrots=5.0; asparagus=5.5; boric acid=5.2; cabbage=5.3
- **Moderately acid:** 5.6–6.0; potatoes=5.6
- **Slightly acid:** 6.1–6.5; salmon=6.2; cow's milk=6.5
- **Neutral:** 6.6–7.3; saliva=6.6–7.3; blood=7.3; shrimp=7.0
- **Slightly alkaline:** 7.4–7.8; eggs=7.6–7.8
- **Moderately alkaline:** 7.9–8.4; sea water=8.2; sodium bicarbonate=8.4
- **Strongly alkaline:** 8.5–9.0; borax=9.0
- **Very strongly alkaline:** > than 9.1; milk of magnesia=10.5, ammonia=11.1; lime=12

## Soil pH

A step by step guide for testing  
and correcting soil pH.



## **Measuring Soil pH**

Soil pH provides various clues about soil properties and is easily determined. The most accurate method of determining soil pH is by a pH meter. A second method which is simple and easy but less accurate than using a pH meter, consists of using certain indicators or dyes.

Many dyes change color with an increase or decrease of pH making it possible to estimate soil pH. In making a pH determination on soil, the sample is saturated with the dye for a few minutes and the color observed. This method is accurate enough for most purposes. Kits (pH) containing the necessary chemicals and color charts are available from garden stores.

There may be considerable variation in the soil pH from one spot in a field or lawn to another. To determine the average soil pH of a field or lawn it is necessary to collect soil from several locations and combine into one sample.

## **pH Affects Nutrients, Minerals and Growth**

The effect of soil pH is great on the solubility of minerals or nutrients. Fourteen of the seventeen essential plant nutrients are obtained from the soil. Before a nutrient can be used by plants it must be dissolved in the soil solution.

Most minerals and nutrients are more soluble or available in acid soils than in neutral or slightly alkaline soils.

Phosphorus is never readily soluble in the soil but is most available in soil with a pH range centered around 6.5.

Extremely and strongly acid soils (pH 4.0-5.0) can have high concentrations of soluble aluminum, iron and manganese which may be toxic to the growth of some plants. A pH range of approximately 6 to 7 promotes the most ready availability of plant nutrients.

But some plants, such as azaleas, rhododendrons, blueberries, white potatoes and conifer trees, tolerate strong acid soils and grow well. Also, some plants do well only in slightly acid to moderately alkaline soils. However, a slightly alkaline (pH 7.4-7.8) or higher pH soil can cause a problem with the availability of iron to pin oak and a few other trees in Central New York causing chlorosis of the leaves which will put the tree under stress leading to tree decline and eventual mortality.

The soil pH can also influence plant growth by its effect on activity of beneficial microorganisms Bacteria that decompose soil organic matter are hindered in strong acid soils. This prevents organic matter from breaking down, resulting in an accumulation of organic matter and the tie up of nutrients, particularly nitrogen, that are held in the organic matter.

## **Changes in Soil pH**

Soils tend to become acidic as a result of: (1) rainwater leaching away basic ions (calcium, magnesium, potassium and sodium); (2) carbon dioxide from decomposing organic matter and root respiration dissolving in soil water to form a weak organic acid; (3) formation of strong organic and inorganic acids, such as nitric and sulfuric acid, from decaying organic matter and oxidation of ammonium and sulfur fertilizers. Strongly acid soils are usually the result of the action of these strong organic and inorganic acids.

Lime is usually added to acid soils to increase soil pH. The addition of lime not only replaces hydrogen ions and raises soil pH, thereby eliminating most major problems associated with acid soils but it also provides two nutrients, calcium and magnesium to the soil. Lime also makes phosphorus that is added to the soil more available for plant growth and increases the availability of nitrogen by hastening the decomposition of organic matter. Liming materials are relatively inexpensive, comparatively mild to handle and leave no objectionable residues in the soil.

Some common liming materials are: (1) Calcitic limestone which is ground limestone; (2) Dolomitic limestone from ground limestone high in magnesium; and (3) Miscellaneous sources such as wood ashes. The amount of lime to apply to correct a soil acidity problem is affected by a number of factors, including soil pH, texture (amount of sand, silt and clay), structure, and amount of organic matter. In addition to soil variables the crops or plants to be grown influence the amount of lime needed.

In addition to monitoring soil pH the nutrient status of the soil should be examined.