УДК 631

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СОСТАВ ПОЧВЫ

Почва является смесь минералов, органических веществ, газов, жидкостей и бесчисленных организмов, которые вместе поддерживают жизнь на земле. Почва является естественным орган, известный как педосферы и который выполняет четыре важные функции: она является средством для роста растений; это средство хранения воды, снабжения и очистки; это модификатор атмосферы Земли; это среда обитания для организмов; все из которых, в свою очередь, изменить почву. Почва является конечным продуктом влияния климата, рельефа (высота, ориентация и наклон местности), организмов и родительских материалов (оригинал), взаимодействующих минералов с течением времени. Почва постоянно подвергается развитию путем многочисленных физических, химических и биологических процессов, которые включают в себя выветривания с соответствующим эрозии.

Ключевые слова: *почва, менералы, педосфера.*

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СКЛАД ҐРУНТУ

Ґрунт – це суміш мінералів, органічних речовин, газів, рідин і незліченних організмів, які разом підтримують життя на землі. Ґрунт – це природний орган, відомий як педосфера і який виконує чотири функції: вона є засобом для росту рослин; це засіб зберігання води, постачання та очищення; це модифікатор атмосфери Землі; це середовище проживання для організмів; всі з яких, у свою чергу, змінити грунт. Ґрунт є кінцевим продуктом впливу клімату, рельєфу (висота, орієнтація і нахил місцевості), батьківських організмів і матеріалів (оригінал), взаємодіючих мінералів з плином часу. Ґрунт постійно піддається розвитку шляхом численних фізичних, хімічних і біологічних процесів, які включають в себе вивітрювання з відповідним ерозії.

Ключові слова: *ґрунт, менерали, педосфера.*

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SOIL COMPOSITION

Abstract. *Soil is the mixture of minerals, organic matter, gases, liquids, and the countless organisms that together support life on earth. Soil is a natural body known as the pedosphere and which performs four important functions: it is a medium for plant growth; it is a means of water storage, supply and purification; it is a modifier of the atmosphere of Earth; it is a habitat for organisms; all of which, in turn, modify the soil. Soil is the end product of the influence of the climate, relief (elevation, orientation, and slope of terrain), organisms, and parent materials (original minerals) interacting over time. Soil continually undergoes development by way of numerous physical, chemical and biological processes, which include weathering with associated erosion.*

Keywords: *soil, minerals, pedosphere.*

Introduction. Soil composition is an important aspect of nutrient management. While soil minerals and organic matter hold and store nutrients, soil water is what readily provides nutrients for plant uptake. Soil air, too, plays an integral role since many of the microorganisms that live in the soil need air to undergo the biological processes that release additional nutrients into the soil.

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.

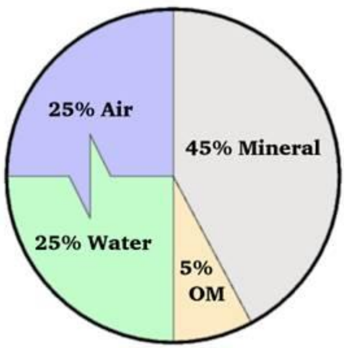

Figure 1. ***Approximate composition of soil.***

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, we are generally referring to the second category of particle size: the fine earth fraction. This is because the soils 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.

Table 1. ***Description of sand, silt, and clay classes.***

The Fine Earth Fraction			
	Size	Texture	Characteristics
Sand	2.0 mm -0.05 mm	Gritty	Sand is visible to the naked eye, consists of particles with low surface area, and permits excessive drainage.
Silt	0.05 mm - 0.002 mm	Buttery	Silt is not visible to the naked eye and increases the water holding capacity of soil.
Clay	< 0.002 mm	Sticky	Clay has a high surface area, high water holding capacity, many small pores, and possesses charged surfaces to attract and hold nutrients.

COARSE FRACTION. The coarse fraction of soil includes any soil particles greater than 2mm. The coarse fraction includes boulders, stones, gravels, and coarse sands. These are rocky fragments and are generally a combination of more than one type of mineral.

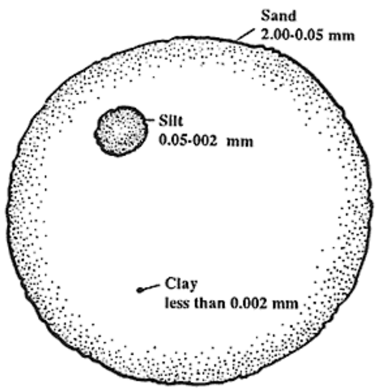

Figure 2. Relative size comparison between sand, silt, and clay of the fine earth fraction.

Weathering of Soil Minerals and Change in Mineral Composition. Weathering is the principal process that acts upon the earth’s primary minerals to form the smaller and finer particles that we call “soil.” In terms of nutrient management, the process of weathering greatly influences the availability of plant nutrients. Initially, as soil particles begin to weather, primary minerals release nutrients into the soil. As these particles decrease in size, the soil is also able to retain greater amounts of nutrients. Ultimately, however, the capacity to hold and retain nutrients is greatly reduced in highly weathered soils, since most nutrients have been lost due to leaching.

There are two types of weathering: physical weathering and chemical weathering. Differences in weathering patterns are the reason why there is a great range in soil particle size. Boulders are much less weathered than gravel. In return, gravel is much less weathered than clay particles. Clay particles may even weather into other materials, such as iron and aluminum oxides, which are generally resistant to further weathering. In the tropics, chemical weathering is very important. Since the climate is typically warm and moist year-round, it provides a suitable environment for continuous chemical weathering to occur. Over time, with sufficient amounts of rainfall and warm temperatures, mineral particles weather into smaller and smaller soil particles. As a result, tropical soils tend to be highly weathered soils. Table 2 provides a list of common primary, secondary minerals, aluminum and iron oxides, and amorphous materials.

PHYSICAL WEATHERING. Physical weathering is a process that breaks up and disintegrates parent rock, or primary minerals, within the earth. In the tropics, physical weathering is caused by the wetting and drying of rocks; erosion; actions of plants and animals; or the falling, smashing, or breaking of rock materials into smaller pieces.

CHEMICAL WEATHERING. Chemical weathering is important in nutrient management since the resulting soil particles retain and supply nutrients. However, when highly weathered, the soil loses much of its nutrients due to excessive leaching. Thus, highly weathered soils tend to be infertile soils, while moderately weathered soils are generally more fertile.

Table 2. Important Primary Minerals and Weathered Materials

Important Minerals and Weathered Materials of Basalt Rock	
Primary Minerals of Basalt Rock	Plagioclase Feldspar Olivine Augite Others: magnetite, apatite, ilmenite
Secondary Minerals	Smectite, such as montmorillonite (less weathered) Kaolin, such as halloysite (more weathered)
Iron Oxides	Hematite Goethite Magnetite Maghemite Lepidocrosite Ferrihydride
Aluminum Oxide	Gibbsite
Amorphous Minerals	Allophane Imogolite
Amorphous Substances	No specific names given

Once parent rock has broken down into smaller pieces, another process acts upon the rock. This process is chemical weathering. Chemical weathering involves the change, or transformation, of primary minerals into secondary minerals. Secondary minerals serve as the basic building blocks of the small particles with the soil. As a result, new materials may be synthesized, residual material may accumulate from materials (such as oxides) which cannot be furthered weathered, or materials can be lost as the result of leaching.

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.

Soil Water. In nutrient management, a proper balance between soil water and soil air is critical since both water and air are required by most processes that release nutrients into the soil. Soil water is particularly important in nutrient management. In addition to sustaining all life on Earth, soil water provides a pool of dissolved nutrients that are readily available for plant uptake. Therefore, it is important to maintain proper levels of soil moisture.

Soil water is important for three special reasons:

- ✓ The presence of water is essential for the all life on Earth, including the lives of plants and organisms in the soil.
- ✓ Water is a necessary for the weathering of soil. Areas with high rainfall typically have highly weathered soils. Since soils vary in their degree of weathering, it is expected that soils have been affected by different amounts of water.

- ✓ Soil water is the medium from which all plant nutrients are assimilated by plants. Soil water, sometimes referred to as the soil solution, contains dissolved organic and inorganic substances and transports dissolved nutrients, such as nitrogen, phosphorus, potassium, and calcium, to the plant roots for absorption.

The amount of water in the soil is dependent upon two factors:

- ✓ First, soil water is intimately related to the climate, or the long term precipitation patterns, of an area.
- ✓ Secondly, the amount of water in the soil depends upon how much water a soil may hold.

Soil water holding capacity. Before we discuss the capacity of soils to hold water, we must understand the concept of capillarity.

Capillarity

- ✓ Water molecules behave in two ways:
  - Cohesion Force: Because of cohesion forces, water molecules are attracted to one another. Cohesion causes water molecules to stick to one another and form water droplets.
  - Adhesion Force: This force is responsible for the attraction between water and solid surfaces. For example, a drop of water can stick to a glass surface as the result of adhesion.
- ✓ Water also exhibits a property of surface tension:
  - Water surfaces behave in an unusual way because of cohesion. Since water molecules are more attracted to other water molecules as opposed to air particles, water surfaces behave like expandable films. This phenomenon is what makes it possible for certain insects to walk along water surfaces.
- ✓ Capillary Action:
  - Capillary action, also referred to as capillary motion or capillarity, is a combination of cohesion/adhesion and surface tension forces.
  - Capillary action is demonstrated by the upward movement of water through a narrow tube against the force of gravity.
  - Capillary action occurs when the adhesive intermolecular forces between a liquid, such as water, and the solid surface of the tube are stronger than the cohesive intermolecular forces between water molecules.
  - As the result of capillarity, a concave meniscus (or curved, U-shaped surface) forms where the liquid is in contact with a vertical surface.
  - Capillary rise is the height to which the water rises within the tube, and decreases as the width of the tube increases. Thus, the narrower the tube, the water will rise to a greater height.

This picture demonstrates the phenomenon of capillary rise. As you can see, the liquid rises to the greatest height in the narrowest tube (at far right), whereas capillary rise is lowest in the widest tube (at far left). Although easily demonstrated by simple experiments using tubes, capillary action occurs in soils. Smaller pores that exist in finely-textured soils have a greater capacity to hold and retain water than coarser soils with larger pores.

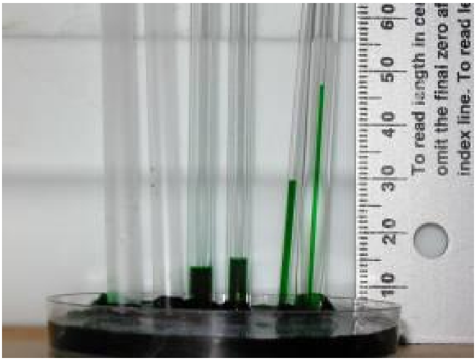

Figure 3. Capillary rise in tubes of varied widths.

Capillary action is the same effect that causes porous materials, such as sponges, to soak up liquids.

- ✓ Capillarity is the primary force that enables the soil to retain water, as well as to regulate its movement.

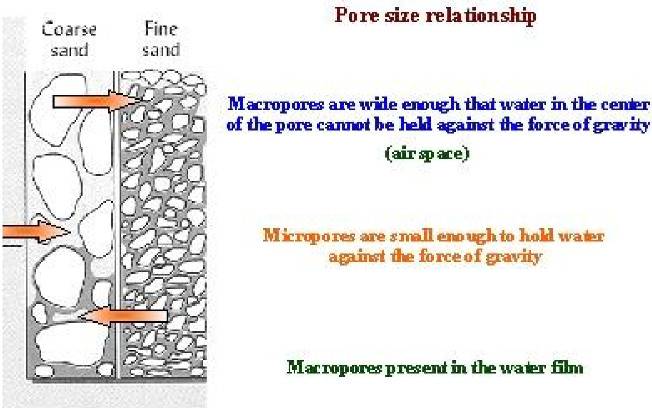

Figure 4. This picture shows how more water may be held between finer particles against the force of gravity, as compared to coarser particles. As a result, finer-textured soils have greater water holding capacities.

- The phenomenon of capillarity also occurs in the soil. In the same way that water moves upwards through a tube against the force of gravity; water moves upwards through soil pores, or the spaces between soil particles.
- The height to which the water rises is dependent upon pore size. As a result, the smaller the soil pores, the higher the capillary rise.
- Finely-textured soils, like in Maui, typically have smaller pores than

coarsely-textured soils. Therefore, finely-textured soils have a greater ability to hold and retain water in the soil in the inter-particle spaces. We refer to the pores between small clay particles as micropores. In contrast, the larger pore spacing between lager particles, such as sand, are called macropores.

- In addition to water retention, capillarity in soil also enables the upward and horizontal movement of water within the soil profile, as opposed to downward movement caused by gravity. This upward and horizontal movement occurs when lower soil layers have more moisture than the upper soil layers and is important because it may be absorbed by roots.

Water holding capacity. Since water is held within the pores of the soil, the water holding capacity depends on capillary action and the size of the pores that exist between soil particles. Sandy soils have large particles and large pores. However, large pores do not have a great ability to hold water. As a result, sandy soils drain excessively. On the other hand, clayey soils have small particles and small pores. Since small pores have a greater ability to hold water, clayey soils tend to have high water holding capacity.

Soil Air. In nutrient management, soil aeration influences the availability of many nutrients. Particularly, soil air is needed by many of the microorganisms that release plant nutrients to the soil. An appropriate balance between soil air and soil water must be maintained since soil air is displaced by soil water. Air can fill soil pores as water drains or is removed from a soil pore by evaporation or root absorption. The network of pores within the soil aerates, or ventilates, the soil. This aeration network becomes blocked when water enters soil pores. Not only are both soil air and soil water very dynamic parts of soil, but both are often inversely related:

- ✓ An increase in soil water content often causes a reduction in soil aeration.
- ✓ Likewise, reducing soil water content may mean an increase in soil aeration.
- ✓ Since plant roots require water and oxygen (from the air in pore spaces), maintaining the balance between root and aeration and soil water availability is a critical aspect of managing crop plants.

Soil air is very different than the above-ground atmosphere. A significant difference is between the levels of carbon dioxide. Since the soil contains high amounts of carbon dioxide, oxygen levels may become limited. Since plants must have oxygen to live, it is important to allow proper aeration in the soil. See Tables 3 and 4 for references to soil air composition.

Table 3. Comparison between soil air and atmospheric composition

Component	Soil air (%)	Atmosphere (%)
N_2	79.2	79.0
O_2	20.6	20.9
CO_2	0.25	0.03

Source: Russel, E. J., and Appleyard, A. 1915. The atmosphere of the soil, its composition and causes of variation. *J. Agr. Sci.* 7:1–48.

Table 4. Soil Oxygen and Carbon Dioxide Content at Various Depths

Depth of sampling in cm	Oxygen content		Carbon dioxide content			Carbon dioxide gradient per cent per cm	
	Wet Oct.–Jan.	Dry Feb.–May	Wet Oct.–Jan.	Early dry Feb.	Late dry April–May	Wet Oct.–Jan.	Dry April–May
10	13·7	20·6	6·5	1·0	0·5	0·65	0·05
25	12·7	19·8	8·5	2·1	1·2	0·13	0·06
45	12·2	18·8	9·7	4·3	2·1	0·04	0·07
90	7·6	17·3	10·0	6·7	3·7	0·01	0·06
120	7·8	16·4	9·6	8·5	5·1	–0·01	0·06

Soil Atmosphere.

- ✓ The soil atmosphere is not uniform throughout the soil because there can be localized pockets of air.
- ✓ The relative humidity of soil air is close to 100%, unlike most atmospheric humidity.
- ✓ Air in the soil often contains several hundred times more carbon dioxide.

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