

## **FACTORS OF SOIL FORMATION**

There are five soil forming factors:- parent material, topography, climate, biological activity, and time.

### **Parent material**

Parent material is the initial mineral substance that forms a soil. It is derived from the weathering of rocks and may reside at the site of its origin or be transported from somewhere else to its current location.

Material can be eroded from one place and transported to another where it becomes parent material for a soil at the new site.

Several forces can supply energy for the transportation of parent material: ice, wind, water, and gravity.

#### ***Ice***

Glacial deposits occur at the front and sides of advancing ice.

#### ***Wind***

Wind deposits two major types of material: eolian sands and loess.

Eolian sands are windblown deposits of material predominantly greater than 0.05 mm (0.05 to 2 mm) in diameter.

Loess, which is windblown silt-sized material (0.002 to 0.05 mm), once airborne, can travel several hundred kilometers before deposition. Windblown material tends to have sharp edges, a conchoidal shape, and surface etching.

#### ***Water***

An alluvial or stream-borne deposit occurs in floodplains, fans, and deltas.

#### ***Gravity***

Colluvium or hillslope sediments result from the force of gravity and runoff moving downslope.

### **Topography (relief)**

Topographic relief, or the slope and aspect of the land, has a strong influence on the distribution of soils on a landscape. Two aspects of topography that influences soil formation are the altitude and the slope.

Slope affects soil depth, water infiltration rate and runoff while altitude modifies the microclimate.

### **Climate**

Two aspects of climate that are important in the process of soil formation are rainfall and temperature. The total amount of rainfall as well as its intensity and distribution pattern affects the rate of soil development differently. Temperature affects the rate of biochemical and biophysical reactions taking place in the soil environment.

Climate also affects the type and amount of vegetation in a region.

### **Biological activity**

Biological activity and climate are active forces in soil formation. Soil pedogenesis involves a variety of animals, plants, and microorganisms. Ants, earthworms, and burrowing animals, for example, mix more soil than do humans through plowing and construction

### **Time**

Soils develop over time. Soil formation is a dynamic process, where a steady state is slowly approached but only rarely reached.

## **WEATHERING**

Weathering is the physical and chemical processes by which rocks and minerals are disintegrated, decomposed, and re-synthesized into new compounds. Weathering encompasses both physical and biogeochemical processes, which generally occur simultaneously.

### **PHYSICAL WEATHERING**

Physical weathering is the mechanical disintegration of rocks and minerals into smaller sizes. Some of the several mechanisms that work to break apart rocks include: temperature, water, ice, glaciers, erosion, wind, plants and animals.

#### ***Temperature***

Seasonal and even day-to-night temperature changes cause the outer surface to separate and peel off.

#### ***Water***

The force of raindrops beating down on soft rocks, and the scouring effect of suspended material in water flowing over rocks can wear the rocks away with time.

#### ***Ice***

Water can infiltrate the cracks and pores of rocks and freeze. As the ice expands and thaws, the rocks break up.

### ***Glaciers***

Glaciers weather rocks in several ways. The weight of a glacier can crush rocks. As it moves over an area, a glacier can grind and pulverize rocks. As it recedes, the pressure release can cause rocks to expand and crack.

### ***Erosion***

Erosion causes pressure-release related weathering.

### ***Wind***

Wind suspends fine particles. As the particles are pushed and bounced over one another, they abrade the rock surfaces over which they pass, slowly wearing the rocks down.

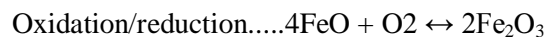
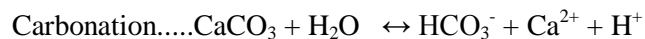
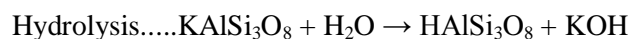
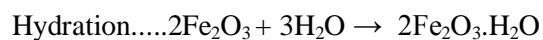
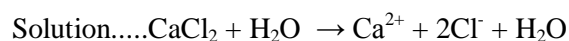
### ***Plants and Animals***

The expansion and decomposition of roots growing in soil can alter the density and coherence of particles. The digging and burrowing of animals can have the same effect.

## **CHEMICAL WEATHERING**

The process of chemical weathering changes the atomic makeup of a mineral.

Mechanisms of chemical weathering includes:-



## **COMMON MINERALS IN SOILS**

Soil minerals are also referred to as either *primary* or *secondary* minerals. They are usually derived from igneous or metamorphic rocks, but they can be inherited from sedimentary rocks as well.

Although different classification schemes could be used, mineralogists have classified soil minerals based on the dominant anion or anionic group. The classes include: (1) native elements, (2) sulphides, (3) sulphosalts, (4) oxides and hydroxides, (5) halides, (6) carbonates, (7) nitrates, (8) borates, (9) phosphates, (10) sulphates, (11) tungstates, and (12) silicates

The native elements, sulphosalts, nitrates, borates, and tungstates occur rarely in soil.

### **1. Halide, Sulphate, and Carbonate Minerals**

The major soil minerals of this group are halite (NaCl), gypsum ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ), calcite ( $\text{CaCO}_3$ ), and dolomite [ $\text{CaMg}(\text{CO}_3)_2$ ]. This group is characterized by minerals with relatively simple structures. The other minerals in this group have similar structures with cations such as  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ , or  $\text{Fe}^{2+}$  alternating with anions such as  $\text{S}_2^{2-}$ ,  $\text{SO}_4^{2-}$ , or  $\text{CO}_3^{2-}$ . The bonds between the cations and anions are predominantly ionic.

The minerals are highly soluble, easily leached and are therefore lost early during the weathering process.

They are only present in appreciable quantities only in young soils or under arid conditions

### **2. Sulphides**

Pyrite,  $\text{FeS}_2$ , the most common mineral in this group, does not occur extensively in soils, but when it is present it causes some unique problems. Pyrite often occurs in close association with coal. Pyrite is unstable under oxidizing conditions. Pyritic oxidizes in when waterlogged soils are drained or when mining leaves pyritic material on the surface to jarosite,  $\text{KFe}_3(\text{SO}_4)_2(\text{OH})_6$ , and gypsum and sulfuric acid,  $\text{H}_2\text{SO}_4$  causing high soil acidity. Soils affected by pyrite are referred to as acid-sulphate soils.

### **3. Oxides, Hydroxides and Oxy-hydroxides**

Primary minerals break down during weathering and release cations and anions that recombine to form other more stable minerals. Several elements, in particular Al, Fe, and Mn, form oxide, hydroxide, or oxy-hydroxide minerals that are stable in the soil weathering environment.

#### *a. Aluminum*

Gibbsite,  $[\text{Al}(\text{OH})_3]$  is the most common Al hydroxide mineral in soils. It is generally associated with the latter stages of weathering when leaching of silica has progressed to the point that phyllosilicate minerals

no longer form. Gibbsite is common Oxisols, Andisols and weathering interface between igneous rock and saprolite.

#### *b. Iron*

Iron oxide minerals form from Fe released from primary minerals. Iron oxides are strong pigments and small amounts of these minerals account for most of the brown and red colors of soils. Goethite (FeOOH) is the most common mineral of this group and accounts for the brownish to yellowish color of many soils, while hematite (Fe<sub>2</sub>O<sub>3</sub>) is responsible for the red color of many soils. Large amounts of these two minerals occur in association with gibbsite and kaolinite in highly weathered soils

#### *c. Manganese*

Manganese oxides and hydroxides are commonly found in soils as brown or black nodules or as thin coatings on the faces of soil structural units. They are often associated with Fe oxides. Manganese occurs frequently as birnessite or lithiophorite in soils.

#### *d. Titanium*

Rutile and ilmenite occur in soils mainly as primary minerals inherited from igneous rocks. Anatase is less common and is generally considered a secondary mineral. Although frequently found in soils, these minerals do not occur in sufficient quantity to impact soil physical or chemical properties.

### **4. Silicates**

The silicate mineral class is an extremely large and important group of minerals. Nearly 40% of the common minerals are silicates, as are most minerals in igneous rocks. Silicates occur as both primary minerals inherited from igneous or metamorphic rocks and as secondary minerals formed from the weathering products of primary minerals. The fundamental unit of all silicate structures is the SiO<sub>4</sub> tetrahedron. It consists of four O<sup>2-</sup> ions at the apices of a regular tetrahedron coordinated to one Si<sup>4+</sup> at the center. The individual tetrahedra are linked together by sharing O<sup>2-</sup> ions to form more complex structures. Several different arrangements of the SiO<sub>4</sub> tetrahedra occur, partly accounting for the large number of silicate minerals and providing the basis for their classification. The tetrahedra may be present as single

tetrahedra (nesosilicates), double tetrahedra (sorosilicates), rings (cyclosilicates), single or double chains (inosilicates), sheets (phyllosilicates) or three-dimensional frameworks (tectosilicates)

### **Soil Morphological Characteristics**

This refers to the properties of the soil that can be observed either by sight or feel

### **COLOR**

The most obvious soil characteristic is color. Although color is not used as a quantitative measure, it does give a good indication of organic matter contents, drainage conditions and mineralogical compositions. Black soil may indicate the presence of organic matter, red indicates the presence of oxidized iron while gray or bluish gray color indicates water saturation. Soil color is described by three attributes: hue, value, and chroma.

**Hue:** is the dominant spectral color. It is related to the wavelength of light reflected by soil particles.

**Value:** Value is the lightness or darkness of the color. It is a measure of the amount of light reflected.

**Chroma:** Chroma is the strength or purity of color. It indicates the degree of difference between white, black, or neutral color.

**Munsell Soil Color Charts** is used for the determination of soil color and contain several series of distinctively colored chips. Each page represents a different hue. The chart normally has 15 pages, each with a number (10, 7.5, 5, or 2.5) followed by a letter or letters indicating red (R), yellow (Y), green (G), blue (B), or combinations of these.

**Value** units range between 0 and 10. The numbers ascend vertically on the page from the lowest to highest numbers, indicating dark to light values.

**Chroma** units are arranged horizontally across the page from 0 to 10, increasing in numbers from left to right. Low numbers indicate an increase in grayness, while high numbers signify a pure color with little mixing with other hues.

### **Colour Mottles**

The mottles must be described by their abundance, size, and contrast to the background.

*Abundance:* Abundance is the relative amount of mottling. Abundance can be classified as *few*; *common* or *many*.

*Size:* Size is a measure of the estimated average diameter of individual mottles along their greatest dimension. It could be *fine*; *medium*; or *coarse*.

*Contrast:* Contrast is an indication of the relative difference in color between the matrix and mottles.

Mottle contrast may be described as faint, distinct or *prominent*