Unit # 11

SOIL FORMING FACTORS AND ITS CLASSIFICATION

The "Soil" the essential medium in which all terrestrial life is nurtured. Almost all plants sprout from this precious medium, that is spread so thinly across the continental surface, with an average worldwide depth of only about 15 cm (6 inch). Soil is one of the most complex features produced in nature, a varying mixture of weathered mineral particles, decaying organic matter, living organisms, gases and liquid solutions.

The development of soil is initiated by physical and chemical disintegration of rock that is exposed to the atmosphere and the action of water percolating down from the surface. Although soil layer is thinly distributed over the surface of the land, but it functions as a fundamental interface where atmosphere, lithosphere, hydrosphere and biosphere meet. The bulk of most of soils is inorganic, so soil is usually classed as part of the lithosphere, but its relationship to the other three spheres is both intimate and complex.

1. Soil Components:

Soil contains four components, the detail is as under (see fig. 11.1):

1.1 Minerals:

The minerals are naturally occurring chemical elements, the most common elements in the earth's crust are silicon, aluminum, iron, calcium, sodium, potassium and magnesium. When rocks breakdown into soils, these mineral components become available to plants as nutrients.

1.2 Organic Matter:

Organic matter is the material that forms from the living matter. In the upper layers of the soil, there is an accumulation of decaying and decayed remains of the leaves, stems and roots of plants. All of these contribute to the organic content of the soil.

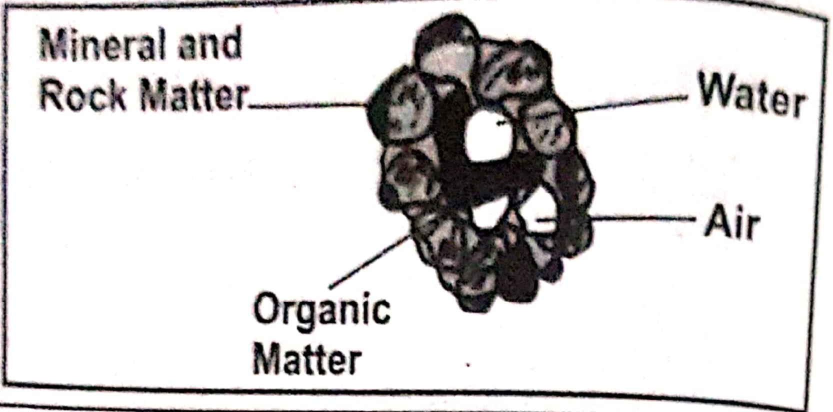


Fig. 11.1: *The four major components within a tiny clump of soil*

1.3 Water:

Water fills much of the space between the matters combining the soil. Even in very dry soil, the attraction is so persistent, that there may be a thin film of water. This water is not pure, but exists as a weak solution of the various chemicals found in the soil. Without water, the many chemical changes that must occur in the soil could not take place.

1.4 Air:

Air fills the mineral particles, organic matter and water (see fig. 11.1). It is not exactly the kind of air in the atmosphere. Soil air contains more carbon dioxide (CO_2) and less oxygen (O_2) and nitrogen (N), than atmospheric air does.

All these four components of soil came from the other spheres of the earth system.

2. Soil Forming Factors:

The most important influenceable five soil forming factors are discussed as under:

2.1 The Geologic Factors:

The source of the fragments is the parent material that have been transported from elsewhere by the action of water, wind or ice. The nature of the parent material often has a prominent influence on the characteristics of the soil that develops from it.

A bedrock that weathers into relatively larged-sized particles, such as sandstone, normally will produce a coarse-textured soil, one that is easily penetrated by air and water to some depth. On the other hand, a shale parent material weathers into very minute fragments, yielding a texture that has a minimum of pore spaces for air and water penetration.

It is evident then that the geologic factor provides the bulk of the material from which soil is developed, but it is passive factor, whose relative significance fades with time.

2.2 The Climatic Factors:

One of the very active factors in the soil formation is climate. Temperature and moisture are the climatic variables of greatest significance. High temperatures tend to speed up the chemical weathering of parent material, the decay activities of soil microorganisms, and the rate of plant growth. Similarly, an abundance of water percolating through the soil and regolith facilitates deeper and more rapid weathering and enhances plant growth. Water also carries along dissolved chemicals in solution and usually also tiny particles of matter in suspension.

In terms of general soil characteristics, climate is likely to be the single most influential of the soil forming factors. This generalization has many exceptions and when soils are considered on a local scale, climate is likely to be less prominent as a determinant.

2.3 The Topographic Factors:

Another passive factor in soil formation is provided by the topography, where the land is flat soil tend to develop at the bottom more rapidly than it is removed at the top by normal erosion. This does not mean that the downward development is speedy, rather that surface erosion is extraordinarily slow. Thus deepest soils are usually on flat land. Where slopes are relatively steep, on the other hand, surface erosion progresses more rapidly than soil deepening, with the result that, such soils are nearly always thin and immaturely developed. Likewise the presence or absence of impermeable layers are more influential than the slope of the surface.

2.4 The Biological Factors:

Although soil is about half mineral and about half air and water. with only a small fraction, being organic (see fig. 11.1). However, the organic fraction, consisting of both living plants and animals and dead plants and animals material is of utmost importance. Almost every soil contains a quantity of living organism and dead decaying matter. Plant roots work their way down and around, providing passageways for drainage and aeration, moreover dead plants are frequently added to the soil as they accumulate and decay.

Many kind of animals contribute to soil development as well. Ants, worms and all other land animals fertilize the soil with their waste products and contribute their carcasses for eventual decomposition and incorporation into the soil, when they die.

2.5 The Chronological Factors:

For soil to develop on a newly exposed land surface requires time, which may be long or very long. Soil forming processes are generally very slow, and centuries or tens of centuries, may be required for an inch or two of soil to evolve on a newly exposed surface. A warm, moist environment is inducive to soil development. and the relevant processes operate optimally under such conditions.

Normally of much greater importance, however, are the attributes of the parent material. For example, soil can develop from some kinds of sediments relatively quickly, because the breakdown of rock into small particles has already been accomplished. A soil that originates on a bedrock surface on the other hand, must undergo a much longer period of development, because the solid rock disintegrates very slowly.

3. Soil Properties:

As one looks at, feels, smells, tastes and otherwise examines soils, various physical and chemical characteristics appear, which can be very useful in describing and classifying various soils. Some soil properties are easily recognized such as:

3.1 Colour:

Soil scientists recognize 175 different gradation of colour in their descriptions, based on the widely accepted Munsell colour chart. The standard colours are generally shades of black, brown, red, yellow, gray and white. Soil colour occasionally reflects the colour of unstained mineral grains, but in most cases, it is imparted by stains on the surface of the particles, due to metallic oxides or organic matter.

Black or dark brown colours usually indicate a considerable humus content; the blacker the soil, the more humus it contains.

Reddish and yellowish colours generally indicate iron oxide on the outside of the soil particles. Similarly, a red colour be speaks good drainage, and a yellowish hue suggests imperfect drainage.

Light coloured soils — gray of white may develop in varying environments. In humid areas, a light colour implies so much leaching, but in dry climates, it indicates an accumulation of white alkali or other salts, and lack of organic matter.

3.2 Soil Texture:

Rolling a sample of soil about between the fingers can provide a "feel" for the principal particle sizes (see table: 11.1). The standard classification of particle size groups are called separates. The three principal separates are sand, silt and clay (see fig. 11.2).

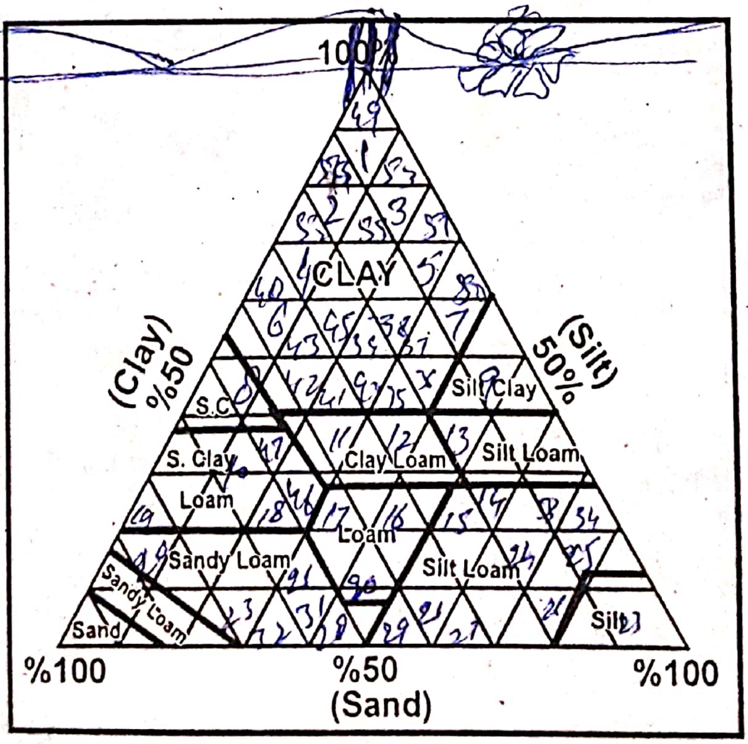
No soil is made up of particles of uniform size, so the texture of any soil represents the proportional occurrence of the various separates. Near the center of the triangle is term *loam*, in which none of the separates dominates the other two. On the other hand, larger the percentage of a separate, greater is it domination (see fig. 11.2). The fairly even texture mix is generally the most productive for plants.

Table: 11.1

STANDARD SOIL PARTICLE SIZES

Separate	Diameter (Inch)	Diameter (mm)
Gravel	>0.08	>2.0
V. Coarse Sand	0.04 — 0.08	1.0 — 2.0
Coarse Sand	0.02 — 0.04	0.5 — 1.0
Medium Sand	0.01 — 0.02	0.25 — 0.5
Fine Sand	0.004 — 0.01	0.1 — 0.25
Very Fine Sand	0.002 — 0.004	0.05 — 0.1
Coarse Silt	0.0008 — 0.002	0.02 — 0.05
Medium Silt	0.00024 — 0.00008	0.006 — 0.02
Fine Silt	0.00008 — 0.00024	0.002 — 0.006
Clay	< 0.00008	< 0.002

Source: ("*Physical Geo.*" by T.L. McKnight, P. 328)



3.3 Soil Structure:

The individual particles of most soils tend to aggregate into large clumps, called *peds*, which determine the structure of the soil. Soils exhibit four basic structures: (see fig. 11.3)

(*i*) Platy Structure:

Involves layered peds that look like flakes stacked horizontally (see fig. 11.3, a). The individual plates are as much as 1 to 2 cm (0.4 to 0.8 inch) across, and occasionally even larger.

(*ii*) Prismatic Structure:

Prismatic structure reveals peds arranged in columns, giving the soil vertical strength. Individual peds in soils with prismatic structure range from 0.5 cm (0.2 inch) to as large as 10 cm (4 inch) (see fig. 11.3, c).

(*iii*) Blocky/Angular Structure:

These peds, however, have straight sides that fit against the flat surfaces of adjacent peds, giving the soil considerable strength (see fig. 11.3, b).

(*iv*) Spheroidal/Granular Structure:

These peds are usually very small and often nearly round in shape (see fig. 11.3, d), so the soil looks like a layer of bread crumbs. Such soil are very porous, weak so they are more susceptible to erosion.

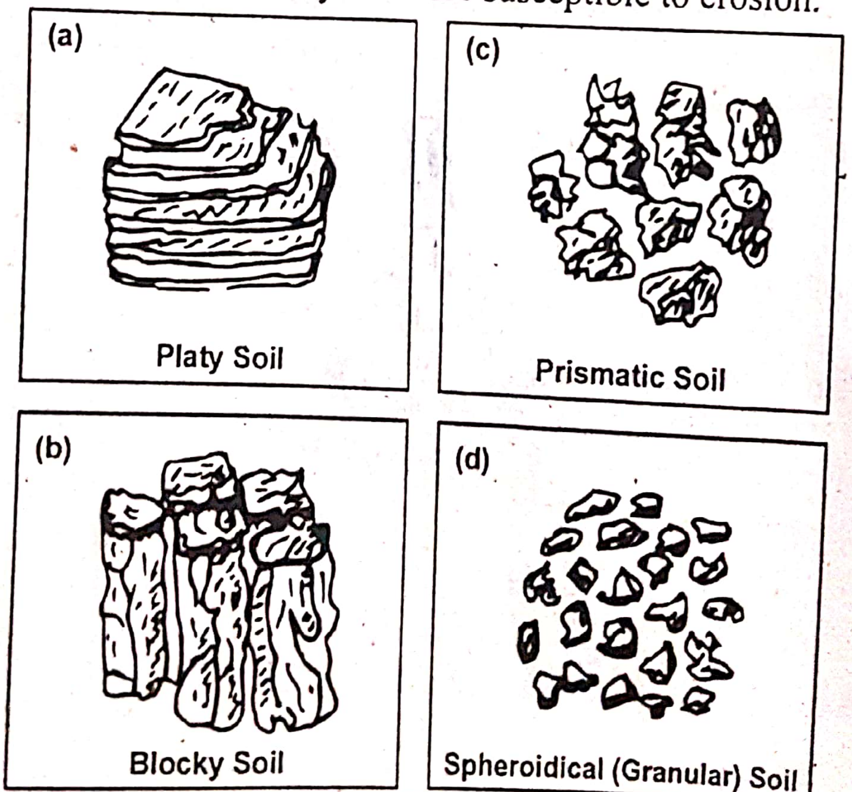
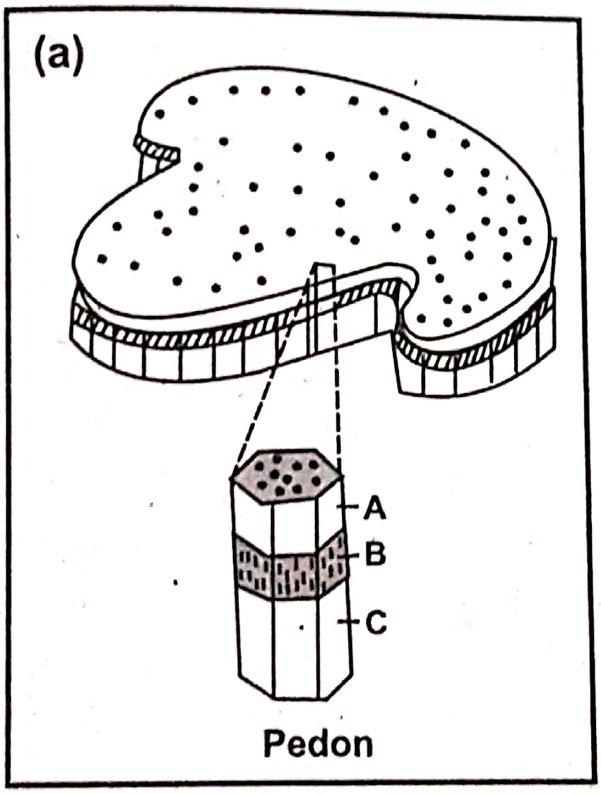


Fig. 11.3: *Soil structure, (a) platy, (b) blocky, (c) prismatic, and (d) granular.*

4. Soil Profiles:

If we dig a hole or pit into the soil, it is revealed a series of layers changes in colour and by the feel or texture of the material (particles), which they are made. Each of these soil layers is called a *soil horizon*. The differentiation of soil into distinct layers is called *horizonation*. All the horizons from top to bottom, are known as the *soil profile* (see fig. 11.4). Thus a vertical section (column) through the soil is called, soil profile, while the distinct layers consisting horizontally are known as soil horizons, each with different characteristics. Figure (11.4, b) presents an idealized sketch of well-developed soil profile in which five major horizons (with some sub-horizons) are differentiated. These five horizons are summarized below:



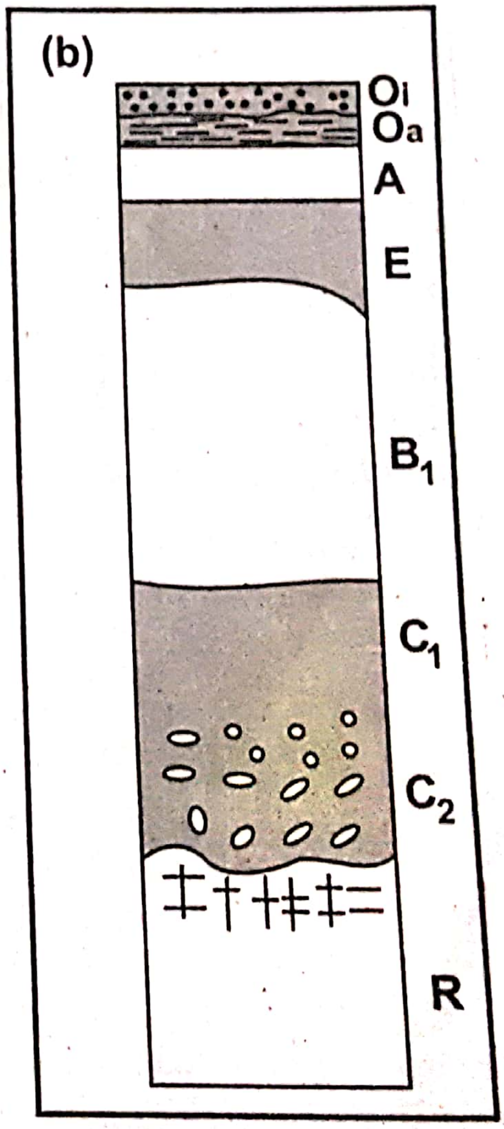


Fig. 11.4: *A complete soil column or pedon (a), and an idealized diagram of a soil profile (b).*

The O-Horizon:

The O, horizon is the immediate surface layer, in which organic matter, both fresh and decaying makes up most of the volume (see fig. 11.4, b).

The A-Horizon:

The A, horizon is a mineral horizon, that also contains considerable organic matter. It is usually dark in colour. It is formed at the surface or below O, horizon (see fig. 11.4, b). Seeds germinate mostly in the A horizon.

The E-Horizon:

The E, horizon is normally lighter in colour than either the overlying A, or the underlying B, horizons. It is essentially an alluvial layer in which silicate, clay, iron and aluminum have been removed, leaving a concentration of sand or silt particles of a resistant composition, such as silica.

The B-Horizon:

It is a mineral horizon of illuviation, where most of materials removed from above have been deposited. It is a collecting zone of clay, iron and aluminum. It is usually a heavier texture, greater density and relatively greater clay content than the A horizon.

The C-Horizon:

The C, horizon is unconsolidated parent material (regolith) beyond the reach of plant roots and most soil-forming processes except weathering. It is lacking in organic matter.

The R-Horizon:

The R, horizon is consolidated bedrock.

The true soil, or *solum*, includes only the top four horizons; O, the organic surface layer, A the topsoil, E the eluvial layer, and B, the subsoil. Soil scientists (pedologists) sometimes recognize a number of variations of this basic profile pattern. The A, horizon, for example, may have sub-divisions labelled A_1, A_2, A_3 etc.

The profile is such an important indicator of the characteristics and capabilities of a soil that it is the principal diagnostic factor in soil classification. The almost infinite variety of soils in the world usually are grouped and classified on the basis of differences exhibited in their profiles.