Soil Sci

CHAPTER I NOR. Saba 1st 701

7. SOIL FORMATION

Soil formation means both the production of parent material by weathering processes and the soil profile development. Actually the process of weathering and the changes within the soil mass occur simultaneously.

7.1. Processes of Soil Formation

Changes during soil formation take place by the following four processes simultaneously.

7.1.1. Additions

These are made by water (rainfall, irrigation), nitrogen from bacterial fixation, energy as sunlight, sediment from wind and water, salts, organic residues, and fertilizers. A very common example is the addition of organ from fallen plant leaves

7.1.2. Losses

These result from chemicals soluble in soil water, eroded small-sized fractions, nutrients in harvested plants, water losses, carbon losses as carbon dioxide and nitrogen losses.

7.1.3. Transformations

These occur due to many chemical and biological reactions that decompose organic matter, form insoluble materials from the soluble substances, and alter or dissolve some minerals.

7.1.4. Translocations

As water and organisms move within the soil, many substances are translocated to different depths. e.g., clay to deeper depths; soluble salts to the soil surface as water evaporates.

7.2. Factors of Soil Formation

The formation of soil is a diverse and complex process and is affected by certain factors working in combination.

Soil formation factors may be defined as the variables, usually interrelated natural agencies that are active in and responsible for the formation of soil. These factors are usually grouped into five major categories.

Translocations involve movement of inorganic & organic materials laterally within the horizon or vertically from one horizon up or down to another.

7.2.1. Climate

Climate is an increasingly dominant factor in soil formation mainly because of the effects of rainfall ., temperature, and winds. These sub-factors affect the rates of chemical, physical and biological processes that are responsible for the development of soil profile.

a The biochemical changes are sensitive to temperature. These changes are favoured by a temperature range of 20-30°C. Temperature also influences organic matter content of the soil. Decomposition of organic matter is more at higher temperatures. e.g., Organic matter is generally low in soils of dry region like Pakistan.

b Moisture is important in soil formation. Rainfall is the source that provides moisture. In areas receiving low rainfall, there is shallow accumulation of carbonates in the soil. In humid areas (having high rainfall), acid soils are developed under conditions of intense weathering and leaching. Erosion caused by water may remove upper portion of soils and may deposit it to some other place. A soil is said to be "developed" when it has detectable layers (Horizons), such as accumlated clays, organic colloids, or soluble salts that have been moved by water.

c Wind can affect soil development through erosion as it may decrease the depth of soil developed and may damage the lower vegetation. In sandy areas (e.g., Cholistan), the destruction effects of winds are more pronounced.

d Climate also influences the natural vegetation. In humid regions, high rainfall provides an environment favourable for the growth of trees. In contrast, grasslands are dominant native vegetation in semiarid, and shrubs of various kinds in arid areas. In these areas, the vegetation is not dense enough to protect soil from wind and water erosions.

7.2.2. Parent material

The nature of parent material greatly influences soil characteristics. Parent materials influence soil formation by:

a) their different rates of weathering

b) the nutrients they contain for plant use

c) the particle size they contain

For example, sandstones give rise to sandy, conglomerates to rocky, and shales to clayey soils.

The less developed a soil is, the greater will be the effect of parent material on the properties of the soil. However, even the properties of well-developed soils are greatly influenced by the parent material. All soils at the lowest category of soil classification (soil series) are placed into separate series if parent materials are different.

Parent material may be dominant in determining soil properties. Soils from weakly cemented sandstones will be sandy; soils from shales will be fine textured. Parent material also influences the quantity and type of clay minerals present in the soil profile, ... soils developed from potassium rich parent material may have illite as the dominent clay mineral.

7.2.3. Living organisms

The activity of living plants and animals and the decomposition of their organic wastes and residues have marked influence on soil development.

Soil organisms play a major role in profile differentiation, organic matter accumulation, profile mixing, nutrient cycling, and structural stability are all enhanced by the activities of organisms in the soil. ~~Burrowing~~ Animals such as moles, earthworms, ants and termites are highly important when they exist in large numbers. Soils having a large number of these animals have ~~fewer but~~ deeper horizons because of the constant mixing with in the soil profile.

Microorganisms present in the soil attack plant and animal residues producing organic materials. These along with an abundance of plant roots help bind soil particles in stable aggregates. Similarly, certain microorganisms can "fix" atmospheric nitrogen into compounds usable by the plants. This provides an

$S = f(cl, o, r, p, t)$

cl = climate, o = organism, r = relief, p = parent material & t = time.

Climate & organisms = active factors

Parent material, topography/relief & time are passive factors

(They may inhibit or resist the active processes of soil formation)

Topography: It refers to the configuration of the land surface & can be described as elevations or inequalities of land surface ~~considered collectively~~. It is described as level, flat, rolling, hilly & mountainous

- Topography influences profile development through its effects on quantity of precipitation absorbed & retained in the soil * the amount of water lost as runoff, * soil erosion * drainage, & microclimate of site.
- slope control soil properties e.g depth of the solum, thickness & O.M content of horizon, relativeness wetness of profile, color of profile, degree of differentiation, soluble salt content kind & degree of pan development, temperature etc

e.g In ~~northern hemisphere~~, soils on south & west facing slopes recieve more direct rays of the sun & are warmer & drier than north & east-facing slopes.

Time ⇒ Most soil forming processes are time-dependent, so development of many features of soil formation are also time-dependent

- Soils are classified into young, mature & old soils which are weakly, moderately & strongly developed.
- Under ideal conditions, a profile may develope in 200 years (inceptisols), otherwise it may take 4000 - 10,000 years. (alfisols)

According to Boul (1980)

A horizon	1 - 20 years/cm
A + B	40 - 100 years/cm
Complete weathering in the solum	100 - 750 years/cm