RAMA UNIVERSITY

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FACULTY OF AGRICULTURAL SCIENCES & ALLIED INDUSTRIES

SOIL FORMATION

SOIL FORMING FACTORS

Soil formation is a process of two consecutive but overlapping stages

1. The weathering of rock (R) in to parent material,
2. The formation of the soil from parent material

Weathering processes Rock ..... ? Parent material ..... ? Soil forming

Dokuchaev (1889) was the first person to show that soils usually form a pattern in the landscape and established that they develop as a result of the interplay of soil forming factors viz: parent material, climate and organism, which he put forward in the form of an equation

$$S = f(P, Cl, O)$$

Jenny (1941) formulated the following equation $S = F(Cl, B, R, P, T)$

S= any soil property **Cl** = Climate **B** = Biosphere **R** = Relief / topography **P** =Parent Material **T**= Time additio nal unspecified factors.

Soil can be defined in terms of soil forming factors. “Soil is a dynamic natural body having properties derived from the combined effect of climate and biotic activities as modified by topography acting on parent materials over a period of time.

Joffe divided the soil forming factors into active and passive factors. Parent material, Relief / Topography and Time -- Passive factors Climate, Vegetation & Organisms- Active factors

Active soil forming factors

The active soil forming factors are those which supply energy that acts on the mass for the purpose of soil formation.

Climate: Temperature and rainfall are the two climatic agents that influence the process of soil formation. Amongst all the soil forming factors, climate perhaps is the most influential in soil development. Climate affects the soil formation directly and indirectly. Directly climate affects.

the soil formation by supplying water and heat to react with parent material. Indirectly it determines the flora and fauna activities which furnish a source of energy in the form of organic matter. This energy acts on the rocks and minerals in form of acids and salts that are released, during decomposition of the organic matter. The climate i.e. precipitation an d temperature affects the rate of chemical, physical and biological processes responsible for profile development.

Soils formed under the predominant influence of climate, where the parent material effects are obliterated, are known as 'Ectodynamomorphic soils'. Soils are formed under the supreme influence of parent material are known as 'Endodynamomorphic soils'

Rainfall:

- Humid regions: If precipitation or rain fall > PET (Potential evapo transpiration) leaching of bases take place. pH of the soils is decreased. Soils become acidic. Vegetation will be more. The soils have more organic matter due to less decomposition. Soils exhibits good horizonation.
- High rain fall leads to loss of soil through runoff and erosion in sloppy areas and accumulation of materials in plains leading to the development of different soils..
- Arid and semi arid regions: Rainfall < PET. Here percolation of water will be less. So bases accumulate. pH of soils will be more. Soil horizonation is poor.

Temperature:

- According to Vant Hoff's law For every 10ºC rise in temperature , the chemical reactions are increased by a factor of 2 or 3. Hence as temperature increases the weathering of rocks increases due to more biological activity and faster chemical reactions. Usually weather ing will be more in tropical climate than temperate climate.
- In cold humid climate the soils are grayish and in warm humid climate the soils redder in colour.

Biota (Vegetation and Organisms): The nature of vegetation in an area is influenced by the type of parent material in the initial stages, but with time, it is the climate which controls the kind of vegetation i.e. grasses, forests, shrubs etc., The nature of the soil thus developed to a great extent is governed by the type of vegetation.

- The organic matter content of the grass land soils is generally higher than that of soils in forested areas, especially in sub surface horizons. Structural stability of soil aggregates is more under grass land vegetation.
- Under coniferous vegetation soil acidity is li kely, because the leaves of cone trees are low in basic cations i.e. Ca, Mg,K,Na ; and also the leaching is rapid under this vegetation.
- Under deciduous trees (oaks and maples) cycling of nutrients through continuous litter is more and soils would be rich with base saturation.

With organic enrichment of soils, microbial activity would be enhanced and soil is likely to be enriched with available nutrients .Soil organisms play a major role in profile differentiation. Organic matter accumulation profile mixi ng, nutrient cycling and structural stability are all enhanced by the activities of organisms in soil. Vegetative cover reduces natural soil erosion rates, there by slowing down the rate of mineral surface removal.

Human activity like deforestation, tilli ng soils, irrigation and fertilization significantly influences soil forming processes.

Parent Material : Parent material as such exerts significant influence on soil characteristics during the initial stages of soil development. The nature of parent material profoundly influences soil characteristics like texture, which is the basic property of the soil and can not be altered easily. Soil texture controls downward movement of water, there by affecting the translocation of fine soil particles and plant nutr ients.

The role of parent material in soil formation is passive and so there would be weak correlation between the parent material and soils formed from them. In the initial stages soil properties are mainly determined by the kind of parent material.

Basalt ---------- Red Soils (Ultisols)

Basalt ---------- Black Cotton Soils (Vertisols)

Acid igneous rocks ------light textured podzolic soils

Basic igneous rocks---------- fine textured cracking clay soils (Vertisols)

Basic alluvium materials fine to coarse textured soils (Entisols or Inceptisols)

The nature of the elements released during the decaying of rocks has a specific role in soil formation.

1. Silicon and aluminum furnish the skeleton for the production of secondary minerals.
2. Fe and Mn are important for imparting red color to soils and for oxidation and reduction phenomena.
3. Na and K are important dispersing agents for clay and humus colloids.
4. Ca and Mg have a fl occulating effect and result in favourable and stable soil structure for plant growth.

Relief: Relief or topography relates to the configuration of the land surface and is described in terms of difference in elevation, slope and so on. The topography of t he land can hasten or delay the work of climatic forces.

- The significance of topography, as a genetic factor, is more noticeable locally as it influences the climate and vegetation of an area.

- Topography influences the thickness of the profile. The soils on flat topography tend to be thick, but as the slope increases, so does the erosion hazard resulting in thin stony soils.
- Soil climate is more humid on gentle slopes than steeply sloping lands and still moist or wet in valleys and depressions or valley land.
- The soils on steep slopes are generally shallow, stony and have a weakly developed profile with less distinct horizonization. It is due to accelerated erosion which removes surface material before it has time to develop.

Red soils---------- Higher topographic position Black cotton soil Lower topographic position.

Time : The length of time required for a soil to develop the distinct layers, called as genetic horizons (Matured soil with A,B,C horizons) depends on many interrelated fa ctors of climate, nature of plant material, organism and topography.

- Horizons tend to develop more rapidly under the warm humid and forested conditions than in cold or hot, and arid climates.
- Generally soils age faster on flat to gently sloping uplands than on flat low lands or on steeply sloping positions.

Soils on river flood plains remain younger due to periodic erosion or accumulation of soil material.

Weathering stages:

Initial stage: Unweathered parent material

Juvenile stage: Weathering has just started but much of original material can be seen. Virile stage: Easily weathered minerals are not seen (completely decomposed)

Senile stage: Only most resistant minerals like quartz survive in these soils.

Final stage: Soil development is complete under the prevailing conditions.