1. Details of Module and its structure

Module Detail	
Subject Name	Geography
Course Name	Geography 02 (Class XI, Semester - 2)
Module Name/Title	Soil as an Organism – Part 1
Module Id	kegy_20601
Pre-requisites	Basic Knowledge about soils, soil profile and factors determining soil formation
Objectives	After going through this module, the learners will be able to know about : 1. Characteristics of Soils 2. Soil Profile 3. Factors determining soil formation
Keywords	Soil, Soil Profile

2. Development Team

Role	Name	Affiliation
National MOOC Coordinator	Prof. Amarendra P. Behera	CIET, NCERT, New Delhi
Program Coordinator	Dr. Rejaul Karim Barbhuiya	CIET, NCERT, New Delhi
Course Coordinator (CC) / PI	Prof. Tannu Malik	DESS, NCERT New Delhi
Course Co-Coordinator / Co-PI	Dr. Nidhi Gusain	CIET, NCERT, New Delhi
Subject Matter Expert (SME)	Dr. Swagata Basu	SSV (PG) College, Hapur
Review Team	Prof. B.S Butola	School of Social Sciences, JNU, New Delhi
Technical Team	Mr. Shobit Saxena Ms. Khushboo Sharma	CIET, NCERT, New Delhi CIET, NCERT, New Delhi

Table of content

Introduction:

Human beings are dependent on soils. It may also be said that good soils are also dependent on human beings as it is the humans who make use of soils as well as preserve and conserve soils. Soils are natural bodies that help plants thrive, and human beings and all other living organisms depend on plants for food and fibre. It would not be an exaggeration to say that great civilizations have thrived on good soils. It is not just plants, but houses, factories, highways and other structures depend on soil as their foundation.

Soil - Definition:

The origin of the soil, it's classification and it's description are the subject matter of *Pedology*. There are two approaches of understanding the concept of soils. These are: Pedological and Edaphological Concepts of Soils.

Pedolgy considers soil as a natural body and does not consider the practical uses of soil. A pedologist studies, examines and classifies soil as they occur in the natural environment. There are two approaches of understanding the concept of soils. These are: Edaphological and Pedological Concepts of Soils.

Edaphology views soil from the perspective of plants and therefore considers the various properties of soils related to growth of plants.

There are four major components that make up soil. Let us find out about the four components.

Four major components of Soil:

Mineral Soils comprise of four major components. These are: mineral materials, organic matter, air and water.

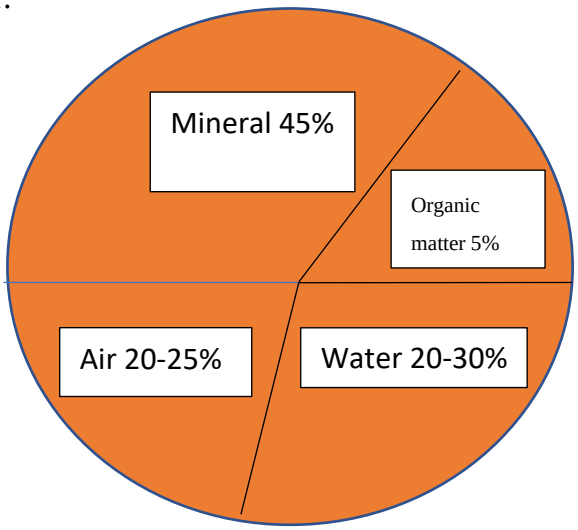

Fig 1. Four Major Components of Soil

In order to understand the formation and types of soils found over the surface of the earth, it is essential to learn about the soil profile

Soil Profile:

When soil is examined in vertical sections appearing below the surface of the earth, one finds that distinct horizontal layers may be observed. Such a layered appearance of soil in vertical sections is known as **Soil Profile**.

The individual layers are called Horizons

Every well developed, undistributed soils have its unique profile characteristics and distinctive horizons. The study of soil horizons and the soil profile help in survey and classification of soils.

Soil Horizons:

The upper layers or horizons of the soils contain a great amount of organic matter and are generally dark in appearance. When soil is ploughed for farming, these layers are termed as the 'top soil' or the surface soil.

The layers that lie below the top soil are known as 'sub soil'. The sub soil contains lesser amount of organic matter than the top soil.

The various layers of the soil profile are not always well defined or distinct. The transition from one horizon of the soil to the other is so gradual that it often becomes very difficult to mark the boundaries between these horizons.

Yet, these horizons are of great importance as these determine which kind of plants may grow on the soils.

The topsoil is of great importance since the roots of plants grow in it. The nutrients that the plant absorbs and also the water that the plant requires are all sourced from this layer.

Even though sub-soil may not be visible from the surface, but it controls the choice of activities that may be carried out in that particular soil. Certain plants have deep roots that go down into the sub-soil. The storage of nutrients and water of the sub-soil greatly affects the kind of plants that may grow over it. Other than agricultural uses, what kind of buildings may be constructed over the soil or whether roadways and other communication lines may be successfully built on a particular soil are also dependent on the nature of the sub-soil.

Major horizons that make up the soil profile have specific terminologies for studying soils and describing them.

The keys used for denoting the Horizons are: O, A, E, B, C and R.

Let us now find out what each of these Soil Horizons are made up of.

O – Organic Horizon – The O group are Organic Horizons that form above the mineral soil. They are formed from the litter of dead plants and animals. O layer is usually rich and deep in forested areas and are very shallow or almost absent in regions dominated by grasslands.

Fig: 2. Leaf Litter over Forest Soil

https://commons.wikimedia.org/wiki/File:Leaf_litter_in_Epping_Forest_off_Fairmead_Road,_High_Beach,_Essex,_England.jpg

The O layer may contain Organic matter in the form of animal and plant residues on the top, followed by residue that is partially decomposed and in the lowest layer highly decomposed residue.

Eluvial Horizons: This group of mineral horizons that lie at or near the surface have zones of maximum leaching or eluviation and deposition of maximum organic matter.

The Horizon is marked as A or E.

A Horizon: It is the topmost mineral horizon. This horizon comprises of humified organic matter which gives this layer a dark colour compared to the lower horizons.

E Horizon: This layer contains the maximum amount of clay, iron, aluminum oxides and concentration of hard minerals like quartz. It is usually lighter in colour than the A Horizon.

The transition zone between A and E Horizon are sometimes absent

Illuvial Horizons: This is the layer where maximum minerals are concentrated. It is in this layer that minerals such as aluminum and iron oxides as well as silicate clays are concentrated.

B Horizon – B Horizon comprises of various sub-layers. The topmost part of the B Horizon comprises of the transition zone between A or E and the B horizon. This is followed by the zone that is known to have the highest concentration of clays and oxides that have moved down from the top layers. Organic matter content is more than that of E horizon but more than what is found in A horizon.

The B horizon ends with a transition zone between the B and the C horizon

C Horizon – The C horizon comprises of unconsolidated matter underlying Horizon A and B. It may or may not be of made of the same material as the parent material from which horizons A and B are formed. In this zone biological activities are absent. With the passage of time, the upper layers of the C horizon may become a part of the B horizon due to the processes of weathering and erosion

Horizon R – This horizon comprises of the consolidated rocks

The diagram shows the various horizons that comprise the Soil Profile

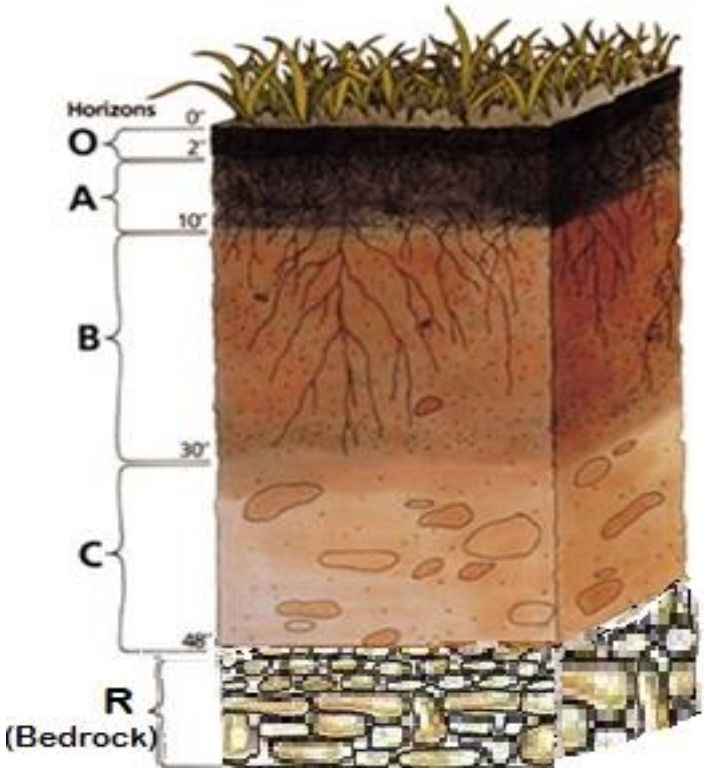

Fig 3. Soil Profile with Horizons

https://commons.wikimedia.org/wiki/File:SOIL_PROFILE.png

Each type of soil presents it's own distinctive Soil Horizons.

Let us now look at the factors that influence the formation of Soils

Factors of Soil Formation:

Studies on formation of soils across the world reveal that there exist five important factors that play key roles in formation of soils.

The five major factors are:

1. Climate – (particularly temperature and precipitation
2. Living Organisms (particularly vegetation and human beings)
3. Nature of the Parent Material – a. Texture and Structure; b. Chemical and mineralogical composition.
4. Topography
5. Time duration during which the parent material is subjected to soil formation.

Soils are often defined in terms of the above mentioned factors as "dynamic natural bodies that possess properties derived from the combined effect of climate and biotic activities, which is then modified by topography acting on parent materials over varying periods of time.

Let us now find out how each of these factors help in the formation of soils

Climate: Climate is the most influential factors that helps in the formation of soils. Climatic conditions control the nature of weathering that takes place on rocks. The amount of precipitation and the temperature regime play crucial roles in deciding the rates of physical as well as chemical processes that lead to the creation of soil profile. Climatic conditions tend to dominate over the rest of the factors involved in the formation of soils.

It has been documented that for every 10 degrees rise in temperature, the rate of chemical weathering doubles. Biochemical changes by soil organisms are sensitive to temperature and moisture regime of the region where the soil formation takes place. This is the reason why one finds very modest profiles in arid regions whereas in the humid tropics, soil profiles are deeply weathered.

The figure shows how distinct soil types develop in different climatic regimes. In the diagram, the influence of precipitation, temperature and evapotranspiration is shown as important controlling factors prevailing over an area that may modify the soils found there.

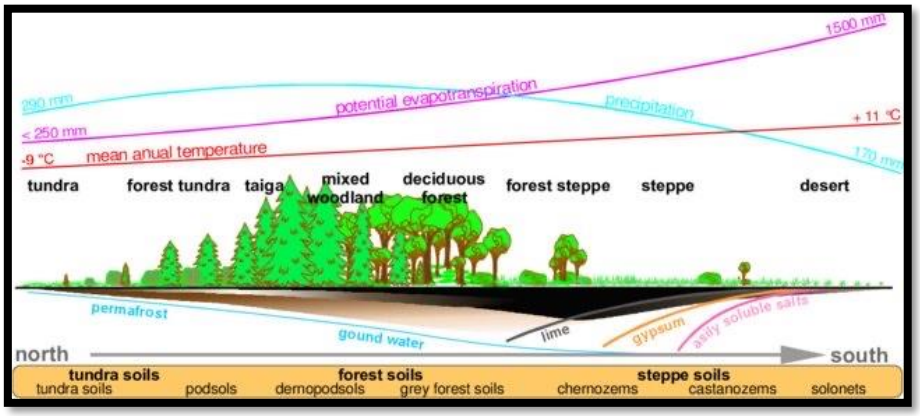

Fig 4: Soil Types and Climatic Regimes

https://www.researchgate.net/publication/34754933_Investigation_of_the_thermal_and_biological_stability_of_soil_organic_matter_Untersuchungen_zur_thermischen_und_biologischen_Stabilitat_der_organischen_Bodensubstanz/figures?lo=1

Climatic regime of a region also influences the vegetative cover found there. The vegetation in turn, exerts it's influence on soil formation. In humid regions, abundance of rainfall makes growth of trees possible while in the semi-arid regions, grassland may be found. So, climate indirectly influences the soil profiles through the type of vegetation it supports.

Fig 5. Forests

https://pixabay.com/photos/forest-forests-tucholski-poland-1973952/

Fig 6: Grassland

https://commons.wikimedia.org/wiki/File:Antelope,_Kiowa_National_Grasslands.jpg

Living Organisms: The role played by biotic activity in formation of soils is of great importance. Organic matter accumulation, profile mixing, nutrient cycling and structural stability are all influenced by the activities of living organisms that are present in the soil.

Fig 7: Earthworm

https://commons.wikimedia.org/wiki/File:Earthworm_on_earth_-_heart.jpg

Fig 8: Star Nosed Mole

https://pxhere.com/en/photo/1359582

Micro-organisms also help in nitrogen fixation in soils in association with certain plants. The plant cover over the soils also play an important role in checking soil erosion and thereby slow down the process of removal of nutrients from the soil.

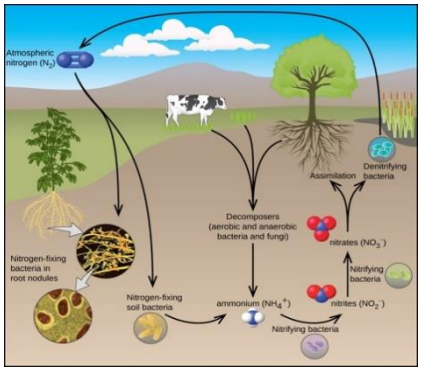

Fig 9: Nitrogen Fixation Process

https://commons.wikimedia.org/wiki/File:CNX_Chem_18_07_Nitrogen.png

Fig 10: Nitrogen Fixing Nodules

https://commons.wikimedia.org/wiki/File:Nitrogenfixing_nodules_in_the_roots_of_legumes..JPG

When one compares the effect of vegetation on the soils of two discreet regions like the forest and the grasslands, the properties of soils of the two regions vary greatly.

The organics matter content is much higher in soils of grasslands especially in the sub-soil horizon. The concentration of organics matter gives the horizon a dark colour.

Fig 11: Dark Coloured Organic Matter

https://upload.wikimedia.org/wikipedia/commons/e/ea/Organicmatter.jpg

The horizon is also capable of storing more moisture when compared to forest soils. In the grasslands, the structural stability is more pronounced.

The minerals present in the leaves, stems and branches of the vegetation which fall over the soil and decompose also contribute to the mineral content of the soil. Coniferous trees have less of potassium, magnesium and calcium so, these minerals will be deficient in soils that are covered by coniferous trees as compared to soils that are covered by deciduous trees.

Soils under pine forests tend to be acidic in nature and leaching activities are more common in soils which are dominated by coniferous vegetation.

Fig 12: Soil below Pine Forest

https://pxhere.com/en/photo/1628684

Human activities also play a significant role in the soil forming factors. Activities such as de-forestation, and cultivation of crops modifies the soil forming factors.

Fig 13: Cultivation

https://upload.wikimedia.org/wikipedia/commons/2/21/Indian_agriculture_cultivation.jpg

Irrigation, addition of lime and fertilizers to the soil by human beings also alters the nutrient composition of the soils.

Fig 14: Irrigation

https://upload.wikimedia.org/wikipedia/commons/f/f9/Peanuts_irrigation_in_india.jpg

Even though the role of human activities in soil formation process is a very recent influence if we consider the geologic history of soil formation, yet it may be observed that in certain regions human beings have made significant influence in soil formation process.

Parent Material: The characteristics of the parent material of the soil asserts a very strong influence on the on the properties of the soil. This true even for soils that are highly weathered. Parent material determines the texture of sandy soils.

Fig 15: Sandstone (Parent Material of Sandy Soil)

https://upload.wikimedia.org/wikipedia/commons/b/b8/Sandstone_in_Petra_Jordan.jpg

The downward percolation of water is dependent on the texture of the parent material.

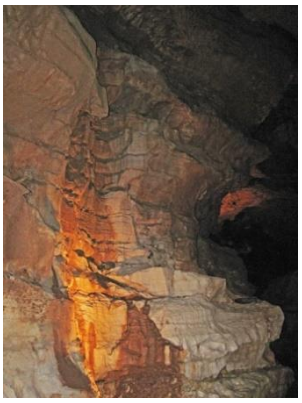

Fig 16: Downward percolation of Water

https://upload.wikimedia.org/wikipedia/commons/0/05/Domepit_along_canyon_passage_%28Diamond_Caverns%2C_Kentucky%2C_USA%29_1_%2831732425022%29.jpg

The chemical and mineralogical composition of parent material not only determines the effectiveness of weathering but in some cases partially controls the natural vegetation. The presence of limestone in humid region soil will delay the development of acidity which is otherwise the climatic conditions would induce acidity in those soils.

Parent material also influences the type of clay minerals in the soil profile. The parent material itself might contain clay minerals from it's earlier weathering cycles. The nature of parent material also influences the nature of that is found in the soil. Illite, tends to form from mildly weathered potash containing micas while smectitite is formed in parent materials that have high concentration of calcium and magnesium.

Fig 17: Illite

https://upload.wikimedia.org/wikipedia/commons/6/6b/Illite-RM.jpg

Fig 18: Azurite Kaolinite

https://upload.wikimedia.org/wikipedia/commons/5/56/Azurite-kaolinite_1_%2832878789928%29.jpg

From the above discussion it may be concluded that parent material plays a significant role in the formation of soils.

Topography: The topography of the land may have a strong influence in expediting or delaying the work of climatic agents which in turn plays a crucial role in soil formation.

In plain areas excess of water takes a long time to be removed while in a rolling topography, water drains off quickly.

Fig 19: Plain area

https://upload.wikimedia.org/wikipedia/commons/4/4a/Flat_flood_plain_of_the_River_Rother_-_geograph.org.uk_-_1754795.jpg

Fig 20: Rolling Hills

https://pixabay.com/photos/canola-fields-rolling-hills-4107064/

Rolling topography also encourages natural erosional processes in the surface layers thereby limits the possibility of formation of deep soil. In areas that experience stagnation of water round the year, there, the climatic influences become quite ineffective in regulating soil development.

Topography and vegetation together have a significant influence on the formation of soils. In the grassland-forest transition zones, whereever there exist depressions on the surface, growth of trees in those depressions may be found.

Fig 21: Trees in depression

https://upload.wikimedia.org/wikipedia/commons/0/0a/Loch_Orodale_Through_The_Trees._-_geograph.org.uk_-_555406.jpg

The presence of trees in the depression influences the type of soil found in those depressions varying significantly from the soils found in the uplands in the vicinity. Topography is not only a controller of climatic factors but is also an influencer in formation of soils.

Time: The length of time that materials have been subjected to weathering plays a significant role in soil formation. A comparison of soils from a glaciated region with those in a comparable area untouched by the ice sheet illustrates the significance of time.

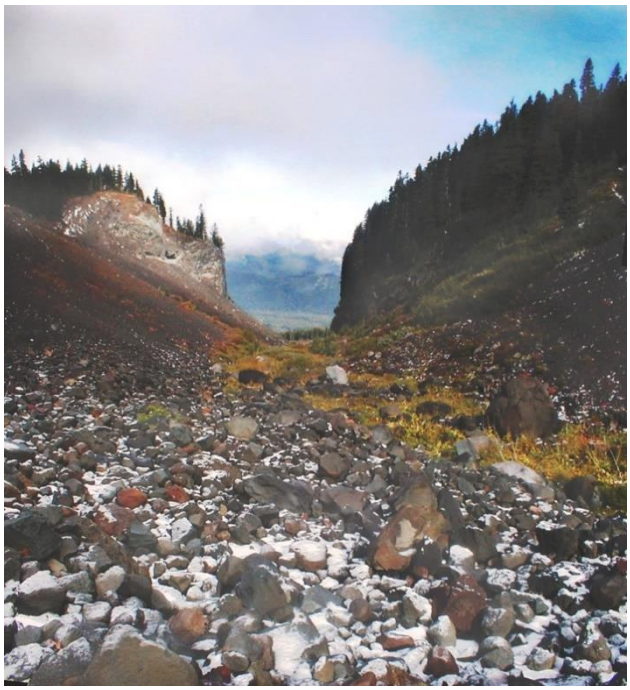

Fig 22: Glaciated Region

https://upload.wikimedia.org/wikipedia/commons/4/4a/Glacial_Valley_MtHoodWilderness.jpg

Fig 23: Ice Sheet

https://upload.wikimedia.org/wikipedia/commons/f/f9/Greenland-ice_sheet_hg.jpg

The influence of parent material is much more apparent in the soils of glaciated regions, where insufficient time has elapsed since the ice retreated to permit the full development of soils.

Soils located on alluvial or lacustrine soils, generally have not had much time to develop as the surrounding upland soils.

Fig 24: Lacustrine Soils

https://upload.wikimedia.org/wikipedia/commons/5/57/Lacustrine_deposits.jpg

Fig 25: Upland Soils

https://upload.wikimedia.org/wikipedia/commons/1/12/Erosion_gulleys_on_unterraced_farmland_in_Yunnan.jpg

Some coastal plain parent materials have been uplifted only in recent geological time, and consequently, these the soils these have had relatively less time for weathering.

Fig 26: Coastal Plains

https://upload.wikimedia.org/wikipedia/commons/0/09/View_from_Rosh_Hanikra_mount.jpg

The interaction of time with other factors, affecting soil formation must be emphasized. The time required for development of a horizon will be related to the parent material, the climate, and the vegetation. It is easy to visualize the interdependence of these factors in determining the kind of soil that develops.