THE SOIL PROFILE

Soil profile is the term used for the vertical section of mature soil generally upto the depth of 2 meters or upto the parent material to show different layers or horizons of soil for the study of soil in its undisturbed state. It is made up of a succession of horizontal layers or **horizons**, each of which varies in thickness, colour, texture, structure, consistency, porosity, acidity and composition.

In general, soils have following four horizons : an **organic** or **O-horizon** and three **mineral (A, B, C) horizons**. Some workers recognized a **D-horizon**, in which rocks are in active weathering state, in between C and R-horizons. **R-horizon** is the consolidated bed rock on which a soil profile rests. A and B-horizons form the **true soil** or **solum**. Each horizon of soil profile is further subdivided. Horizon subdivisions are indicated by a series of letters with arabic numbers as subscripts, *e.g.*, O_1, O_2, A_1, A_2, etc., (Fig.) Different layers of soil profile have following characteristics :

O Horizon

The uppermost horizon of soil profile is called **O horizon** or **litter zone**. It is present in soils of forests but absent in the soils of deserts, grasslands and cultivated fields. It includes following two sublayers :

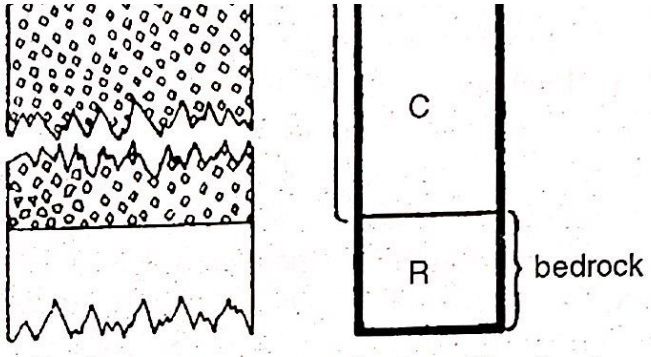

Fig. *A generalized profile of soil*

O_1 horizon (Aoo or L horizon) : It is the top layer of soil consisting of freshly fallen litter (*i.e.*, dead leaves, twigs, bark, flowers, fruits and animal excreta and remains). In O_1 horizon, original form of plant and animal residues can be recognized with the naked eye and in it, the decomposition has not yet started. The A_1 level may be seasonal in nature: it is thickest in a deciduous forest immediately after leaf fall, when the forest floor is covered with fresh leaves and is virtually gone by the end of the following summer, when the leaves have largely decomposed.

O_2 horizon (Ao or H horizon) : O_2 horizon underlies the O_1 or litter horizon and contains blackened unrecognizable decomposed litter. The upper portion of O_2 horizon contains partially decomposed detritus, the **duff**, so is called **duff layer**. Its lower part contains completely decomposed, light and amorphous organic matter, the **humus** and is called **humus** or **H layer**. Insects and other small animals are abundant in this layer.

A Horizon

Underlying the litter zone is the A horizon or **topsoil**. It is the **zone of eluviation** (leaching) or the horizon in which materials are brought into aqueous suspension or solution and move downward through the soil. The amount of material that is actually leached out of this zone is a function of the amount of percolating gravitational water. The topsoil or A horizon includes following three subzones:

A_1 horizon : The A_1 horizon is the **zone of humus incorporation** with minerals of soil. It is almost always dark coloured and relatively rich in organic materials thoroughly mixed with the mineral soil. Micro-organisms like bacteria and fungi are present in huge numbers in A_1 layer.

A_2 horizon : The A_2 horizon underlies A_1 horizon and is the **zone of maximum leaching** (eluviation). It contains less humus and is a light-coloured horizon from which materials like silicates, clays, oxides of iron (Fe) and aluminium (Al), etc., are being removed at the greatest rate. **A_3 horizon.** It is transitional to the subjacent B horizon.

B Horizon

B horizon or **subsoil** underlies A horizon and is the **zone of illuviation** (collection of materials) in which much of the material leached out of the zone of eluviation (*i.e.*, A horizon) is precipitated and enriched. It is coarse textured and deep coloured with aluminium, iron and organic colloids and it is rich in clay. B horizon can also be divided into three zones of which the B_1 and B_3 are transitional to the A and the C horizons, respectively and B_2 is the zone of maximum precipitation of transported material. The roots of shrubs and trees usualy reach upto this horizon.

C Horizon

Underlying the B horizon is the weathered rock or sediment that serves as the parent material for the mineral fraction of the soil. It is called **C horizon** or **regolith**. It is a light-coloured and is virtually lacking in organic materials.

R Horizon

C horizon is underlain by unweathered bedrock which is called **R horizon.** The relative thickness and importance of the major horizons are highly variable. However, the concept of the soil profile is of great value **because** it provides a single genetic model by which all zonal soils can be compared.

CHEMICAL PROPERTIES OF SOIL

Soil is a mixture of various inorganic and organic chemical compounds and exhibits certain significant chemical properties, all of which can be discussed as follows:

Inorganic Matter of Soil

The chief inorganic constituents of soil are the compounds of following elements—Al, Si, Ca, Mg, Fe, K and Na. Soil also contains smaller amounts of compounds of following inorganic elements — B, Mn, Cu, Zn, Mo, Co, I, F etc. Most of these inorganic salts exists in soil in the form of weak solution. Soil solution may contain complex mixtures of minerals as carbonates, sulphates, nitrates, chlorides and also organic salts of calcium, magnesium, sodium, potassium, etc. The chemical nature of nutrient solution depends on the nature of the parent matter through which water has percolated and climatic conditions of the region and it affects the types of vegetation of that region. Soils with suboptimal concentration of nutrients are called **oligotrophic** and those with more or less optimal concentrations of nutrient solutes as **eutrophic**. The oligotrophic soils cause many physiological disorders in plants which have very poor root system and fruiting. To compensate the efficiency of nutrients, fertilizers containing N, P and K salts are added to such soils.

Organic Matter of Soil

The chief organic component of soil is **humus** which chemically contains—amino acids, proteins, purines, pyrimidines, aromatic compounds, hexose

sugars, sugar alcohols, methyl sugars, fats, oils, waxes, resins, tannins, lignin and some pigments. Further, humus is black coloured, odourless, homogeneous complex substance.

pH of Soil

Many chemical properties of soils centre around soil reaction. As regards their nature, some soils

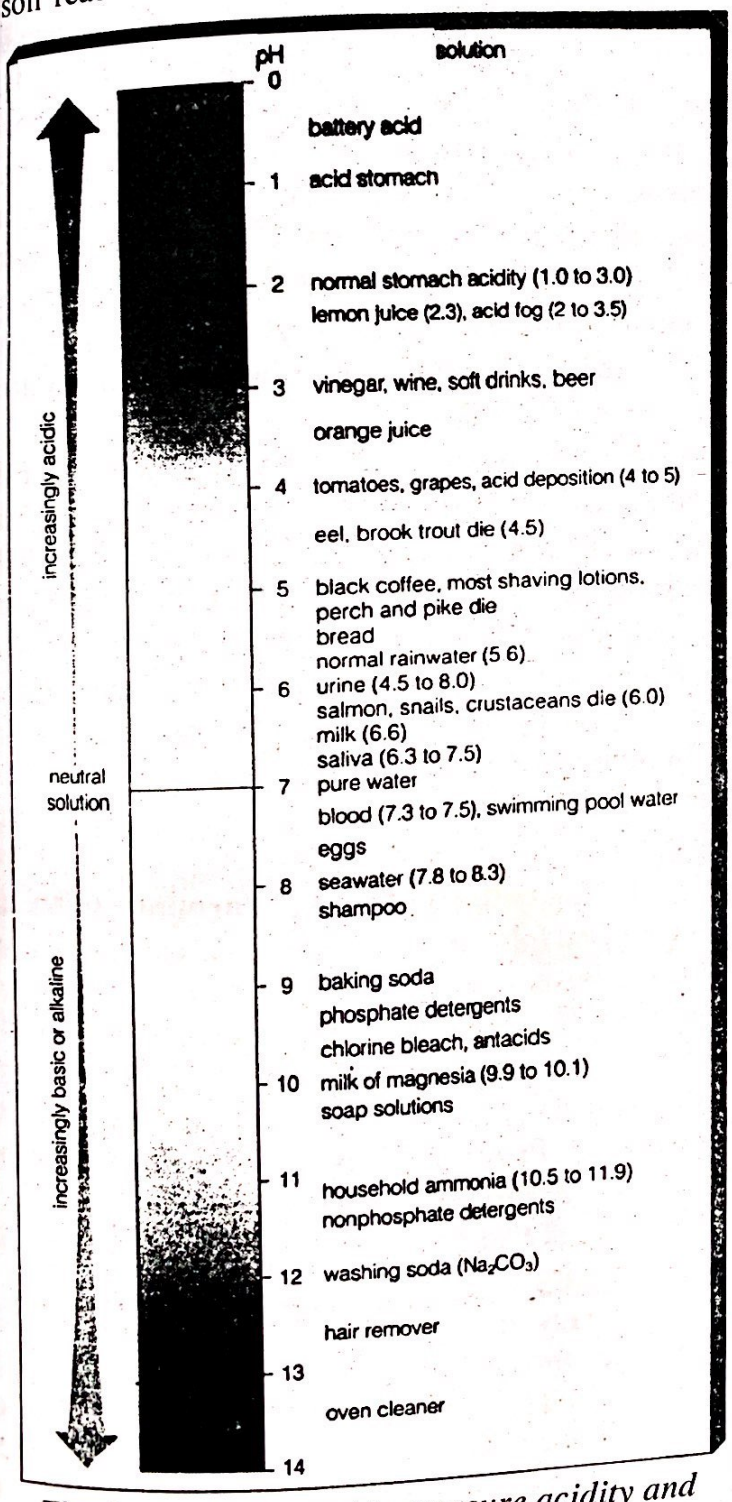

Fig. *Scale of pH, used to measure acidity and basicity (alkalinity) of water solutions*

are **neutral**, some are **acidic** and some **basic**. The acidity, alkalinity and neutrality of soils are described in terms of **hydrogen-ion concentrations** or **pH** values. A **pH** value of 7.0 indicates neutrality, a value above this figure (7.1-14) indicates alkaline condition and a value below (0–6.9) indicates acid conditions. Normally, pH value of soils lies between 2.2 and 9.6. Surface soils are more acidic. Warm, dry climate soils are strongly basic. In India, acidic soils (pH below 5.5 to 5.6) occur in the high rainfall areas of Western ghats, Kerala, Eastern Orissa, West Bengal, Tripura. Manipur and Assam (Asom). The saline, alkali or basic soils (called '*Usar*', contain pH upto 8.5) of India, occur in U.P., West Bengal, Punjab, Bihar, Orissa, Maharashtra, Tamil Nadu, M.P., A.P., Gujarat, Delhi and Rajasthan.

pH value of soil controls the concentration and availability of other minerals also. For example, certain plants require considerable amounts of calcium (**calciphytes**) and thus grow on basic soils. Plants requiring low calcium amounts are called **oxylophytes**. At low pH, generally copper, iron, zinc, manganese and aluminium become toxic. Highly acidic and highly saline or alkaline soils are often injurious for plant growth and micro-organisms, etc. Neutral or slightly acidic soil, however, are best for the growth of majority of plants.

SOIL TYPES OF INDIA

Geographically soils of India are divided into the following three groups :

1. Mature soils of Peninsular India (include red soils, black soils, lateritic soils).
2. Alluvial soils of Indogangetic plain.
3. Scantly soil of Himalayas. Further, in India the alluvial soils occur in the belt of the submountain regions running along the base of the Himalayas (in Punjab, Uttar Pradesh, Bihar, West Bengal) and valleys of Narmada, Tapti (Madhya Pradesh), Godavari, Krishna and Cauvery. The black cotton soils occur in West Madhya Pradesh, Maharashtra, parts of

Andhra, Bihar, West Bengal, Assam (Asom), Tamil Nadu, Orissa, etc. Red soils occur in large areas of Madras (Chennai), Mysore, North East Andhra and other regions. Laterites and laterite soils occur on the summit hills of Deccan, Madhya Pradesh, Eastern Ghats, parts of Orissa, Assam (Asom), Mysore and Kerala. Besides these there are mountain soils, desert soils peaty and other organic soils. Peaty soils are mostly found in Kerala. They are black and acidic (pH 3.9).

SOIL (FAUNA AND FLORA)

Soil supports a wide array of organisms of different body-sizes and taxonomic groups. Generally, soil organisms are classified into three major groups namely **micro-fauna** and **micro-flora, meso-fauna** or **meio-fauna**, and **macro-fauna**. Mesoflora and macroflora because occur above the surface of soil (land-surface):

1. Microfauna : It includes animals with body size within the range of 20μ to 200μ. It includes all Protozoa and small-sized mites, nematodes, rotifers, tradigrades and copepode Crustacea. Soil inhabiting **protozoans** like amoeba, ciliates, zoomastigine flagellates occur near the surface soils, while the testate forms like *Thecamoeba, Euglypha* and *Diffugia*, have a wider vertical distribution. The common terrestrial **polyclad** is *Bipalium.* The **nematodes** such as *Rhabditis, Diplogaster, Tylenchus, Heterodera, Aphelenchoides, Mononchus, Pratylenchus, Xiphinema* and *Criconemoides* abound by as much as 1–3 million in raw humus soils to 20 million/ m_2 in grassland soils.

2. Microflora : The microflora of soil includes bacteria, soil fungi, soil actionomycetes, blue green algae and algae. In soil, microflora bacteria form about 90 percent of the total population. Fungi and algae together represent one percent and actionomycetes cover only 9 percent.

Soil bacteria grow fairly well in the neutral soils richly supplied with organic nutrients. Soil inhabitant bacteria fall into two categories namely—**autotrophic bacteria** and **heterotrophic bacteria**. The autotrophic bacteria derive their energy from the oxidation of simple carbon compounds or from inorganic substances and their carbon from the atmospheric CO_2. The common autotrophic bacteria of soil are nitrifying bacteria, hydrogen bacteria, sulphur bacteria, iron bacteria, manganese bacteria, carbon monoxide bacteria and methane bacteria. Most of soil bacteria are heterotrophic bacteria depending upon the organic matter of soil for their energy source and are primarily concerned with the decomposition of cellulose, and other carbohydrates, proteins, fats and waxes. They bring about mineralization of organic matter of soil and release considerable amount of nitrogen, phosphorus and other nutrients for plants. The common nitrogen-fixing bacteria of soil are *Rhizobium* (occurs in root nodules of leguminous plants); *Azobacter* and *Clostridium pasteurianum* (the latter two are free occurring in soil).

3. Mesofauna : Mesofauna include animals with body size within the range 200μ to 1 cm. The micro-arthropods Acarina (mites) and Collembola (spring tails) are important members of this group which also includes the larger nematodes, rotifers, and tardigrades, together with most of the isopods, Arachnida (spiders), Chelognathi (pseudoscorpions), Opiliones (harvestment), Enchytraeidae (potworms), insect larvae and small millipedes (Diplopoda), isopods and molluscs.

4. Macroflora of Soil : Warming (1909) has recognised following five ecological classes of plants on the basis of soil characteristics on which they grow : **1. Oxylophytes :** Plants usually found on acid soils, *e.g., Rhododendron, Rumex sp.* **2. Halophytes :** Plants usually found on saline soils, *e.g., Salsola foetida*. **3. Psammophytes :** These plants grow on sand **4. Lithophytes :** Plants which grow on rock surfaces. **5. Chasmophytes :** Plants which grow in rock crevices.

5. Macrofauna of Soil : Macrofauna of soil includes those animals whose body size is greater than 1 cm. Here belong the majority of Lumbricidae, the Mollusca, the large-sized chilopods, arachnids and insects and the soil-dwelling or fossorial vertebrates.

Earthworms usually occur in abundance in alkaline and moist soils and sparse in acid soils. They have been proverbial for their influence on the process of breaking up litter fragments, decomposition of organic materials and mixing them thoroughly with mineral soils resulting in the formation of organic soils.

Nitrogen Pathways and NPK in Soils

This is one of the most important naturally occurring events. This process is described as under:

(a) Nitrogen Fixation
(b) Conversion of N in Soil
(c) Mineralization

(a) Nitrogen Fixation:

- Nitrogen is a very inert gas which constitutes 78% of the atmospheric air, it has low chemical reactivity.
- For use by plants it has to be converted to ammonium (NH_4^+) or nitrate (NO_3^-).
- Only a few microorganisms can utilize N gas which is referred to as N fixation.
- Fixation is effected by microbial action, industrial synthesis and high thermal combustion and lightning.

(b) Conversion of N in Soil:

N occurs in soils in the following form:

- Soluble mineral forms, ammonium, nitrate, nitrous oxide (gas).
- Soluble organic compounds, urea, amino acids.
- Living organisms, plant roots, fungi, bacteria, soil animals.
- Insoluble forms, organic nitrogen, ammonia bonded to clay.

Transformation between the different form is mediated by soil microorganisms.

(c) Mineralization:

- Conversion of N in organic residues and soil organic N into soluble forms through mineralization.
- Carbon sources are degraded sources of energy.
- N in excess of microbial need is liberated.

The following sequence of reactions takes place.

(*i*) **Ammonification:** Complex protein compounds are broken down to ammonium compounds by micro-organisms.

(*ii*) **Nitrification:** Ammonium compounds are oxidized to nitrite and to nitrate by two specific types of soil bacteria, *Nitrosomonas* and *Nitrobactor*.

(*iii*) **Denitrification:** The nitrates are reduced to nitrogen gas under poorly aerated conditions through specific microorganism. Nitrate form of N is lost through denitrification where nitrogen gas or nitrous oxide is released. This loss occurs mainly in paddy soils and in upland soils which are saturated with water periodically or part of the time.