

## LECTURE 21

### SOIL AIR

Soil is composed of solid, liquid and gaseous constituents in various proportions. The size and arrangement of soil particles or soil aggregates will determine the pore space. It is the part of the soil, not occupied by soil solids. This pore space is normally occupied by soil water and soil air in reciprocally varying amounts. An important characteristic of the pore space is its continuity. The degree of continuity of both soil water and the soil air is of great importance in determining the physical properties of soil.

**Composition :** The composition of soil air is not the same as that of the atmosphere. The plant life and microorganism cause the soil atmosphere to become dynamic with respect to the ratio of oxygen to carbon-di-oxide. The principal components of soil air are nitrogen, oxygen, inert gases, carbondioxide, water vapour and hydrogen. Methane, hydrogen sulfide etc., are present in negligible quantities. The proportion of nitrogen plus argon is usually found to be equal to that in the atmosphere and is 79 per cent by volume. Oxygen and carbondioxide vary in complementary proportions to make up the remaining 21 per cent.

Gases	Soil air (%)	Atmospheric air (%)
Nitrogen	79.20	79.00
Oxygen	20.60	20.97
Carbondioxide	0.50(variable)	0.033
Other gases	traces	

CO<sub>2</sub> content vary from 10-10000 times to that of atmospheric air

Since soil air is located in the net work of soil pores separated by soil solids, it varies in composition from place to place in the soil. In local pockets, reactions involving gases can greatly modify the composition of the soil air. The composition of soil air at the surface and atmospheric air are mostly similar, because of rapid gas exchange at surface, but this similarity decreases with increase in the depth of soil.

The composition of air is the resultant of two sets of processes that function simultaneously viz : chemical and biological reactions that result in the production of CO<sub>2</sub> at the

use of O<sub>2</sub>; and physical processes that affect the interchange of gaseous constituents between the soil voids and the atmosphere. First process accentuates the differences, whereas the second one minimizes the differences.

### **Gaseous exchange in soil**

The exchange of gases in between soil air and atmospheric air is referred to as soil aeration. This is very important for growth of plants and soil microorganisms and thin biological activities. Two mechanisms have been identified in the interchange of gases between soil voids and the atmosphere i.e. mass flow and diffusive flow.

**Mass flow :** Mass flow of gases in to and out of the soil occurs whenever there is a difference in total pressure between the soil air and atmosphere. This difference is mainly due to expansion and contraction of soil gases due to changes in temperature and barometric pressure, air replacement through rainfall, irrigation and drainage.

**Diffusion :** Diffusion is the random movement of molecules (molecular motion) of a gas or of a liquid. Net movement of gases by diffusion occurs when the partial pressures of individual gases in two neighbouring systems are different, but the total pressure is the same in both. Diffusion accounts for >90% of gaseous exchange.

In soils, due to biological activity, there is a continuous production of CO<sub>2</sub> at the exhaustion of oxygen. This results in the increased partial pressure of CO<sub>2</sub> and reduced partial pressure of oxygen. It leads to continuous interchange of CO<sub>2</sub> and O<sub>2</sub> in between soil and atmosphere.

According to Fick's law, diffusion is a function of the concentration gradient, the diffusion co-efficient of the medium, and the cross sectional area.

$$dQ = DA \left( \frac{dc}{dx} \right) dt$$

where dQ is the mass flow (moles) during the time at across area A (sq.cm), dc/dx the concentration gradient [moles/cc (cm) ], and D the proportionally constant or diffusion coefficient (sq.cm/sec).

### Characterization of soil aeration

There are various parameters that can be used for characterizing soil aeration.

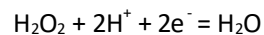
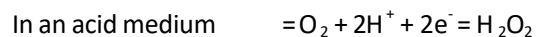
- The volume percentage of soil air or air capacity: Indicates the part of pore space filled with air. Minimum of 10-12 % is required.
- Gaseous composition.
- The oxygen diffusion rate: Determines the rate at which oxygen can be replenished if it is used by respiring plant roots or microbes.
- Oxidation reduction potential: Indicates whether the soil is in oxidized or reduced state. It is a measure of tendency of a system to reduce or oxidize expressed as negative and positive potentials, respectively.
- Composition of soil for its reduced components.

### Measurement of ODR

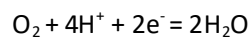
The equipment for the measurement of oxygen diffusion rate consists of the platinum microelectrode, the reference electrode, the voltmeter, the ammeter, the variable resistor and the battery.

When a certain electrical potential is applied between a reference electrode and a platinum electrode inserted in the soil, oxygen gets reduced at a platinum surface resulting in a current flowing in between the electrodes. This current is proportional to the rate of oxygen reduction, that is, the current is governed by the rate of oxygen diffusion to the electrode.

Each molecule of oxygen which diffuses to the surface of the electrode takes up four electrons and reacts with hydrogen ions to form water in an acid solution, or, reacts with water to form a hydroxyl ion in an alkaline solution.

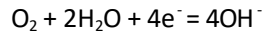
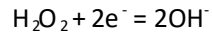


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In neutral or alkaline soils =  $O_2 + 2H_2O + 2e^- = H_2O_2 + 2OH^-$



It is found that root growth ceased when the ODR dropped to about  $20 \times 10^8$  g/cm<sup>2</sup>/min.

#### **Effect of soil air on plant growth, soil properties and nutrient availability**

Soil air with its constituents plays a vital role in modifying the physical, chemical and biological properties of the soils, there by governs the nutrient and water availability and ultimately the plant growth.

- Under poor aerated conditions development of plant roots will be restricted or inhibited.
- Absorption of water and nutrients will be decreased.
- Toxic substances will be formed.
- Soil aeration influences the activity of soil micro organism and also affects the rate of decomposition of organic matter.
- BNF and many nutrient transformations will be carried out by microbes under will aerated conditions. Many nutrients like Fe and Mn will be at their toxic levels under poorly aerated conditions.
- Many toxic organic acids like lactic, butyric and citric acid etc., will be found under anaerobic conditions and cause injury to plant roots thereby minimize the ability of roots to absorb nutrients and water.

- Zn and Mn availability will be reduced under poor aeration conditions.
- Incidence and virulence of diseases largely controlled by soil aeration.

#### **Management of soil aeration**

- ODR should be at least  $30 \times 10^{-8} \text{ g/cm}^2/\text{min}$ .
- Oxygen concentration in the soil air should be at least 10%.

#### **Measures to improve soil aeration**

- Since diffusion is the main agent for air renewal, a more open structure, a lower moisture content and a higher temperature will be helpful in increasing diffusion rate of air.
- Tillage, incorporation of organic matter and mulching are the standard methods to create porosity in the soil system.
- Providing drainage facilities is a remedy to improve air capacity of soil.

## **LECTURE 22**

### **SOIL COLLOIDS**

Thomas Graham (1861) coined the term 'colloid' ( Greek Kolla = glue eidos = like ) In a true solution as sugar or salt in water the solute particles are dispersed in the solvent as single molecules or ions. In this case the diameter of dispersed particles ranges from  $1\text{A}^0$  to  $10\text{A}^0$  (0.00001 to 0.001 $\mu$ ).

In a suspension as sand stirred in water, the solute particles are aggregates of millions of molecules. The diameter of these particles is of the order of  $2000\text{A}^0$  or more.

When the diameter of the particle of a substance dispersed in a solvent ranges from about  $10\text{A}^0$  to  $2000 \text{A}^0$  the system is termed a colloidal solution, colloidal dispersion or simply a colloid (0.001 to 0.2  $\mu$ )