5) **SOIL pH** Mam. Noor-us-Saba

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Soil pH is the negative logarithm of the hydrogen ion (H^+) activity in a soil.

OR

It may be defined as the hydrogen ion activity of a soil, expressed by a set of negative logarithmic values. The term pH is from the French pouvoir hydrogene "hydrogen power".

Soil reaction is an indication of the degree of acidity or alkalinity of a soil and is determined by means of a glass or other suitable electrode or indicator at a specified water content or soil-water ratio.

$pH = -\log(H^+) = \log 1/(H^+)$ where (H^+) represents the hydrogen ion activity in mol/L. The pH scale is the logarithm to the base 10 of the reciprocal of the hydrogen ion concentration. So as the pH of a solution goes from 7 to 6, the hydrogen ion concentration increases 10 times. The pH scale extends from 1 to 14, with pH 7 as being the neutral point. This means that at pH 7, hydrogen and hydroxyl ions concentration are equal at 10^{-7} moles per liter (e.g., for water). Soils with pH less than 7 are acidic and those with a pH above 7 are alkaline or basic. Most productive agricultural soils are in the pH range of 5.5 to 8.3.

The product of the H^+ concentration times OH^- concentration is always constant, i.e.,

$(H^+) \times (OH^-) = 10^{-14}$ moles per liter. For example, when H^+ ion concentration is 10^{-6}, OH^- concentration will be 10^{-8} moles per liter.

IMPORTANCE OF THE SOIL pH

1. The soil pH is easily measured and indicates/provides various information about other soil properties. Plants are generally not directly affected but the indirect effect may be drastic.
2. pH influences the processes involved in the formation and development of soils.
3. Soil pH greatly affects due to abundance of ions toxic to plants. A strongly acid soils (pH 4-5) has been intensively leached, is low in exchangeable basic nutrient cations and usually have high and toxic concentrations of soluble Al and Mn.
4. It affects the availability of nutrients to the plants. Alkaline pH reduces the solubility of all the micronutrients (particularly Fe, Mn, Zn, Cu) except Mo and Cl. Within a pH range of 6-7, most of the essential nutrients (especially phosphate) are available to the plants. Phosphate is not readily available at high pH (precipitate with Ca) and at low pH precipitate with Fe and Al).
5. The soil pH also affects plant growth by influencing the activity of beneficial soil microbes. Most N-fixing bacteria are not very active in strongly acidic soils. Bacteria that decompose soil organic matter and thus release nitrogen and other nutrients for plant use are depressed by strong acidity. Fungi usually tolerate acidity better than do other microbes.
6. Soil pH is the single characteristic which elucidates an overall picture of the medium for plant growth including nutrient supply trend, fate of added nutrients, salinity/sodicity status and mineralogy of soil. Numerical pH values in Pakistan are always more than 8 which may approach 10. Hence a decrease in soil pH due to any land management strategy is always desirable.
7. Plant growth is also affected at high pH due to an excess of sodium ions both in soil exchange complex and solution which actually deteriorates soil's physical condition for plant growth. Moreover, nutrient imbalance and sodium toxicity may also decrease plant growth.

SOIL ACIDITY: (Active vs Exchange vs Residual)

ACTIVE ACIDITY:

It is a measure of the activity of H^+ ions in the soil solution at a given time. It is measured and expressed as a pH value. The quantity of H^+ ion due to active acidity is very small when compared with other two forms but it is important as this is the one to which micro-organisms and plants are exposed.

SALT-REPLACEABLE /EXCHANGE ACIDITY:

It is associated with the exchangeable Al and H ions that are generally present in acidic soils and contributes only a small portion of the total soil acidity.

RESIDUAL ACIDITY:

Residual acidity is that which remains in the soil after active and exchange acidity has been neutralized. It is generally associated with aluminum hydroxyl ions and with Al and H atoms that are bound in nonexchangeable forms by organic matter and silicate clays.

It is generally much greater than either the active or exchange acidity. The residual acidity is usually 10-1000 times greater than the active or soil solution acidity.

Total acidity = Active acidity + Exchange acidity + Residual acidity

BUFFERING OF SOILS:

Chemically a buffer solution is defined as one that resist a change in pH on addition of acid or alkali. In soils, the clay and humic fractions act as a buffer system. Most soils can resist significant changes in pH when large amounts of a material either strongly basic or acidic is added. This capacity of a soil to resist marked changes in pH is called **buffering capacity of the soil.** Consequently, soil that is well buffered is one whose pH is not easily altered appreciably. Buffering capacity is greater in clay soils than in sandy soils. The CEC of soils gives them most of their buffering capacity as the majority of the acidic and basic ions are held exchangeably to the surface of the soil. So, soils high in humus and/or clay (particularly vermiculite and montmorillonite clays) will have high buffering capacity. Most buffering reactions work best in a particular pH range.

To exhibit buffering, the soil must neutralize the OH^+ ions of added bases or remove the H^+ ions of added acids. When basic ions are dissolved in the colloidal-rich soil solution, there is very small increase in pH because hydrogen ions are released from the colloidal surfaces to neutralize the base that was added.

SOIL BUFFER COMPOUNDS:

The soil and solution phase components of soils that resist marked pH changes in the soil solution are carbonates, phosphates, phyllosilicates, oxides and some organic materials.

SIGNIFICANCE OF BUFFERING:

1. The buffering capacity is the amount of base needed to produce a certain pH increase or the amount of acid needed to produce a certain pH decrease. The larger the buffering capacity, the larger the amounts of lime or acid needed to raise or lower the soil pH to the desired level.
2. Buffering action should be effective in controlling soluble and even sometimes toxic concentrations of Al^{3+}, H^+, Na^+, K^+, Ca^{2+} and Mg^{2+}.
3. It is also important for plants, microbes and animals as these are sensitive to a sudden change in pH because of its effects on nutrient availability as well as some direct effects of alkalinity and acidity.

pH 4.5 5.0 5.5 6.0 6.5 7 7.5 8.0 8.5 9.0 9.5

Extreme acidic

very strong alkali

N
P
K
S
Ca
Mg
Fe
Mn

← Acidity

H^+ ion conc

→ Alkalinity

OH^- ion conc