SOIL ACIDITY AND MANAGEMENT

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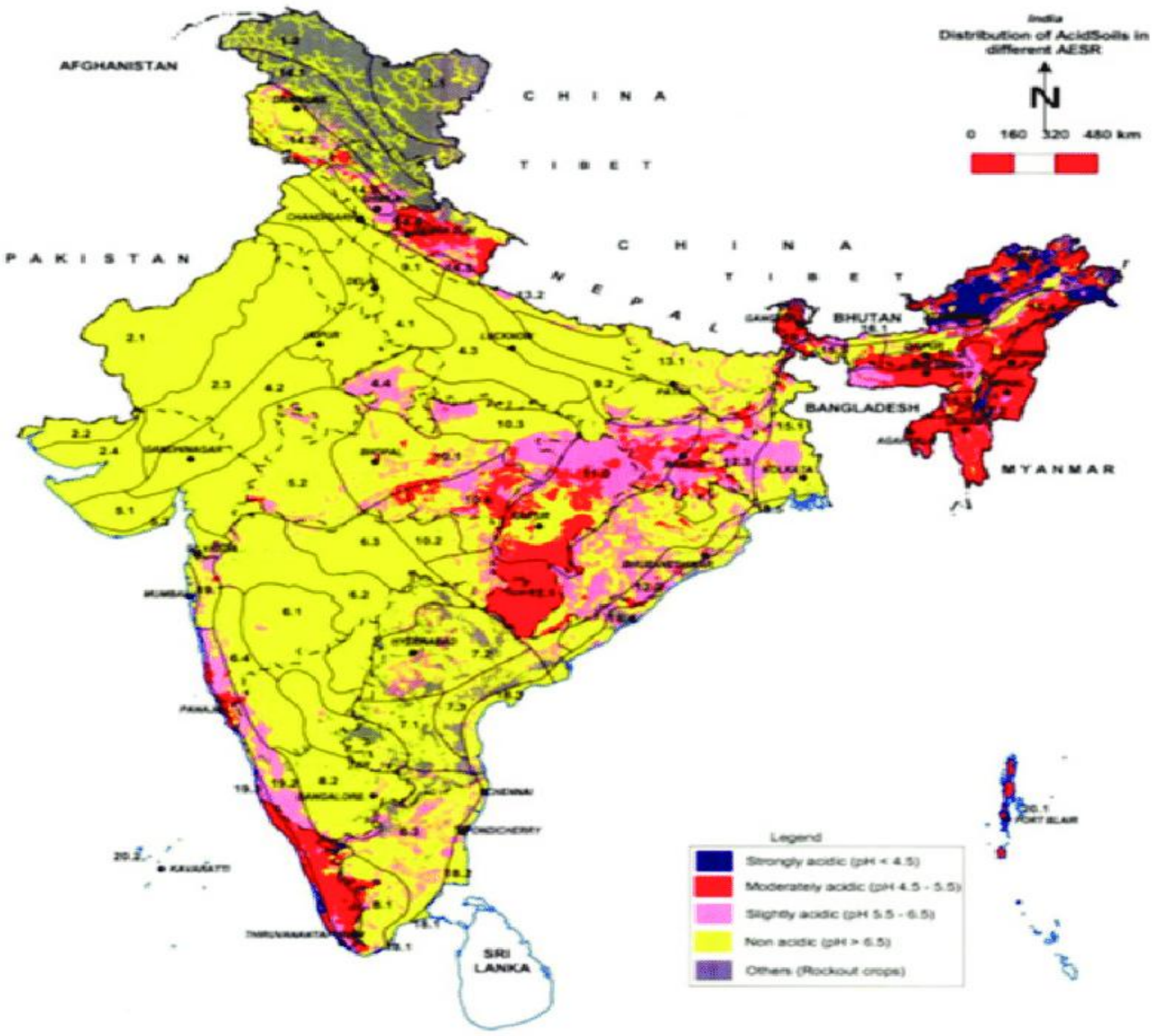
Acidity and Alkalinity in Soils

- Acid soils have higher concentrations of H+ and Al ions in the soil solution and in exchange complex
- More the H ions in the solution the more acidic and lower the pH
- Dominance of hydroxyl ions causes alkalinity.
- When hydrogen and hydroxyl ions are equal it is **neutral**

ACID SOILS OF INDIA DISTRIBUTION



Blue	-	Strongly acid	-	< 4.5
Red	-	Moderately acid	-	4.5-5.5
Pink	-	Slightly acid	-	5. - .6.5
Yellow	-	Non Acid	-	> 6.5

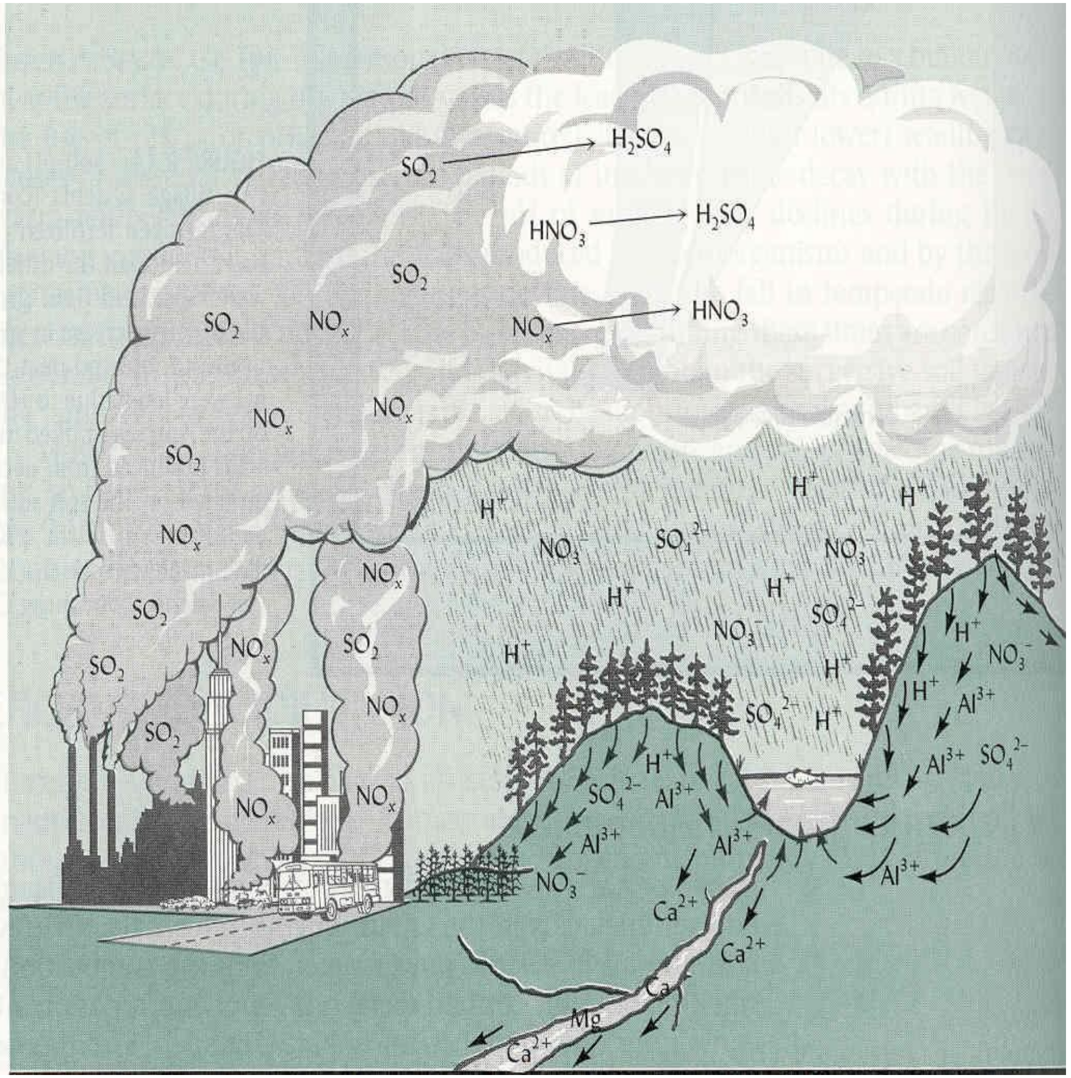
Distribution of Acid Soils

- Occur in areas where precipitation exceeds evapo-transpiration
- Intense leaching causing loss of bases from soil and whole profile becomes acidic.
- Global estimates indicate 800 million ha
- India has 100 million ha
- Kerala has 90 percent of geographic area under acid soils

Sources of acidity

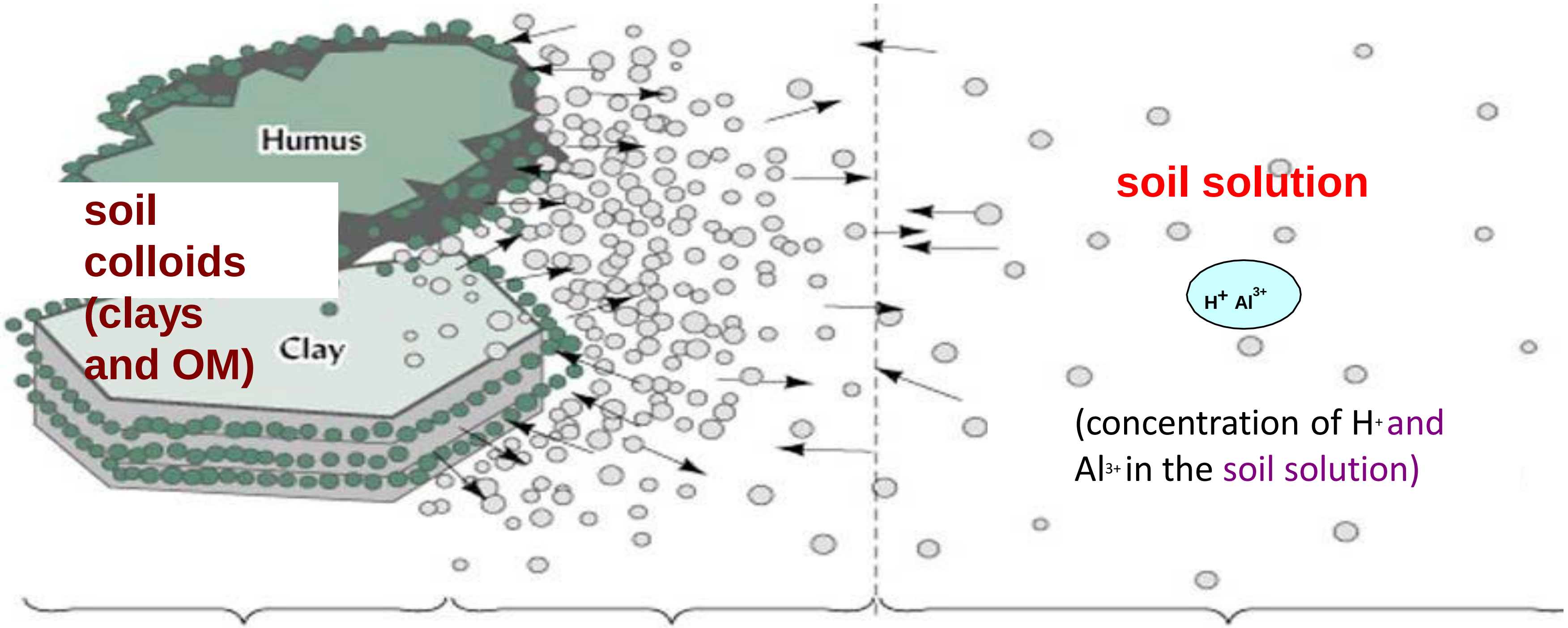
- Leaching of bases due to heavy rainfall
- Acidic parent material and alumino silicate minerals
- Acid forming fertilizers
- Humus and other organic acids
- Carbon dioxide and hydrous oxides
- Acid rain

Formation of Acid Rain



N and S emissions from fuels (electric power plants and vehicles) from the atmosphere return as Sulfuric and nitric acids to earth through rain and dry deposition causing soil acidification through losses of Ca and Mg ions from sensitive watersheds causing decline in forest wealth and degradation of aquatic ecosystems

Forms of Acidity



Total acidity = (Residual + exchangeable) = active

Measurement of acidity/alkalinity - pH scale

- ❖Measurement of pH can be done by a simple and less accurate method using pH/litmus paper
- ❖More precisely in the laboratory using an electronic device the pH meter.
- ❖pH paper is available in strips as short range with pH difference of 0.5 units or long range with difference of 1.0 unit
- ❖Shows characteristic colors at different pH values as shown below.
- ❖Values obtained are not so accurate but is sufficient for most field purposes

Estimation of soil pH using pH meter

- Usually measured in a 1: 2.5 soil /water suspension
- Measured in the supernatant liquid using a pH paper or glass electrode
- Also measured using 0.01 m $CaCl_{,2}$ gives lower value (0.5-0.7 units) than pH water
- More reliable and consistent, as it simulates soil conditions and accounts for electrolyte content in soil
- pH measurement with 0.1 M KCl, estimates exchange acidity, recording still lower values than pH water (0.7-0.8 units)
- pH meters are available either as laboratory models or pocket type for field level use.

pH concept

- The term pH symbolizes the hydrogen ion concentration
- The pH scale covers a range from 0-14 and a pH value of 7 is neutral
- Solution with more H ions than OH ions, is acidic and has pH less than 7
- Turns blue litmus red
- More H ions in solution the stronger the acid, and the lower the pH value
- Solution with more OH ions than H ions, is basic with pH higher than 7
- Turns red litmus paper blue
- More OH ions in a solution indicate stronger basicity and higher pH value
- Concentration of H and OH ions are expressed in the logarithmic scale.
- One unit change in the pH scale involves 10 fold changes in the acidity /basicity.
- Solution of pH 5 will have 10 times more hydrogen ions than a solution with pH 6.
- Solution with 9 will have 10 times more hydroxyl ions

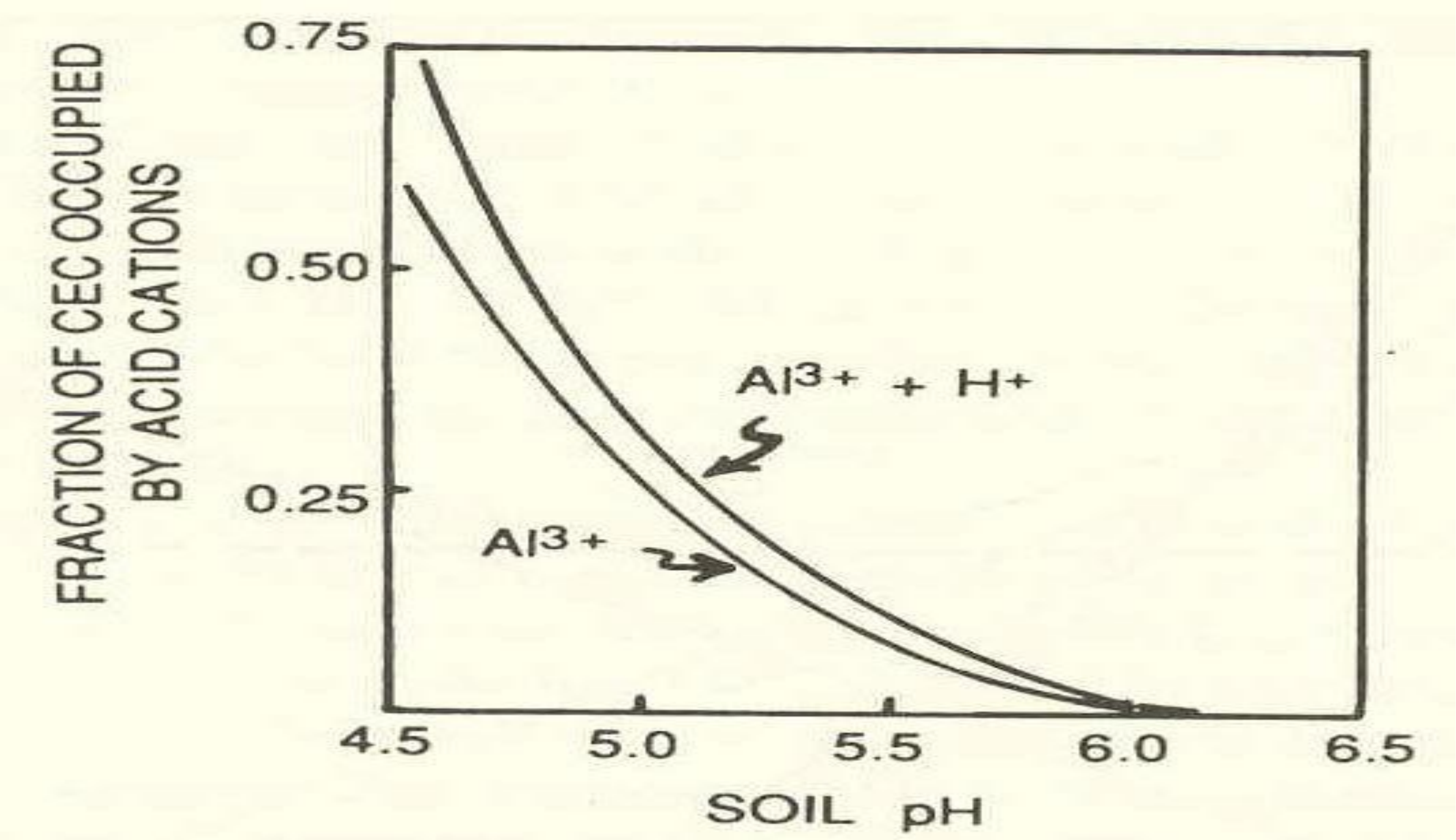
Crop production constraints related to acidity

- ❖Increased solubility and toxicity of Al, Mn and Fe
- ❖Deficiency of Ca and Mg,
- ❖Reduced availability of P and Mo
- ❖Reduced microbial activity
- ❖Direct effect on plant growth (roots) and microorganisms
- ❖Indirect effects on plants and microorganisms
- ❖Indicator of chemical imbalances
- ❖Controls chemical reactions in soils
- ❖Ultra acid (< 3) or very strongly alkaline (>9) pH values
- ❖low pH (<5) toxicity of Al, Mn, Zn, Cu
- ❖High pH (> 7) Deficiency of Zn, Fe, Cu, Mn
- ❖pH > 8.5: Na+ on exchange sites
- ❖pH < 3: sulfide toxicity

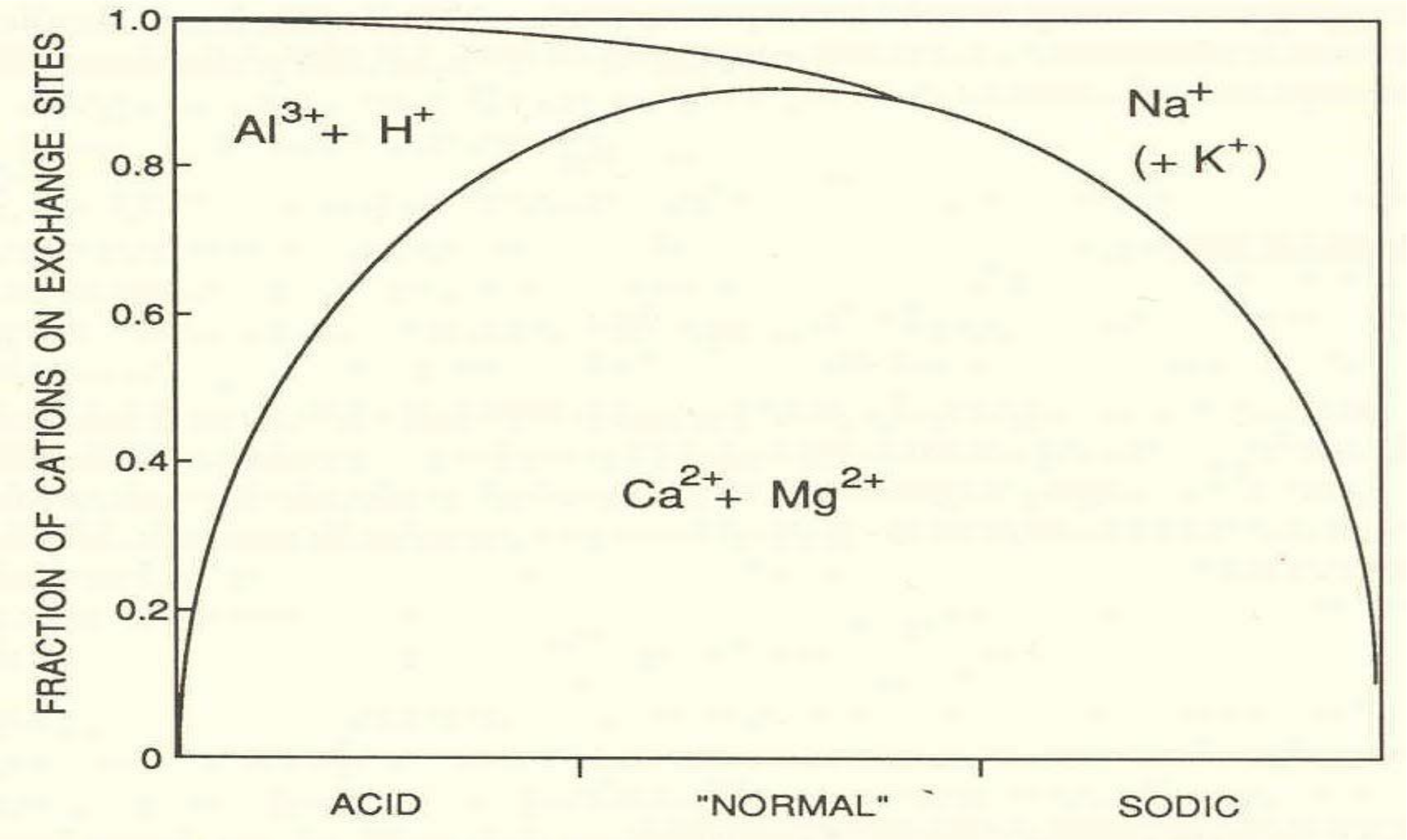
Buffering in soils

- ❖Tendency of the soil colloid to resist sudden changes in pH is referred to as buffering action of the soil
- ❖Achieved through adsorption of H^+ and Al^{3+} ions from soil solution to colloid or the reverse (Colloid to the soil solution) to maintain the equilibrium the soil solution
- ❖ Buffering mainly due to residual and exchangeable acidity
- ❖ At low pH buffering due to the hydrolysis and precipitation of aluminum compounds
- ❖ At high pH it is by the precipitation and dissociation of calcium carbonate.
- ❖At intermediate pH (4.5–7.5) equillibrium is maintained by cation exchange - protonation or deprotonation (gain or loss of H+ ions) of pH-dependent exchange sites on clay and humus colloids.
- ❖Well-buffered soil will have a high content of organic matter and/ highly charged clay

Unique characteristics of acid soils –Acidic cations Al and H on exchange sites Vs pH



Relative cation composition in acd, typical and sodic soil



Aluminum toxicity

- Most common and severe in acid soils below pH 5.2
- Affects bacterial populations
- In plants the effects are
- Block entry of Ca into plants,
- Binds with P (in ATP) and inhibits energy transfer
- Restricts cell wall expansion
- Rarely a problem above a pH of 5.2

$$\text{Base saturation} = \frac{\text{No of exchange sites occupied by cations}}{\text{CEC}} \times 100$$

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$$\frac{\text{Acid cation saturation Percentage } (Al^{+} + H^{+})}{\text{CEC}} \times 100$$

Cations - (Ca, Mg, K, Na) All in cmols /kg)

pH is closely related to the percentage acid cation saturation than the absolute content of cations

Acid soils of Kerala

- Soils of Kerala developed from acidic parent rocks under the humid tropical environment,
- High rainfall and temperature conditions are conducive to intensive leaching and removal of bases from the soil.
- Majority (85-90 %) of the soils of Kerala are acidic
- Patches of Calcareous, alkaline soils pH (7-8.5) occur in Chittur and adjoining areas
- Around 70 % of soils are very strongly to moderately acidic (4.5-6.0)
- Waterlogged problem areas of Kuttanad, Kole ,Pokkali and Kaipad lands with potential acid sulphate soils are ultra acid with pH less than 3.5.

Management of soil Acidity

- Application of lime most common method to ameliorate soil acidity.
- Raises soil pH, to levels optimum for plant growth thereby eliminating toxic effects

Lime Requirement

- Lime requirement of an acid soil is the amount of lime that must be added to raise the pH to some prescribed value usually pH 6.0-7.0 for satisfactory plant growth
- Common method for Determination of Lime Requirement in temperate region soils is the SMP (Shoemaker-McLean-Pratt) Buffer method
- This method is inaccurate in, sandy soils, organic matte rich (greater than 10%), soils with a predominance of kaolinite and Al and Fe oxides
- LR values are very high 10 -15 tons/ha and very uneconomical
- Liming recommendations based on exchangeable Al present in the top soil more appropriate
- Only a moderate amount of lime is needed to raise soil pH to values to precipitate Al in the top layer of soil (around pH 5.5).
- The LR values for Kerala soils have been worked out base on the concept of exchangeable Al

Soil reaction (pH) classes and Lime recommendation

	Classes	pH range	Lime (kg/ha)
1.	Ultra acid	<3.5	1000
2.	Extremely acid	3.5 -4.4	850
3.	Very strongly acid	4.5- 5.0	600
4.	Strongly acid	5.1-5.5	350
5.	Moderately acid	5.6-6.0	250
6.	Slightly acid	6.1-6.5	100
7.	Neutral	6.6-7.3	-
8.	Slightly alkaline	7.4-7.8	-
9.	Moderately alkaline	7.9-8.4	-
10.	Strongly alkaline	8.5 -9.0	-
11.	Very strongly alkaline	>9.0	-

Liming Reactions

- $CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$
- $Ca(HCO_3)_2 \rightarrow Ca^{2+} + 2HCO_3$
- (Takes part in cation exchange reactions)
- H^+ + CO_3^- $\rightarrow H_2CO_3 \leftrightarrow H_2O + CO_2$
- (From soil) (from lime) Soil solution
- The acidity of the soil is, therefore, neutralized and the per cent base saturation is increased.

Benefits of Liming

- Brings about reduction in toxicity of Al and Mn,
- Increases P availability, N fixation and organic matter mineralization.
- Application of dolomite as the liming material meets the requirement of both Ca and Mg
- Improves soil structural development, greater air and water movement and microbial activity

Choice of liming material

- Neutrlizing value/ Calcium carbonate equivalent of liming material
- Defined as the acid neutralizing capacity of a liming material expressed as weight percentage of calcium carbonate.

$$\text{NV or CCE of liming material} \quad \frac{\text{M.Wt Of } CaCO_3}{\text{M. Wt of liming material}} \times 100$$

- Particle size - smaller the particle size greater the reactivity and efficiency
- Purity of liming material decides the NV which is the efficiency to neutralize acidity
- Particles passing through 60 mesh sieve (0.25 mm) gives 100 percent efficiency

Quality standards (BIS) for liming materials (BIS: 5409 (part 2-1985).

(A). Requirements for hydrated lime and burnt lime

Fineness: 90 per cent of the material shall pass through 2 mm (10 mesh) sieve and 25 per cent shall pass through 0.15 mm (100 mesh) sieve

	Grade I	Grade II
Neutralizing value expressed as calcium carbonate equivalent (%), min	100	80
Active lime (as CaO), (%), min	80	70
Moisture content (%), max.	10	12

(B).Requirements for limestone and dolomite

Fineness: 90 per cent material shall pass through 2 mm (10 mesh) sieve and 50 per cent shall pass through 0.25 mm (60 mesh) sieve

Neutralizing value expressed as calcium carbonate equivalent (%),min. : 70

Total lime and magnesia (as CaO + MgO) (%), min : 50

Moisture content (%), max. 5

References

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Thank You