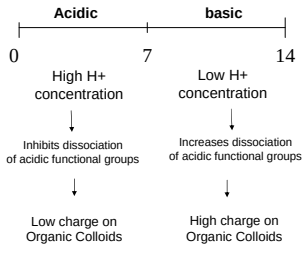
Soil Acidity and pH

Acid

Any substance which increases the Hydrogen ion concentration in solution.

H^+

Hydrogen Ions and Organic Matter



$COOH \longrightarrow COO^- + H^+$

Sources of Hydrogen Ions

CO_2 from microbial respiration/atmosphere

CO_2 dissolved in water produces carbonic acid H_2CO_3

Acid functional groups on organic matter

COOH ⟶ COO^- + $\mathbf{H^+}$

Plant root exudation (release) of H^+

Acids in rainfall

Gaseous nitrogen and sulfur oxides make acid rain

Hydrolysis of aluminum can produce acids

What are the acids in soils?

Two Ions considered Acidic in Soils

H^+ Aluminum

Both are cationic

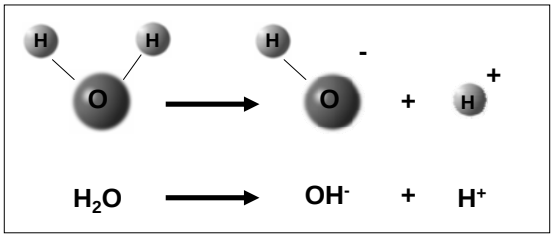
Remember that aluminum is a common constituent of silicate clays

Aluminum participates in “hydrolysis” reactions with water.

Hydrolysis of Water

(ionization of water)

$H_2O \longrightarrow OH^- + H^+$



Hydrolysis

Aluminum has the ability to break water apart and react with the resulting OH^-

Hydrogen and Aluminum

The only soil ions considered to be acidic

Hydolysis by Aluminum

$H_2O \longrightarrow OH^- + H^+$

$Al^{3+} + H_20 = Al(OH)^{2+} + H^+$

$Al(OH)^{2+} + H_20 = Al(OH)_2^{+} + H^+$

$Al(OH)_2^{+} + H_20 = Al(OH)^o_3 + H^+$

Strongly Acid Soils (pH < 5)

Aluminum is soluble => Al^{3+} or $Al(OH)^{2+}$

Both are exchangeable and strongly adsorbed
They are also in equilibrium with aluminum in solution
The aluminum cations in solution can hydrolyze => H^+

Moderately Acid Soils (pH 5 – 6.5)

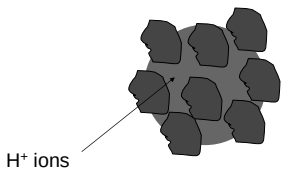
Aluminum exists as $Al(OH)^{2+}$ and $Al(OH)_2^+$

Both are exchangeable and can be strongly adsorbed
They are also in equilibrium with aluminum in solution.
The solution aluminum cations hydrolyze => **H^+**

Types of Soil Acidity

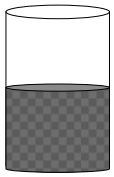
Active Acidity

Acidity associated with soil solution



Active Acidity

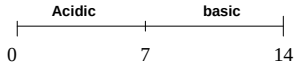
Acidity associated with the soil solution

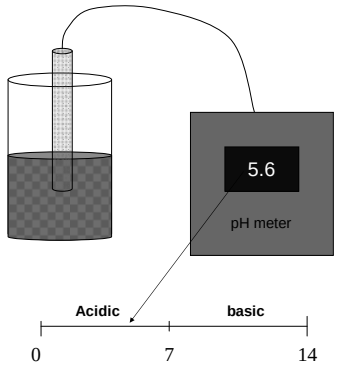


Typically a 1:1 or 2:1 extract

10 g soil and 10 mL water

10 g soil and 20 mL water





Active Acidity

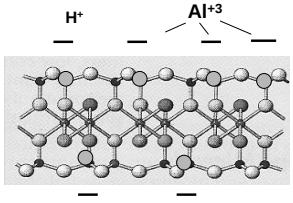
Plant	pH Range
Alfalfa Sweet Clover	6.0 – 8.0
Beets Cauliflower	5.5 - 8.0
Spinach Peas Carrots	5.3 - 7.5
Cotton Wheat Tomatoes	5.0 – 7.2
Potatoes Blueberries Azaleas	4.5 – 5.5 < 5

Sometimes soil pH must be adjusted to accommodate plants

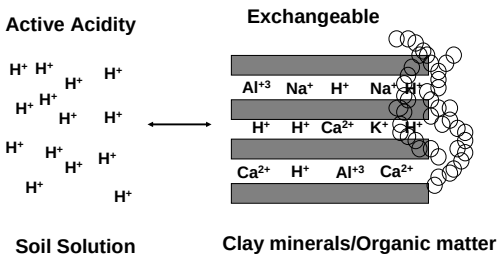
Exchangeable Acidity

Exchangeable Acidity

Acidity associated with cation exchange sites on mineral or organic colloids.

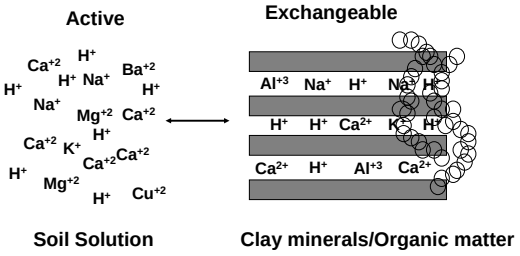


Types of Acidity

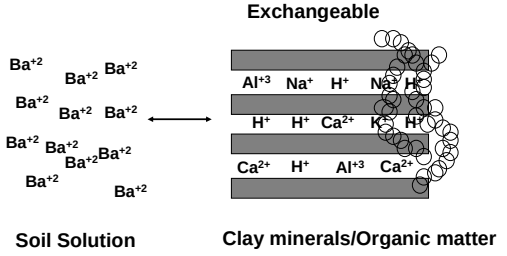


Measurement

Initial Equilibrium

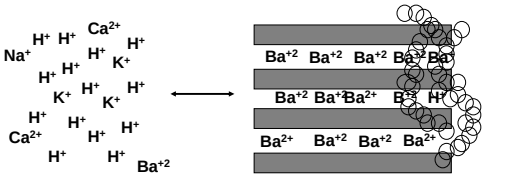


Flood System with Ba^{2+}



Total Acidity

Active and Exchangeable



Soil Solution **Clay minerals/Organic matter**

Exchangeable acidity can be many times greater than active acidity.

Managing soil acidity must account for exchangeable acidity as well as active acidity.

Importance

Percent Base Saturation

The percentage of the total number of exchange sites that are occupied by non-acidic cations.

Acid cations	Non-Acid cations (base cations)
Hydrogen Aluminum	Ca, K, Mg, Na

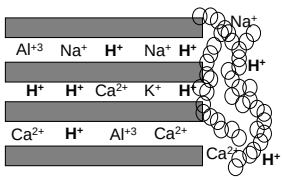
Percent Base Saturation

(charge basis)

Exchangeable base cations (cmol/kg)
Cation exchange capacity (cmol/kg)

Base charge = 12
Exch. Cap. = 27

% B.S. = 44.4%



Clay minerals/Organic matter

Base Cations: Na, K, Mg, Ca

Relevance of Base Saturation

CEC alone is not always a good indicator of fertility

CEC = 10 cmo/kg

80% B.S.	35% B.S.
High amount of cations important to fertility	Low amount of cations important to fertility

Soil Buffering and
Management of Acid Soils