NUTRIENT TRANSFORMATIONS IN SUBMERGED SOIL

(MAJOR AND SECONDARY)

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Organic matter and Plant nutrients follow a different pathway in their transformations in a submerged soil as compared to an aerobic soil

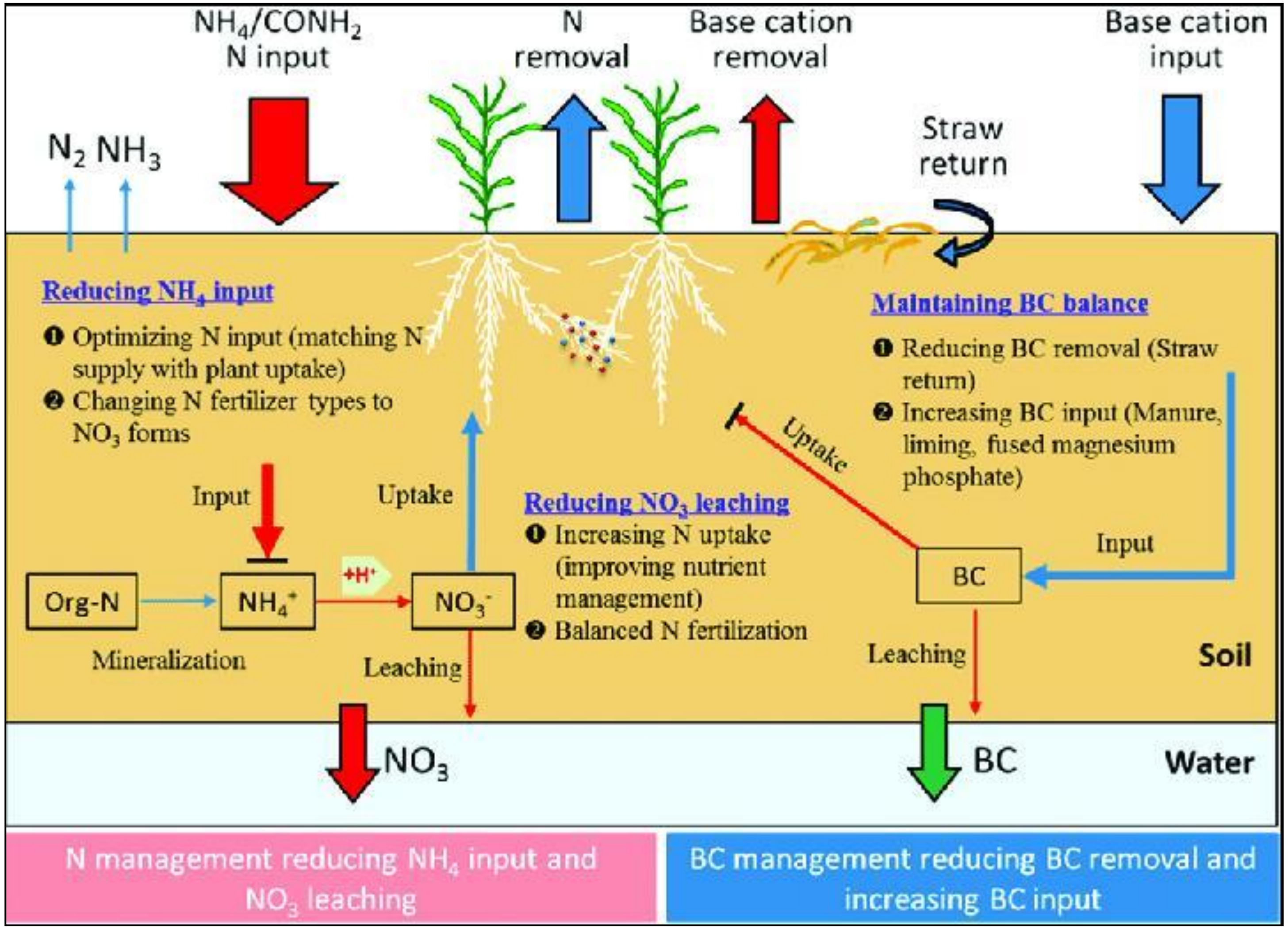
Decomposition of organic matter

- Well drained soil, aerobic microbes will decompose organic matter to form NO_3^-, SO_4^{2-} .
- Submerged condition anaerobic microbes decompose organic matter to produce CO_2, H_2, CH_4, NH_4^+, amines, mercaptans, H_2S and partially humified residues

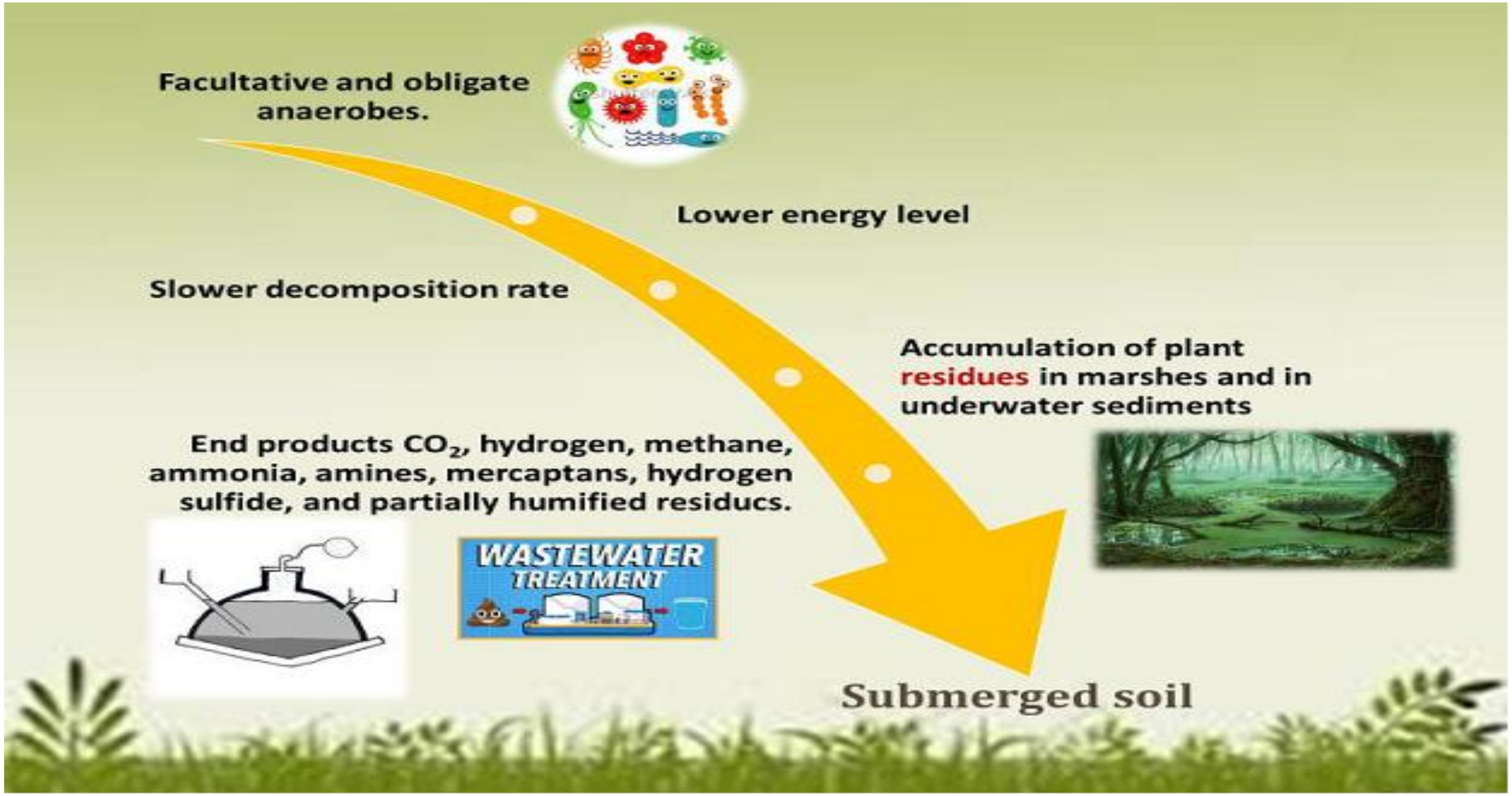
Transformations of Nitrogen- Pathways

- Ammonification
- Nitrification and denitrification
- Mineralization and Immobilization
- Leaching losses of nitrogen

Transformations of Nitrogen



Transformations of carbon



Chemical Changes and Transformations of Nutrients in Submerged and Aerobic soil

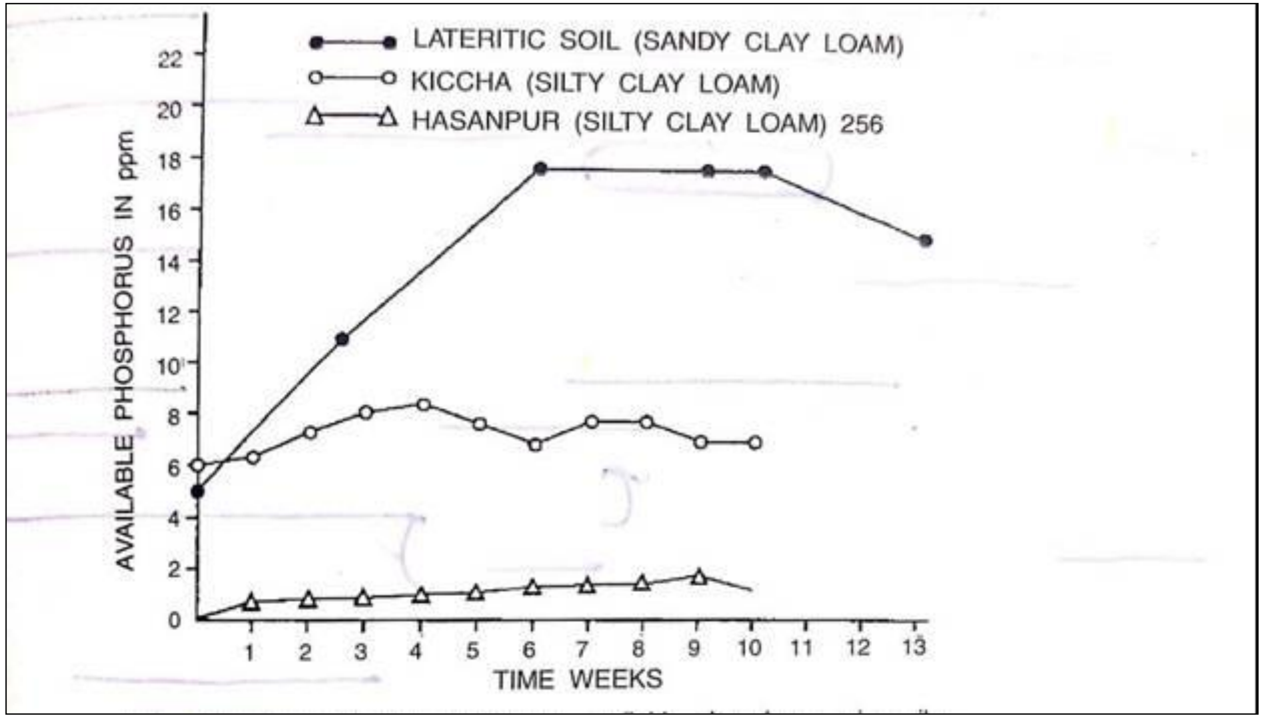
Element	Aerated soil (Oxidized)	Submerged soil (Reduced)
Oxygen (O)	Oxygen gas (O_2)	Water (H_2O)
Nitrogen (N)	Nitrate ion (NO_3^-)	Nitrogen gas (N_2)
Manganese (Mn)	Manganese IV ion (Mn^{4+})	Manganese II ion (Mn^{2+})
Iron (Fe)	Iron III ion (Fe^{3+})	Iron II ion (Fe^{2+})
Sulfur (S)	Sulfate ion (SO_4^{2-})	Hydrogen sulfide (H_2S)
Carbon (C)	Carbon dioxide (CO_2)	Methane (CH_4)

Transformation of Phosphorus

- Aerobic soil on submergence, the availability of native as well as applied phosphorus increases initially and thereafter declines with the period of submergence.
- P transformation is also known to be associated with pH changes on submergence. with availability maximum between pH 6 to 7
- Solubility of iron in the soil usually increase phosphorus solubility.
- Phosphate is chemically associated in an aerobic soil (oxidized soil) as insoluble iron phosphate compounds such as strengite ($FePO_4.2H_2O$)
- Soluble phosphate compounds like calcium and magnesium phosphates are

  co-precipitated with insoluble ferric oxy-hydroxide in calcareous soils

- Submergence and Available Phosphorus



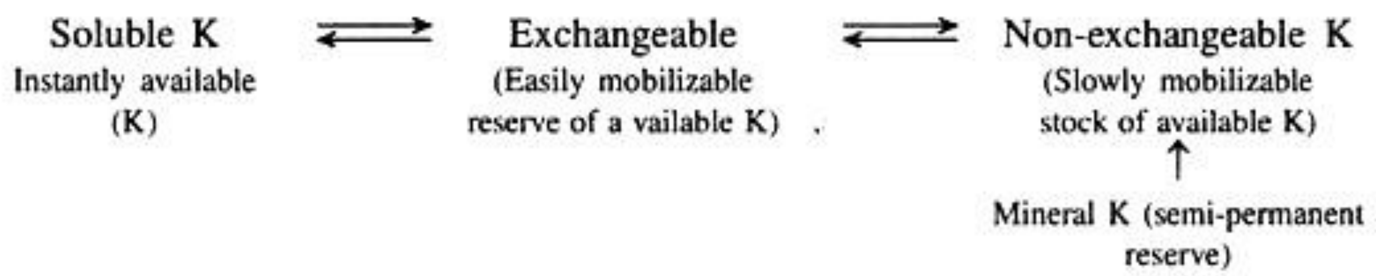
Mechanisms that increase phosphorus availability on submergence

- Release of P from the mineralization of organic residues,
- Reduction of $FePO_4.2H_2O$ to the more soluble $Fe_3(PO_4)_2$, $8H_2O$ and increase in solubility of $FePO_4.2H_2O$ and $AlPO_4.2H_2O$ caused by the increase in pH coupled with the reduction of acid soils.
- Release of co-precipitated or occluded phosphorus due to reduction of ferric oxy hydroxide.(FeO (OH) also called Ferric hydrite
- Displacement of P from ferric and aluminium phosphates by organic anions
- Increased solubility of calcium phosphates ($CaHPO_4.2H_2O$ (dicalcium phosphare) , $Ca_{10} (PO_4)_6 (OH)_2$(Hydroxy apatite), $Ca_{10}(PO_4)_6CO_3$ (carbonated apatie) and $Ca_{10} (PO_4)_6F_2$) (Fluor apatite) associated with the decrease in pH caused by increase in $p(CO_2)$ of in the calcareous soils.
- Release of P due to anion exchange reactions between clay and phosphate or organic anions and phosphate
- Decrease in the concentration of available P at the later period of submergence may be due to the fixation through adsorption) of released phosphorus by clay colloids (kaolinite, montmorillonite and hydrous oxides of Fe and Al).
- Decreased concentration of phosphorus may also be due to the decreased solubility of phosphorus associated with calcium

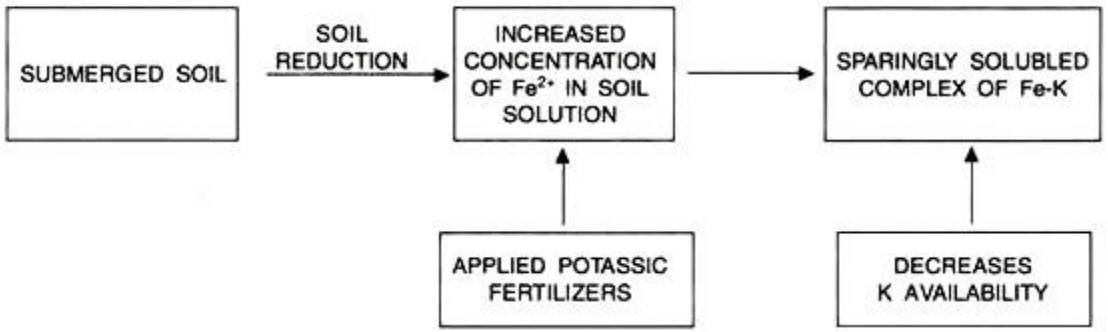
Transformations of Potassium

- Two factors influence the availability of K to plants
- Intensity factor (I) which is the concentration of an element in the soil solution
- Capacity factor (Q), which is the ability of solid phases (soil) to replenish element as it is depleted from soil solution.
- As plants remove K+ ions from the soil solution, the concentration of K+ ions in immediate vicinity of roots is reduced and diffusion gradients are established.
- Potassium is present in soils in four forms, which are in dynamic equilibrium

Transformations of Potassium in soil



Potassium availability on submerged soils



- Submergence causes solubility and increase of ferrous (Fe) and manganous (Mn) ions in soil solution which displaces exchangeable K from colloids into the soil solution.
- Release of K from micas may be the contributing factor for the increase in soil solution K
- Rice plants absorbs more K from the non- exchangeable form under submergence than aerated soils

Transformation of Sulphur in Submerged soils

- Dominant reduction is of sulphate (SO4) to H2S and sulphide (S2)
- Transformation of the amino acids, cysteine, cystine and methionine to H2S.
- H2S react with heavy metals (Zn, Cu, Cd, Pb etc.) to insoluble sulphides reducing availability
- Fe3+ reduction to Fe2+ precedes SO42- reduction,
- Fe in soil solution and hydrogen sulphide (H2S) forms insoluble iron sulphide (FeS) under submergence
- FeS protects micro-organisms and higher plants from toxicity of hydrogen sulphide (H2S).
- In muck and sandy soils low in iron, FeS formation retarded and H2S becomes toxic to rice plant
- In submerged soils availability of sulphur decreased due to reduction of sulfates to S
- In rice plants oxidation of S to sulfate on the root surface enables absorption

Reference

Ponnamperuma, F.N. (1972). The Chemistry of S ubmerged Soils, Reprinted from: Advances in Agronomy, Vol. 24, ©1972,Academic Press, Inc


Thank You