Phosphorous and Sulphur Cycle

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INTRODUCTION

- Phosphorous is one of the key element of the biosphere. It is an essential component of the cell viz. DNA, RNA and also of those ATP and phospholipids. So, it is the requirement of all the living organisms irrespective of being micro-organisms or macro-organisms.
- Phosphorous reservoir are mostly in the form of rock deposits. It is not present in gaseous form in the biosphere.
- Thus it is a sedimentary biogeochemical cycle. Phosphorous is present in the environment as phosphates of Calcium and Iron which are usually insoluble. As a result Phosphorous is not available to the living organisms.

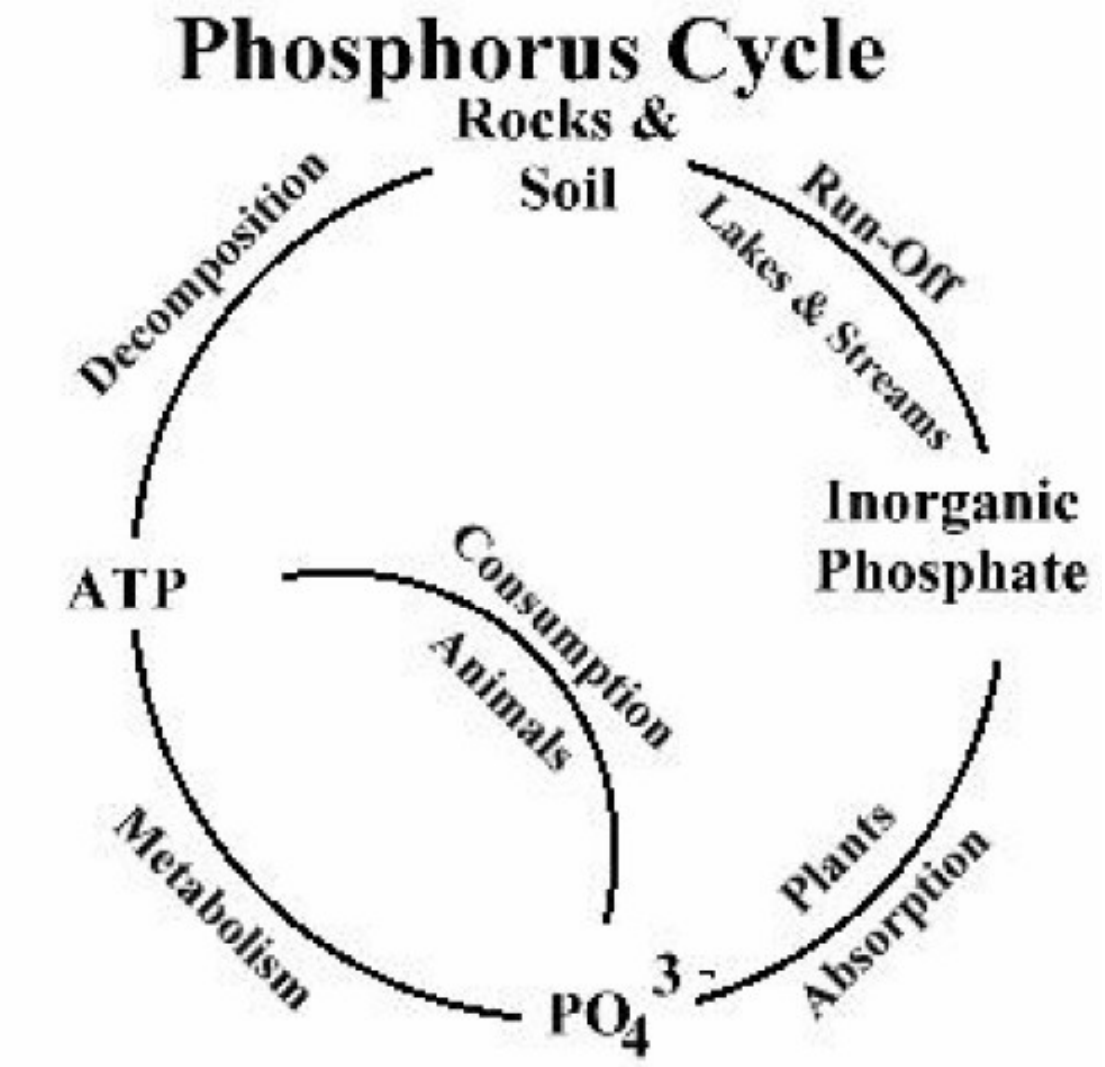


Fig Phosphorous Cycle (brief)

- The dead remains of the flora and fauna including microbes act as the source of phosphorous to the soil environment.
- In atmosphere phosphorous is present as phosphine which is a volatile gas and is toxic. This phosphine ignites with a greenish glow. Phosphine is formed as a result of the activity of the microbes when they use phosphate as a terminal electron acceptor.
- Phosphate which enters the aquatic ecosystem does not return back and becomes part of the marine sediment.
- As a result the marine environment becomes rich in phosphate.

- Phosphorous precipitates at neutral and alkaline pH in the presence of bivalent metals like calcium or magnesium.
- Phosphorous is present in soil as insoluble salts of Iron, Magnesium, Aluminium.
- Plants and microbes assimilate organic phosphate from soluble inorganic phosphate.

The phosphorus cycle has two main steps :-

- (i) Dissolution of inorganic phosphorous and then
  (ii) it's conversion to organic phosphate.
- This involves the process of solubilisation and mineralisation which is operated by the soil microbial population mostly belonging to the rhizosphere e.g. *Bacillus, Micrococcus, Pseudomonas.*
- Phosphorous converts into soluble form by chelation, iron reduction and acidification.
- Phosphorous that enters the cell needs to be mineralized to prevent it's immobilization.
- Mineralisation occurs with the help of enzymes- phytases and phosphatases.
- Phosphorous mineralisation is mainly carried out by the microbial population present in the ecosystem.

- Besides the bacterial population fungi are also involved in the solubilisation of phosphorous for e.g. *Aspergillus, Penicillium.*
- If phosphate solubilising microbial population is present in that rhizosphere region then phosphate assimilation might increase in higher plants.
- VAM are reported to enhance the mobilization of soluble phosphorous.
- Phosphorous solubilisation is affected by a number of factors such as temperature, pH, aeration, carbon and nitrogen source etc.

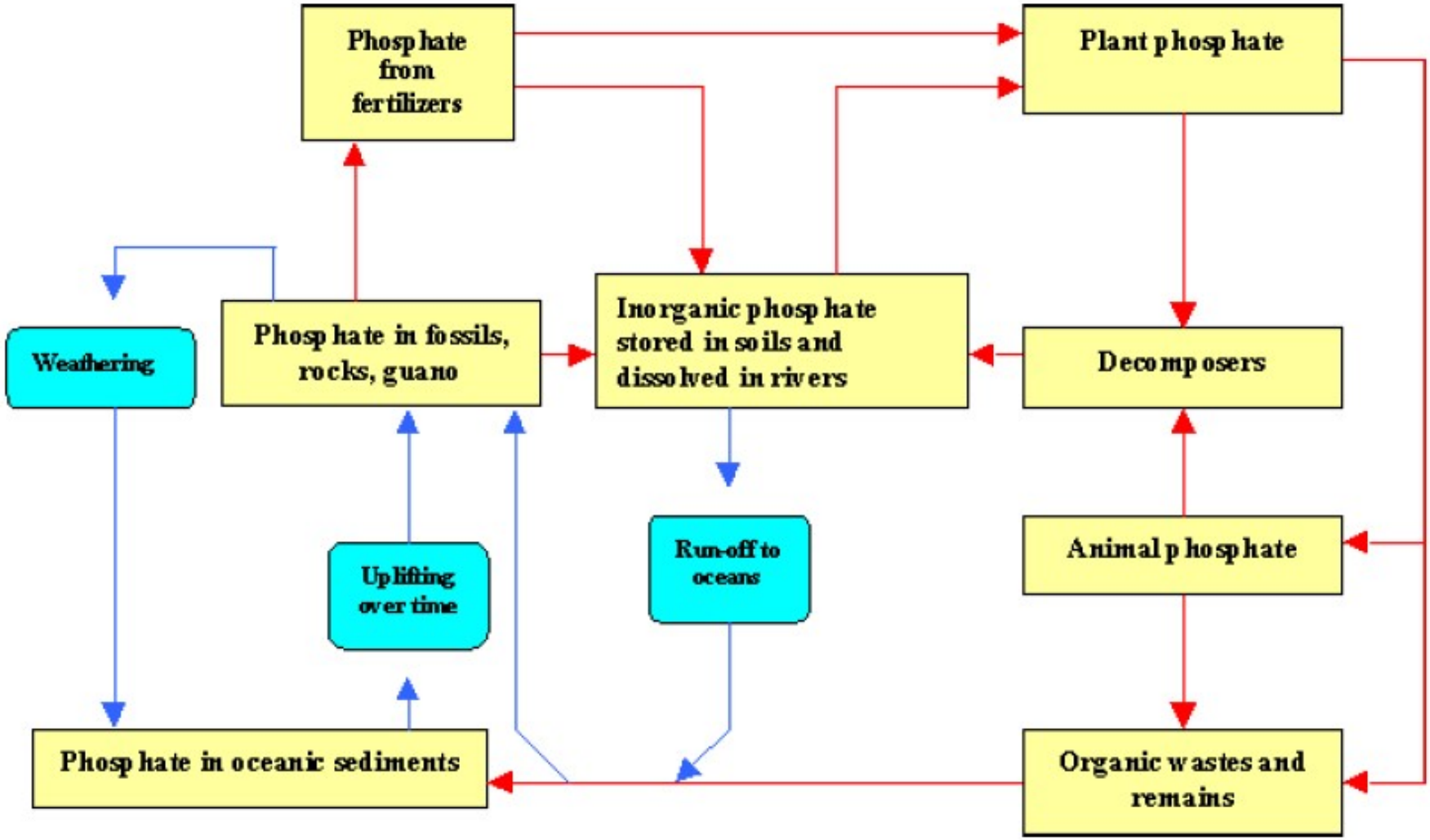


Fig. : Phosphorous cycle as it occurs in environment

- In marine environment the availability of Phosphorous depends on the temperature of the surface water.
- The dissolved Phosphorous present gets incorporated in the phytoplanktons.
- The Phosphorous present deeper in the ocean is not available to the biotic component.
- When Phosphorous is transported to the surface layer from sediments it becomes available to the biota.

- Phosphorous is excreted out as a waste also in the form of urine and faecal matter.
- This
- Phosphorous has to be recycled to make it available to the biotic community of the ecosystem
- which is done by the micro organisms.

Sulphur Cycle

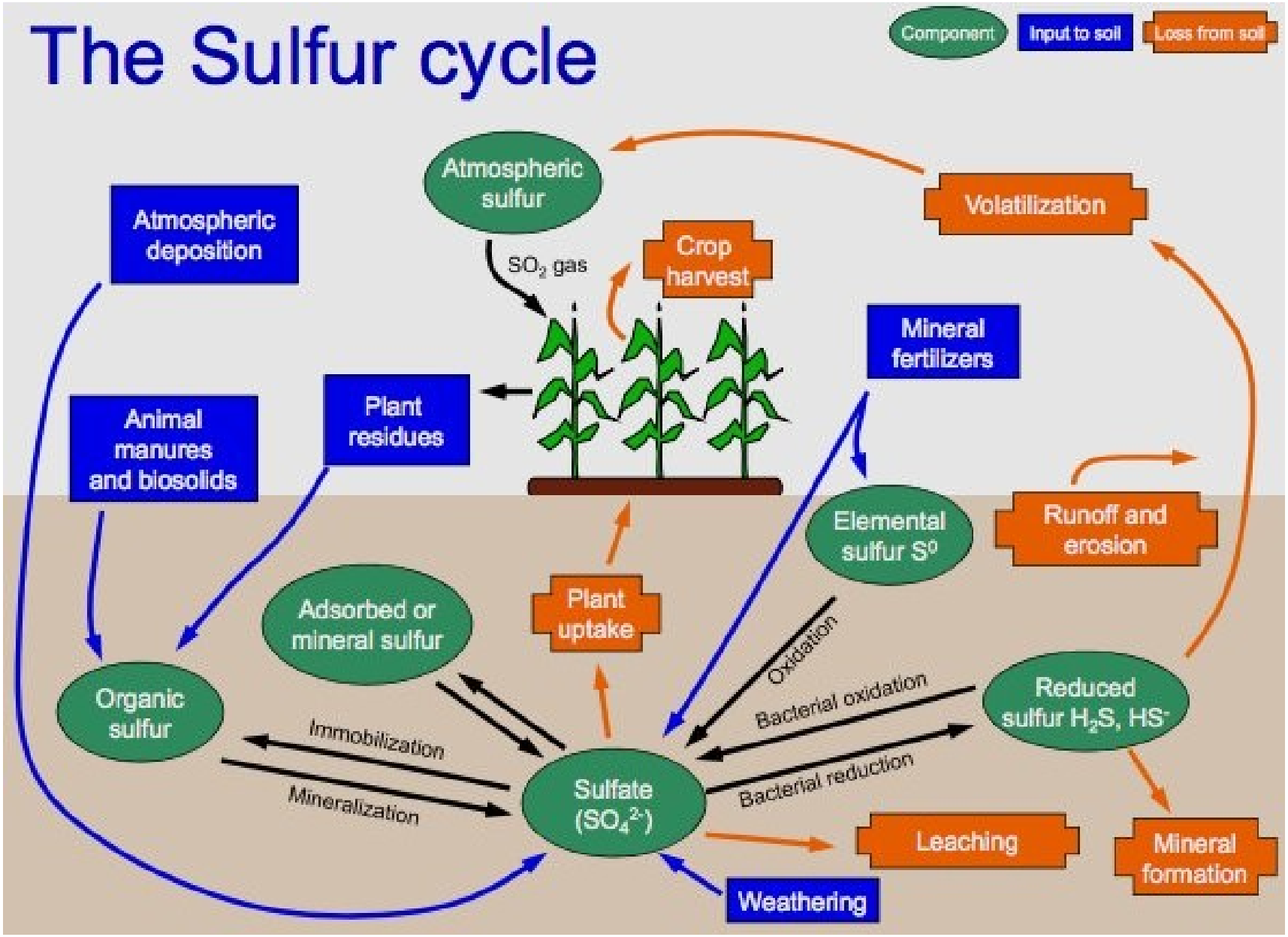
Sulphur Cycle

- It is another element of the sedimentary biogeochemical cycle. It is an essential nutrient component of the biotic community as a trace element.
- It is part of certain amino acids and proteins. Sulphur cycle is basically an oxidation reduction cycle**.**
- Soil is the largest reservoir of sulphur, others are oceans, swamps, marshes, volcanoes etc.
- Sulphur is present in three forms in the biosphere:

  1. Elemental Sulphur – Which is available as sulphur deposits and sulphide ores.

  2. Inorganic Sulphur – Which is available as sulphate in aerobic soil environment and as sulphide in anaerobic soil environment.

  3. Organic Sulphur – Is present in the form of amino acids and plants/animal residues.


The Sulfur cycle
Component
Input to soil
Loss from soil
Atmospheric sulfur
Atmospheric deposition
SO_2 gas
Crop harvest
Volatilization
Mineral fertilizers
Animal manures and biosolids
Plant residues
Elemental sulfur S^0
Runoff and erosion
Adsorbed or mineral sulfur
Plant uptake
Oxidation
Organic sulfur
Immobilization
Mineralization
Bacterial oxidation
Bacterial reduction
Reduced sulfur H_2S, HS^-
Sulfate (SO_4^{2-})
Leaching
Mineral formation
Weathering

- Sulphur is mineralized, assimilated, oxidized and reduced in the ecosystem by a variety of microbes.
- Mineralisation of sulphur involves the decomposition of organic sulphur compounds finally getting converted to simpler inorganic compounds.
- Sulphates are formed by mineralisation under aerobic condition while hydrogen sulphide and mercaptans are formed in anaerobic conditions (a process referred as desulphuration).
- Major decomposition product in marine environment is dimethylsulphide.

- Sulphur is assimilated by the plants, algae and also most heterotrophic microbes of the ecosphere in the form of sulphate under aerobic atmosphere.
- Some anaerobes are capable of assimilating reduced sulphur as hydrogen sulphide under anaerobic conditions produced in low amounts.
- The above two processes (mineralisation and assimilation) involves the oxidation and reduction of sulphur in the ecosystem.
- The oxidation process supports the population of chemolithotrophs like *Beggiatoa, Thiothrix, Thermothrix (thermophile).*
- *Species of Thiobacillus (T.thioparus and T.novellas) are also* involved. *Thiobacillus thiooxidans, an acid tolerant, oxidizes elemental sulphur to sulphuric* acid.

- The archaen genus *sulfolobus inhabiting hot acidic environment oxidizes elemental* sulphur.
- The oxidation of sulphur results in solublisation and mobilization of phosphorous and mineral nutrients because of the production of mineral acids thus benefiting the microbial population and plants.
- Temperature conducive for sulphur oxidation ranges between 34-37ºC.

- The reductive sulphur cycle operates in the ecosystem with the help of anaerobic chemolithotrophic bacterial population; viz. *Desulfovibrio desulfuricans, Desulfovibrio giga, Desulfuromonas acetoxidans, Desulfobacter curvatum (Desulfo-refers to sulphur reducing organisms).*
- Microbes like *Thermoproteus* and *Pyrodictium* which have been isolated from hydrothermal vents showed capability of sulphur respiration with hydrogen gas.
- These organisms are extreme thermophiles and have the advantage of sulphur being present in molten state in the region of hydrothermal vents otherwise it is hydrophobic solid at room temperature.

- The obligate anaerobic bacteria that carry out the dissmilatory sulphate reduction process are called as sulphate reducers or hydrogen sulfodogens (these reduce sulphate liberating sulphide) e.g. *Desulfovibrio,* and *Desulfotomaculum.*
- *Some others belonging to this category are Desulfobacter, Desulfobulbus, Desulfococcus, Desulfosarcina.*
- *Besides the above mentioned* genera a few others reported to belong to this category are *Bacillus, Pseudomonas (bacteria)* and *Saccharomyces (Yeast).*

- The sulphur reducing process could be assimilatory or dissimilatory.
- In assimilatory sulphur reduction hydrogen sulphide produced is immediately incorporated into organic compound by the organisms.
- On the contrary, in dissimilatory sulphur reduction hydrogen sulphide is released in the environment.
- The hydrogen sulphide is toxic to aerobic population of any habitat as it reacts with the heavy metals of the cytochrome.
- Hydrogen sulphide is found to kill nematodes and other animals in water logged conditions.

- Environment acts as a sink of voatile sulpur. Compounds like hydrogen sulphide, dimethyl sulphide and other volatile reduced sulphur compounds on reaching the atmosphere are subjected to oxidation and photo-oxidation, as a result they get converted to sulphate.
- Thiobacilli are capable of rapid oxidation of hydrogen sulphide and other reduced sulphur compounds to sulphate under aerobic soil conditions and sediments.

THANKS