Canned Food Drive Collection

Wednesday in Class

½ point bonus for each can up to 5 cans

Phosphorous

Importance

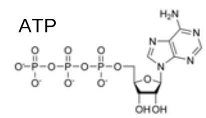
Essential Macronutrient (# 2 or # 3)
Limiting Resource
Present in Fertilizers and wastes
Quantity/Quality Relationship (availability)

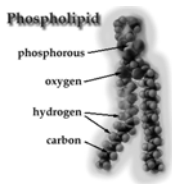
Organic Phosphorous

Components of soil organic matter and plant tissue

Phosphate sugars
Nucleic Acids (DNA/RNA)
ATP
Phospholipids

ATP





Fertility

- -Total soil phosphorous is low (1000 kg/HFS)
- -Most is unavailable to plants
- -Most soil forms of P are of low solubility
  (combine with cations in soil solution: Al, Fe, Ca, Mg)

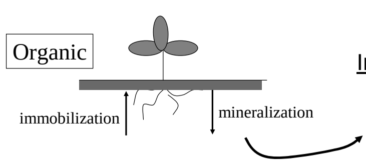
P in solution: 0.8 mg/L
N in solution: 60 mg/L

10-15% of applied fertilizer phosphorous used by plants
=>excess application
=>saturation of soil capacity

Deficiency Symptoms – stunted, thin-stemmed
- dark, bluish-green foliage

Groups of P Compounds

Plant Available P = 0.01% of total soil P



Inorganic Fates
-Plant Available
-Fe, Al bound
-Calcium bound
-exchangeable
- Fixed

Soil Phosphorous

Inorganic

PO_4^{-3}

(Orthophosphate)

H_3PO_4 $H_2PO_4^-$ HPO_4^{-2}

The form of available phosphorus is pH-dependent

Plant Availablity

$H_2PO_4^-$ $\xleftrightarrow{\text{Most Available}}$ HPO_4^{-2}

pH 3-6 pH 6-8 pH 8-11

Optimum pH = 6.5 for mineral soils

Acidic Soils

Acid Soils (Low pH)

Aluminum and Iron availability increased at low pH

$Al(OH)_3$ FeOOH

Solubility increased

↓

Al^{3+} Fe^{3+}

example

$Al(OH)_3 + 3H^+ = Al^{3+} + 3H_2O$

Aluminum Precipitation at Low pH

Form of available P at low pH: $H_2PO_4^-$ (pH 3-6)

$H_2PO_4^-$ combines with solution Al^{3+} and Fe^{3+}

(Insoluble)

$$Al^{3+} + H_2PO_4^- + 2H_20 = Al(OH)_2H_2PO_4 + 2H^+$$

↓

$Al(PO_4) \bullet H_2O$

Variscite

simplified

$Al^{3+} + PO_4^{-3} = Al(PO_4)$

Basic Soils (High pH)

Calcium Binding in Basic Soils

$CaCO_3$ (higher calcium availability)

$H_2(PO_4)^-$ is the available form of P

$$CaCO_3 + 2H_2(PO_4)^- = Ca[H_2(PO_4)]_2 + CO_3^{2-}$$

$$\downarrow$$

$$CaHPO_4$$

$$\downarrow$$

$$Ca_3(PO_4)_2 \quad \text{(Apatite)}$$

Availability and pH

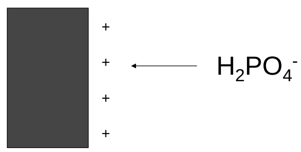
Low pH	High pH
Aluminum and Iron phosphates	Calcium Phosphates

Insoluble solids

Reaction with Soil Minerals

Anion Exchange

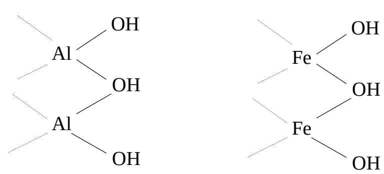
It is possible for clays to develop positive change at their edges when they are broken during weathering



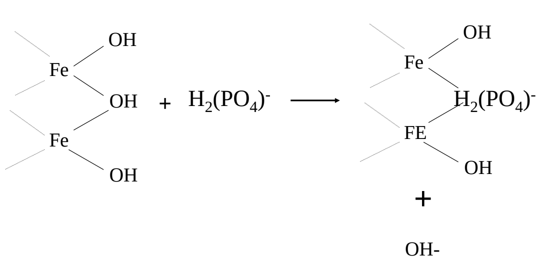
Small quantities of P

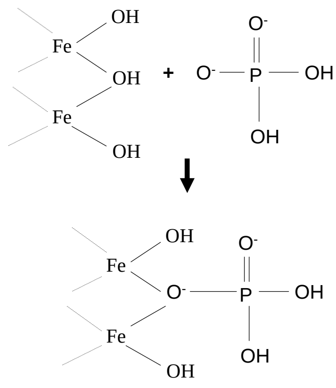
Fixation on Iron and Aluminum

A dominant interaction between Phosphorus and soils is strong interaction with Iron and Aluminum Oxides

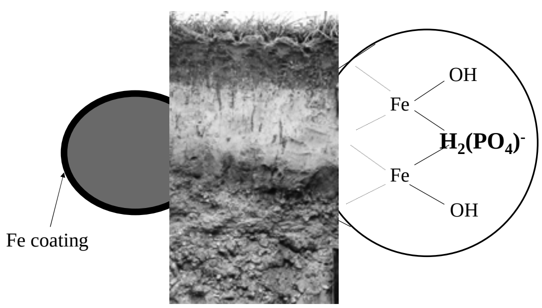


Fixation: Aluminum/Iron oxides





Coatings on Sands and Silicate Clays



Organic Matter

Organic matter does not typically bind strongly with phosphorus.

Organic matter covers fixation sites
Organic matter reacts with free Fe and Al
Organic matter competes for anion exch. sites

Organic Matter tends to increase P availability

Inorganic Soil Phosphorous

Inorganic

-Plant Available (low) $H_2PO_4^- \longleftrightarrow HPO_4^{-2}$

-Fe, Al bound $Al(PO_4) \cdot H_2O$

-Calcium bound $Ca_3(PO_4)_2$

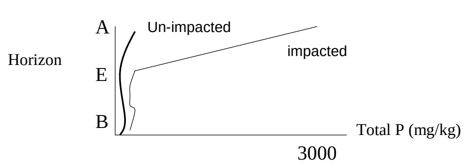
-exchangeable $H_2PO_4^- \longrightarrow$ +

- Fixed on oxides $H_2PO_4^-$

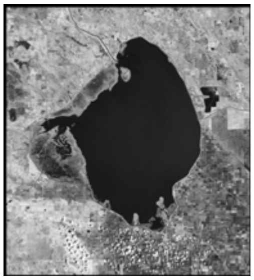
Phosphorus and the Environment

Environmental Impact

Additions
- Fertilizers (excesses, time)
- Manure application (N vs. P)
- Livestock (cattle 10x human)



Example: Lake Okeechobee



730 square miles

third-largest lake completely within the United States

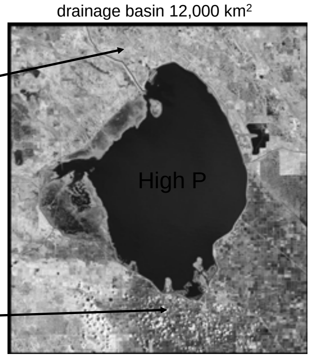
average depth of 3 m (9 ft).

about 6000 years old

Phosphorus

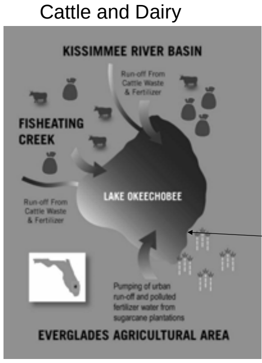
drainage basin 12,000 km^2

Dairy and Beef (1947)



Sugar, Rice, Veg.

Cattle and Dairy



EAA

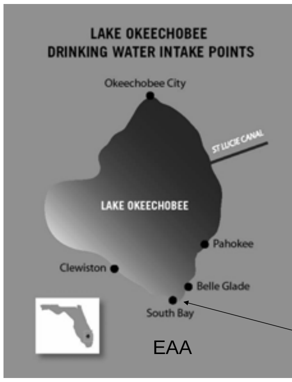
Phosphorous pollution levels about 40 parts-per-billion in 1960

240 parts-per-billion in 2005.

Phosphorous is a main ingredient in fertilizer and is an important component of animal waste and sewage.

S-3 pumping station

32 billion gallons each year.



Drinking Water Source

Eutrophication of the lake has led to blue-green algae blooms

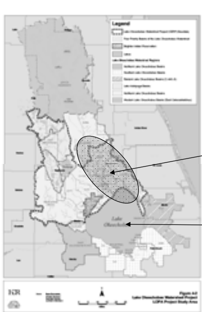
Blue-green algae toxins can affect the liver, nervous system, and skin

2005 algal toxin levels in Lake Okeechobee was 65 times greater than the World Health Organization's safe drinking water guidelines

Pumping Station S-2, is within 2.5 miles of the drinking water intake of South Bay

Efforts

Surface Water Improvement Management Act: SWIM



annual phosphorus load level of 397 tons

Clean Water act: 154.3 tons per year

deadline of January 1, 2015

SWIM Plan priority basins

Lake

Some Strategies

The Dairy Rule

creating lagoons to capture and contain dairy waste

Dairy Buy-Out Program

to facilitate removal of animals from dairies not able to comply

Works of the District Rule

permits are required for all discharges into waterways

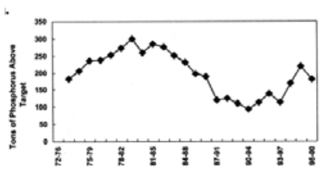
Implement BMPs

buffer areas around places animals congregate, eliminating phosphorus fertilization near tributaries, reducing phosphorus imports in animal feeds, reducing animal density

Since 1990

Phosphorus concentrations in the Lake remain at about 117 ppb

The target level is 40 ppb.



SWIM target: 397 tons

Internal Loading

Dissolved phosphorus combines with oxidized iron (Fe^{3+}) to create an insoluble compound that becomes buried in lake sediments.

$$Fe^{3+} + PO_4^{3-} = \underset{\text{solid}}{Fe(PO_4)}$$

If oxygen contents are reduced (anoxic bottom sediments) the Fe^{3+} converts to Fe^{2+} which solubilizes the compound returning P to water.

P released by sediments is taken up by photosynthetic algae faster than it can be returned to the sediments

Lake Okeechobee Action Plan
Developed by the Lake Okeechobee Issue Team
December 6, 1999

RECOMMENDATION – Control Internal Phosphorus Loading.

Phosphorus-rich mud sediments need to be removed from the lake to the maximum extent that is practical, in order to reduce internal phosphorus loading. Unless this internal loading is substantially reduced, it may take as long as 100 years for the lake to respond to watershed phosphorus control programs.