PHOSPHORUS REMOVAL
FOR
LAGOON OPERATORS

WHY THE CONCERN OVER

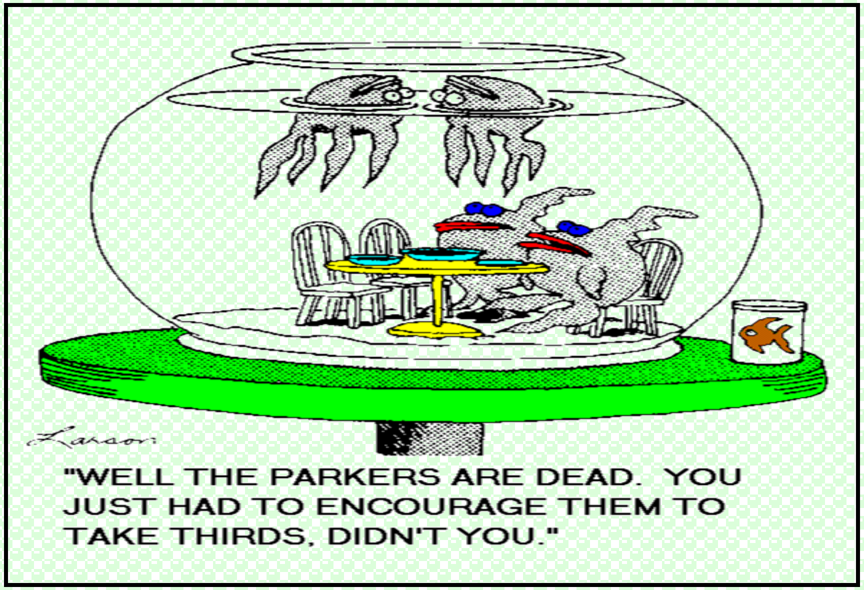
P

Eutrophication

From the Greek word "Eutrophos", meaning "well nourished"

Describes the biological reactions of aquatic systems to nutrient enrichment

Natural aging process



“Eutrophos”, meaning “well nourished”

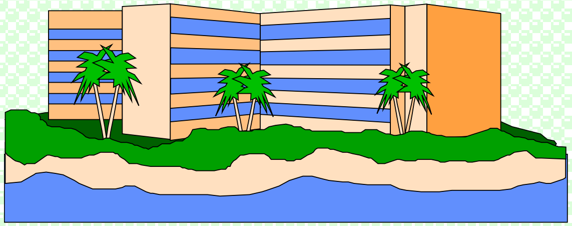
Biological reactions of aquatic systems to nutrient enrichment

Natural Aging Process

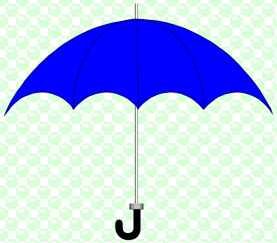
Eutrophication

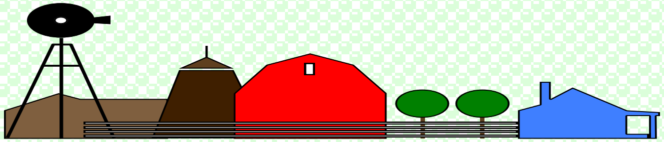
Rate of Eutrophication is increased by human activities (Cultural Eutrophication)

Development



Stormwater Run-Off





Agriculture

Wastewater Discharges

WWTP

On-Site Systems

Combined Sewer Overflow

Control of Eutrophication

Control Development

Weed Control

- Mechanical
- Chemical

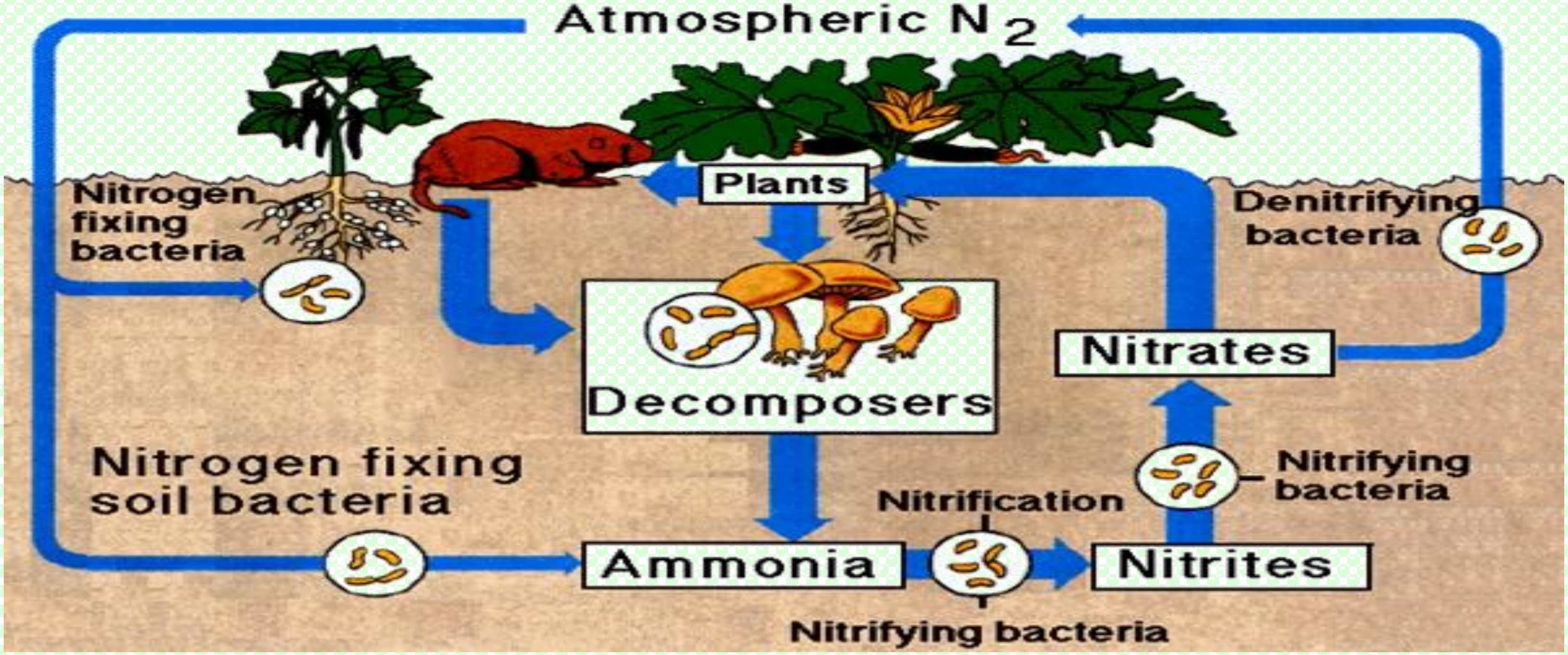
Control Discharge of Nutrients

- Organics
- Nitrogen
- Phosphorus

Control of Eutrophication - Nutrient Control

Nitrogen

Essential Nutrient
Very available in nature
Not practical to control

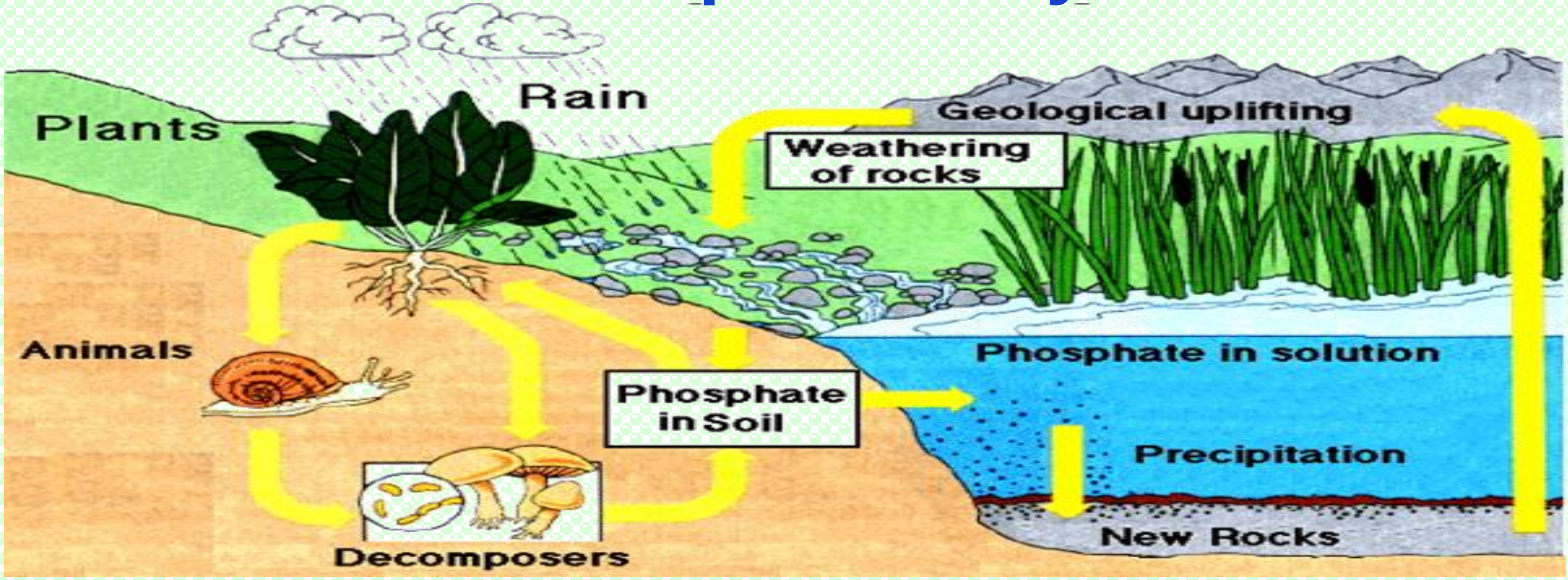


Control of Eutrophication - Nutrient Control

Phosphorus

Essential Nutrient
Not easily replaced in nature
P removal is practical

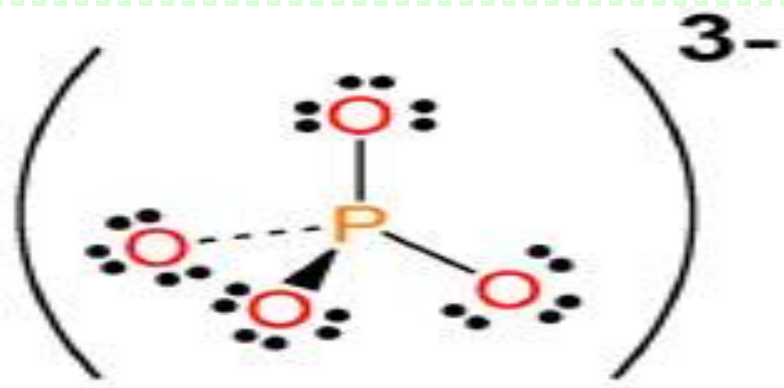
The Phosphorus Cycle

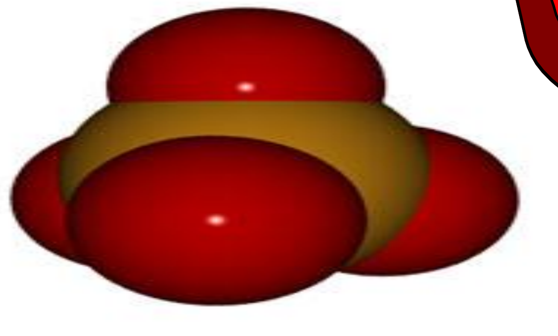


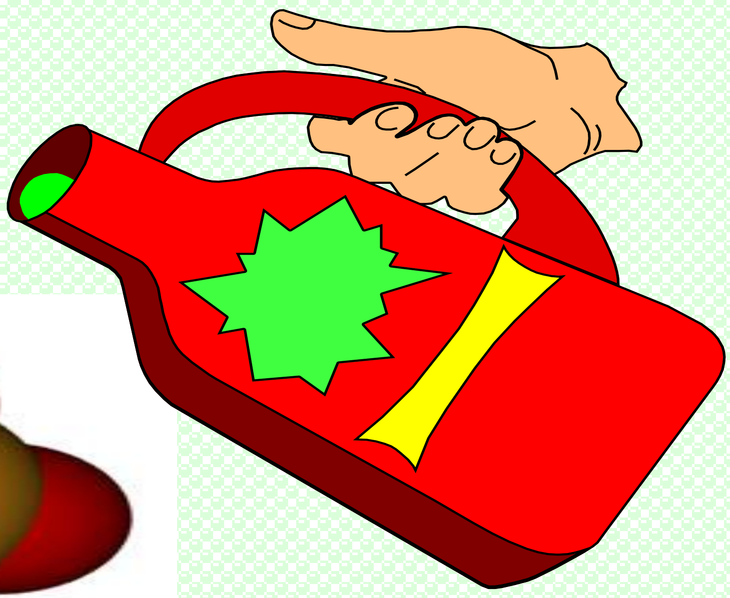
Forms and Sources of Phosphorus

<u>Orthophosphate</u>

- Simple Phosphate, PO_4
- soluble
- household cleaning agents
- industrial cleaners; phosphoric acid



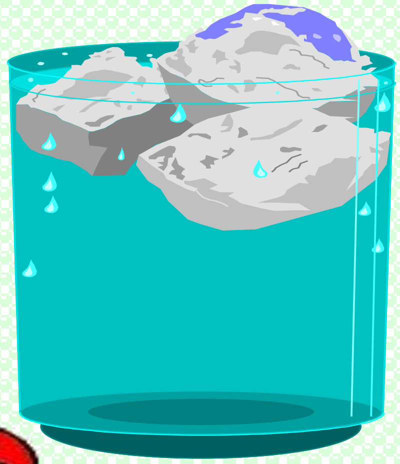


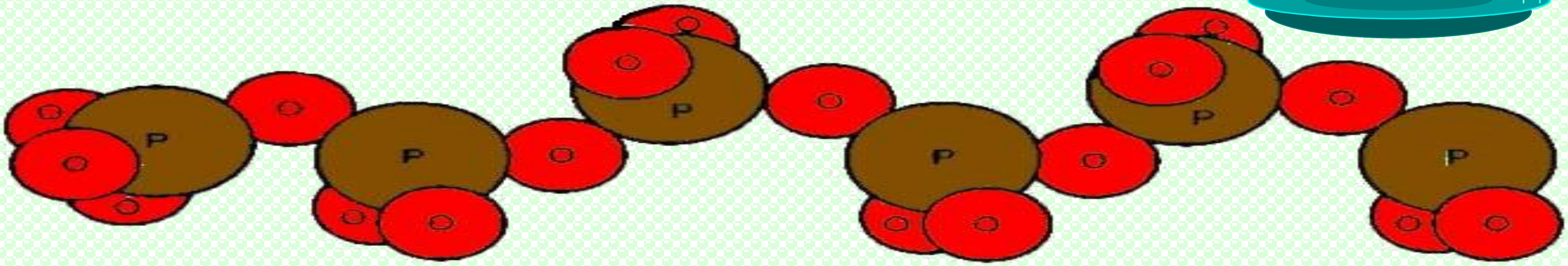


Forms and Sources of Phosphorus

<u>**Polyphosphate**</u> **(condensed phosphate)**

- more complex, chained molecules
- soluble
- home, industrial detergents
- potable water treatment
- decomposes to Ortho-P

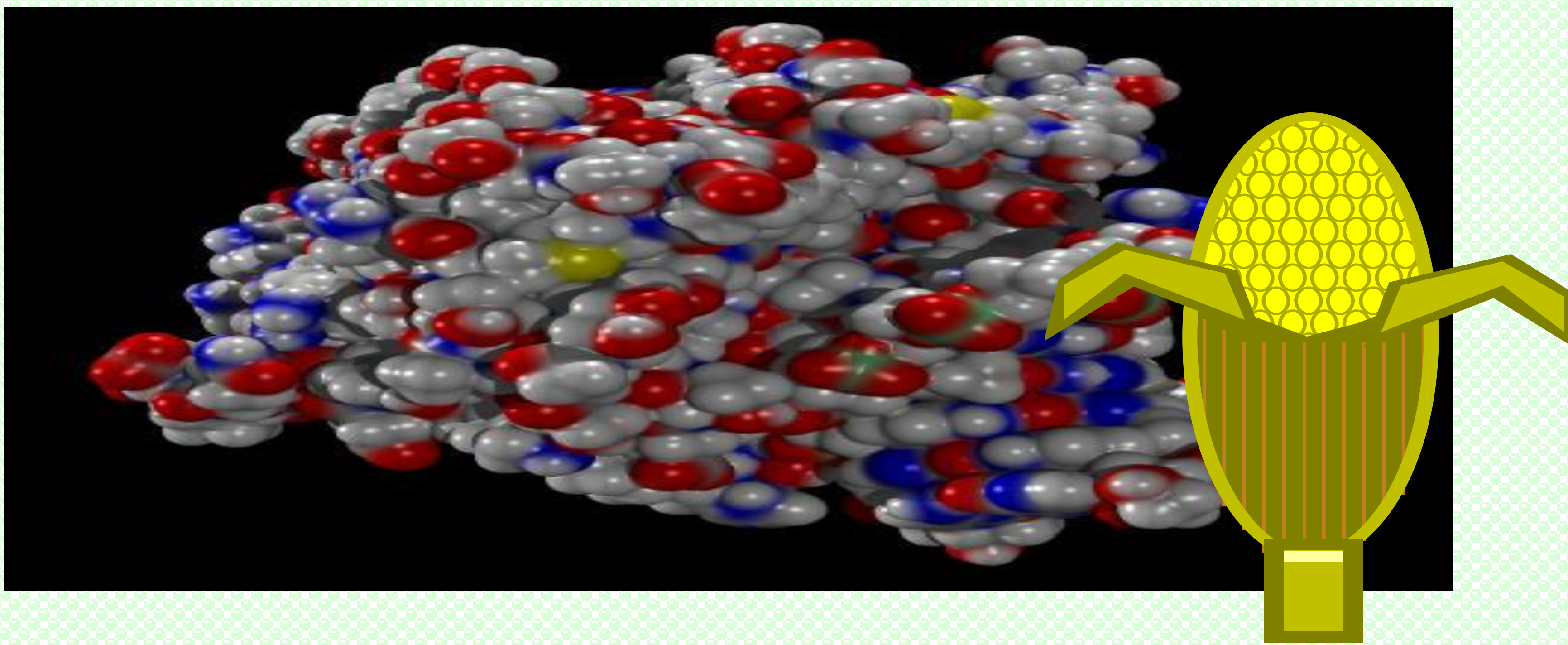




Forms and Sources of Phosphorus

Organic Phosphorus

- complex organic compounds
- soluble or particulate
- decomposes to Ortho-P



Phosphorus Removal

- **Removal of Settleable Solids Provides Some Phosphorus Removal**

  Primary Sedimentation 5 - 15 %

- **Biological Wastewater Treatment Systems Will Remove Phosphorus**

  100:5:1 (C:N:P)

  Primary and TF 20 - 30 %

  Primary and AS 30 - 50 %

- **Total Influent P Typically 4 - 6 mg/L**

- **NPDES Permits Limit Effluent P 1 mg/L and Lower**

Phosphorus Removal

Removal of Ortho-P may Occur Through:

1. ~~Enhanced Biological Uptake~~
2. Chemical Precipitation

Treatment Process

Precipitation

↓

Coagulation

↓

Flocculation

↓

Separation

Phosphorus Removal

Chemical Precipitation

- **Organic and Condensed** Phosphorus

Compounds Must Be Converted to

Ortho-P

for Efficient P Removal

Chemical Phosphorus Removal

Soluble Phosphate

plus

Metal Salts

form

Insoluble Phosphorus Compounds

Chemical Removal

$$M^{+3} + PO_4^{-3} \rightarrow MPO_4 \downarrow$$

(M^{+3} = Metal in Solution)

PRECIPITATION

Metals used are:

Aluminum, Al

Iron, Fe

Chemicals Used for Precipitation

Most Common in Michigan:

Alum

Ferric Chloride

FERRIC IRON - Fe^{+3}

$$M^{+3} + PO_4^{-3} \longrightarrow MPO_4 \downarrow$$

$$Fe^{+3} + PO_4^{-3} \longrightarrow FePO_4 \downarrow$$

Weight Ratio

Fe^{+3} to P

1.8 : 1

$FeCl_3$: P

5.2 : 1

Starting Dosage 20-25 mg/L

ALUMINUM COMPOUNDS

Aluminum Sulfate (Alum)

$Al_2(SO_4)_3 \cdot 14H_2O$

Sodium Aluminate

$Na_2Al_2O_4$

Aluminum Chloride

$AlCl_3$

Alum Dosage Rates

$$Al_2(SO_4)_3 + 2PO_4^{-3} \longrightarrow 2AlPO_4 \downarrow$$

Weight Ratio

Al^{+3} : P

0.87 : 1

Alum to Phosphorus

9.6 : 1

Starting Dosage 40-50 mg/L

Phosphorus Removal

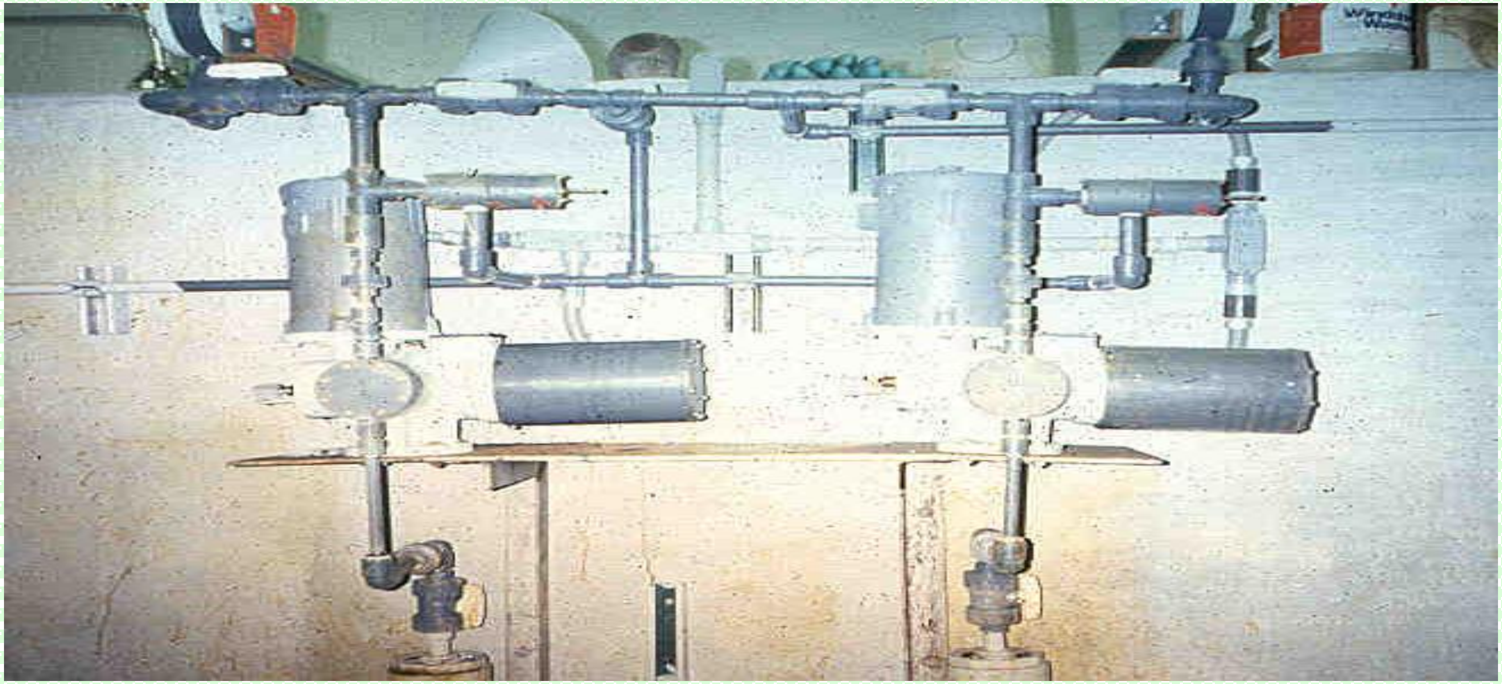
Chemical Precipitation

- **Organic and Condensed Phosphorus Compounds Must Be Converted to Ortho-P for Efficient P Removal**

AFTER PRIMARY POND


BELDING

DISCONNECT
POWER CORD
BEFORE
TERNAL
EXTE
NPUT
LMI
MILTON ROY
EMPTY
60 HZ
120. Vac 50/60 Hz 1.40 A
MODEL # A751-390SI
SERIAL # 970521015
MAX 1.00 MAX 110



Treatment Process

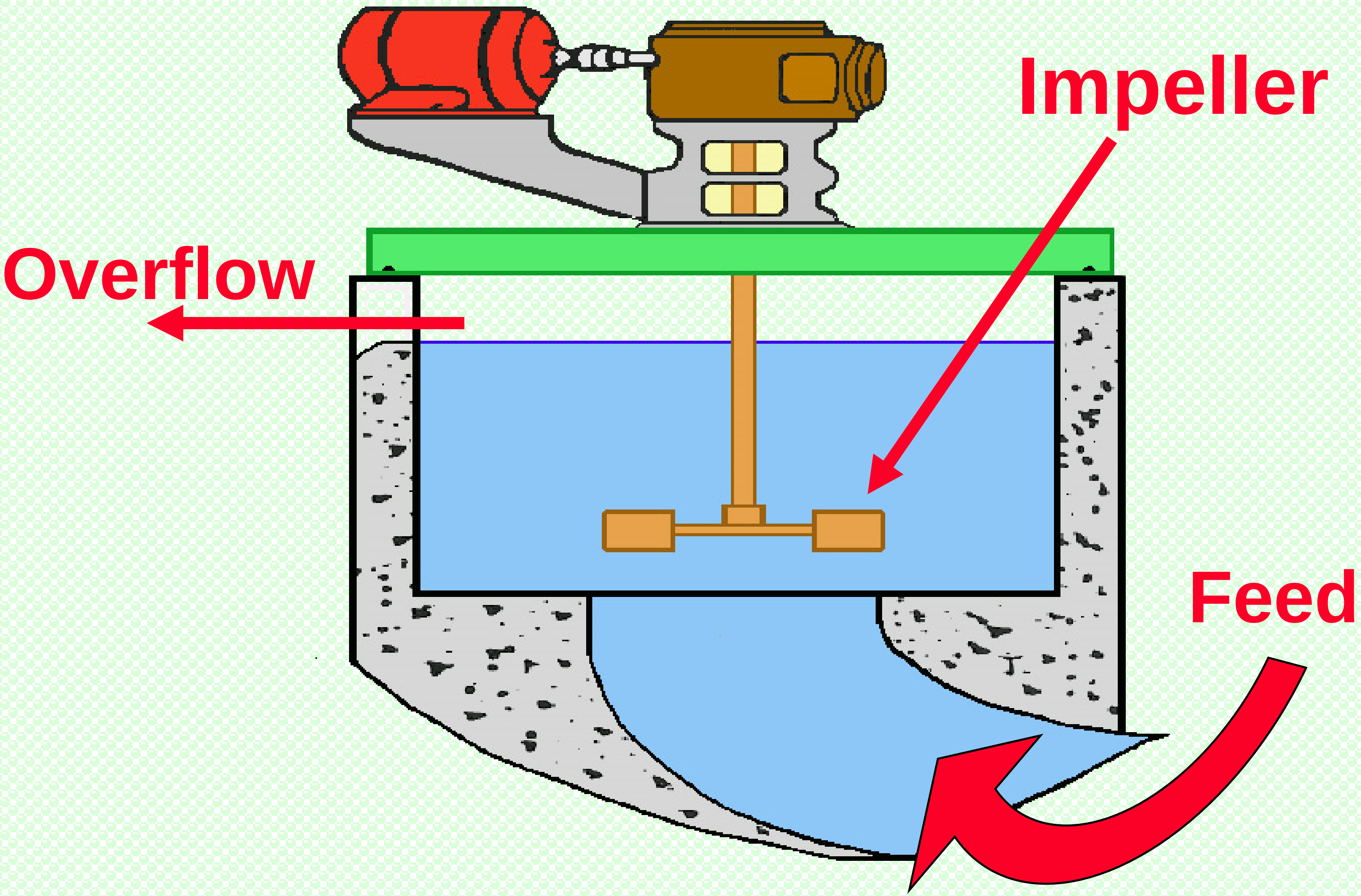
Precipitation

Coagulation

Flocculation

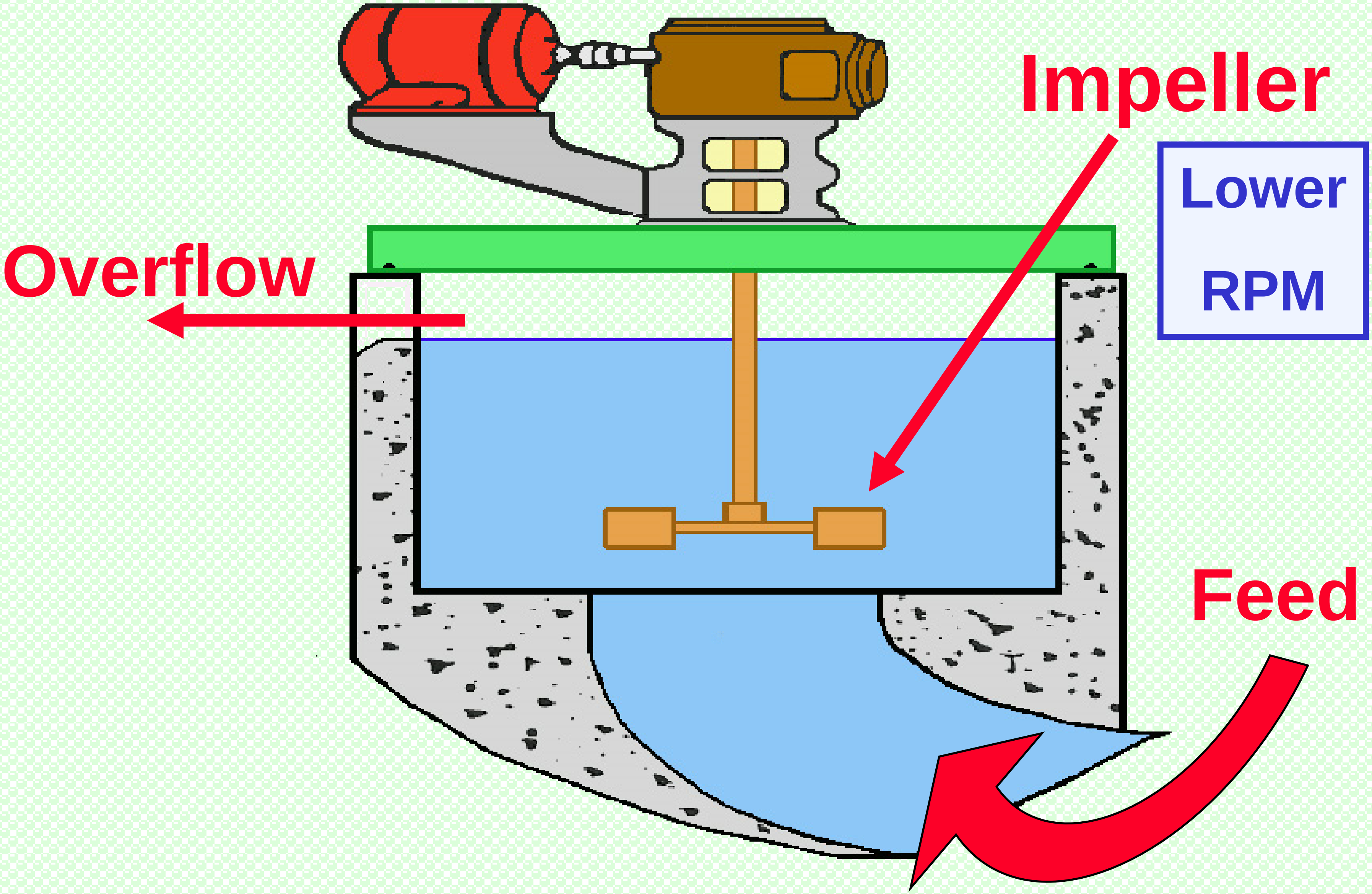
Separation

FLASH MIX TANK



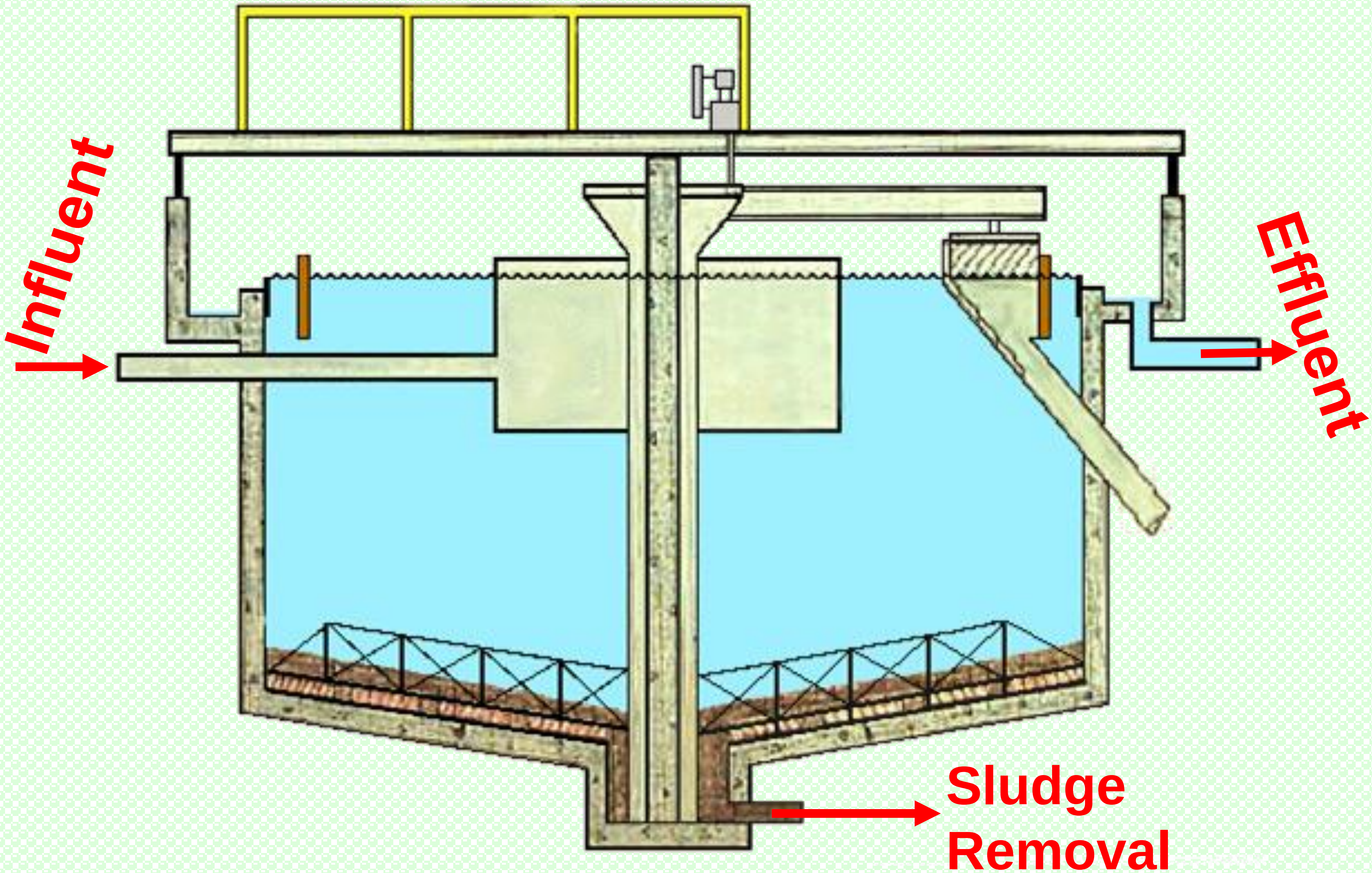
FLASH MIX TANK

FLOCCULATION TANK

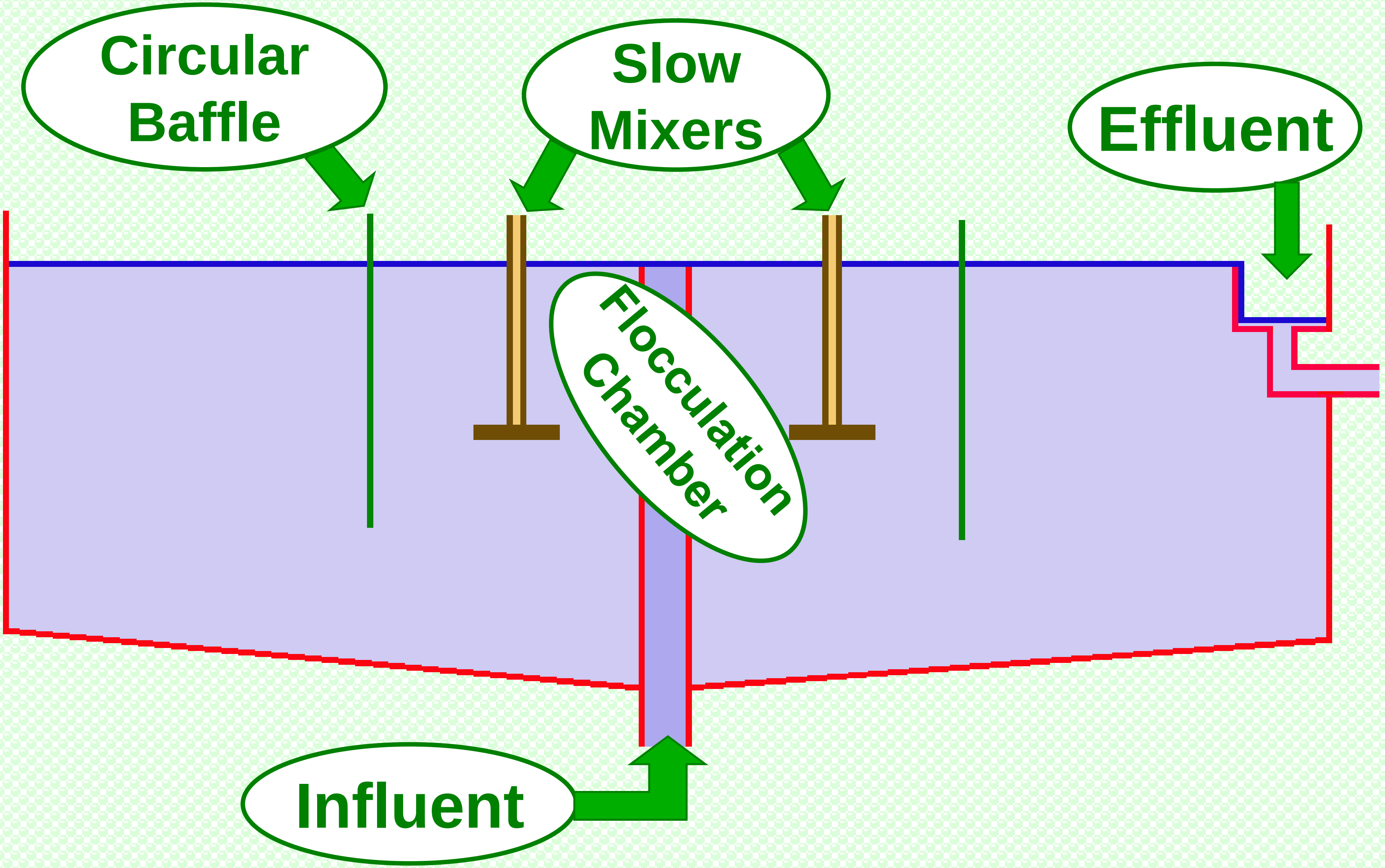


Clarifier

Clarifier



Typical Mechanically Mixed Flocculating Clarifier




PHOSPHORUS REMOVAL FOR LAGOON OPERATORS

DOSAGE CALCULATIONS

BENCH ANALYSIS
OF A CHEMICAL REMOVAL SYSTEM
(JAR TEST)

After jar testing has been used to determine best chemical dosage in mg/L, pounds of chemical needed into a given flow or volume can be calculated.

Pounds/day = Conc, $_{mg/L}$ **X Flow,** $_{MGD}$ **X 8.34** $_{lbs/gal}$

ie) A dosage of 25 mg/L Ferric Chloride is needed. The flow to be treated is 350,000 gallons per day. How many lbs of Ferric Chloride will have to be fed each day?

lbs/D = 25 mg/L X 0.35 MGD X 8.34 lbs/gal

= 73 lbs/D $FeCL_3$

Given lbs/d of dry chemical to feed, need to calculate the gallons of solution to feed.

Specific Gravity

Specific Gravity = the number of times heavier or lighter the solution is than water

1 gallon of water weighs 8.34 lbs
Specific gravity of water = 1.000

Specific Gravity

If a solution has a Specific Gravity of 1.510, then this solution is 1.510 times heavier than water.

8.34 lbs/gal X 1.510 = 12.59 lbs/gal

Chemical Handling

Chemical Handling

Strength of Concentrated Solutions are usually given as Percent by Weight

35 % = 35 per 100

$$35\ \% = \frac{35 \text{ lbs dry chem}}{100 \text{ lbs solution}}$$

In 100 lbs of a 35 % solution there are 35 lbs of dry chemical

If the weight of a gallon of solution is known, the weight of dry chemical in each gallon of the solution can be calculated:

A 40% solution has a specific gravity of 1.43

A. Determine the weight of a gallon of the solution.

8.34 lbs/gallon X 1.43 = 11.93 pounds per gallon liquid

B. Determine the pounds of dry chemical in each gallon.

$$11.93 \text{ pounds} \times \frac{40 \text{ lbs dry chem}}{100 \text{ lbs solution}} = 4.77 \text{ lbs dry chem/ gal}$$

OR

11.93 pounds X 0.40 = 4.77 lbs dry chem/ gal

Feed Rates

If the lbs per day of chemical to be fed is known, and we know the pounds of dry chemical in each gallon of the solution, the gallons per day of solution to be fed can be calculated.

$$\frac{\text{lbs/day dry chem needed}}{\text{lbs dry chem / gal}} = \text{gal/day soln to be fed}$$

ie) 150 lbs per day ferric chloride are to be fed. The solution to be used is 38% with a specific gravity of 1.413. Calculate the gallons of solution to feed each day.

8.34 lbs/gal X 1.413 = 11.78 lbs/gal

0.38 X 11.78 lbs/gal = 4.48 lbs dry chem/gal

$$\frac{\text{150 lbs/d dry chem needed}}{\text{4.48 lbs dry chem/gal}} = \text{33.5 gal/day}$$

Pumping Rate Calculations

Given gallons per day of chemical needed, calculate gallons per minute

$$\frac{\text{Gal}}{\text{Day}} \times \frac{1\ \text{Day}}{24\ \text{Hrs}} \times \frac{1\ \text{Hr}}{60\ \text{Min}} = \frac{\text{Gal}}{\text{Min}}$$

Pumping Rate Calculations

Given gallons per day of chemical needed, calculate gallons per minute

$$\frac{\text{Gal}}{\text{Day}} \times \frac{1\ \text{Day}}{24\ \text{Hrs}} \times \frac{1\ \text{Hr}}{60\ \text{Min}} = \frac{\text{Gal}}{\text{Min}}$$

$$\frac{\text{mL}}{\text{Sec}} \times \frac{1\ \text{Gal}}{3785\ \text{mL}} \times \frac{60\ \text{Sec}}{\text{Min}} = \frac{\text{Gal}}{\text{Min}}$$

Chemical Feed Summary

1. Determine lbs/day of dry chemical needed.

mg/L X MGD X 8.34 lbs/gal = lbs/d dry chem

2. Determine the weight (lbs/gal) of the soln.

8.34 lbs/gal X Sp.Gr. = lbs/gal (liquid weight)

3. Determine weight of dry chem in each gallon.

lbs/gal (liquid wt) X % soln = lbs dry/gallon

4. Determine gallons per day to be fed.

$$\frac{\text{Lbs dry needed per day}}{\text{lbs dry/gallon}} = \text{gal/day to be fed}$$

5. To Determine pumping rate in gallons/minute:

$$\frac{\text{gal}}{\text{Day}} \times \frac{1\ \text{Day}}{24\ \text{Hrs}} \times \frac{1\ \text{Hr}}{60\ \text{Min}} = \frac{\text{Gal}}{\text{Min}}$$

6. Calibrate the chemical feed pump.

Phosphorus Removal Dosage Calculations
Example Problem

Jar testing indicates that a dosage of 23 mg/L of ferric chloride will be needed to provide adequate treatment of a lagoon with a volume of 3.5 MG. The ferric chloride solution has a concentration of 40 % and a specific gravity of 1.430. Calculate the gallons of the ferric chloride solution that should be used.

Calculate the pounds of dry chemical that are needed.

23 mg/L X 3.5 MG X 8.34 lbs/gal = 671.37 lbs

Phosphorus Removal Dosage Calculations
Example Problem

Jar testing indicates that a dosage of 23 mg/L of ferric chloride will be needed to provide adequate treatment of a lagoon with a volume of 3.5 MG. The ferric chloride solution has a concentration of 40 % and a specific gravity of 1.430. Calculate the gallons of the ferric chloride solution that should be used.

Calculate the pounds of dry ferric chloride in each gallon of the solution.

8.34 lbs/gal X Sp. Grav. X % Solution =
lbs dry ferric chloride / gallon of solution

8.34 lbs/gal X 1.430 X 0.40 =

4.77 lbs dry ferric chloride / gallon of solution

Phosphorus Removal Dosage Calculations
Example Problem

Jar testing indicates that a dosage of 23 mg/L of ferric chloride will be needed to provide adequate treatment of a lagoon with a volume of 3.5 MG. The ferric chloride solution has a concentration of 40 % and a specific gravity of 1.430. Calculate the gallons of the ferric chloride solution that should be used.

Calculate the gallons of ferric chloride solution needed.

$$\frac{\text{671.37 lbs dry ferric chloride needed}}{\text{4.77 lbs dry ferric chloride / gallon solution}}$$

= 140.75 gallons of ferric chloride solution needed

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