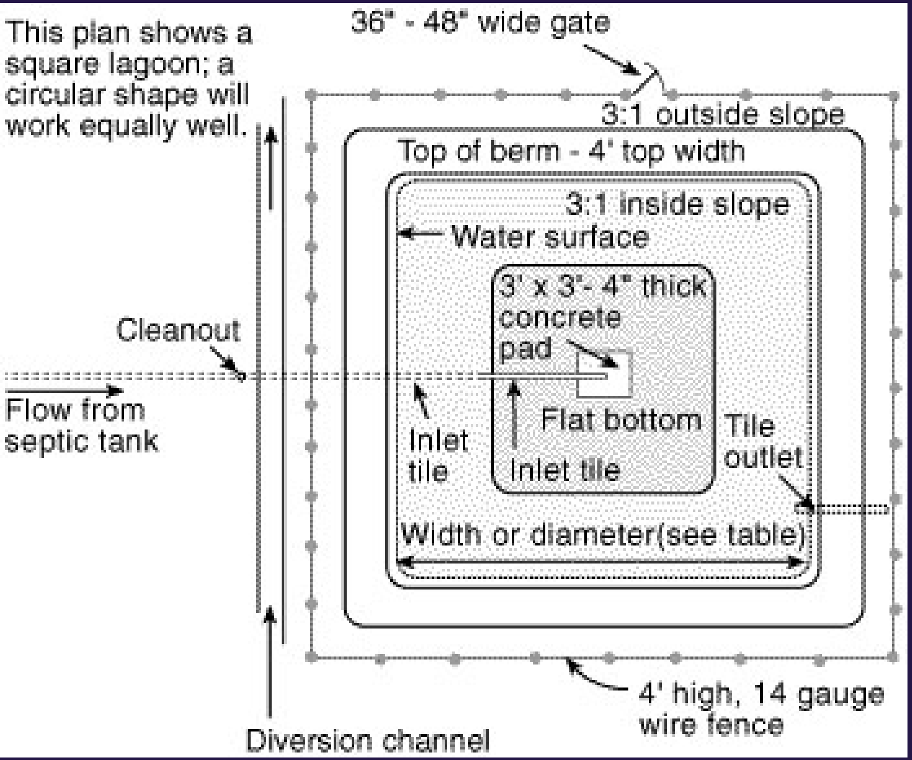
Day 4: Lagoon Design, Construction, and Advanced Treatment



Outline for Today

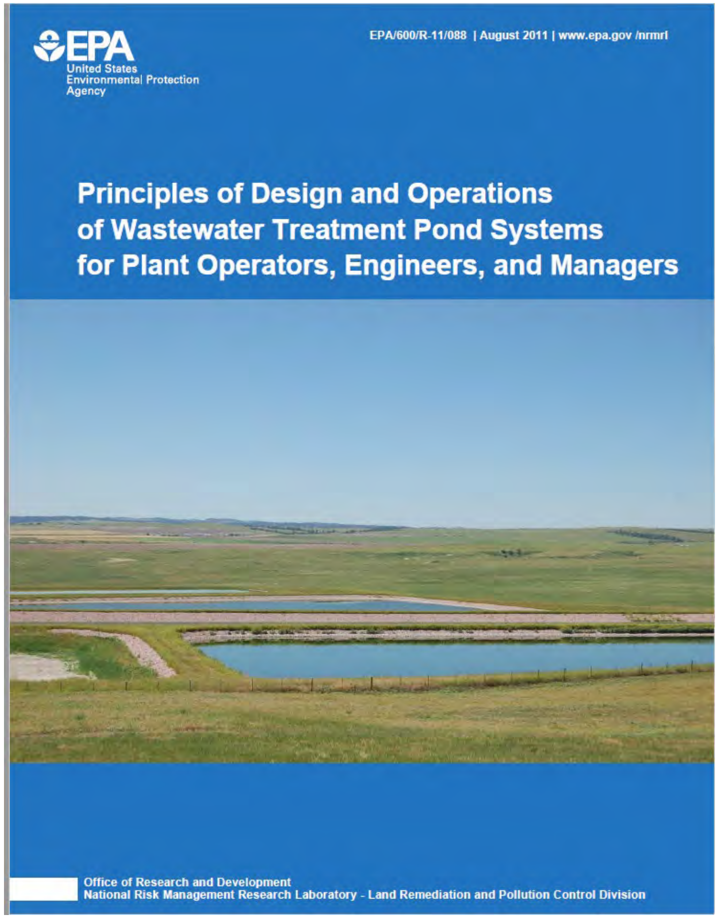
1. Lagoon Design Considerations and Components
2. Groundwater Considerations
3. Calculations
4. Permits
5. Advanced Treatment

Pre-Quiz – write answers down for later

1. What types of lagoon liners are available?
2. What are different methods of flow measurement?
3. What features might be desireable on an inlet or outlet structure?
4. What are some factors that should be considered when designing a new lagoon?
5. What federal regulation covers sludge disposal
6. What is a diurnal curve?
7. What are the nutrients most commonly required to be removed from wastewater?
8. Can phosphorus be removed biologically?

1. LAGOON DESIGN CONSIDERATIONS AND COMPONENTS

Resources



General Considerations:

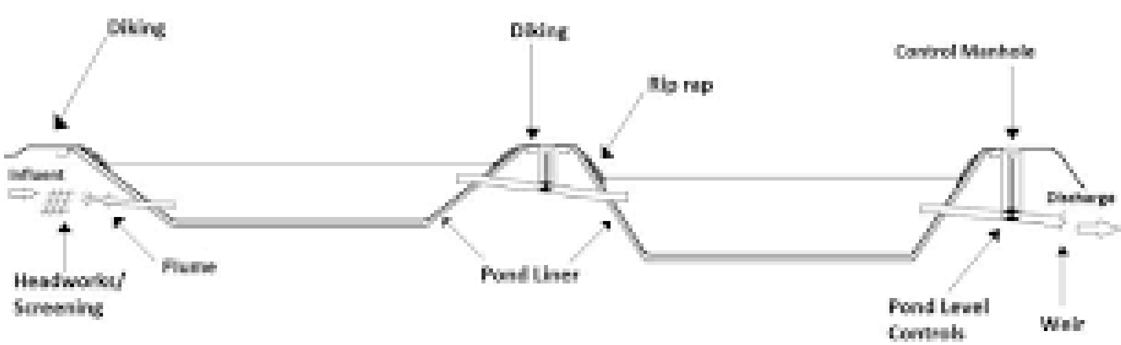
- Where is there space to put the pond?
- Proximity to neighbors who might find it a nuisance.
- Will treated wastewater be discharged or does it need to evaporate? (this will control the size).
- Preferably downhill from users!

Design Criteria

- Loading rates
- Flow
- HRT
- Location
- Soil conditions
- Wastewater characteristics
- Pond configuration and shape
- Inlet/outlet structures
- Hydraulics
- Treated effluent disposal
- Solids disposal
- Flow measuring devices
- Inlet/outlet structures
- Note:
  - Each state has different design standards

Pond Configuration

- Number of impoundments needed is decided during design
- Operated in series or parallel
  - Pipes connecting each pond
  - Valves to isolate each pond
  - Separate influent pipe to each pond

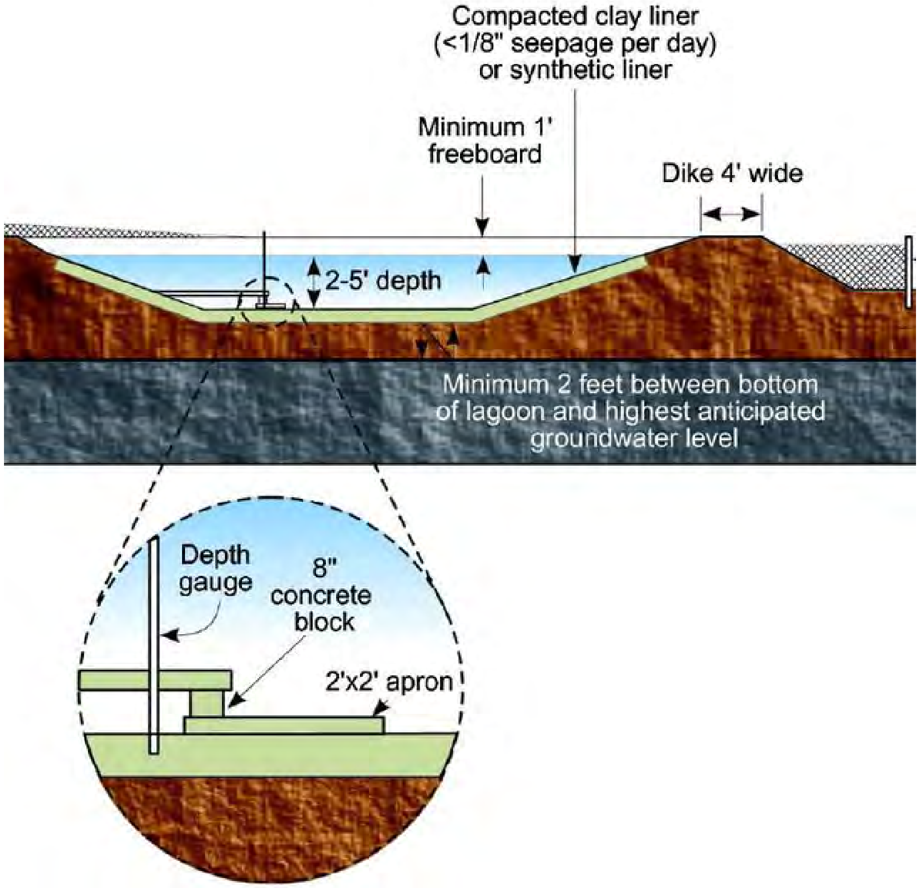


Pond Configuration

Dikes

- Need to withstand weather and burrowing animals
  - Riprap
  - Fabric
  - Grass
  - Concrete
  - Gravel
- Designed to minimize seepage
- May require bank stability on the exterior toe
- Fence is typically installed near exterior toe to reduce pond visibility

Design Criteria



Pond Sealing

- The primary motive for sealing ponds is to prevent seepage
- Liners must be impermeable
- Pond sealers can be classified into three categories:
  1. Synthetic and rubber liners
  2. Earthen and cement liners
  3. Natural and chemical treatment sealers
- The most common liners are bentonite clay and geosynthetic

Bentonite Clay Liners

Commonly constructed in the two following ways:

1. Bentonite is spread as a membrane approximately 2.5 to 5 cm thick
   - Covered with 20 to 30 cm of soil and gravel to protect the membrane and increase stability
2. Bentonite is mixed with sand and layered 5 to 10 cm thick
   - Covered with a protective layer of sand or soil

Bentonite Clay Liners

Bentonite Clay Liners

Bentonite Clay Liners

Construction considerations:

- Overexcavated with graders and free of large rocks or sharp angles
- Side slopes cannot exceed 2:1
- Subgrade rolled with steel roller
- Protective cover consists of sand and small gravel, in addition to a cohesive, fine-grained material

Geosynthetic Liners

Geosynthetic Liners

- Essentially zero permeability
- Economical
- Resistant to most chemicals
- Applied in large sheets
- Protect against toxic wastewater

Leakage Detection

- Pond liners must be inspected and tested during construction
- Any leaks detected are required to be fixed
- Hydraulic conductivity specified for the liner shall not exceed the derived value

  $k = 2.6 \times 10^{-9} L$

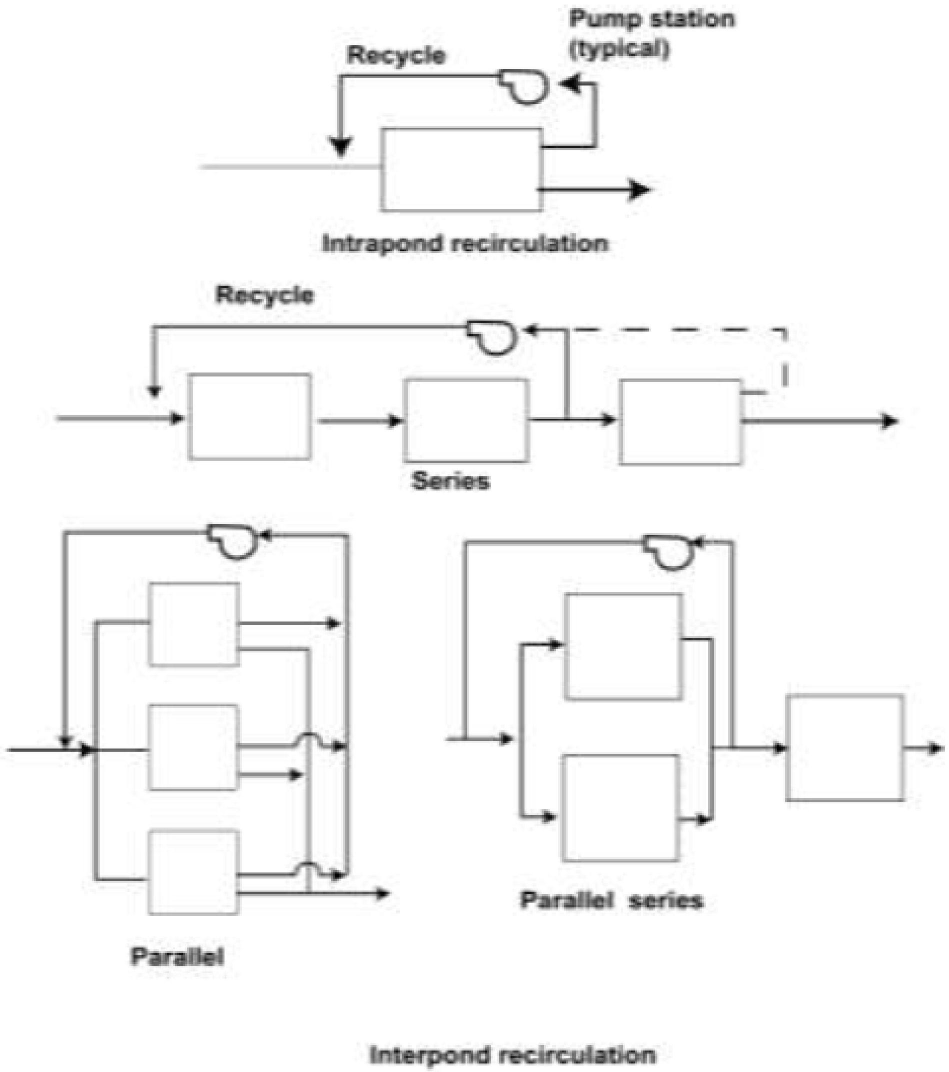
  k = hydraulic conductivity (cm/s), percolation rate

  L = thickness of seal (cm)

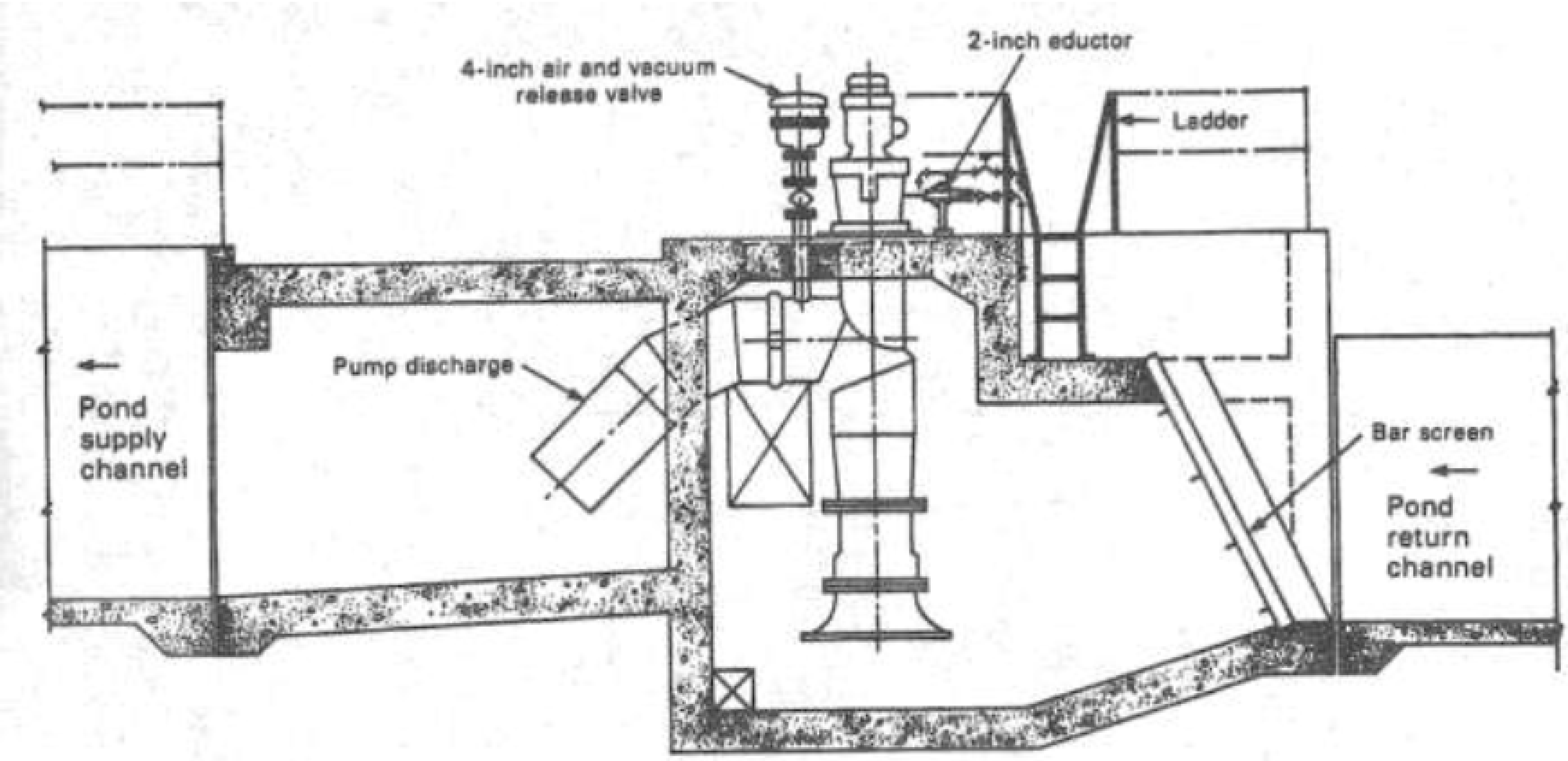
Pond Recirculation

- Requires a pumping station
- Effluents from pond cells are mixed with influent
- Replaces mechanical pond mixing
- Intrapond recirculation:
  - Effluent from a single cell is returned to the influent of that same cell
- Interpond recirculation:
  - Effluent from another pond is returned and mixed with the influent
- Can be done in parallel or series

Pond Recirculation



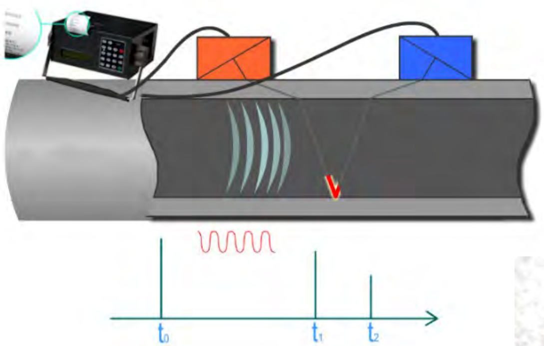
Pond Recirculation



Flow Measuring Devices

1. Weir or Parshall Flume: Measures water levels
2. Area Velocity Meters: Measure velocity and depth
3. Staff Gauge: Sonic device that sends and receives a signal to an electronic recorder
4. Measurements should be taken during low and high flow conditions

Flow Measuring Devices



Flow Measuring Devices

- Parshall Flume
- Gauge measures fluid height; use conversion chart

Inlet/Outlet Structures

- Design and placement avoids short-circuiting
- Split influent between lagoons
- Split effluent to recirculate or discharge
- Must be sealed properly
- Aligned perpendicular to wind

Headworks/Screening

- Remove trash/solids from influent

Treated Effluent Disposal

- Dictated by the discharge permit
- Effluent must meet water quality limits laid out in the permit
- Samples must be taken and reported

Solids Disposal

Options:

1. Drain lagoon and dry sludge in place, then haul to disposal site
2. Drain lagoon and pump sludge to drying beds, then haul to disposal site
3. Use floating dredging equipment to pump solids to drying beds, belt press or land application
4. Bio-stimulation/Bio augmentation

PART 503 - STANDARDS FOR THE USE OR DISPOSAL OF SEWAGE SLUDGE

- General requirements
- Pollutant limits
- Management practices
- Operational standards
- Monitoring and record keeping
- Pathogen and alternative vector attraction reduction rqeuiprments for land application sites

Things to Remember when Draining a Lagoon and Pumping Sludge (p. 101)

1. Know the rules
2. Develop a plan including budget
3. Sludge best removed during spring and early summer
4. Have sludge analyzed
5. Have several land application/storage sites available as options
6. Consider lagoon access and equipment required

Things to Remember when Draining a Lagoon and Pumping Sludge (p. 101)

7. Consider how sludge will be moved to the pump
8. Calculate amt of lime required
9. Secondary lagoons may become overloaded while sludge removal is in progress – Add more air
10. Wash sludge down that sticks to sides (but not dirt)
11. When lagoon is down is a good time for repairs

Things to Remember when Draining a Lagoon and Pumping Sludge (p. 101)

12. The pumps may not pick up sand and gravel. The remaining grit can be spread out evenly.
13. Create a sump within the lagoon for pumping
14. A sludge holding pit can be constructed where sludge can be lime-stabilized. Pit provides a measure of safety due to delays


QUIZ

Quiz

1. What are the two ways in which ponds are operated?

   ✓ Parallel

   ✓ Series

Quiz

2. Why are liners necessary?

   They prevent seepage.

Quiz

3. What materials are the typical liners constructed of?

Clay or geosynthetic

2. GROUNDWATER CONSIDERATIONS

Leakage Detection

- Influent and effluent must be recorded to determine extent of infiltration and/or exfiltration
- Reporting is required per the permit
- Most states require both influent and effluent to be reported
- Monitoring wells:
  - Multiple groundwater monitoring wells must be in place where samples may be collected to determine seepage and groundwater quality
  - Reporting and limitations are required by the permit

Flooding Considerations

- Maps of the floodplain are produced by the USGS
- Flood mitigation procedures must be worked out during design to *not* impact lagoons
- Site evaluations and environmental impacts will be completed during the design phase

Liner Inspections

- Inspect lagoon liners every 6 months
- Visually inspect pipe boot connections
- Check all mechanically battended areas for wear or loose bolts
- Check top of slope on pond liners for rips and tears caused by maintenance, vehicular traffic etc.

Liner Inspections/Repairs

- Inspect after major weather events
- Clean up any fallen tree limbs or debris
- Hire a professional to do repairs
- Keep detailed records of repairs

3. CALCULATIONS

Surface Area, Depth, Volume

<u>Variables</u>

A = Surface area

L = Length

W = Width

d = Depth

V = Volume

r = Radius

D = Diameter

π = Pi = 3.14

s = Side slope (2:1)=2

<u>Rectangle</u>

$A = L * W$

$V = A * d$

<u>Circle</u>

$A = \pi * r^2$ or $\frac{\pi}{4} * D^2$

$V = A * d$

<u>Pond w/ side slopes</u>

V= $[L * W + (L - 2sd)(W - 2sd) + 4(L - sd)(W - sd)] * d/6$

Flow Rate

Variables

Q = Flowrate (volume/time)

V = Velocity (distance/time)

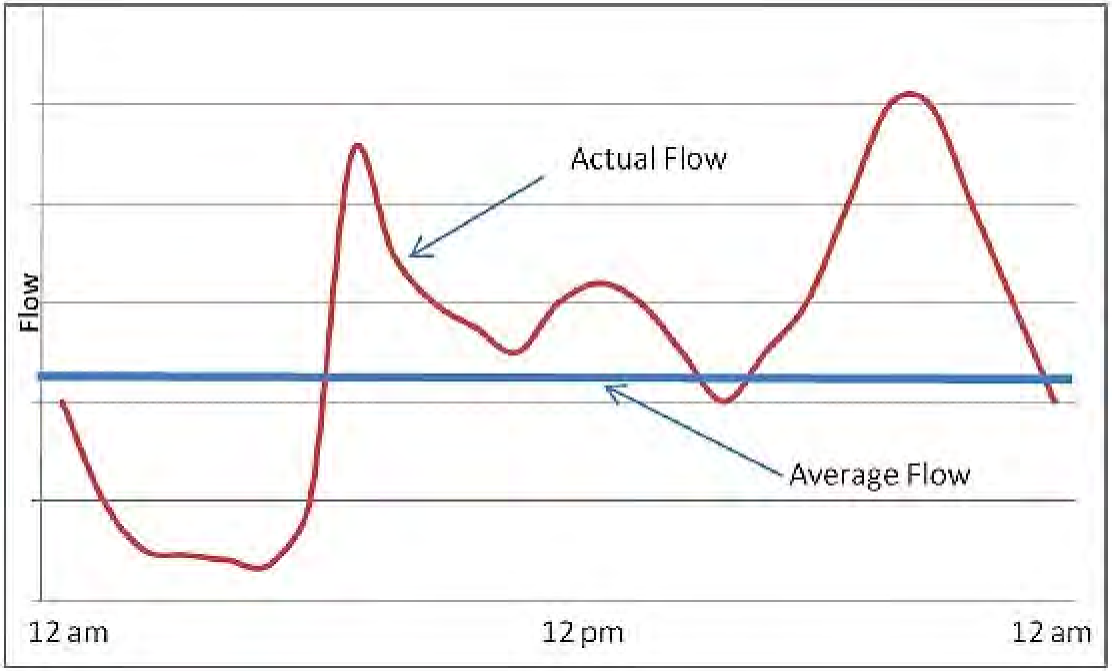
A = Area

$$Q = Q$$

$$Q = V * A$$

Q = ft^3/sec, gpm, m^3/sec

Flow Variations: diurnal curve



Calculations

Organic loading (lb BOD/acre/day) =

$$\frac{(BOD, \frac{mg}{L})(Flow, MGD)(8.34\frac{lb}{gal})}{Lagoon\ area\ in\ acres}$$

BOD removal efficiency = $\frac{BODin - BODout}{BODin} * 100$

Detention time in days = $\frac{Pond\ volume}{Flowrate/day}$


QUIZ

Quiz

1. What is the velocity in a 6-inch pipe if the flow is 300 gpm?

   Area of pipe = PI x (.5/24)^2, V= QA = 3.4 feet per second

Quiz

2. What is the BOD removal rate if the BODin = 245 mg/L and the BODout = 22 mg/L?

   (245-22)/245 x 100 = 91%

Quiz

3. What is the organic loading if the BODin = 300 mg/L, the plant flow is .1 mgd, and the area of the lagoon is 2 ac?

125 lbs BOD/acre/day

4. PERMITS

Regulations and Guidance

- NPDES Permit
- Discharge Permit
- Certified Operator

NPDES

- What is NPDES?
- National Pollutant Discharge Elimination System
- The NPDES permit program addresses water pollution by regulating point sources that discharge pollutants to waters of the United States.
- Created in 1972 by the Clean Water Act, the NPDES permit program authorizes state governments to perform many permitting, administrative, and enforcement aspects of the program.

NPDES Permit

- Contains limits on what can be discharged, monitoring and reporting requirements, and other provisions to ensure water quality and human health
- Must be applied for, prior to discharging
- Protects the waters of the U.S.; specifies where treated effluent can be discharged
- Penalties are in place for permit violations
- Permits are limited to 5 years; can be renewed

Discharge Permit

- New Mexico Environment Department Ground Water Quality Bureau (NMED GWQB)
- Types of facilities that NMED issues permits for:
  - Domestic wastewater facilities
  - Large capacity (> 5,000 gpd)
  - Power generating facilities
  - Dairy facilities
  - Chile processors
  - Mining operations
  - Other commercial and industrial operations
  - Groundwater clean-up systems

Discharge Permit (DP)

Discharge permits indicate the following:

- Operational plan
- Monitoring and reporting
- Contingency plan
- Closure plan
- Record keeping
- Penalties and compliance

Certified Operator

Water Certifications	Examination Application Fee	Experience Required (Years)	Training Credits Required
Water Sampling Tech 1 (WST1)	$25	0	5
Water Sampling Tech 2 (WST2)	$25	0	10
Small Water(SW)	$25	1	10
Adv. Small Water(SWA)	$25	1	10
Water Supply Level 1 (WS1)	$30	1	10
Water Supply Level 2 (WS2)	$30	2	30
Water Supply Level 3 (WS3)	$30	4	50
Water Supply Level 4 (WS4)	$30	1 year as WS3	80
Distribution Systems 1 (DS1)	$30	1	10
Distribution Systems 2 (DS2)	$30	2	30
Distribution Systems 3 (DS3)	$30	4	50

Certified Operator

Wastewater Certifications	Examination Application Fee	Experience Required (Years)	Training Credits Required
Small Wastewater(SWW)	$25	1	10
Adv. Small Wastewater (SWWA)	$25	1	10
Wastewater Level 1 (WW1)	$30	1	10
Wastewater Level 2 (WW2)	$30	2	30
Wastewater Level 3 (WW3)	$30	4	50
Wastewater Level 4 (WW4)	$30	1 year as WW3	80
Wastewater Lab Tech 1 (WWLT1)	$25	1	10
Wastewater Lab Tech 2 (WWLT2)	$30	2	30
Wastewater Lab Tech 3 (WWLT3)	$30	4	50
Collection Systems 1 (CS1)	$30	1	10
Collection Systems 2 (CS2)	$30	2	30


QUIZ

Quiz

1. Why does an operator need to know the treatment facility's permit requirements?

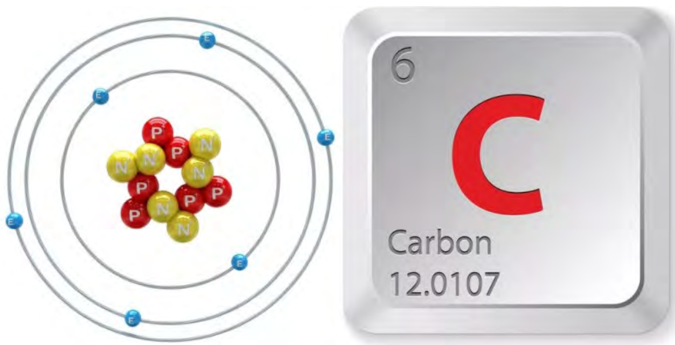
   To ensure compliance and avoid penalties and violations

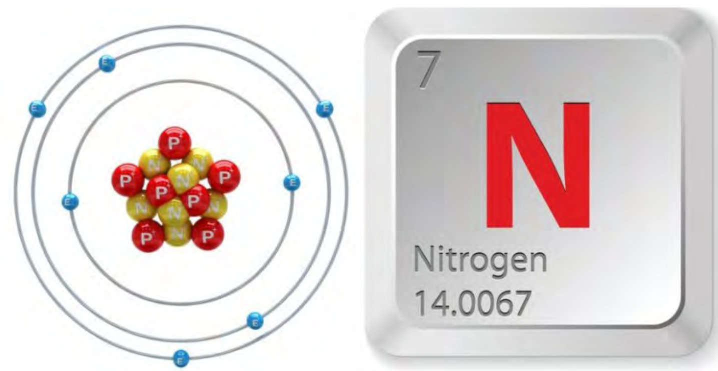
5. ADVANCED TREATMENT

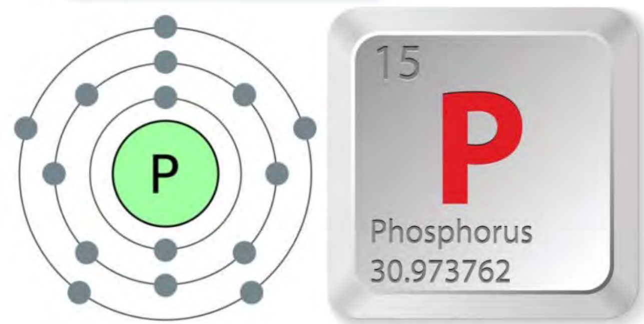
Nutrients -

- What are they and how do we remove them?

What are Nutrients?

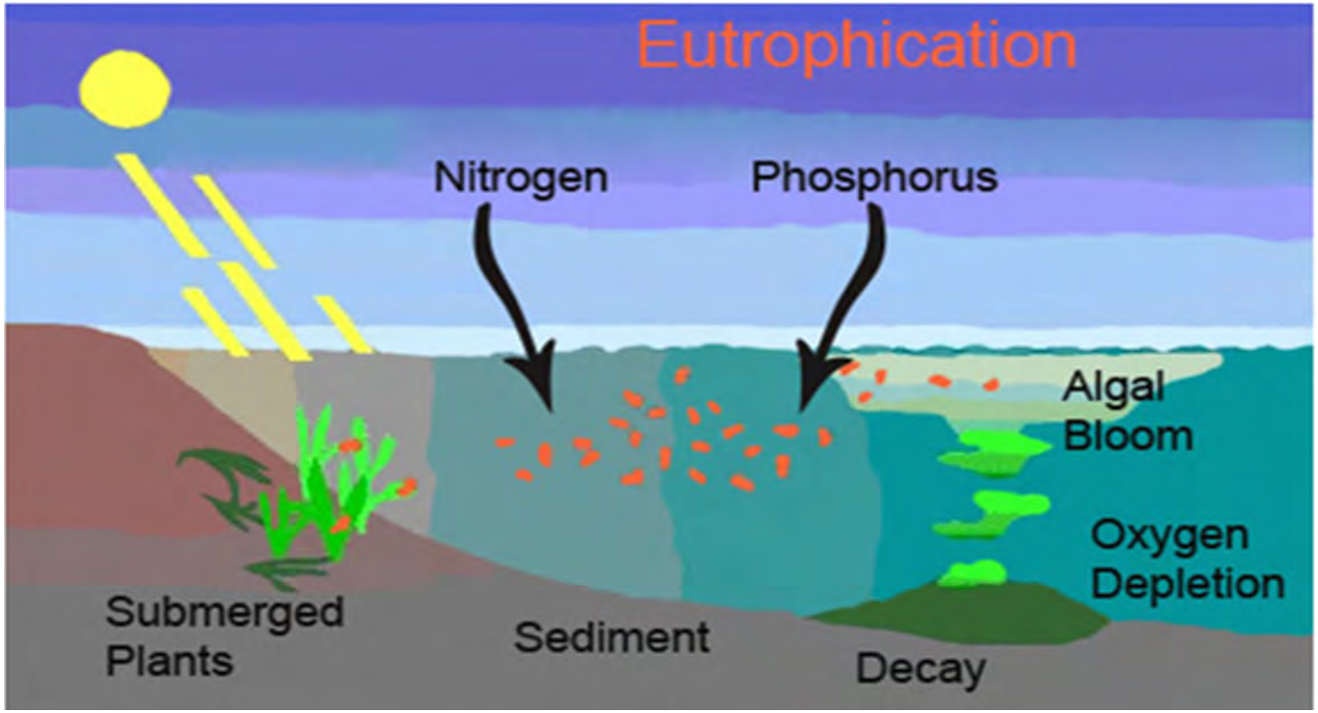






Why Remove Nutrients?

The nutrients in wastewater contribute to eutrophication: “excessive richness of nutrients in a lake or other body of water, frequently due to runoff from the land, which causes a dense growth of plant life and death of animal life from lack of oxygen.”



“Typical” wastewater

- Influent nitrogen – 23 to 69 mg/L total N, 60 to 70% of which is ammonia-nitrogen ; remaining 30 to 40% is organic
- Ammonium typical 5 mg/L, no NO_3- or NO_2-
- Influent phosphorus – 6 to 8 mg/L as P for domestic WW
- Sources are human waste, food and certain soaps and detergents.

Forms of Nitrogen in Wastewater

1) Ammonia (NH_3-N)
2) Nitrite (NO_2-N)
3) Nitrate (NO_3-N)
4) Nitrogen Gas (N_2)

Forms of Nitrogen

Total Kjeldahl Nitrogen (TKN) =

Organic N + NH_3-N

Total Inorganic Nitrogen (TIN) =

NH_3-N+ NO_2-N+ NO_3-N

Influent Nitrogen

- 99% is in the form of TKN
  - 40% organic nitrogen
  - 59% ammonia/ammonium
  - This ratio is dependent on pH, temperature and detention time in the collection system
- Less than 1% nitrate and nitrite

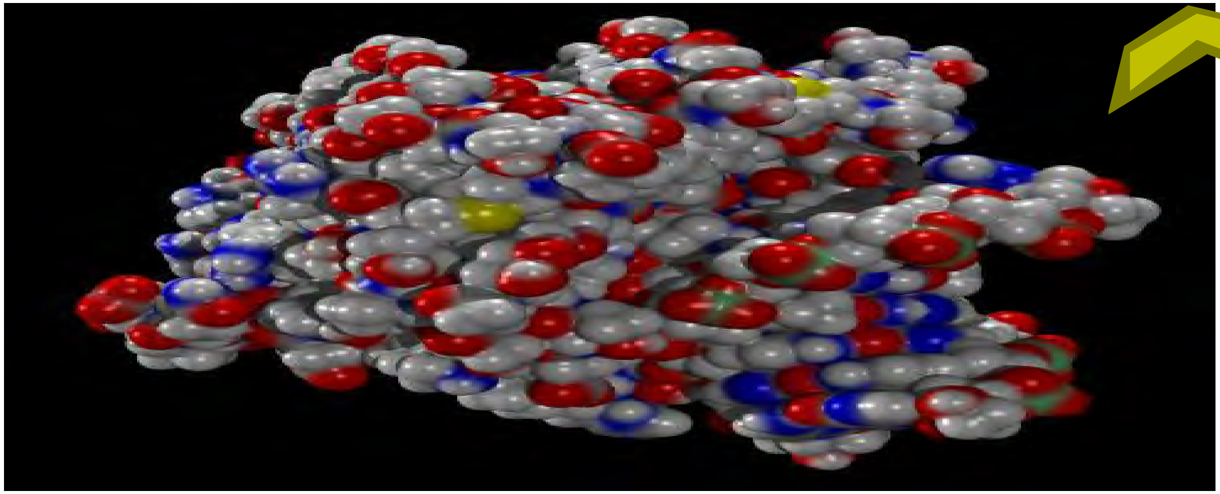
Forms of Influent Phosphorus

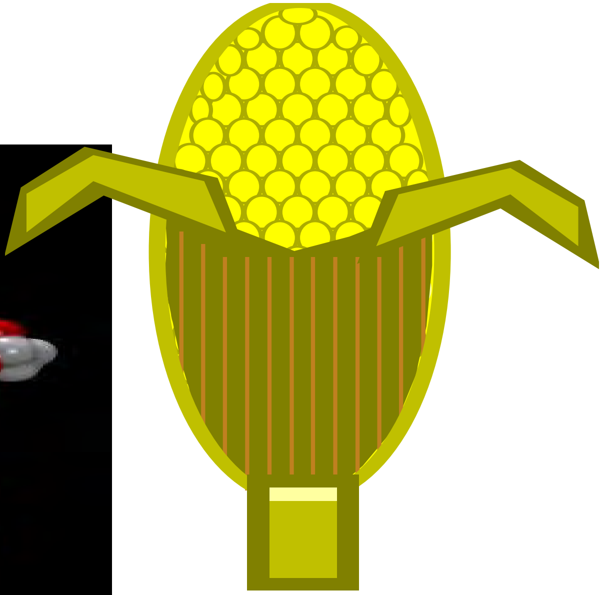
- Phosphate (aka orthophosphate) $H_2PO_4^-$ or HPO_4^{-2}
- Polyphosphate
- Organic phosphorus

Forms and Source of P

<u>Organic Phosphorus</u>

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

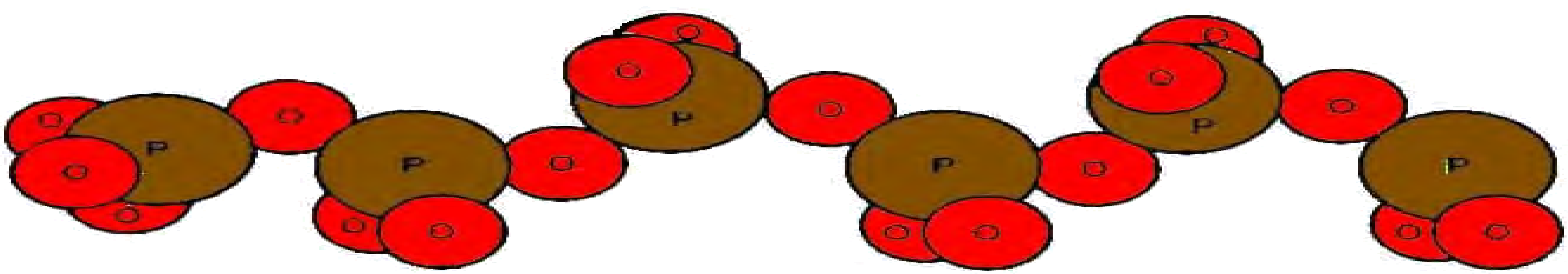




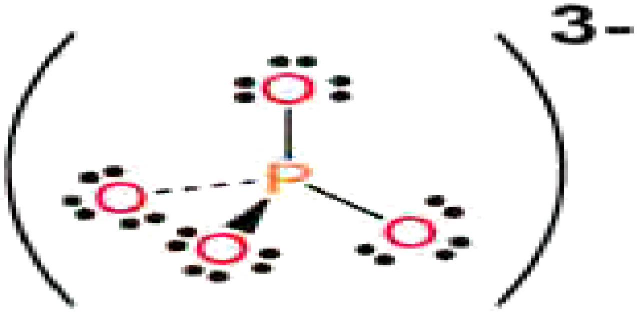
Forms and Sources of P

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

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

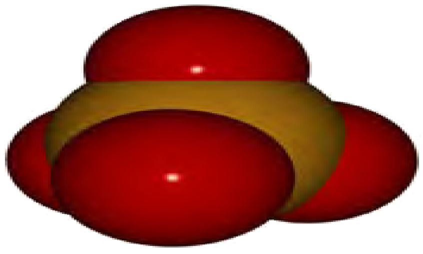


Forms and Sources of P



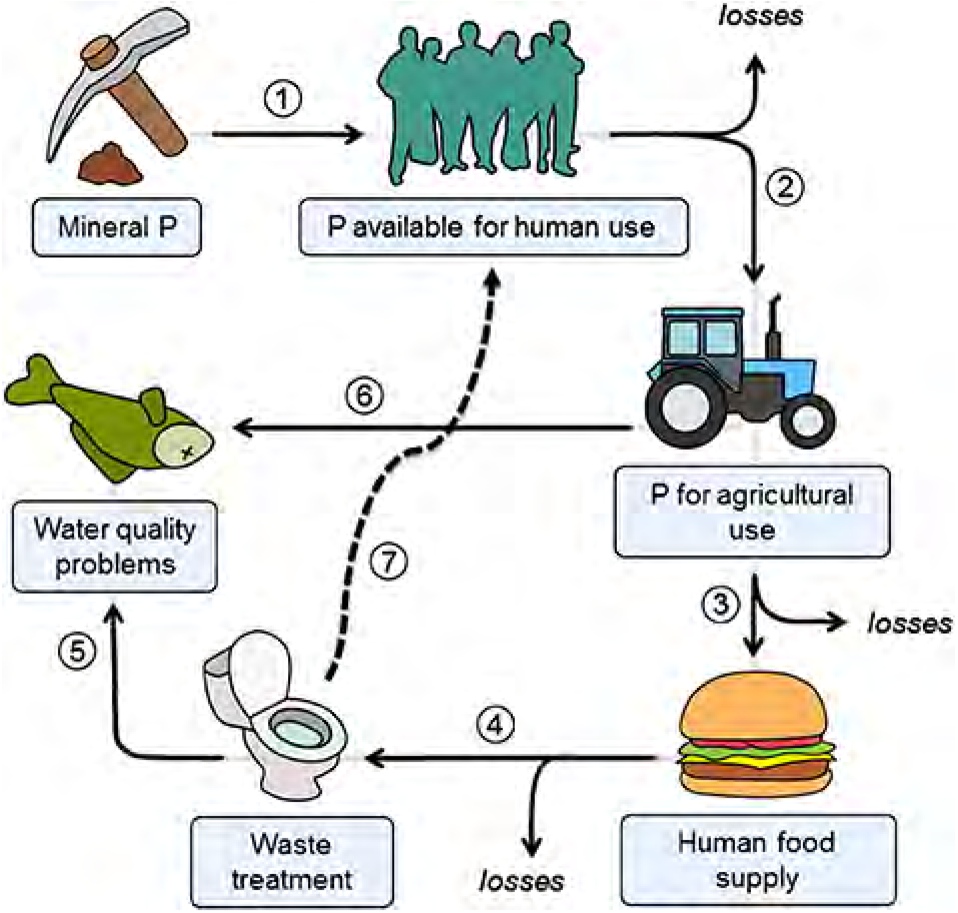
<u>Orthophosphate</u>

- Simple Phosphate, PO4
- soluble
- household cleaning agents
- industrial cleaners;
- phosphoric acid
- conversion of organic and poly phosphate



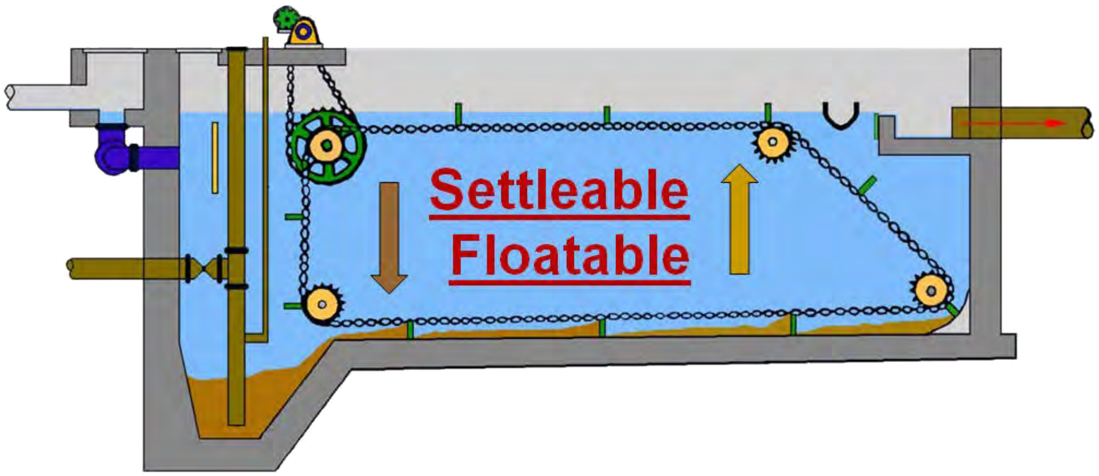
Influent Total Phosphorus

- 6 to 8 mg/L as P for domestic waste
- could be higher from industrial sources



Mechanisms for Nitrogen and Phosphorus Removal

- Bacteria cells contain N and P which are incorporated to the biomass that is removed either through settling (ponds), sloughing (fixed film) or wasting (activated sludge).

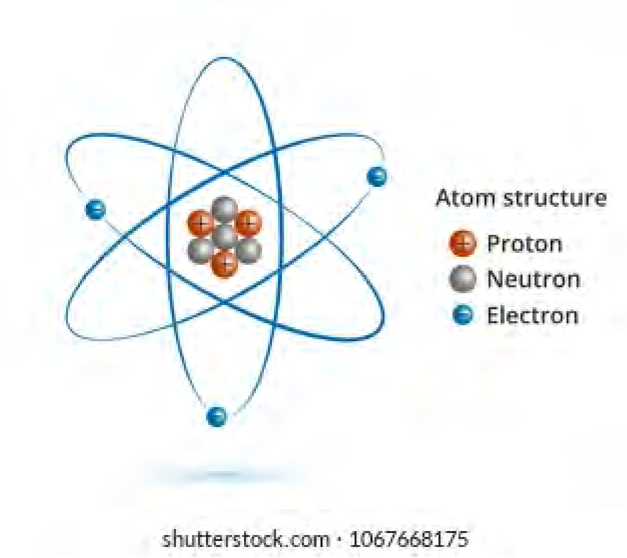


Quiz

1. Why do N and P need to be removed from wastewater?
2. What is a typical concentration of P in influent wastewater?
3. What is a typical concentration of nitrate in influent wastewater?

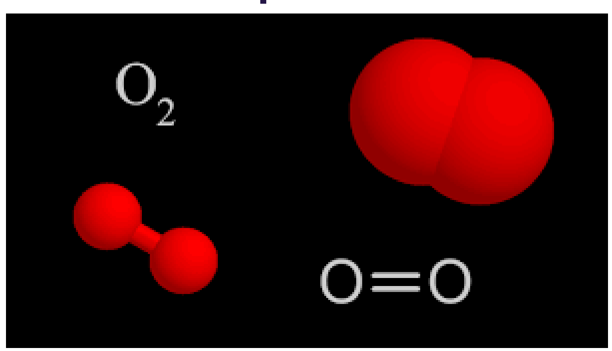
Chemistry Review

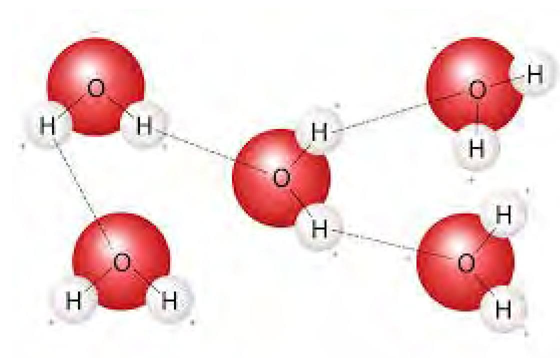
- Atoms: building blocks of nature
- Element: particular type of atom
- Atomic #: # of protons in the atom (specific to the type of element)



Chemistry Review

- Molecules and compounds: combination of 2 or more atoms that are chemically bound together
- Molecules made from 2 or more elements are compounds
- All compounds are molecules but not all molecules are compounds





PERIODIC TABLE OF ELEMENTS

Chemical Group Block

PubChem

Atomic Number | 17 | 35.45 | Atomic Mass, u

Symbol: Cl

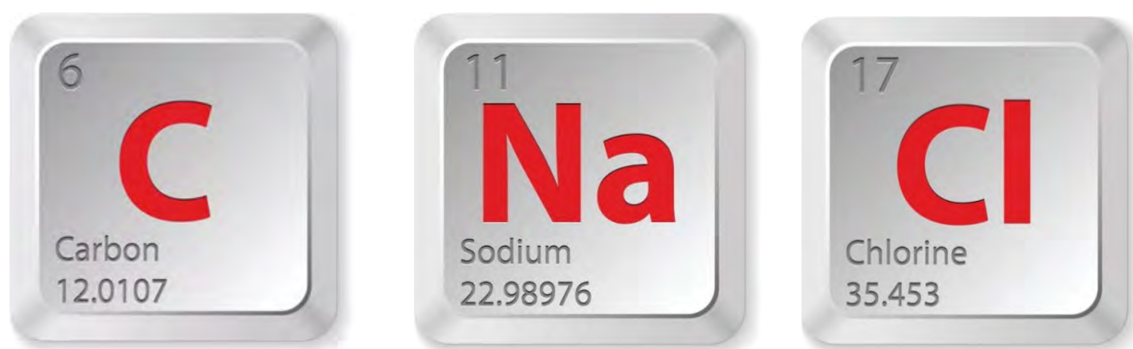
Name: Chlorine

Chemical Group Block: Halogen

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 1.0080 H Hydrogen Nonmetal																	2 4.00260 He Helium Noble Gas
2	3 7.0 Li Lithium Alkali Metal	4 9.012183 Be Beryllium Alkaline Earth Me...											5 10.81 B Boron Metalloid	6 12.011 C Carbon Nonmetal	7 14.007 N Nitrogen Nonmetal	8 15.999 O Oxygen Nonmetal	9 18.9984... F Fluorine Halogen	10 20.180 Ne Neon Noble Gas
3	11 22.989... Na Sodium Alkali Metal	12 24.305 Mg Magnesium Alkaline Earth Me...											13 26.981... Al Aluminum Post-Transition M...	14 28.085 Si Silicon Metalloid	15 30.973... P Phosphorus Nonmetal	16 32.07 S Sulfur Nonmetal	17 35.45 Cl Chlorine Halogen	18 39.9 Ar Argon Noble Gas
4	19 39.0983 K Potassium Alkali Metal	20 40.08 Ca Calcium Alkaline Earth Me...	21 44.95591 Sc Scandium Transition Metal	22 47.867 Ti Titanium Transition Metal	23 50.9415 V Vanadium Transition Metal	24 51.996 Cr Chromium Transition Metal	25 54.93804 Mn Manganese Transition Metal	26 55.84 Fe Iron Transition Metal	27 58.93319 Co Cobalt Transition Metal	28 58.693 Ni Nickel Transition Metal	29 63.55 Cu Copper Transition Metal	30 65.4 Zn Zinc Transition Metal	31 69.723 Ga Gallium Post-Transition M...	32 72.63 Ge Germanium Metalloid	33 74.92159 As Arsenic Metalloid	34 78.97 Se Selenium Nonmetal	35 79.90 Br Bromine Halogen	36 83.80 Kr Krypton Noble Gas
5	37 85.468 Rb Rubidium Alkali Metal	38 87.62 Sr Strontium Alkaline Earth Me...	39 88.90584 Y Yttrium Transition Metal	40 91.22 Zr Zirconium Transition Metal	41 92.90637 Nb Niobium Transition Metal	42 95.95 Mo Molybdenum Transition Metal	43 96.90636 Tc Technetium Transition Metal	44 101.1 Ru Ruthenium Transition Metal	45 102.9055 Rh Rhodium Transition Metal	46 106.42 Pd Palladium Transition Metal	47 107.868 Ag Silver Transition Metal	48 112.41 Cd Cadmium Transition Metal	49 114.818 In Indium Post-Transition M...	50 118.71 Sn Tin Post-Transition M...	51 121.760 Sb Antimony Metalloid	52 127.6 Te Tellurium Metalloid	53 126.9045 I Iodine Halogen	54 131.29 Xe Xenon Noble Gas
6	55 132.90... Cs Cesium Alkali Metal	56 137.33 Ba Barium Alkaline Earth Me...		72 178.49 Hf Hafnium Transition Metal	73 180.9479 Ta Tantalum Transition Metal	74 183.84 W Tungsten Transition Metal	75 186.207 Re Rhenium Transition Metal	76 190.2 Os Osmium Transition Metal	77 192.22 Ir Iridium Transition Metal	78 195.08 Pt Platinum Transition Metal	79 196.96... Au Gold Transition Metal	80 200.59 Hg Mercury Transition Metal	81 204.383 Tl Thallium Post-Transition M...	82 207 Pb Lead Post-Transition M...	83 208.98... Bi Bismuth Post-Transition M...	84 208.98... Po Polonium Metalloid	85 209.98... At Astatine Halogen	86 222.01... Rn Radon Noble Gas
7	87 223.01... Fr Francium Alkali Metal	88 226.02... Ra Radium Alkaline Earth Me...		104 267.1... Rf Rutherfordium Transition Metal	105 268.1... Db Dubnium Transition Metal	106 269.1... Sg Seaborgium Transition Metal	107 270.1... Bh Bohrium Transition Metal	108 269.1... Hs Hassium Transition Metal	109 277.1... Mt Meitnerium Transition Metal	110 282.1... Ds Darmstadtium Transition Metal	111 282.1... Rg Roentgenium Transition Metal	112 286.1... Cn Copernicium Transition Metal	113 286.1... Nh Nihonium Post-Transition M...	114 290.1... Fl Flerovium Post-Transition M...	115 290.1... Mc Moscovium Post-Transition M...	116 293.2... Lv Livermorium Post-Transition M...	117 294.2... Ts Tennessine Halogen	118 295.2... Og Oganesson Noble Gas
				57 138.9055 La Lanthanum Lanthanide	58 140.116 Ce Cerium Lanthanide	59 140.90... Pr Praseodymium Lanthanide	60 144.24 Nd Neodymium Lanthanide	61 144.91... Pm Promethium Lanthanide	62 150.4 Sm Samarium Lanthanide	63 151.964 Eu Europium Lanthanide	64 157.2 Gd Gadolinium Lanthanide	65 158.92... Tb Terbium Lanthanide	66 162.500 Dy Dysprosium Lanthanide	67 164.93... Ho Holmium Lanthanide	68 167.26 Er Erbium Lanthanide	69 168.93... Tm Thulium Lanthanide	70 173.05 Yb Ytterbium Lanthanide	71 174.9668 Lu Lutetium Lanthanide
				89 227.02... Ac Actinium Actinide	90 232.038 Th Thorium Actinide	91 231.03... Pa Protactinium Actinide	92 238.0289 U Uranium Actinide	93 237.04... Np Neptunium Actinide	94 244.06... Pu Plutonium Actinide	95 243.06... Am Americium Actinide	96 247.07... Cm Curium Actinide	97 247.07... Bk Berkelium Actinide	98 251.07... Cf Californium Actinide	99 252.0830 Es Einsteinium Actinide	100 257.0... Fm Fermium Actinide	101 258.0... Md Mendelevium Actinide	102 259.1... No Nobelium Actinide	103 266.1... Lr Lawrencium Actinide

Chemistry Review

- Moles: one mole = 6.022×10^{23} atoms
- Atomic weight: given in grams/mole
- (ex. 602 200 000 000 000 000 000 000 atoms of carbon weighs 12.011 g)
- Molecular weight - how much 1 mole of a molecule weighs (Ex. table salt,NaCl weighs 58.5 g)



More Chemistry Vocabulary

- Ions: atoms or molecules that have a charge (cation +; anion -)
- Chemical Reactions: when molecules interact to form something new
- Stochiometry: the ratio of moles of reactants to moles of products needed to complete a reaction
- Equilibrium = balanced; reaction can go either way

Balancing Chemical Reactions

(ferric chloride + hydrogen sulfide goes to ferric sulfide + hydrochloric acid)

$2FeCl_3 + 3\ H_2S_{\ (aq)}$ <--> $Fe_2S_{3(s)} + 6\ HCL$

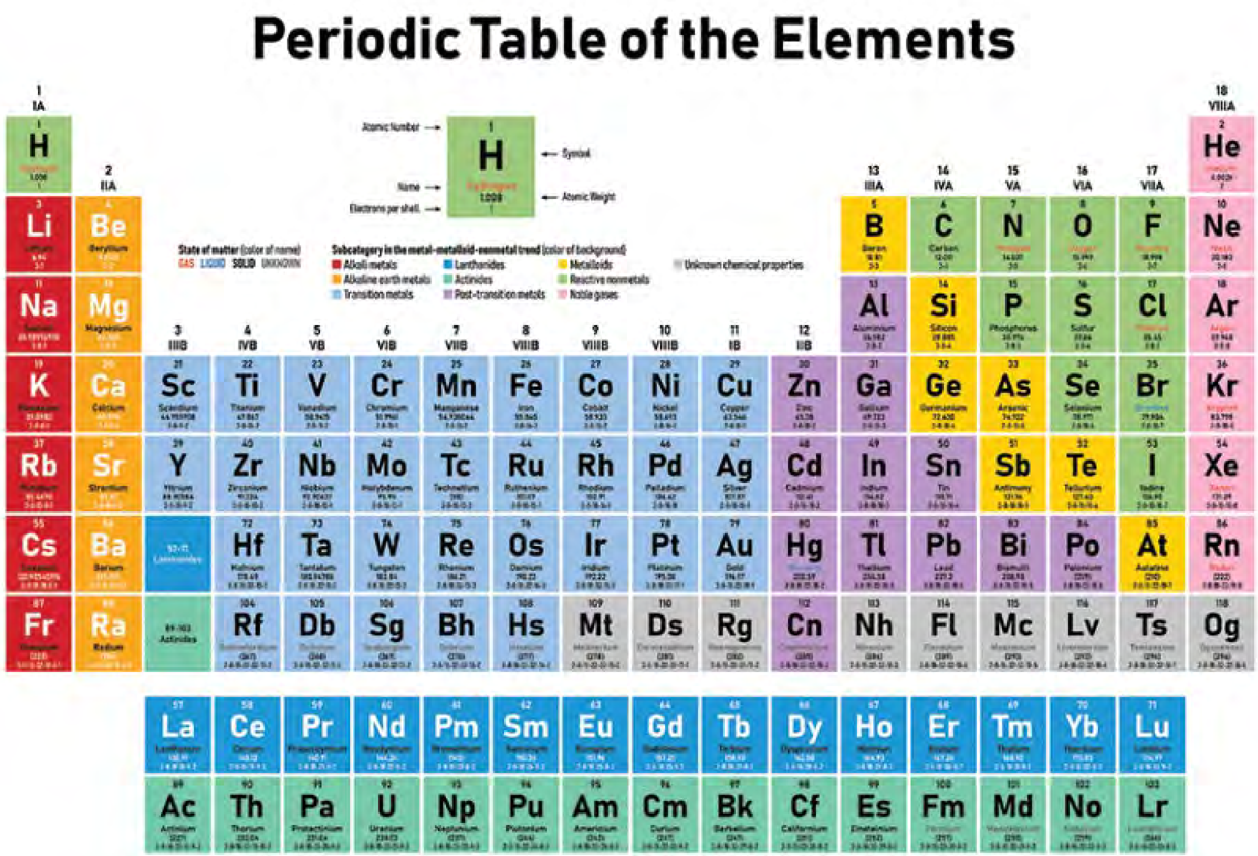
Reactants **Products**

Number of moles reacting

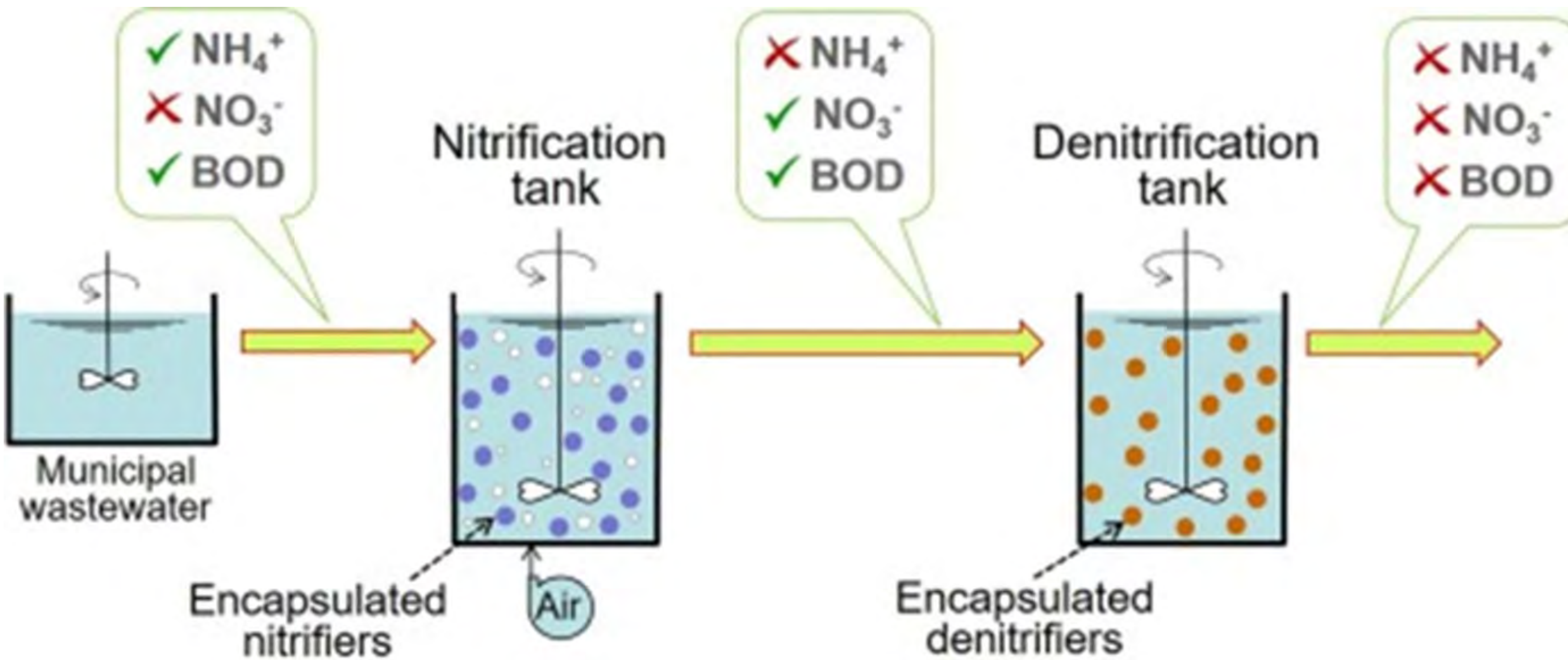
Solid precipitate formed

dissolved in water

Problem – Find the formula weight for calcium carbonate ($CaCO_3$)



Biological Nitrification

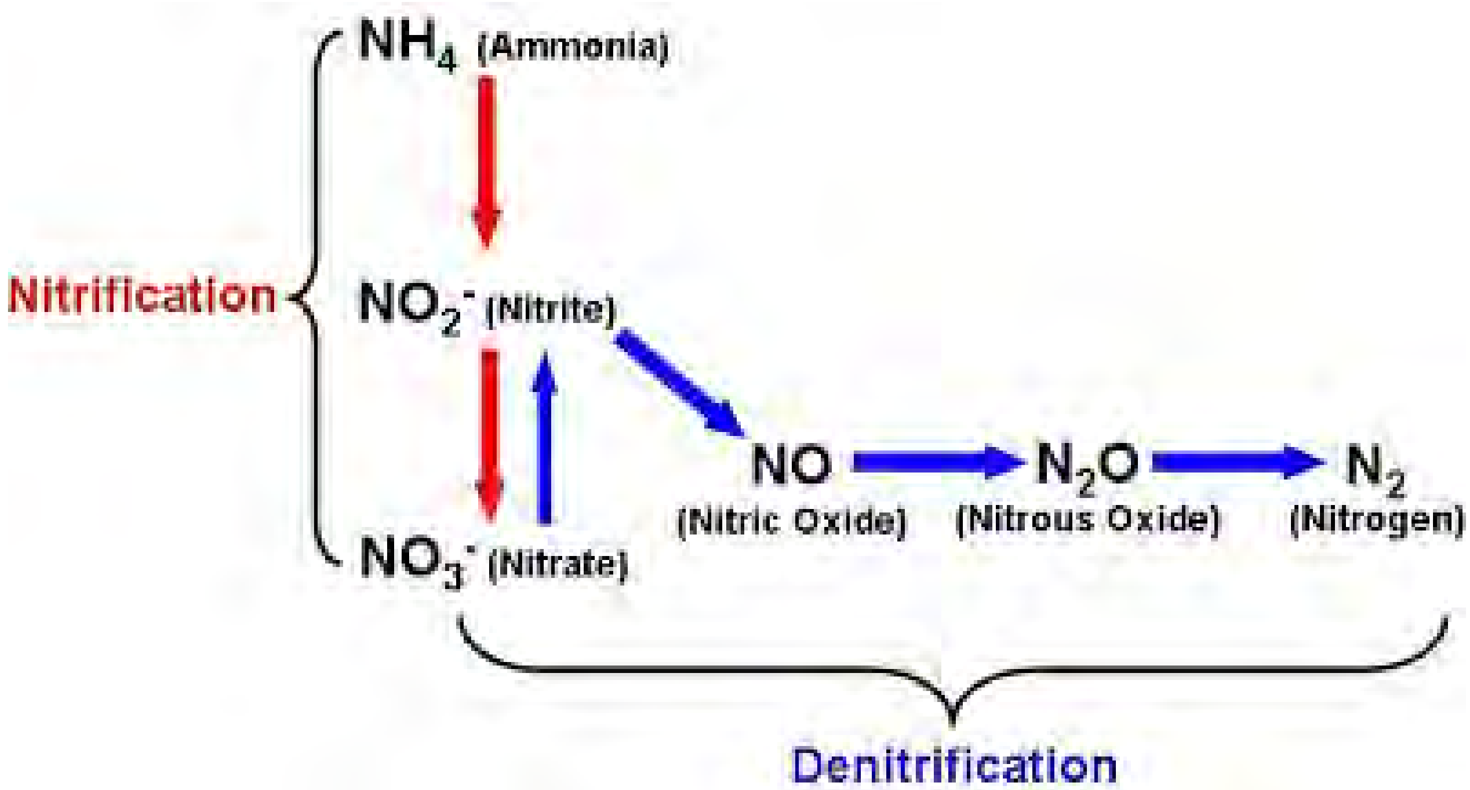


Bacteria

- Ammonia Oxidizing Bacteria (AOB) - convert ammonia (NH_3-N) to nitrite (NO_2-N)
- Nitrite Oxidizing Bacteria (NOB) - convert nitrite (NO_2-N) to nitrate (NO_3)j
- The NOB grow faster than the AOB when the water temperature is below 25°C ($77\,°F$)

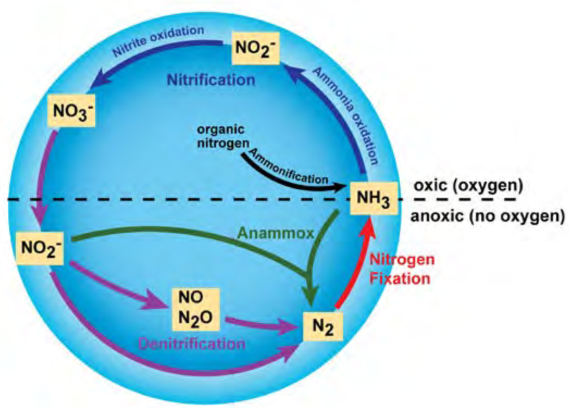
Biological Nitrification

Nitrification/Denitrification

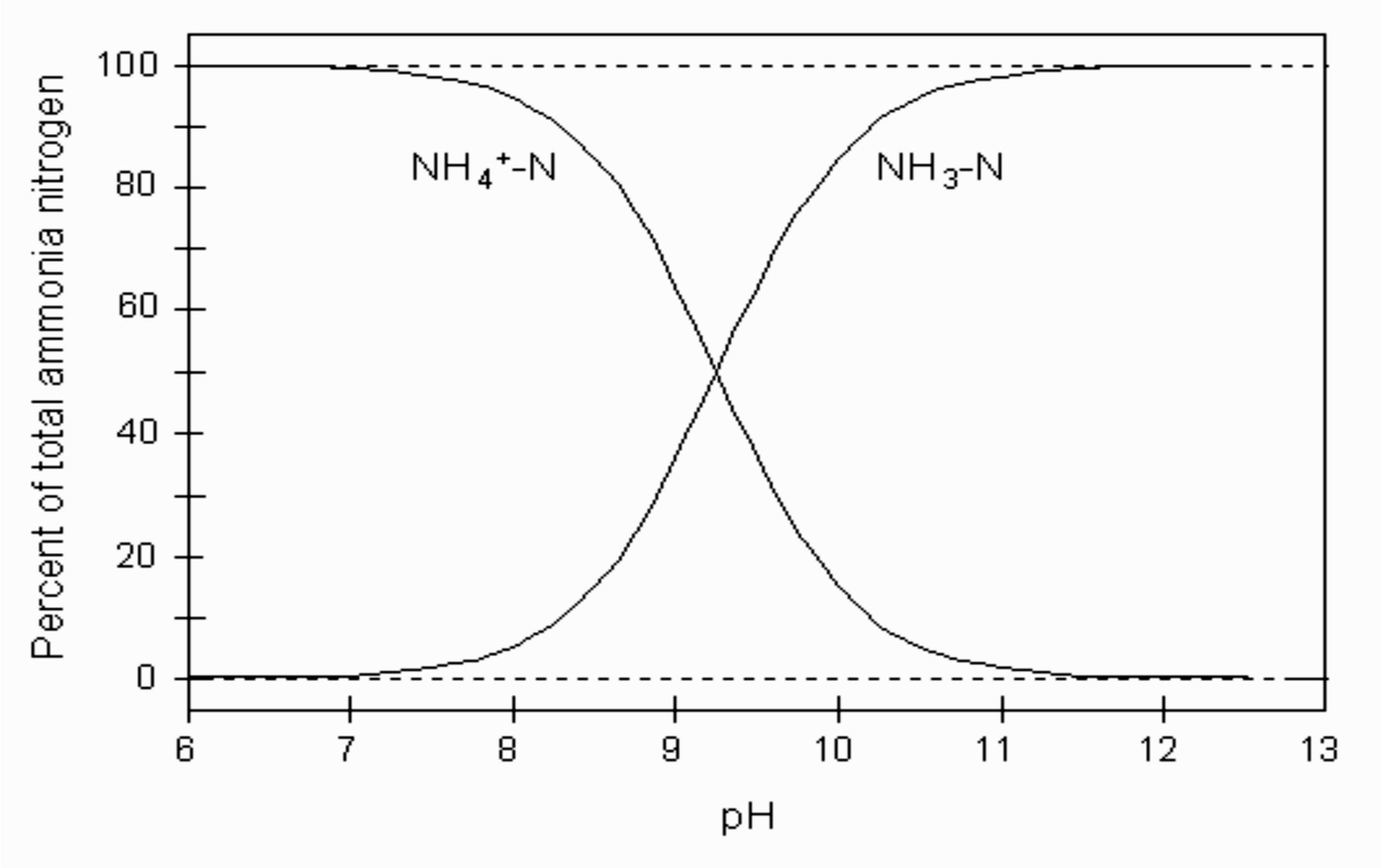


Chemical Reactions of Nitrification/Denitrification

Process	Reaction
Fixation	$N_2\,(g) + 8H^+ + 8e^- \rightarrow 2NH_3\,(g) + H_2\,(g)$
Ammonification	$NH_2\text{-}CO\text{-}NH_2 + H_2O\,(l) \rightarrow 2NH_3(g) + CO_2\,(g)$
Nitrification (Two Steps)	(1) $NH_4^+ + 1.5O_2\,(g) \rightarrow NO_2^- + 2H^+ + H_2O\,(l)$ (2) $NO_2^- + 0.5O_2\,(g) \rightarrow NO_3^-$
Denitrification	$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$



Ammonium ion vs. unionized ammonia - pH and temp sensitive



Quiz

1. Nitrification is a 3 step process involving 2 groups of bacteria. T or F?
2. The NOB obtain their energy from nitrite and their carbon from alkalinity. T or F?
3. The AOB grow faster than the NOB when the water temperature is below 25°C (77 °F) T or F?

Phosphorus Removal

Phosphorus Removal

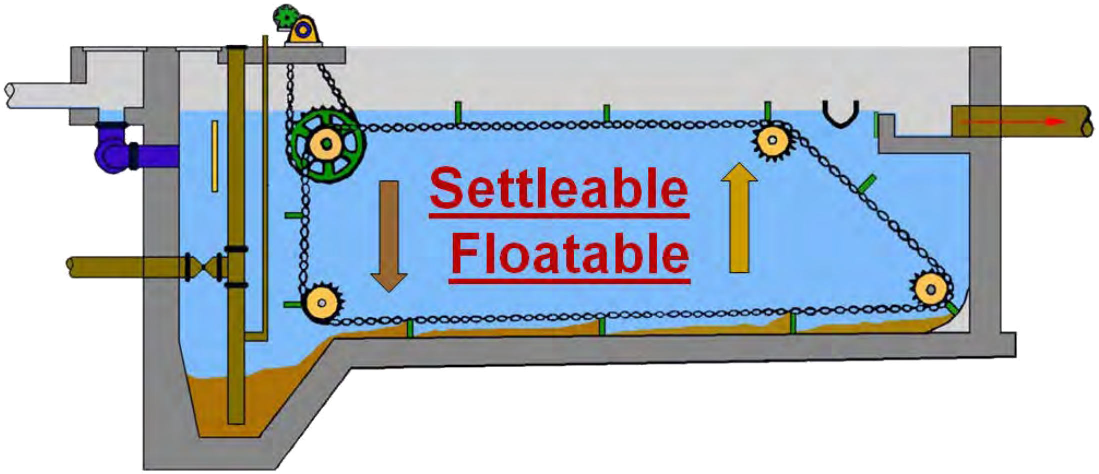
Removal of Ortho-P may Occur Through:

1. Enhanced Biological Update
2. Chemical Precipitation

Settling

- Removal of Settleable Solids can provide some phosphorus removal

Primary Sedimentation 5 - 15 %

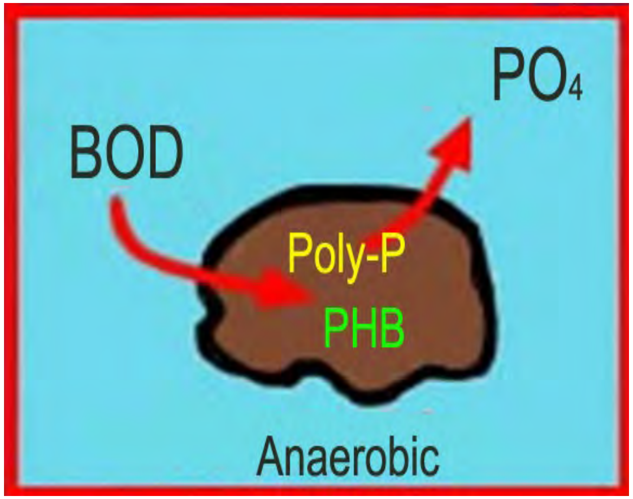


Biological Uptake

- Polyphosphate Accumulating Organisms (PAOs) can be used
- Two stage: 1) anaerobic or "anaerobic selector", and 2) aerobic

Biological P Removal – Stage 1

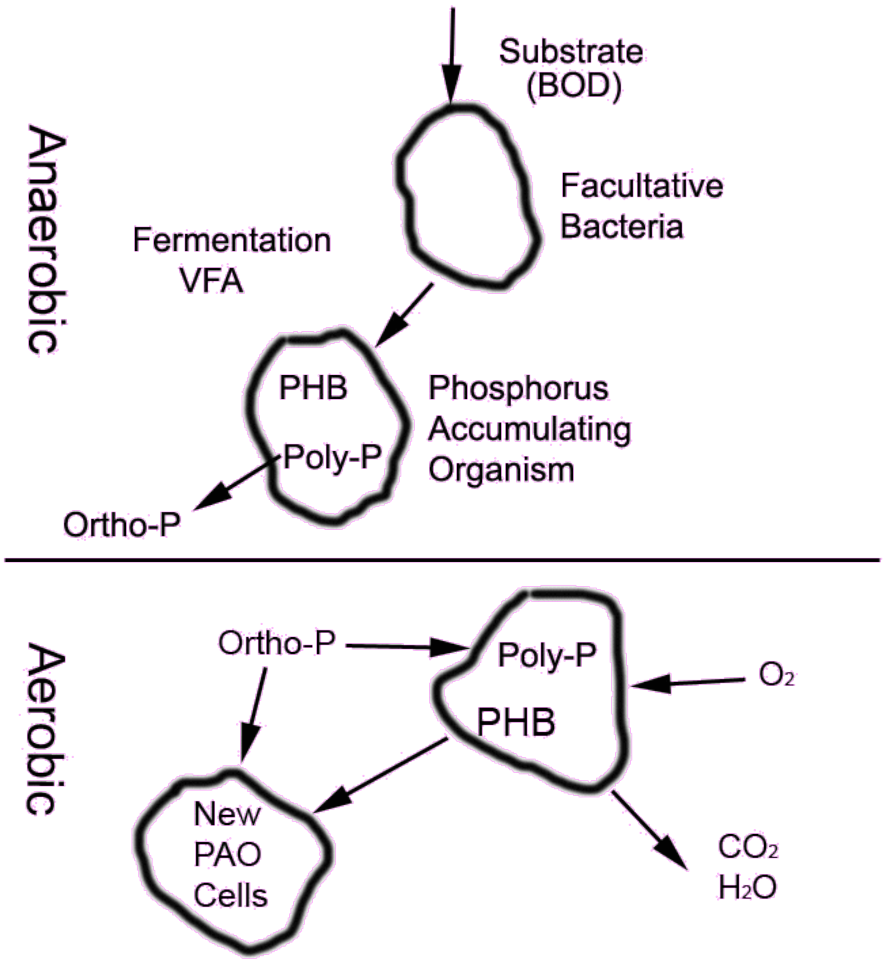
PAO's uptake Volatile Fatty Acids (VFAs) from the organic carbon in the influent (or added as sidestream flow) and store it as polyhydroxyalkanoate (PHA) for later oxidation

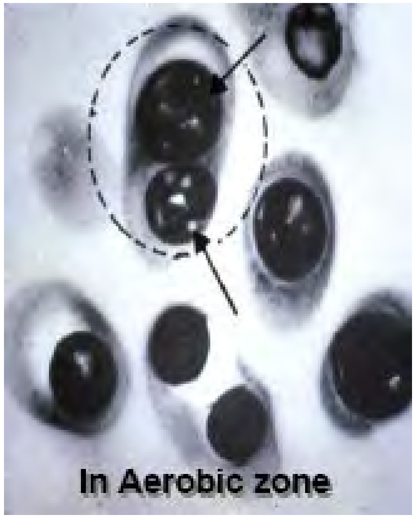


Biological P Removal – Stage 2

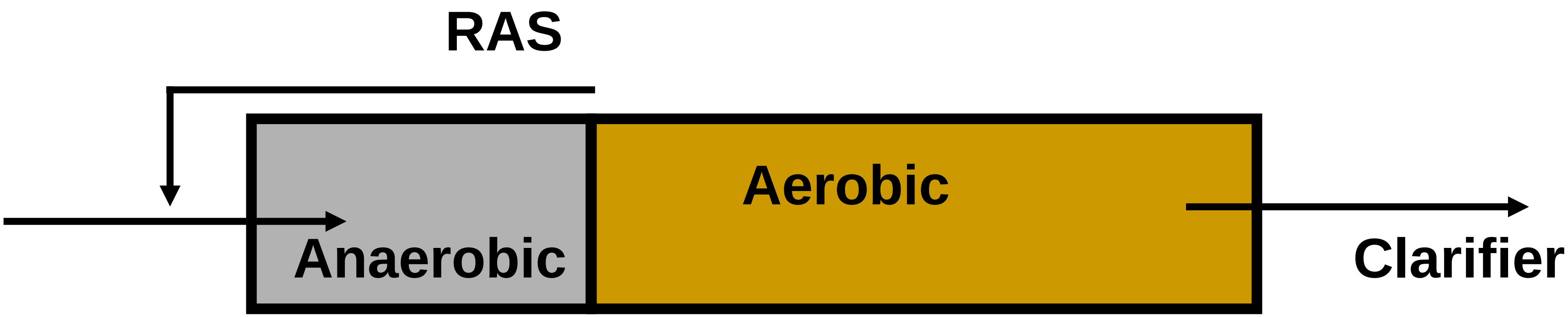
- Stored PHA is metabolized, providing energy for cell growth and luxury uptake of soluble orthophosphate, which is stored as polyphosphates. The PAOs uptake and store more phosphorus under aerobic conditions than is released under anaerobic conditions, providing a net uptake an storage of phosphorus.
- Stored phosphorus is removed from the system with waste sludge.

Biological P Removal





Biological P Removal



The MLSS Cycles From <u>Anaerobic</u> to <u>Aerobic</u>

This Promotes
Phosphate Accumulating Organisms (PAO)

<u>Anaerobic</u>

Fermentation
Acetate Production
P Released to Produce Energy

<u>Aerobic</u>

Stored Food Consumed
Excess P Taken Up
Sludge Wasted

Biological P Removal

Aerobic Conditions

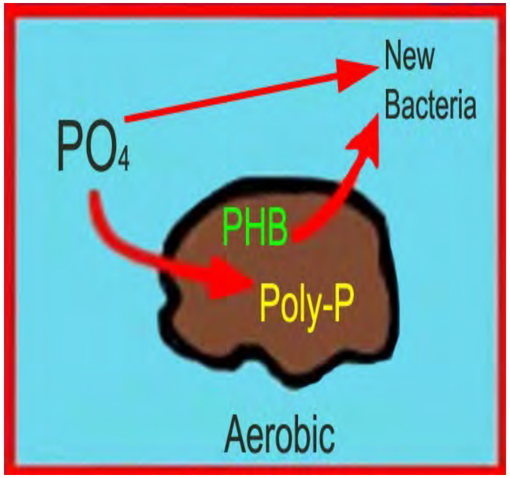
Rapid Aerobic Metabolism of Stored Food (PHB)

Producing New Cells

$\underline{PO_4}$ Used in Cell Production

Excess Stored as Polyphosphate

("Luxury Uptake")



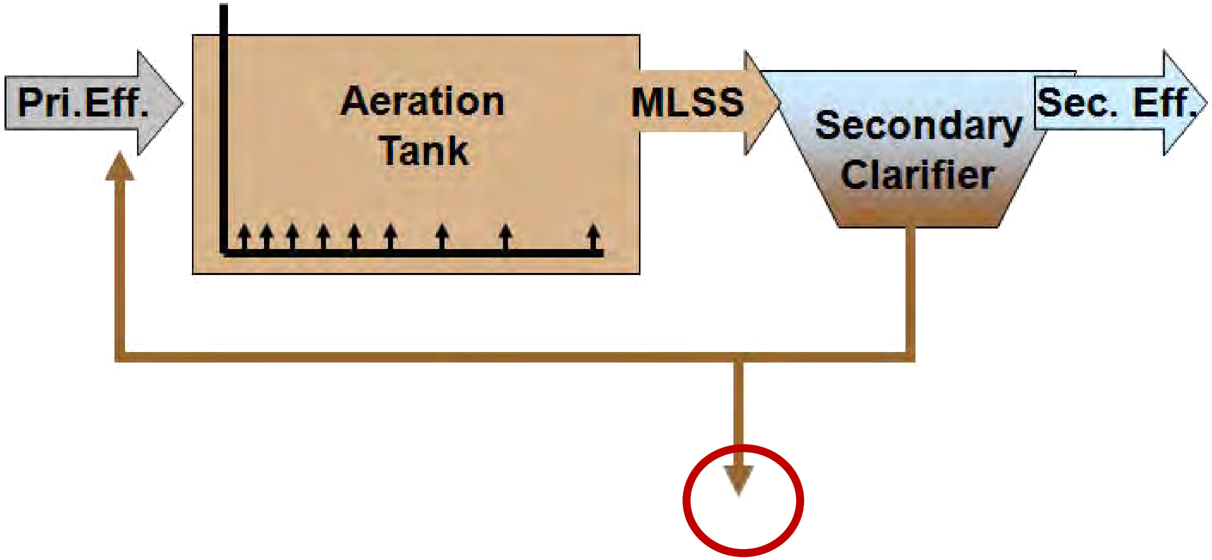
Biological P Removal

Aerobic Conditions

PO_4 Used in Cell Production
Excess Stored as Polyphosphate

Biomass Approximately 5 to 7% P by Weight
(Normal 1.5 to 2 %)

Sludge is Wasted When Loaded With P



Biological P Removal

Anaerobic Conditions

- Heterotrophic Bacteria Break Down Organics
- Fermentation
  - Volatile Fatty Acids (VFAs)
  - Acetate (Acetic Acid)

Also

Selection of PAO - Phosphate Accumulating Organisms

(Able to Out-Compete Other Aerobic Heterotrophic Bacteria for Food When Anaerobic)

Phosphorus Removal

- 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 Ranges from 2 to 8 mg/L

Biological Phosphorus Removal

https://www.youtube.com/watch?v=uc3mDP0OVUc

Questions?

POST-

Post-Quiz

1. What types of lagoon liners are available?
2. What are different methods of flow measurement?
3. What features might be desireable on an inlet or outlet structure?
4. What are some factors that should be considered when designing a new lagoon?
5. What federal regulation covers sludge disposal
6. What is a diurnal curve?
7. What are the nutrients most commonly required to be removed from wastewater?
8. Can phosphorus be removed biologically?

Post-Quiz

1. What types of lagoon liners are available?

   Bentonite (clay) and geosynthetic

Post-Quiz

2. What are different methods of flow measurement?

   Weir, Parshall flume, area velocity meter, staff gage

Post-Quiz

3. What features might be desirable on an inlet or outlet structure?

Flow-splitting, perpendicular alignment to wind, proper sealing

Post-Quiz

4. What are some factors that should be considered when designing a new lagoon?

Biological loading, hydraulic loading, space requirements, effluent disposal, solids disposal, pond configuration

Post-Quiz

5. What federal regulation covers sludge disposal?

   40 CFR Part 503

Post-Quiz

6. What is a diurnal curve?

It is a graph of the daily pattern of flow.

Post-Quiz

7. What nutrients are most commonly required to be removed from wastewater?

   Nitrogen and phosphorus

Post-Quiz

8. Can phosphorus be removed biologically?

   Yes