WASTEWATER LAGOON TRAINING DAY 2: WASTEWATER LAGOON TROUBLESHOOTING

Outline for Today

1. Wastewater Lagoon Microbiology
2. Diagnosing Wastewater Lagoon Problems
3. Diagnosing & Troubleshooting BOD_5 Problems
4. TSS Control
5. Pond Hydraulics & Retention Time
6. Sludge Accumulation and Removal
7. Aeration and Dissolved Oxygen
8. Troubleshooting Nitrogen and Phosphorous Problems
9. Pathogen Control
10. Maintenance
11. Cold Weather Operations
12. Industrial Lagoon Operations

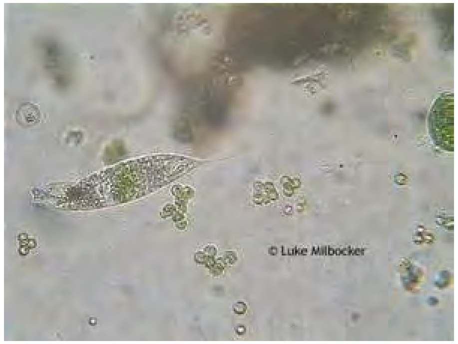
Pre-Quiz – write down the answers for later

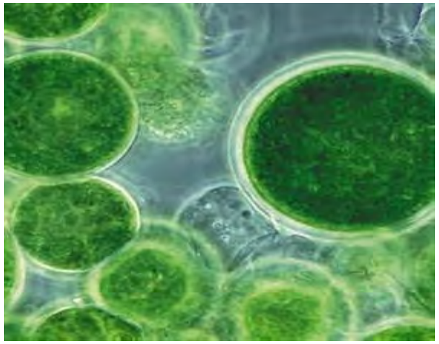
1. What are the 3 different type of lagoons?
2. What is the difference between and anoxic and anaerobic environment?
3. What role do bacteria play in the WW process?
4. What role do algae play in the WW process?
5. What are negative impacts of algae?
6. What testing should be done to diagnose lagoon problems?
7. What does the ratio of VSS to TSS tell us?
8. How do you calculate the BOD removal efficiency?
9. What are the units for BOD loading?
10. What are some signs of pond overloading?

1. WASTEWATER LAGOON MICROBIOLOGY

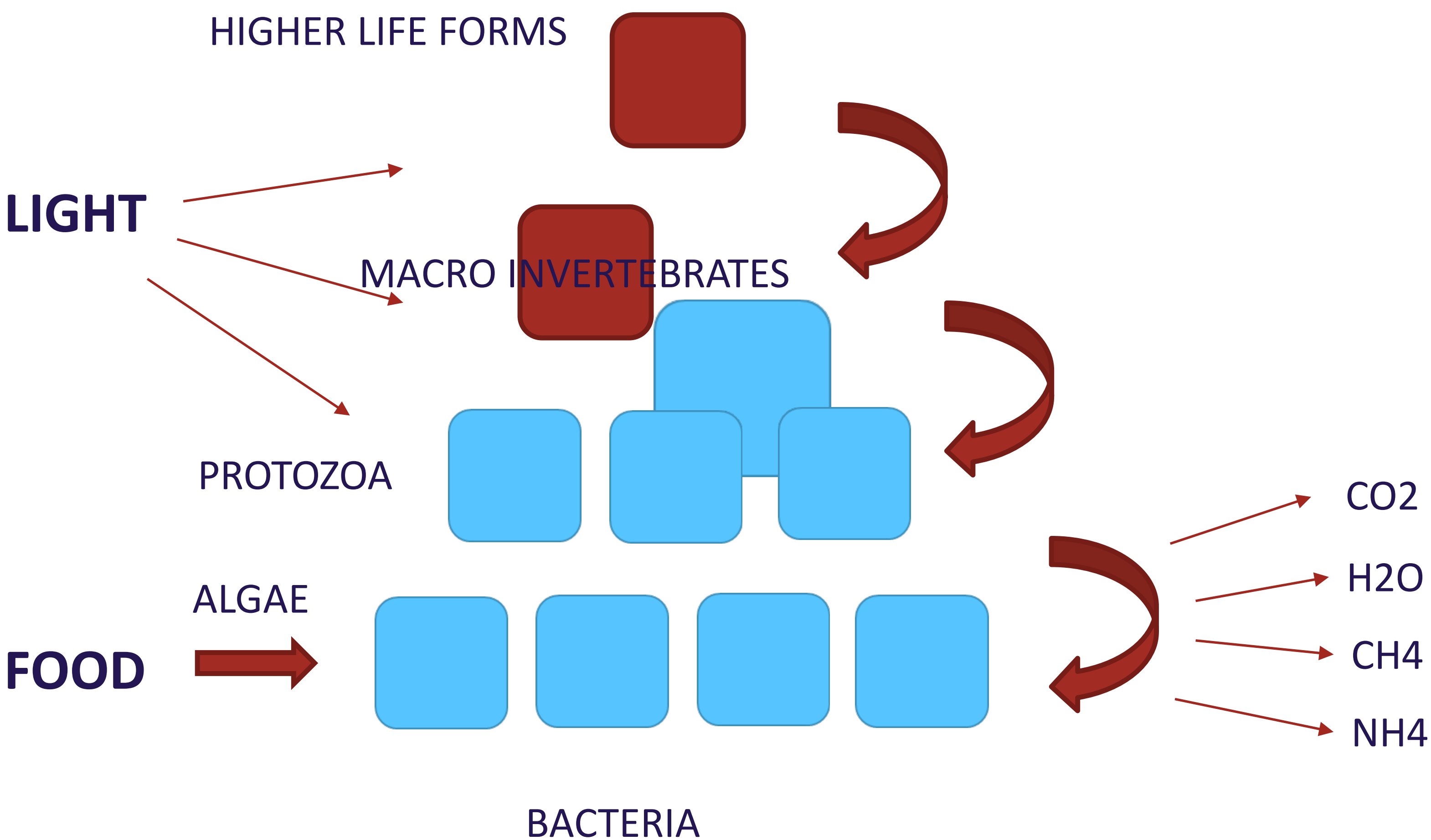
Wastewater Lagoon Microbiology

- Consider what we eat: Carbohydrates, fats, oils, grease, proteins, cellulose and sugars eventually enter the lagoons to be further digested by wastewater microbes
- Bacteria, algae, protozoa, nematodes, filamentous



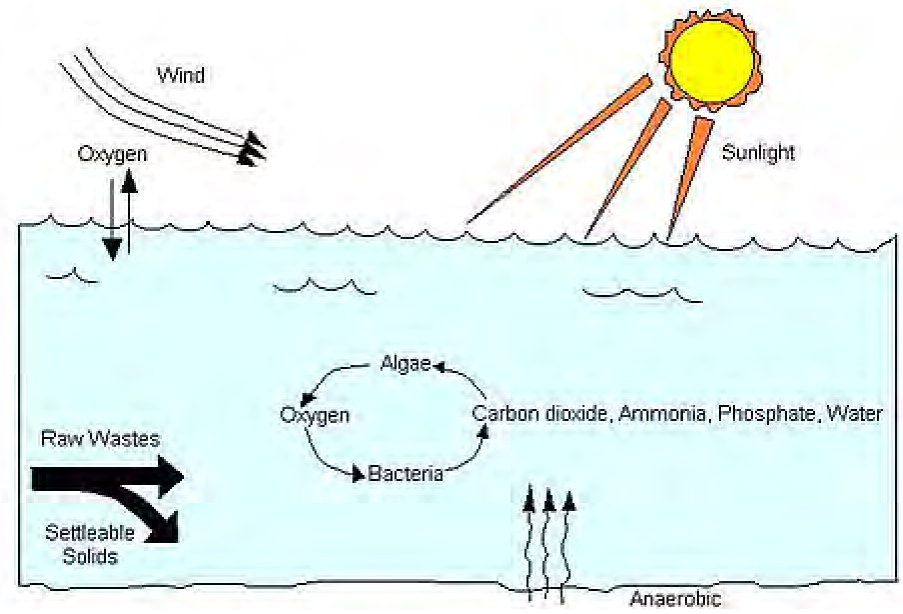


Simplified Wastewater Lagoon Food Web



Nutrient Cycling

As one organism consumes another organism, it excretes inorganic waste.



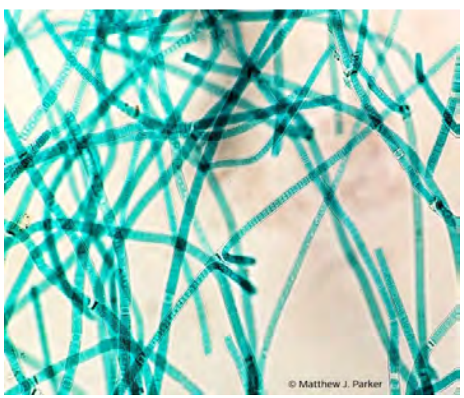
Lagoon Ecosystem

- The excretions of trillions of microbes make lagoon wastewater very complex
- Organisms in lagoons range from the tiniest virus to the more complex protozoa, rotifer, daphania, nematodes, arthropods, insects and small vertebrates



Lagoon Ecosystem

- In lagoons microbes are not uniformly distributed throughout the lagoon.
- Each species and group exits where they can find appropriate nutrition and suitable physical/chemical conditions.



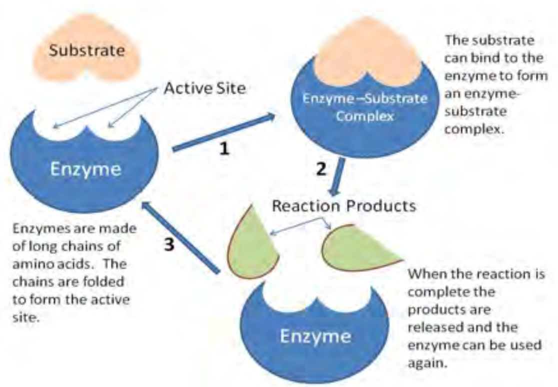
Lagoon Physical Characteristics

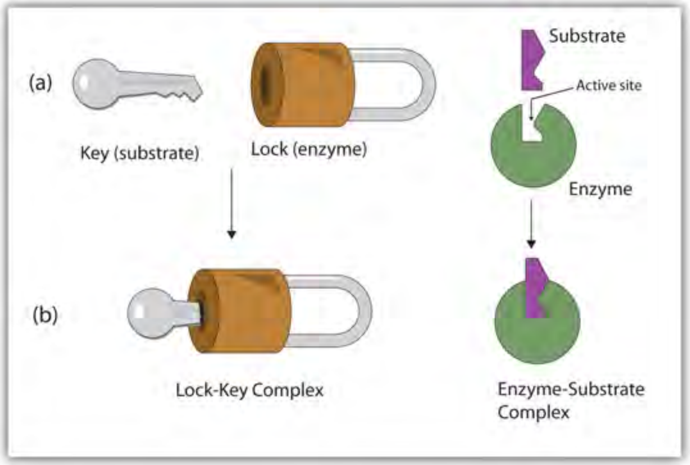
- Dissolved oxygen
- Temperature
- Ph
- Alkalinity
- Sunlight

- "Change in depth - change in water quality"

Enzymes

- Enzyme activity is closely related to microbial growth and activity
- Bacteria, nutrients, BOD and enzyme production are highest at the sludge water interface
- What is an enzyme? => A protein that acts as a catalyst that brings molecules together





Benefits of Healthy Lagoon Food Web

- Nutrient retention and/or conversion: Immobilizes or retains N/P/S, which can settle in the biomass (sludge) producing odors
- Disease suppression: Complex food web contains organisms that can change the water chemistry to eliminate pathogens
- Degradation of pollutants: Oils and other industrial pollutants can be degraded over time

How the Microbial Food Web Serves the Operator

- Odors are controlled
- Nutrient concentrations are reduced
- Sludge accumulations kept to a minimum
- Pathogens are controlled
- Loads to receiving streams are minimized
- Pollutants are degraded
- Water is clarified and buffered
- Water is oxygenated

How the Microbial Food Web Serves the Operator

- Every microbe has a unique job to perform
- When all are working, produce an effluent cleaner than the waters that receive it

Variables Affecting Pond Performance

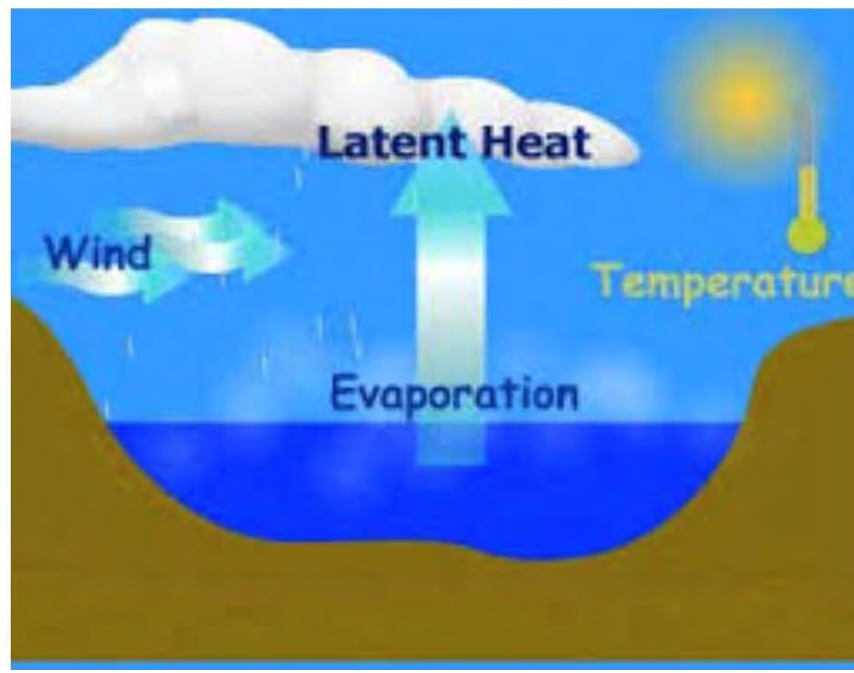
- Chemical influences
- Natural influences
- Physical influences

Chemical Influences

- Loading
- Alkalinity
- pH
- Salinity
- Toxicity
- Composition of liners and dikes

Natural Influences

- Solar radiation
- Temperature
- Wind speed
- Precipitation
- Evaporation
- Ice cover
- Bacteria and algae



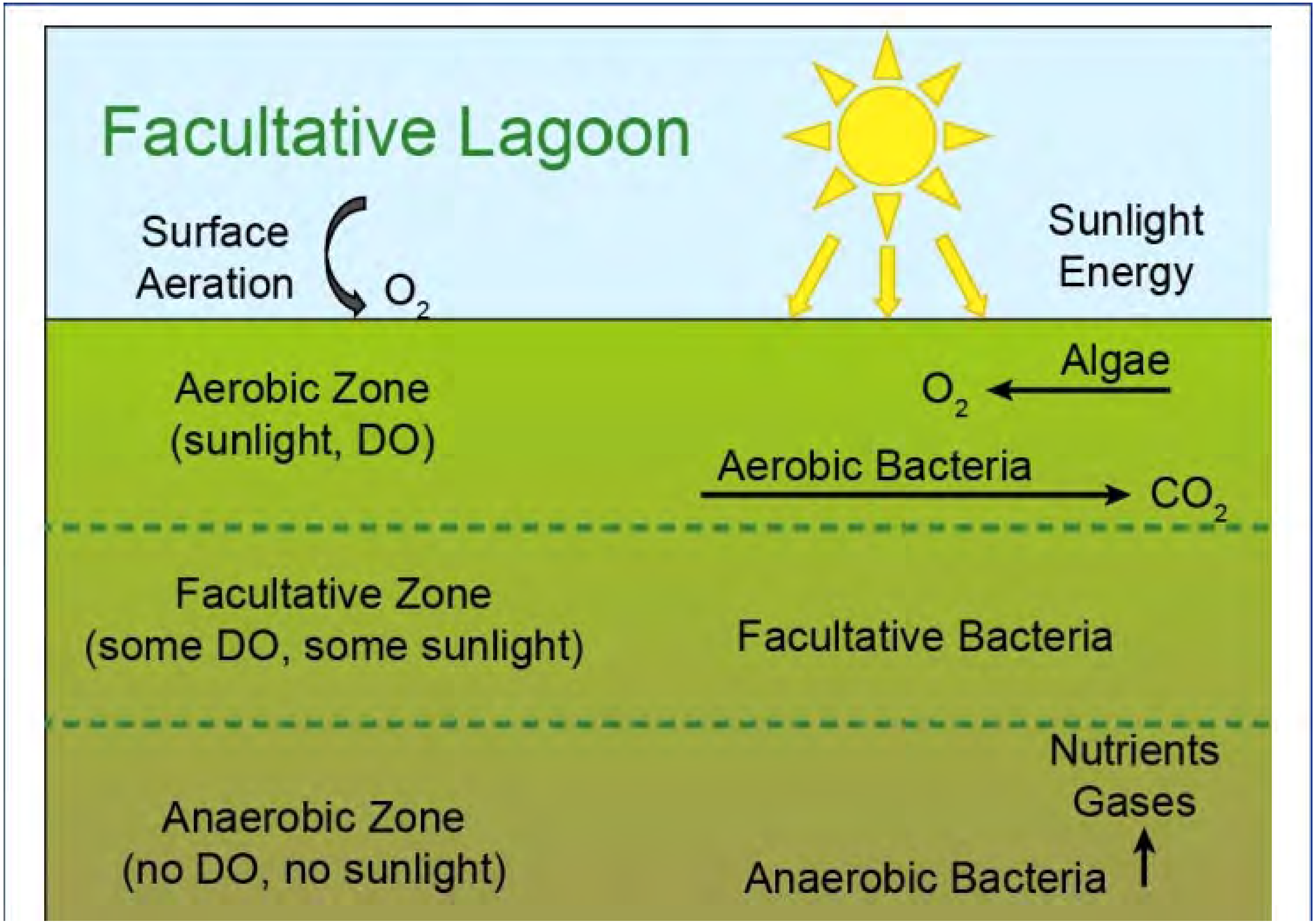
Physical Influences

- Pond configuration
- Pond hydraulics
- Retention time
- Seepage/I & I
- Pond dimensions
- Aeration/mixing

Facultative Lagoon

- Three different wastewater lagoons stacked on each other
- Aerobic: Requiring free oxygen (cells need oxygen to live)
- Anaerobic: Microorganisms break down biodegradable material in the absence of oxygen
- Facultative: Capable of existing in varying environmental conditions
- Facultative parasite can live independently of its host

Facultative Lagoon

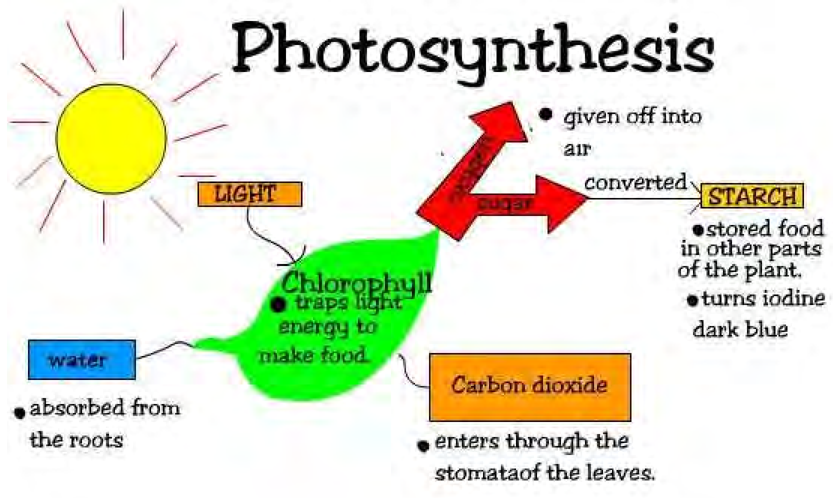


The Aerobic Zone

- Controls pathogens
- Removes BOD and CO_2
- Generates oxygen through photosynthesis
- Controls odors by sulfide oxidation
- Rids wastewater of nutrients through ammonia stripping and nitrification
- Remove metals by elevating the pH
- Re-aerate the lagoon surface

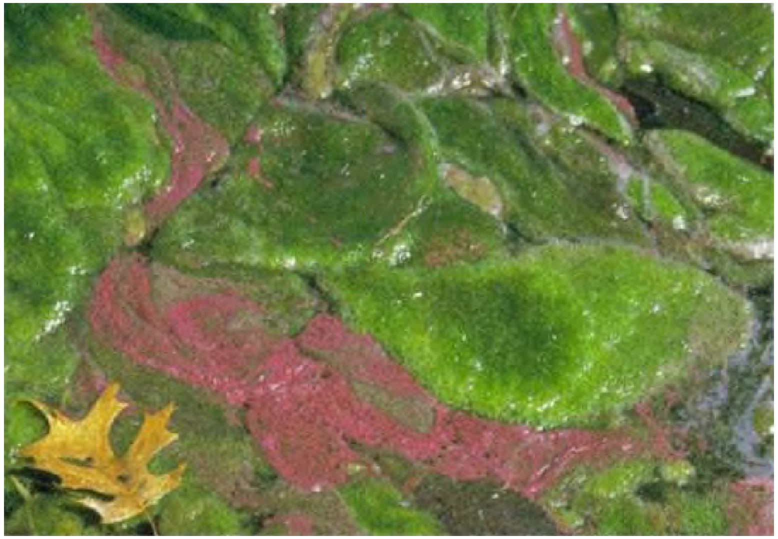
Photosynthesis

- The process by which green plants use sunlight to synthesize foods from carbon dioxide and water.
- Plants generally involves the green pigment chlorophyll and generates oxygen as a byproduct
- Converts CO_2 into oxygen



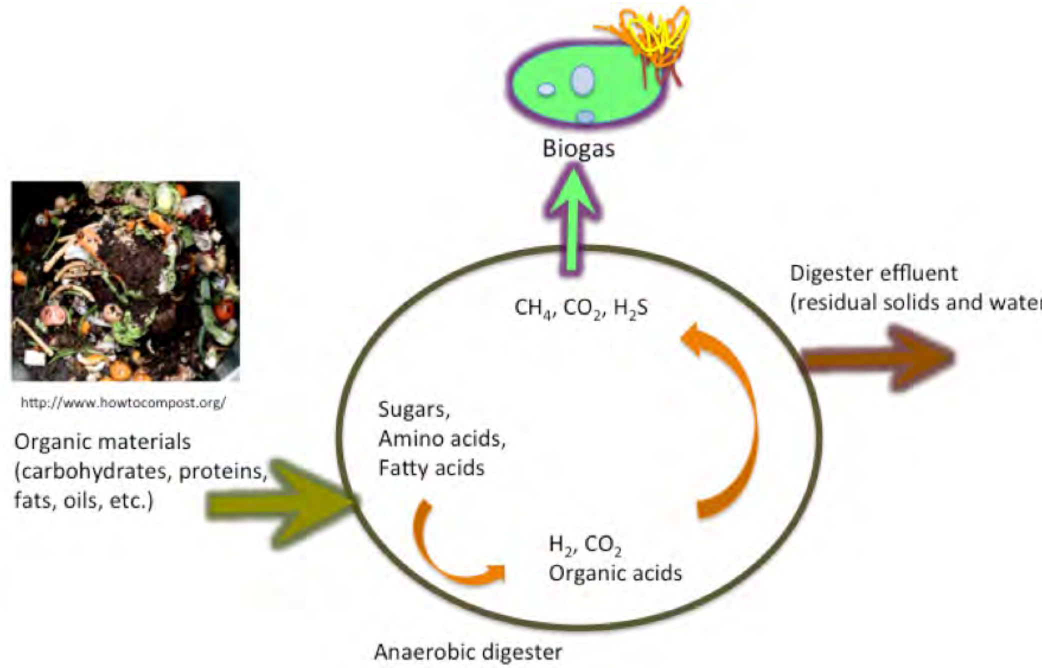
Anoxic Zone

- Low air zone just below the aerobic layer
- Favors the growth of purple sulfur bacteria, which controls the odors by consuming H_2S
- Denitrification



Anaerobic Layer

- Bottom layer
- Generates CO_2
- Retains nutrients
- Sludge digestion
- Sludge storage
- TSS control
- Nitrifiers/denitrifiers
- Removes BOD
- Recovers alkalinity



Denitrification

- de·ni·tri·fy

  (dē-nī′trə-fī′)

  tr.v. de·ni·tri·fied, de·ni·tri·fy·ing, de·ni·tri·fies
- 1. To remove nitrogen or nitrogen groups from (a compound).
- 2. To reduce (nitrates or nitrites) to nitrogen-containing gases, as by bacterial action on soil.

The Role of Microbes in Lagoons

- Bacteria
- Algae
- Protozoa
- Fungi
- Higher life forms

Bacteria

- Feed on other members of the food chain
- Decompose organic matter
- Assimilate nutrients
- Control disease causing organisms
- Degrade pollutants, toxins,
- Control odors
- Oxidize inorganic compounds: ammonia, H_2S, nitrate, sulfur
- Form floc particles: stabilization / settleabilty

One teaspoon contains 100,000,000s bacteria

Algae

- Supply oxygen to aerobic bacteria, protozoa
- Assimilate nitrogen and phosphorous reducing N and P concentrations in receiving water
- Elevate pH
  - Kills pathogens
  - Control odors
  - Precipitate metals
  - Ammonia volatilization
- Helps control odors by generating oxygen
- Cause TSS and BOD problems – use oxygen at night
- Form mats and stink , create toxins

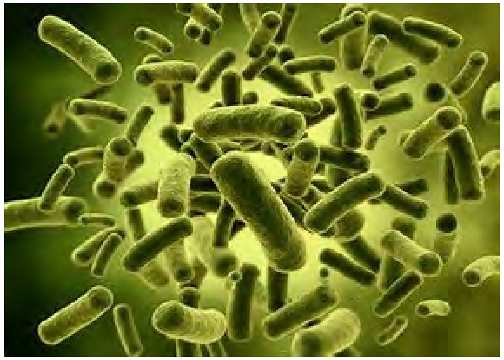
Protozoa

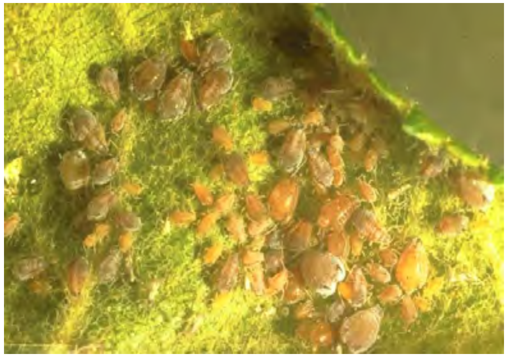
- Control pathogens
- Consume organic matter
- Assist in nutrient cycling
- Lower BOD and TSS
- Help clarify water

Fun Guy

Fungi

- Cycle nutrients
- Control protozoa, algae, and nematodes
- Degrade cellulose, lignin and organic matter





Higher Life Forms

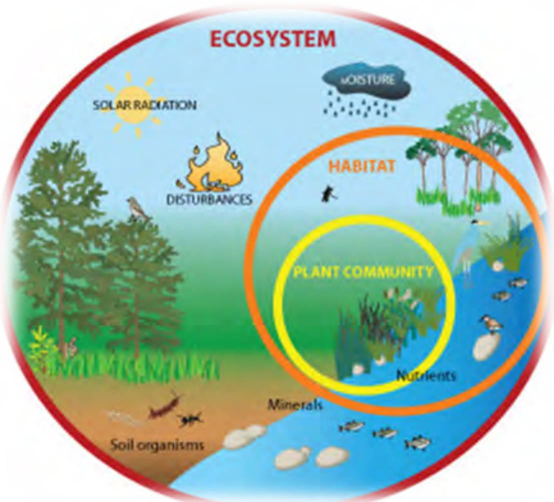
- Daphnia, rotifers, copepods , nematodes, leeches
- Digest organic matter
- Consume algae protozoa, nematodes
- Clarify the water
- Control disease

Nematode

Daphnia

Balanced Lagoon Ecosystem

- Sustaining biological activity, diversity and productivity
- Regulating the flow of dissolved solids
- Storing and cycling nutrients and other elements
- Filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic minerals that are potential pollutants
- Controlling pathogens



Successful Lagoon Management

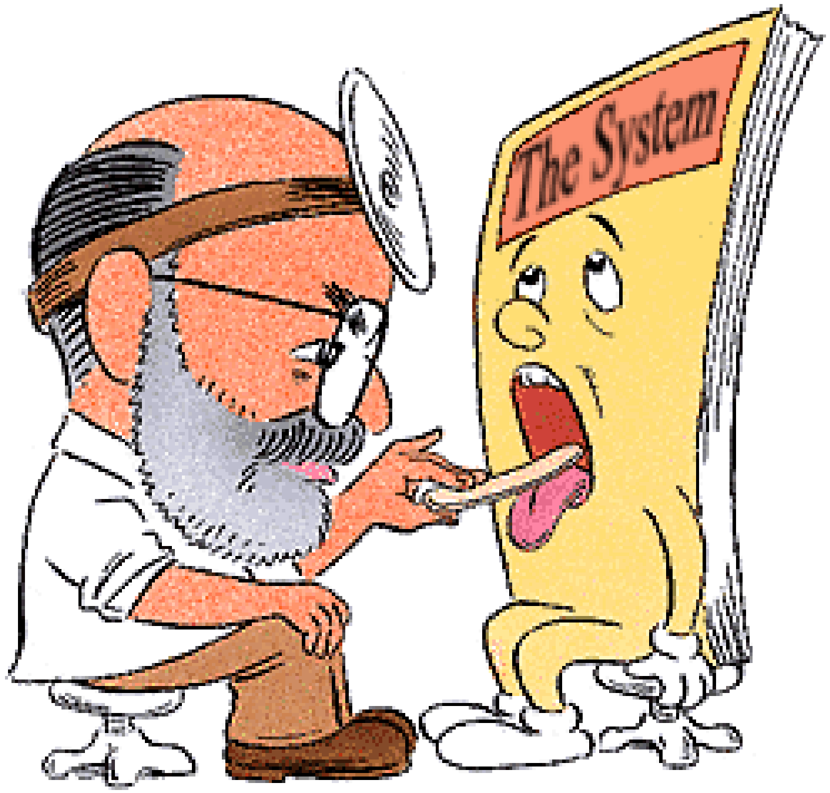
NOT ACCEPTING OR REGULATING

- Septage, grease trap, industrial waste or other high strength waste
- Sludge accumulations to reach design capacities
- Retention time is compromised and water quality suffers
- Weeds that damage dikes and other aquatic life affecting flow patterns
- Vector and burrowing animal habitats

How a Healthy Lagoon Can Serve the Community

- Treatment capacity
- Nitrates and ammonia do not leach into groundwater or escape to the receiving waters
- Water quality is protected when organisms degrade pollutants
- Water and air quality improves as nutrients are cycled
- "A healthy lagoon microbial ecosystem can extend the life of a lagoon"

Diagnosing Lagoon Problems



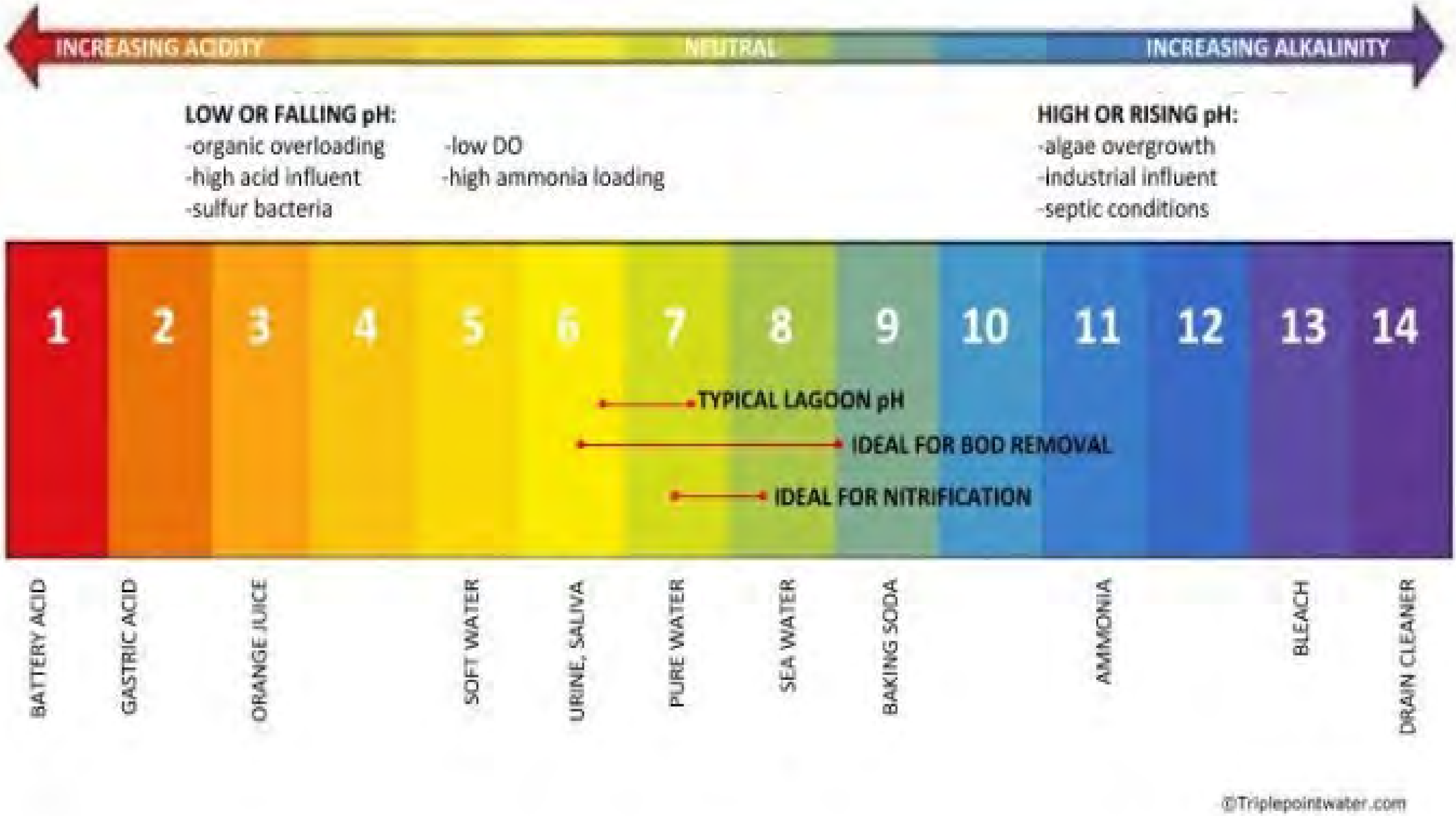
Recommended Tests

- BOD
- TSS
- pH
- Dissolved oxygen
- NH_4
- Alkalinity
- Temperature
- Chlorophyll
- Sludge depth
- Fecal coliform
- Flow
- VSS

$$\frac{BOD5\ (in) - BOD5\ (out)}{BOD5\ (in)} \times 100$$

$$\frac{500 - 20}{500} \times 100$$

$$\frac{480}{500} = 0.96 \times 100 = 96\%$$


INCREASING ACIDITY
NEUTRAL
INCREASING ALKALINITY
LOW OR FALLING pH:
-organic overloading
-high acid influent
-sulfur bacteria
-low DO
-high ammonia loading
HIGH OR RISING pH:
-algae overgrowth
-industrial influent
-septic conditions
1
2
3
4
5
6
7
8
9
10
11
12
13
14
TYPICAL LAGOON pH
IDEAL FOR BOD REMOVAL
IDEAL FOR NITRIFICATION
BATTERY ACID
GASTRIC ACID
ORANGE JUICE
SOFT WATER
URINE, SALIVA
PURE WATER
SEA WATER
BAKING SODA
AMMONIA
BLEACH
DRAIN CLEANER
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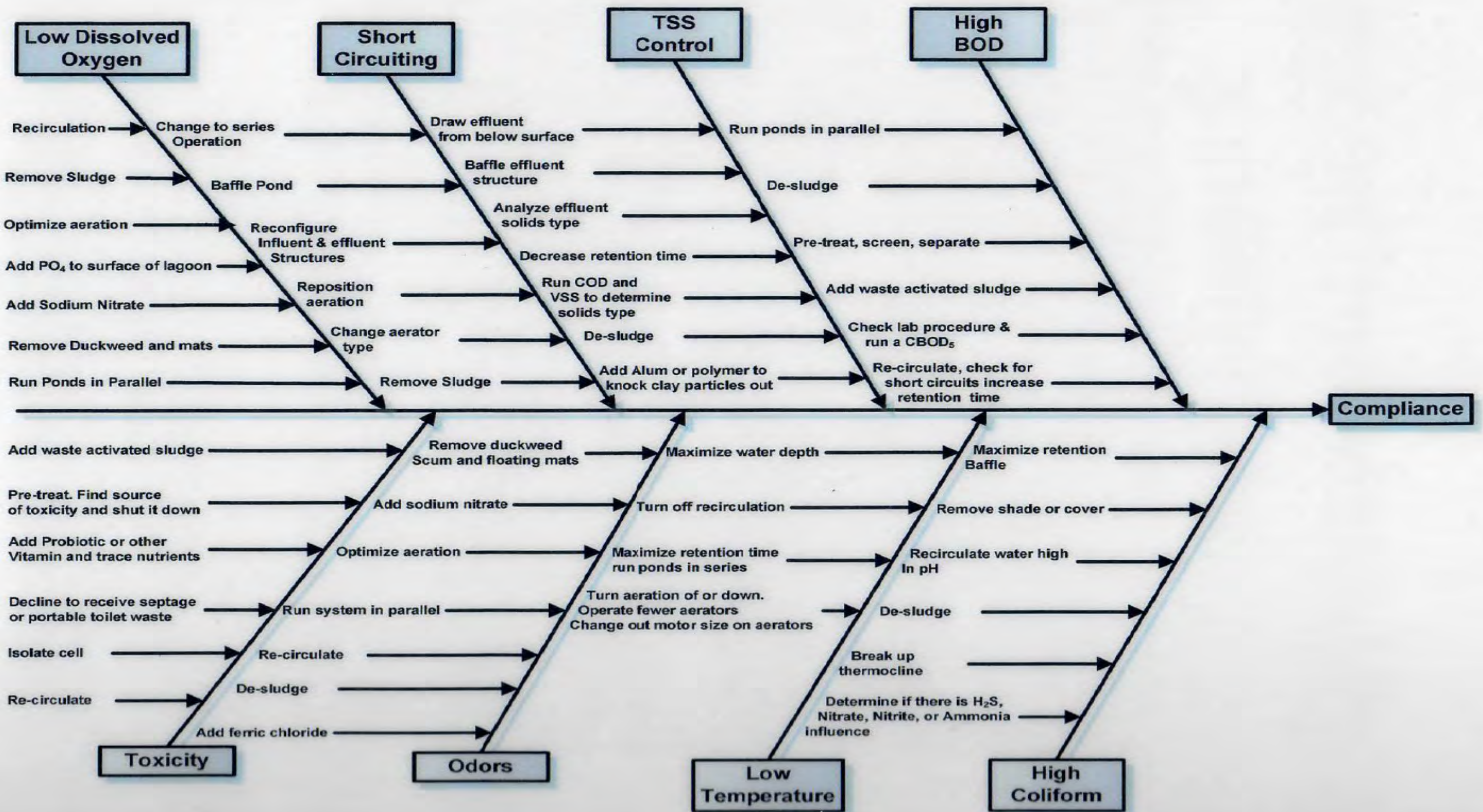
Wastewater Lagoon Troubleshooting Chart









QUIZ

Quiz

1. What is a facultative lagoon?

A lagoon comprised of 3 zones (layers): aerobic, anaerobic, and

facultative

Quiz

2. Describe the difference in each zone.

   Aerobic on the top has oxygen; anaerobic on the bottom is oxygen-deprived; facultative has both aerobic and anaerobic bacteria

   Aerobic and facultative receive some sunlight; anaerobic gets no sunlight, sludge digestion

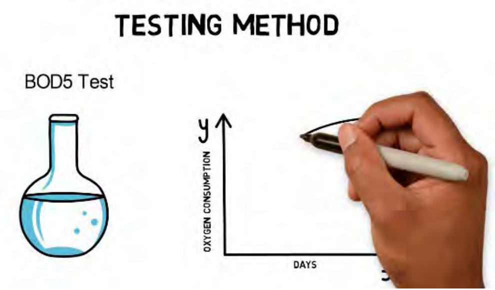
2. DIAGNOSING WASTEWATER LAGOON PROBLEMS

Testing to Diagnose Pond Problems

- TBOD: Total BOD test
  - Test run without adding nitrification suppressant
- CBOD: Carbonaceous BOD (w/nitrification suppressant)
  - Used to determine NBOD (nitrogenous BOD)
  - NBOD represents relative number of nitrifying bacteria present in a sample being tested for BOD

  BOD - CBOD = NBOD
- SCBOD: Soluble carbonaceous BOD
  - Used to determine if benthal feed-back is occurring
  - Used in conjunction w/ other BOD tests to determine algae's part in generating BOD

  CBOD - SCBOD = PCBOD (particulate BOD)



Testing to Diagnose Pond Problems

- TSS
  - Shows particulate matter leaving the lagoon
- pH
  - Diagnose algae problems
- DO
  - Determine aerator efficiency, organic overloading, odors, nitrification
- NH_4
  - Nitrification of ammonia places an oxygen demand on lagoons
  - 4 lb of O_2 for 1 lb of NH_4 oxidized

Testing to Diagnose Pond Problems

- Alkalinity
  - Algae consumes alkalinity and drives up pH
  - Levels above influent cause sulfide generation or denitrification
- Temperature
  - Microbial activity is temperature dependent
  - Affects chemical and biological reaction rates
  - Settleability, O_2 and CO_2 solubility
  - Operators can predict potential problems
- Chlorophyll-a
  - Measure of algae abundance
  - Determines if non-volatile solids are leaving the pond

Testing to Diagnose Pond Problems

- Sludge depth
  - Accumulated sludge creates issues including short-circuiting, benthal feedback, odors, high TSS, poor BOD removal
- Fecal coliform
  - High levels indicates lagoon overload, improper lagoon sizing, or accumulated sludge is growing pathogens
- Flow
  - Essential in calculating loading and retention time
- VSS
  - Volatile component of TSS

Using Test Results to Diagnose Lagoon Problems

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

  Ratio < 1, old sludge solubilization and release of BOD

  Ratio = 1, poor treatment or short circuiting

  Ratio = 1.5, normal treatment performance

  Ratio = 2 to 3, algae bloom or overgrowth, loss of old sludge particles
- High effluent BOD
  - Excessive algae growth, nonsettleable bacterial floc, or nitrification in the test bottles

Determining Cause of TSS and BOD Problems

TSS Solids Type	Possible Meaning
Raw Solids	Short circuiting, too few ponds on-line, high fecal numbers
Sludge Particles	Pond turnover, wind mixing, too much aeration
Dispersed Bacteria	Process upset, low DO, short circuiting
Sulfur Bacteria	Anoxic, overloaded. Rotten egg odors, red colored pond
Filamentous Bacteria	Anoxic, low DO
Bacterial Floc	Turbulent. Increase retention time
Algae	Normal
Protozoa	Normal
Copepods	Normal
Daphnia	If in abundance, watch for low DO and TSS
Higher Life Forms	Normal

Determining Cause of TSS and BOD Problems

- Effluent BOD Tests:
  1. TBOD
  2. SBOD
  3. CBOD
- Compare:

  TBOD = CBOD + NBOD

  CBOD = BOD + NBOD

  PCBOD = CBOD - SCBOD
- Meaning:

  PBOD > 70% of TBOD indicates solids loss

Diagnostic BODs

Test	Definition	Meaning
BOD_5	Standard 5-day test. BOD = CBOD + NBOD	Used to measure strength of WW. Needed to calculate NBOD.
$SBOD_5$	Sample first run through a filter. Measures readily oxidizeable portion of WW. SBOD = SCBOD + SNBOD	Step towards calculating SCBOD. unusual to see SBOD higher than 20% in effluent.
$CBOD_5$	BOD test run with nitrification suppressant added to measure effect on DO. CBOD = BOD - NBOD	Measure of lagoons ability to stabilize waste. NBOD = relative number of nitrifying bacteria.
$SCBOD_5$	BOD test after filtration and nitrification suppressant has been added to test bottle. SCBOD = CBOD - PBOD	Influence of sludge blanket in feeding BOD back to the water column. Used with CBOD to determine algae's effect on BOD test. If PBOD > 70% of BOD in effluent; solids loss problem.

Determining Cause of TSS and BOD Problems

- VSS/TSS ratio
  - % of suspended material that is organic
  - Indicates if digested pond solids are leaving with effluent
- Remaining SBOD consists of:
  - Polysaccharides
  - Proteins
  - Lipids
  - Organic acids
  - Carbohydrates
  - Vitamins
  - Fatty acids
  - Exocellular enzymes
  - Nitrogen
  - Phosphorus
  - Other readily digested organic matter

Determining Cause of TSS and BOD Problems

- Typically 80% of SBOD is removed in the first cell
- SBOD is compared with other cells to determine if accumulated sludge is releasing soluble nutrients into the water column
  - accumulated sludge is storage for microbial food and represents a possible internal load
  - return of organic matter and other nutrients from sediments of the aerobic layer

Determining Cause of TSS and BOD Problems

- Benthal feedback: Resolubilizing of ammonia, phosphorus, trace-nutrients, and other dissolved substrates
  - Causes algal blooms that result in DO crashes at night
  - Increases in ammonia indicate benthal feedback
  - Means that it's time to remove sludge
- COD/BOD ratio: Reveals fraction of organic matter that is non-biodegradable


QUIZ

Quiz

1. Accumulated sludge creates issues such as short-circuiting. (T/F)

   True

Quiz

2. Typically 60% of SBOD is removed in the first cell. (T/F)

   False. 80%

Quiz

3. Algae consumes alkalinity and drives up pH. (T/F)

   True

3. DIAGNOSING & TROUBLESHOOTING BOD_5 PROBLEMS

Sample and Test

★ Sample Points

Sample and Test

- BOD
- CBOD
- SBOD
- DO
- TSS, VSS, COD
- Temperature
- pH
- Chlorophyll-a

Sample and observe the type of solids existing the final effluent. Under the microscope, look for:

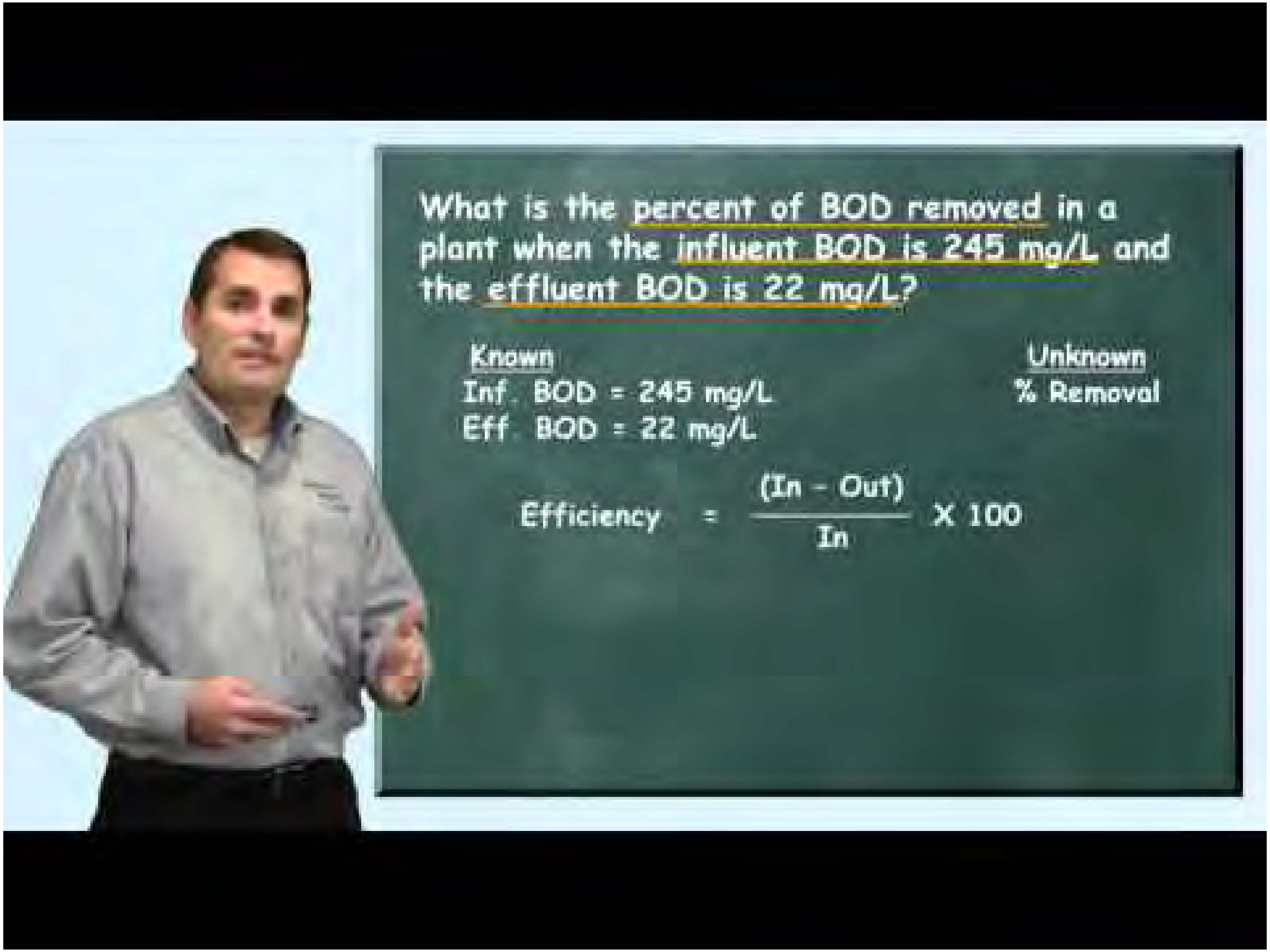
TSS Solids Type	Possible Meaning
Raw Solids	Short circuiting, too few ponds on-line, high fecal numbers
Sludge Particles	Pond turnover, wind mixing, too much aeration
Dispersed Bacteria	Process upset, low DO, short circuiting
Sulfur Bacteria	Anoxic, overloaded. Rotten egg odors, red colored pond
Filamentous Bacteria	Anoxic, low DO
Bacterial Floc	Turbulent. Increase retention time
Algae	Normal
Protozoa	Normal
Copepods	Normal
Daphnia	If in abundance, watch for low DO and TSS
Higher Life Forms	Normal

Calculate and Compare

- Determine BOD removal efficiency of each pond

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

- Things to consider:
  - Pond may be feeding BOD back into the system
  - Operator may decide to take pond offline or temporary bypass
  - Formation of BOD can be the result of organic matter from sludge restabilizing in the water column
  - May indicate too much algae in BOD test bottle


What is the percent of BOD removed in a plant when the influent BOD is 245 mg/L and the effluent BOD is 22 mg/L?
Known
Inf. BOD = 245 mg/L
Eff. BOD = 22 mg/L
Unknown
% Removal
Efficiency = (In - Out) / In X 100

Calculate Actual Loading

$$\text{Organic Loading } \left(\frac{\frac{lb\ BOD}{acre}}{day}\right) = \frac{(BOD, \frac{mg}{L})(Flow, MGD)(8.34 \frac{lb}{gal})}{Lagoon\ area\ in\ acres}$$

$$\text{Metric } \left(\frac{\text{kg} \frac{\text{BOD}}{\text{day}}}{\text{M}^3}\right)$$

- Organic loading can range between 10 to 50 lb of BOD per acre
- One acre of primary pond for every 100 to 120 design population
- Approximately 22 lb BOD/acre/day

Typical BOD Loading Rates, Facultative

Pond Type	Application Loading	Detention Times (days)	Population per acre
Cold water lagoons	Raw or municipal wastewater from primary treatment <8.5 lbs BOD/acre/day	> 200	< 200
Cold season climate, short temperature summers	Raw municipal wastewater 9 - 45 lbs BOD/acre/day	100 - 200	200 - 1,000
Temperate to semi-tropical, occasional ice cover, raw	Raw municipal wastewater 45 - 135 lbs BOD/acre/day	31 - 100	1,000 - 3,000
Tropical, uniformly warm temperatures, sunny, no cloud cover	35 - 315 lbs BOD/acre/day	17 - 33	3,000 - 7,000

Typical BOD Loading Rates

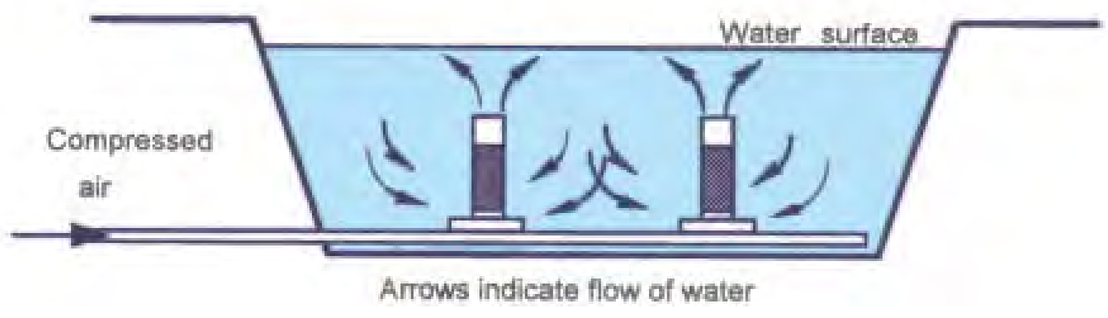
Pond Type	Application Loading	Detention Times (days)	Population per acre
Aerated	Industrial wastewaters or where small foot print is desired 7.5 - 290 lbs/BOD/acre/day	7 - 20	1,700 - 3,400
Anaerobic	Industrial wastewaters 145 - 720 lbs BOD/acre/day	20 - 50	

Recommended BOD Loading Rates

Season	Temperature	Loading Rate
Winter (average)	15^{o}C (59^{o} F)	40 to 80 lbs/acre/day
Winter (cold)	0^{o} C to 15^{o}C (32^{o} F to 59^{o} F)	20 to 40 lbs/acre/day
Winter (very cold)	< 0^{o}C (32^{o} F)	10 to 20 lbs/acre/day
Warm	> 15^{o}C (59^{o} F)	89 lbs/acre/day

Lagoon Loading

- Facultative ponds rely on algae and the sun's influence to add DO to the water column
- Aerated lagoons supply oxygen mechanically and can handle higher loading rates
  - 50 to 200 lb BOD/acre/day
  - Oxygen required is 1.75 to 2.50 lb O_2/lb BOD applied when sludge oxygen demand is included



Lagoon Loading

- Effects of spring thaw and benthal feedback on pond loading
  - Benthal release (accumulated sludge) can double or triple oxygen demand during spring
  - May require O_2 input of up to 6 lb per lb of BOD
- Effects of industrial waste, grease trap waste and septage
  - Typically composed of high strength organic materials
  - Most facultative ponds are not equipped to handle these
  - Prior to receiving, operator must know the design loading of the pond, how much septage to receive, and how many people the lagoon can support

Signs of Lagoon Overloading

- Color changes and smell
  - Red streaks and rotten egg smell indicate anaerobic conditions
  - Gray to black indicates precipitated insoluble metal sulfides and loss of aerobic quality (anaerobic conditions)
- Drop of DO concentrations
- low pH values
- Increases in BOD
- Drop in protozoa count

Troubleshooting BOD

Organic Overloading

- Increase aeration time, add air, place another lagoon on line
- Check sampling and handling techniques
- Reduce loads due to industrial wastes, grease trap wastes or septage
- Increase recirculation
- Additional mixing
- Use parallel operation, lighten load to one pond
- Add oxygen source; calcium nitrate, hydrogen peroxide
- Pull affected pond offline
- Add activated sludge from another treatment plant


Great
Mixing
Here
No
Mixing Here
no sludge or slurry disturbance

Troubleshooting BOD

Short-Circuiting

- Improve inlet/outlet configuration / structures
- Solve infiltration and inflow problems
- Add baffles, recirculation, aeration
- Reposition aeration to mix sludge
- Remove sludge
- Break up summer time thermoclines w/ aeration/mixing

Troubleshooting BOD

Ice-Covered Lagoon

- Conserve heat by reducing aeration run time
- Don’t operation recirculation
- Operate lagoons as deep as possible
- Add air and mix when ice has thawed

Ice-Off: Thaw

- Add air and mixing
- Add 4 lb/lb BOD added

Troubleshooting BOD

Algae Bloom

- Increase mechanical mixing, add shade, floating cover, add algal predator (daphnia), add copper sulfate
- Reduce retention times to < 2.5 days
- Change lagoon configuration to multiple cells in series
- Increase lagoon operating depth
- Break up floating operating mats w/water spray, rakes, mixers, fire-hose or motorboat
- Bypass lagoon

Troubleshooting BOD

Additional troubleshooting (Page 46 - 47)

- Lab error
- Bottom solids escaping
- Bacterial floc
- Partial nitrification
- Toxic material in influent

Industrial Lagoon BOD Problems

Consider the following factors:

1. Pre-treatment, primary clarifiers, DO air floatation, separators
2. pH control or alkalinity adjustment
3. Pre-treatment for toxic materials
4. High temperatures
5. Nutrient deficiencies
6. Biomass die-off
7. Varied loading, flow equalization
8. Anaerobic treatment


QUIZ

Quiz

1. Where are the sample points when troubleshooting BOD problems?

   ✓ Influent
   ✓ Effluent
   ✓ Transfer pipes between lagoons

Quiz

2. When is a lagoon considered overloaded?

When the BOD exceeds the design parameters

Quiz

3. How do you calculate loading?

Test BOD and divide by lagoon area

Quiz

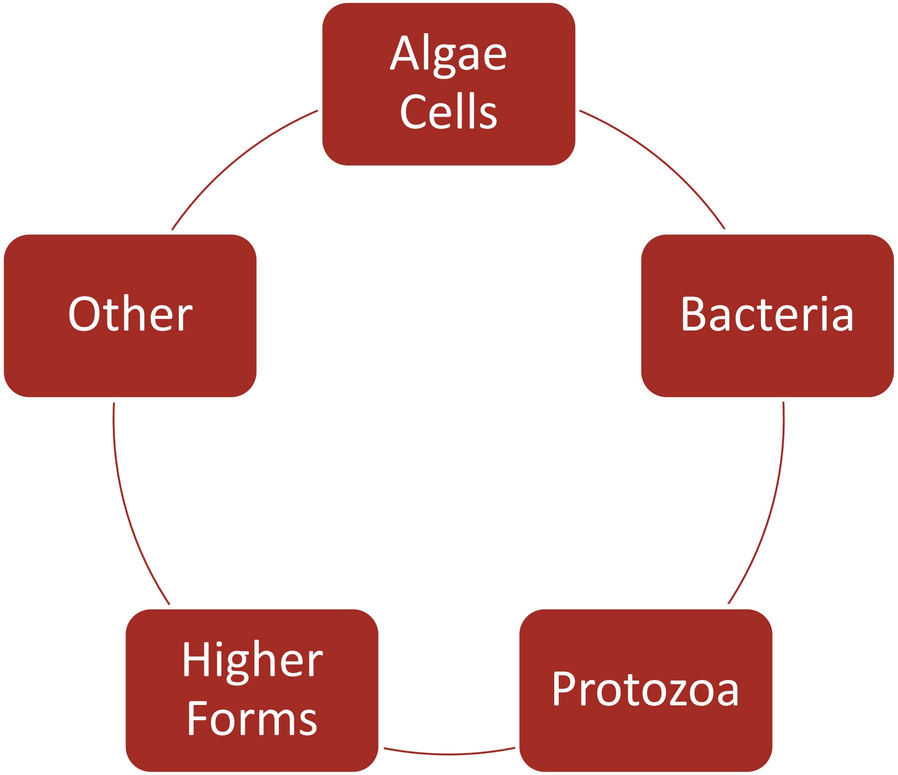
4. What are some things that can be done to reduce loading?

   Increase aeration time; add air; place another lagoon online; check sampling and handling techniques; reduce loads from industrial wastes, grease traps, or septage; increase recirculation; add further mixing; use parallel operation; lighten load to one pond; add oxygen source; use

4. TSS CONTROL

Composition of Suspended Solids

- TSS can be comprised of many different types of solids
- Algae usually makes up the majority



Beneficial Effects of Algae

- Essential to facultative lagoons
- Too much can cause issues
- Algae consumes CO_2 and HCO_3 as a carbon source
  - Elevates pH which is beneficial to the lagoon health
- Produces free oxygen
  - Each lb of algae produces 1.6 lb O_2 on a sunny day
  - O_2 and sunlight kill pathogens

Why is Elevated pH Beneficial?

1. pH above 8.5 prevents odors from escaping. Saturates surface waters with O_2 which oxidize odor causing sulfides to sulfates.
2. Prevents *some* pathogen growth and inactivates others.
3. Assists in volatilization of ammonia. Ammonia exists as a gas in higher pH. Volatilization and sedimentation efficiently remove nitrogen.
4. Can lead to precipitation of metals. Assists in converting phosphorus to hydroxyapatite.

Algae's Problematic Side

Single celled planktonic algae

1. TSS problems
2. Sludge accumulation
3. BOD violations
4. DO crashes (consuming O_2 at night, respiring)
5. Benthal release
6. High pH violations

Algae's Problematic Side

Blue green algae

1. Cause odors and suspended solid issues
2. Excrete toxins
3. Clog equipment
4. Shade the pond, inhibits DO production
5. Interferes w/surface reaeration

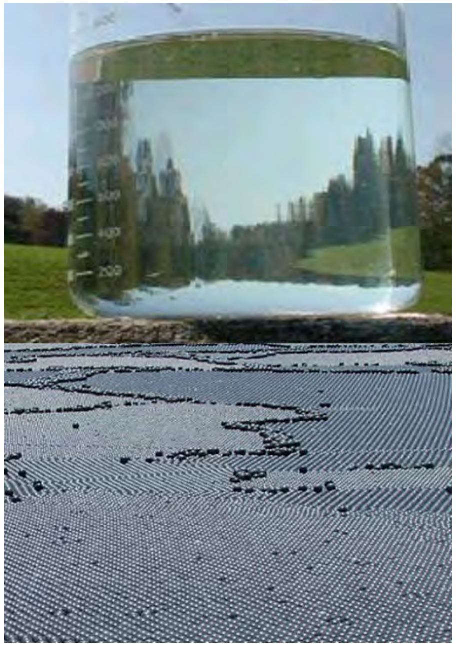
Strategies to Control Algae

Aeration

1. CO_2 is vital for algae growth, aeration mixes water to strip off CO_2
2. Creates foam that covers parts of the pond, reduces sunlight penetration, deprives algae
3. Disrupts thermal stratification, reduces retention time
4. Keeps floc and particles suspended, scatters sunlight, DO absorbs light instead of the algae

Strategies to Reduce and Control TSS

1. Controlling retention time
2. Controlled discharge
3. Confine algae in each treatment cell by varying the depth water is drawn, each transfer pipe and effluent pipe
4. Discharge from the cell w/ the best water quality
5. Chemical control
6. Shading
7. Barley straw
8. Using natural algae predators
9. Baffles
10. Dissolved air floatation
11. Other methods…



Strategies to Reduce and Control TSS

Other methods for controlling algae:

- Over land flow
- Rock filters
- Constructed wetlands
- Micro-screening
- Sand filtration
- Water hyacinth
- Centrifuges
- Alum or polymer in quiescent portion of effluent pond

TSS Control

TSS: BOD5 Ratio	Causes
<1.0	Old sludge solubilization and release of soluble BOD (benthal feedback) Nitrification in the BOD test bottle
1.0	Poor treatment or short-circuiting, with untreated wastewater mixing with the effluent
1.5	Normal for most lagoon systems
2.0–3.0	Algal overgrowth; loss of old sludge particles

Lagoon Condition, P.64

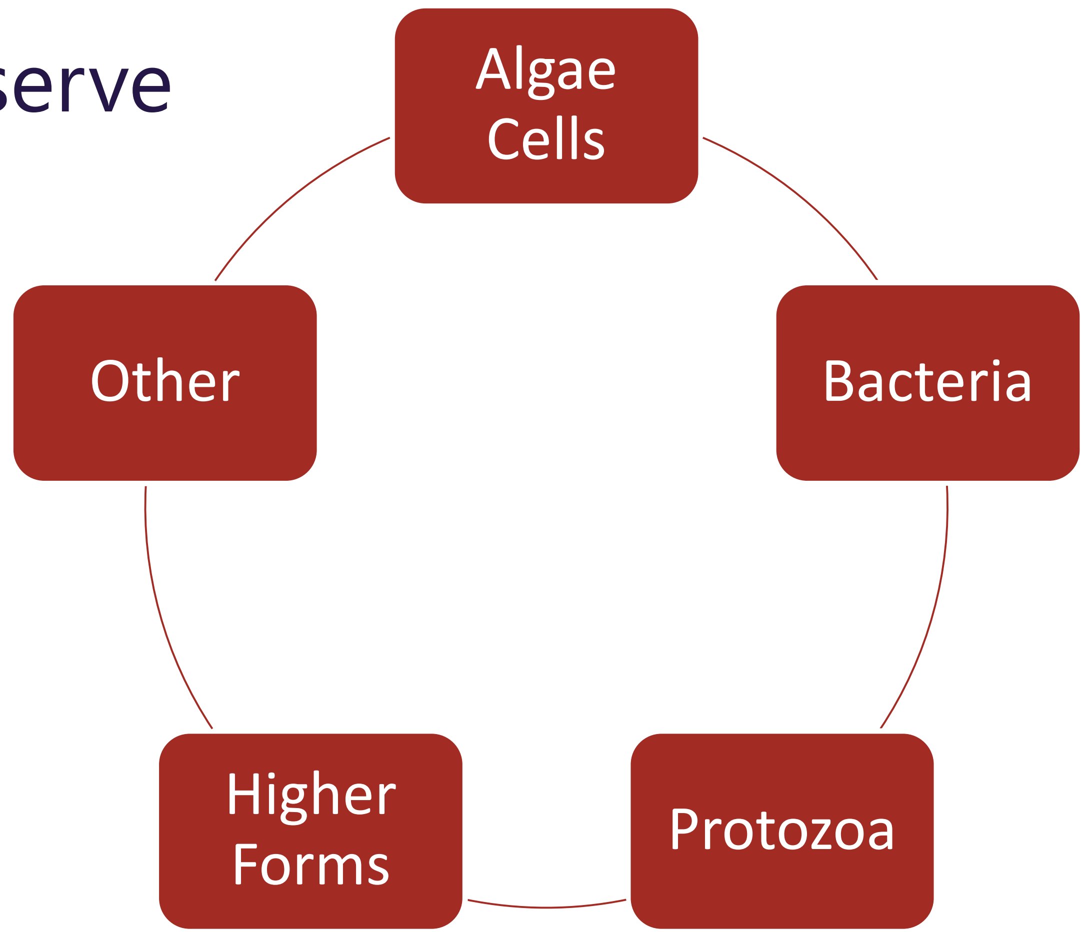
Color as an Indicator of Lagoon Condition

As weather and growth conditions change throughout the year so do algae, bacteria, and protozoa populations. Changing microbial populations and changing pond chemistry combine to cause changes in a pond's color.

Color	Time of Year	Predominant Life Form	Comments
Clear Green	Spring / Fall	Single celled algae, diatoms	*Chlorella* *Scenedesmus*
Green Streaks/ Pea Soup Green	Summer	Filamentous algae Blue Green algae	Fishy smell or pig pen odors. Break up and sink mats.
Clear	Summer	*Daphnia* or Rotifer	*Daphnia* and rotifer over graze eating all the algae. Ammonia or Sulfide toxicity in summer kills algae. When this happens D.O. and pH drops.
	Winter	Low algae and higher life-form counts. Possibly high fecal counts.	
Brown	Spring Summer	Bacteria floc	Good BOD removal. Allow floc to settle
		Brown algae	
Tan (Dinges, R., 1982)	Summer	Bacteria with few algae and even fewer higher life-forms	Low Alkalinity High pH causes metals to precipitate turning water a tan color
Clay color	Spring, Summer, & Fall	Low algae counts Low Chlorophyll-a	Erosion Problem Rip-rap dikes. Set up wind barriers. Add alum or iron salts to coagulate
Red / Pink	Summer	Purple sulfur Bacteria	Overloaded Conditions. Odors. Re-circulate
Grey	Anytime	Filamentous Bacteria	Septic Conditions. Recirculate, Add air
Black	Anytime	Filaments	Septic Conditions. Take off line. Add air
Red patches	Spring, Summer or Fall	*Daphnia*	Low algae count. Falling D.O. and TSS

Diagnosing and Troubleshooting TSS

1. Sample and test
2. Sample and observe
3. TSS consists of:



Troubleshooting TSS Problems

Page 67 - 70

1. Algae bloom
2. Blue green algae
3. Biological treatment solids (bacteria floc)
4. Pond solids (sludge)
5. Higher life forms
6. Lab error
7. Pond solids, clay or dirt
8. Filamentous and sulfur bacteria


QUIZ

Quiz

1. What is TSS composed of in lagoons?

Algae, bacteria, protozoa, higher forms, other

Quiz

2. What is the best strategy to control algae?

   Aeration and mixing

Quiz

3. What is the best strategy to reduce/control TSS? (name 3)

   Control retention time; control discharge; confine algae in each treatment cell by varying water-draw depth in each transfer and effluent pipe; discharge from cell with the best water quality; use chemical control; use shading; use barley straw; use natural algae predators; use baffles; use

5. POND HYDRAULICS & RETENTION TIME

Nature and Pond Performance

Hydraulic retention time is critical because it affects the following:

1. Nitrogen removal
2. Pathogen destruction and inactivation
3. Algae growth
4. BOD/COD removal

Calculating Pond Retention Time

Theoretical Pond Retention Time:

$$Detention\ Time\ (days) = \frac{Pond\ Volume}{Flow\ Rate/day}$$

Pond Retention Time Interference

1. Poor pond design
2. Poor pond orientation with prevailing winds
3. Sludge accumulation
4. Thermoclines: stratification in the water column due to differences in water density
5. Too few ponds online
6. Infiltration and inflow of water during storm events
7. Poor aerator arrangement or inefficient aeration and mixing

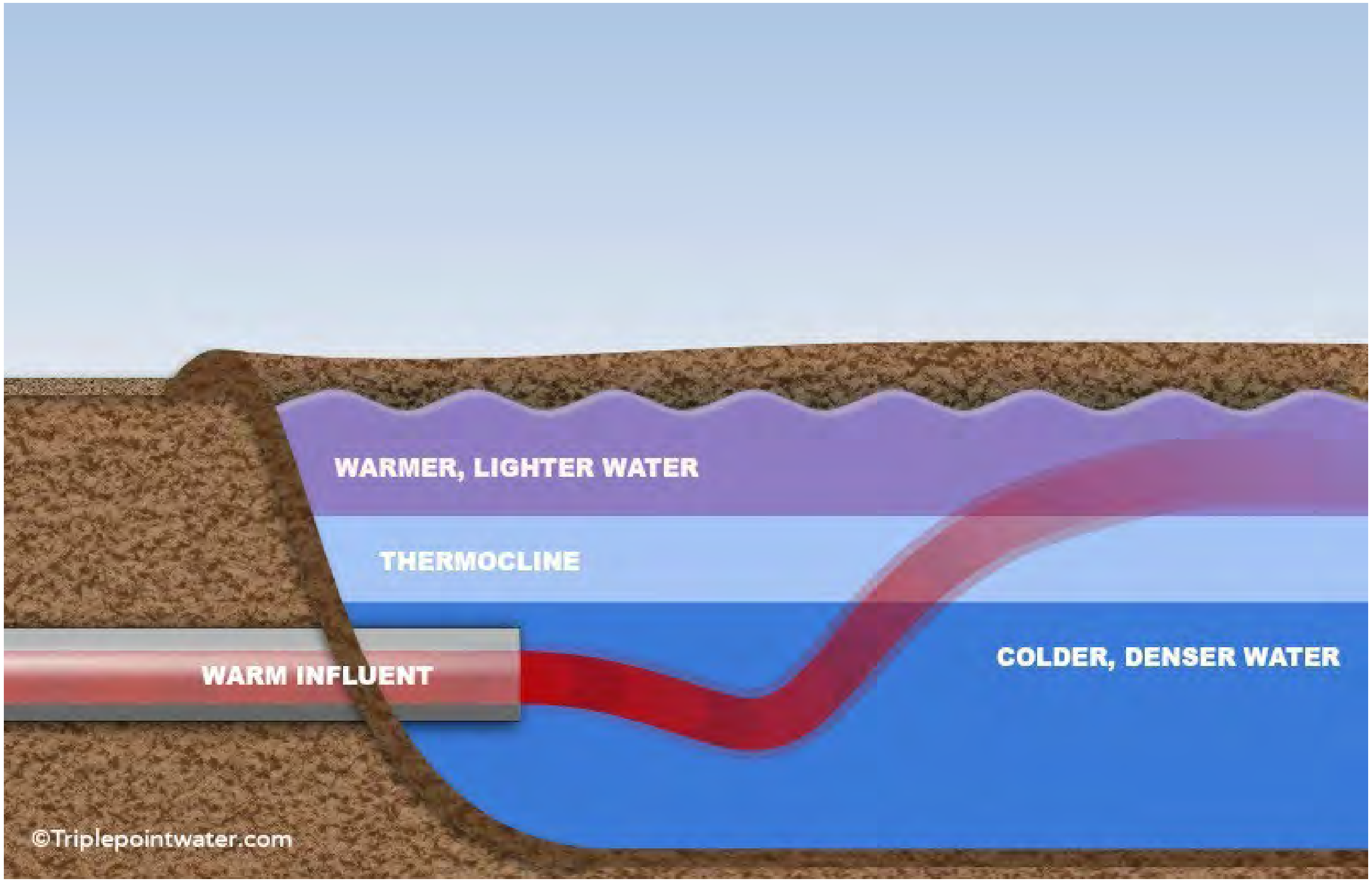
Short-Circuiting: How can you tell?

1. The pond is not meeting limits on BOD or fecal coliform
2. BOD and TSS values are high and TSS:BOD ratio = 1
3. If back-calculated K rates are significantly lower than design
4. Visual observation
   a. If winds push water towards effluent
   b. Accumulation of trash, grease, and algae mats piling up in one area
   c. Accumulated sludge in one area
5. Facultative pond temp, pH, and DO dramatically vary at different depths
   a. Measure every 6 inches from top to bottom

Effects of Temperature on Mixing

- Cooler fall temperatures
  - As air temp drops, surface water cools and becomes more dense displacing warmer water (densimetric mixing)
  - Microbial activity slows, BOD accumulates
- Cold winter temperatures
  - Surface freezes, DO doesn’t reaerate, denser cold water displaces warm
  - Some bacterial activity continues, CO2 trapped, raises pH
- Spring thaw
  - Density driven mixing, stored up BOD may cause overloading, aeration is typically needed
- Warm summer weather
  - Upper surface high in DO, high pH, supports algae growth
  - Deeper layer colder, supports anaerobic activity, low DO, low pH

Mixing Effects in the Summer



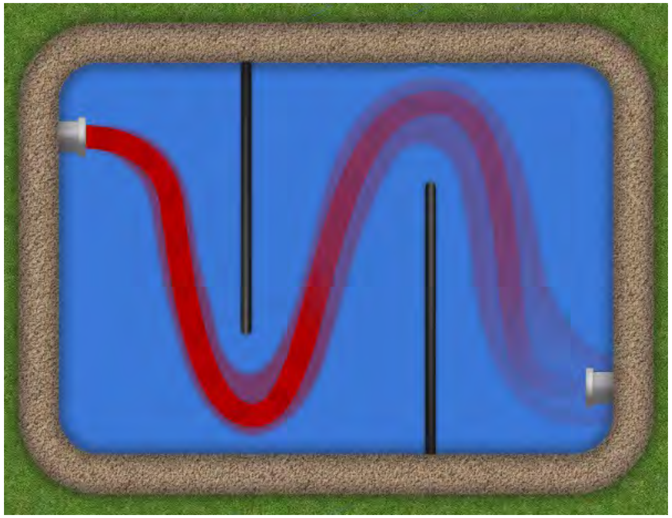
Fecal Coliform Problems in Winter

- Low ultraviolet radiation, lowered pH, low DO
- Possible higher pathogens concentrations
- Warmer influent may ride high over the thermocline and colder denser water
- Short-circuit out of the lagoon

How to Confirm Short-Circuiting

Fluorometric Dyes

1. Fluorescent dyes (Rhodamine WT dye)
2. Lithium ion tracers (LiCl)
3. Biological tracers (Serratia marcescnes)



Fixing Short-Circuiting Issues

- Check influent piping
  - Wastewater than runs through a manifold distributes more evenly
- Change type of aerators or reposition
  - Directional aspirating mixers or change existing patterns
- Redesign influent/effluent structures and transfer pipes
  - See page 81 for arrangement designs
- Baffles
  - Proven to increase retention time
  - Should be 70% of the pond width, minimum of 2 baffles used
- Remove sludge


QUIZ

Quiz

1. How can you tell if a pond is short-circuiting?

   Increased BOD, TSS, fecal coliform; visual - wind, trash accumulation

Quiz

2. What is a method of controlling short-circuiting?

Baffles, rearrange aerators, remove sludge

Quiz

3. Spring thaw may cause overloading with stored-up BOD. (T/F)

True

Quiz

4. Warm summer weather typically has low DO. (T/F)

   False

6. SLUDGE ACCUMULATION & REMOVAL

Problems w/Sludge Accumulation

1. Additional BOD_5 and ammonia load
2. Inadequate treatment
3. Sludge solids leaving the pond with the effluent
4. Odors
5. Interference with oxygen transfer and mixing
6. Burying aerator electrical cords
7. Sludge harbors pathogens

Benefits of Accumulated Sludge

1. Microbiology in the sludge may act as an innocculant for incoming waste
2. Sludge stores nitrogen, phosphorus, and metals
3. Sludge may provide an attachment site for denitrifying bacteria
4. Upper surface of the sludge layer provides environment where bacteria convert carbon to methane permanently removing BOD

Signs That it's Time to Remove Sludge

1. Increase in BOD
2. Increase in TSS
3. Floating, rising sludge
4. Odors
5. Color change in lagoon
6. Increase in turbidity
7. Increase in effluent ammonia and phosphorus
8. Increase in coliform and other pathogenic microbes
9. Blue and green algae bloom
10. Sludge particles leaving effluent
11. Unexplained high chlorine demand

What Affects Sludge Accumulation Rate?

1. Temperature
2. Organic loading
3. Hydraulic loading, washout, scouring
4. Duckweed
5. Pond geometry
6. Infiltration and inflow
7. Pretreatment screens and grit removal
8. Wind speed and direction
9. Influent and effluent structure configuration
10. DO concentrations and sludge interface
11. Leaves, trash, debris
12. Dike erosion
13. Mixing
14. Metals accumulation
15. Ammonia and hydrogen sulfide toxicity

Typical Sludge Accumulation Rates

- Table 6.1, page 91
- The sludge accumulation rate is useful to know when planning for future sludge removal expense
- Repositioning aerators every few years is recommended
  - Best done in the spring to stabilize stirred up organics and nutrients

Volume of Sludge

- Sludge judge: Twice a year
  - Beginning of spring and fall
- Sludge typically shrinks in the summer, thickens in winter
- Helps determine sludge accumulation rate
- Why measure?
  - budget for future sludge removal expense
  - anticipate operational problems
  - determine pond health

Measuring Sludge Blanket

- Sludge judge
- Light sensors
- Depth sensors
- Secchi disks
- White towel method

Measuring Sludge Blanket

Sludge Judge

- Reliable and accurate
- Large diameter
- 2-inch clear plastic tube
- Measures two things:
  1. Sludge blanket mass
  2. Sludge blanket thickness

Sludge Judge

Sludge Judge

Before Sludge Judging

1. Record freeboard and water depth
2. Mark sludge judge every 6 inches w/permanent ink
   Use tape measure for greater accuracy
3. Have wide mouth sample bottles and mark position
4. Bucket for composite samples (if required)
5. Mark sample locations on map of the lagoon
6. Record sample points and depths, perform pH and DO testing
7. Need towels, rubber gloves, eye protection, disinfectant

Sludge Judge Calculations

Sludge Volume =

[(L)(W) + (L-2sd)(W-2sd) + 4(L-sd)(W-sd)]d/6

Example (write it out!)

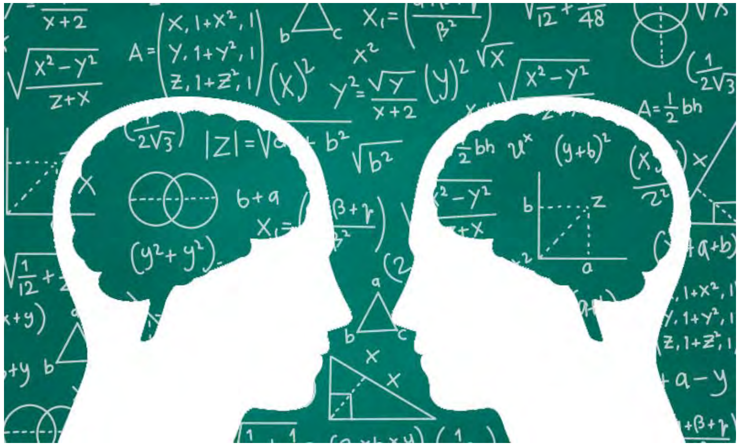
L = 350 feet

W = 220 feet

d = 2.5

s = 3:1

V = ?



Sludge Judge Calculations

Answer:

$V = 182{,}000\ ft^3$

$V = (182{,}000\ ft^3)(7.48 gal/ft^3)$

$= 1{,}361{,}360$ gallons of sludge

Core Sampling

- When measuring sludge blanket depth, also pull samples for total solids (% solids)
- Lab test for volatile solids (VS) concentrations
- Subtract VS from TS to determine sand, grit, silt, dirt, gravel, organic matter
- Degradation occurs when VS/TS ratio declines over time

Tons of dry solids =

$(L)(W)(d)(7.48\ gal/ft^3)(8.34\ lb/gal)(\%\ solids)(1\ Dry\ Ton/2{,}000\ lb)$

Sludge Removal Options

1. Remove pond from service, drain, dry sludge in place, scrape dry solids
2. Remove lagoon from service, drain water cap off, pump sludge to drying beds
3. Remove pond from service, float dredging equipment in pond and pump solids to drying beds, belt press, or land application
4. Biostimulation/bioaugmentation

Sludge Removal

When Draining Lagoons and Pumping Sludge

1. Know the rules and laws on sludge removal and handling
2. Develop sludge removal plan
3. Remove sludge in spring or early summer
4. Analyze sludge for nutrients, metals, contamination
5. Have several land application or storage sites available
6. Consider lagoon access and required equipment
7. Determine how sludge will be moved to the pump
8. Calculate sludge stabilization time
9. Secondary lagoons may now become overloaded
10. Wash sludge residue off sides of the dikes
11. Repair lagoon as needed
12. Spread out remaining grit not pumped out
13. Create a sump in the lagoon if needed
14. Sludge holding pit for excavated sludge if needed

Maximizing Sludge Removal Process

- Sludge can be converted to gas and water (some)
- Bio-oxidative process is naturally occurring to remove sludge
- Anaerobic process takes carbon from sludge, creates CO_2 and CH_4
- Algae and bicarbonate process uses CO_2
- Mixing can be done to accelerate natural sludge removal process

Mixing

- Increases respiration rates
- Re-stabilize solids
- Dragging a chain across the bottom can stir up the sludge
  - releases trapped gasses to increase freeboard and contact time between nutrients, BOD, bacteria
  - mix during the summer, never winter
- Releases ammonia, H_2S, soluble BOD, pathogens

Lagoon Health and Maintenance

Oxygen Toxicity

- Anaerobic sludge digestions suffers in shallow ponds due to oxygen rich environments
- Oxygen barriers or fencing

Grit Removal and Bar Screens

- Essential to extend lagoon life

Pond Maintenance

- Periodically remove leaves, cat-tails, and duckweed
- Riprap levees to prevent dirt and clay


QUIZ

Quiz

1. What is a sludge judge?

   Clear cylinder tube used to calculate sludge thickness

Quiz

2. Sludge is typically measured by rowing around the lagoon with a tape measure. (T/F)

   False

Quiz

3. Sludge can be removed from the lagoon while it’s still in service. (T/F)

   True

Quiz

4. Sludge is removed at least once a year. (T/F)

   False

Quiz

5. Sludge judging is recommended twice a year. (T/F)

   True

7. AERATION AND DISSOLVED OXYGEN

Microbial Oxygen Requirements

- Bacteria and other aerobic microbes require 1.5 to 2 lb of oxygen per 1 lb BOD applied
- During spring thaw and times of benthal release, oxygen per BOD can increase

Factors Competing for Oxygen

- Figure 7.1, P. 110
- Completely mixed aerated lagoons
  - DO concentrations are fairly uniform between day and night
  - Mixers/aerators cause turbidity, inhibit algae growth
    - Bacteria, floc, foam, suspended particles prevent algae from getting sunlight
- Facultative Lagoons
  - Algae and atmospheric reaeration provide oxygen to the system
  - DO concentrations vary widely between day and night

Oxygen Concentrations

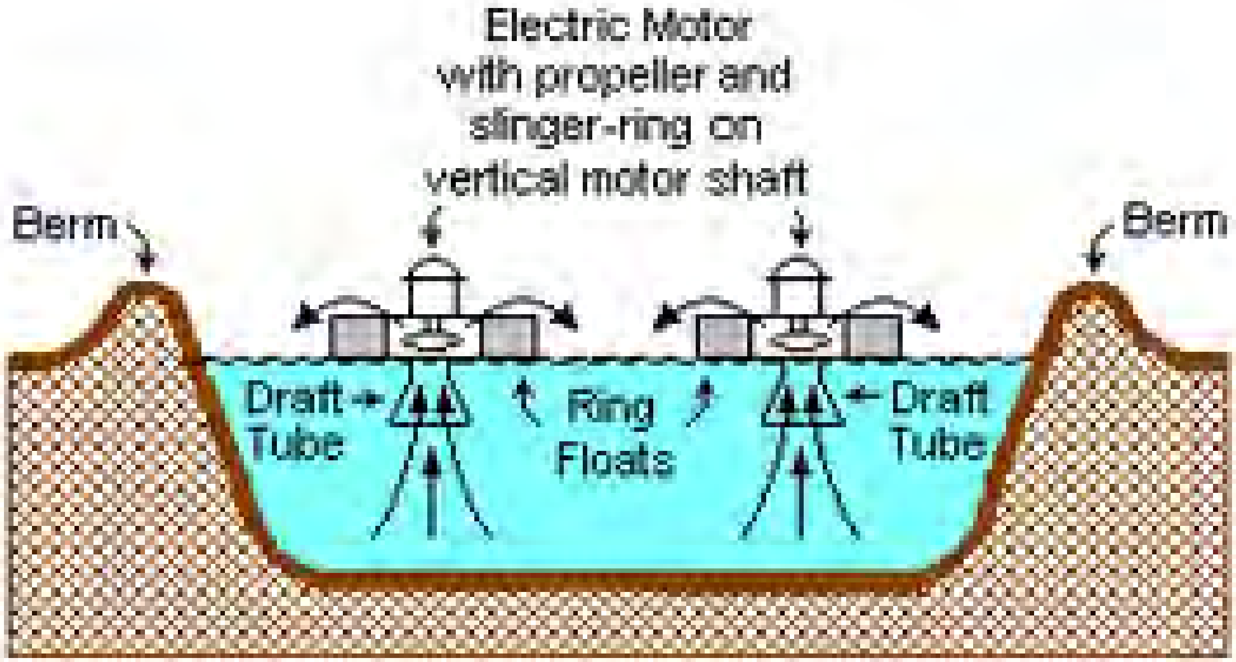
Oxygen in a pond at the correct concentrations control:

1. Odors
2. H_2S toxicity
3. Nitrification
4. BOD/COD/ removal efficiency

Possible Causes of Low DO

1. Poor choice in aeration equipment
2. Improper aerator size
3. Improper placement of aerators
4. NH_3 toxicity
5. Low alkalinity
6. Daphnia eating too much algae
7. H_2S toxicity
8. Wind barriers
9. Pond shading
   a. Ice
   b. Clouds
   c. Duckweed
   d. Excessive scum, floating sludge, algae mats
10. High organic load demanding oxygen
11. Turbidity stirring bottom of pond
12. Nitrification, excess algae, AS put pressure on O_2 reserves

Aeration



A TYPICAL SURFACE – AERATED BASIN

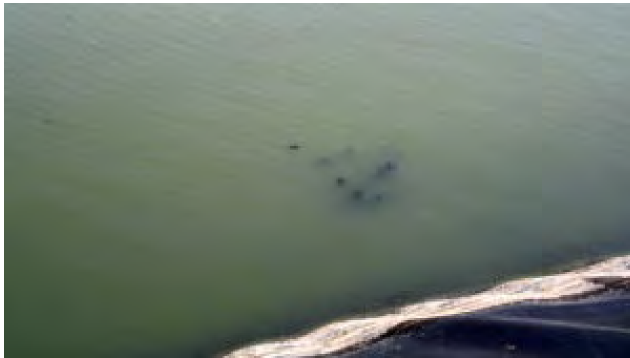
Note: The ring floats are tethered to posts on the berms.

Lagoon Oxygen Testing

- Maintain DO levels of 2 mg/L
- Measure DO at different times of the day, different locations, different depths
  - Early morning, mid-day
- Example calculations p. 114-115

Signs Indicating Oxygen Stressed Conditions

1. Daphnia turn pink to red
2. Filamentous bacteria are present
3. Large concentrations of purple sulfur bacteria turn pond pink to red
4. Excess scum and floating mats of sludge
5. Color changes to grey
6. Reduced BOD removal efficiency
7. Sulfur/rotten egg odors



DO Profile Chart

- Page 118
- Useful table when performing an oxygen profile
- Set up the same as a sludge judge grid
- Record DO and temperature and different locations and depths
- Add pH, nitrogen, phosphorus, TSS, VSS, and tracer concentrations to identify short-circuiting channels

Lagoon System Mixing &Dissolved Oxygen Profile Chart

Depth	A1		A2		A3		A4		A5		B1		B2		B3		B4		B5		C1		C2		C3		C4		C5		D1		D2		D3		D4		D5	
	DO	T pH	DO	T pH	DO	T pH	DO	T pH	DO	T pH	DO	T pH	DO	T pH	DO	T pH	DO	T pH	DO	T pH	DO	T pH	DO	T pH	DO	T pH	DO	T pH	DO	T pH	DO	T pH	DO	T pH	DO	T pH	DO	T pH	DO	T pH
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Oxygen Toxicity

- Anaerobic sludge digestions suffers in shallow ponds in windy areas as oxygen rich water rolls down to the anaerobic zone
  - Inhibits the digestion of sludge
- Oxygen barriers or fencing to create undisturbed anaerobic digester pits
- Figures 7.8 to 7.10, p. 119-120

Solutions to Low DO

1. Add aeration
2. Run ponds in parallel if loading is too high
3. Recirculate oxygen from downstream pond to top of primary
4. Remove duck weed, scum, floating mats of algae, sludge
5. Cut down bushes, trees, cattails, willows
6. Stop septage and grease trap waste influent to reduce loading to the pond
7. Can turn off aerator in afternoon and on at night to conserve reserve O_2
8. Pretreatment
9. Chemical solutions to low DO
   a. Sodium nitrate
   b. Peroxide
   c. Probiotics
   d. Magnesium
   e. Phosphorus, nitrogen

Possible Causes of Low DO

Physical influences

- Shading
- Wind obstructions
- Poor aerator placement
- Low retention time

Possible Causes of Low DO

Chemical

- Hydrogen sulfide
- Low alkalinity
- High ammonia levels
- pH > 8.5
- Excess manganese or magnesium
- Colors of grey, black, or red with odors
- Filamentous bacteria
- Purple sulfur bacteria

Possible Causes of Low DO

Biological

- Daphnis or rotifers
- Clear water
- Low algae populations
- Blue green algae mats


QUIZ

Quiz

1. If a facultative lagoon is not aerated, how is oxygen provided to the system?

   Atmospheric aeration, wind, algae

Quiz

2. Maintain DO concentrations >3mg/L in lagoons. (T/F)

   False.

   DO concentrations of 2 mg/L

Quiz

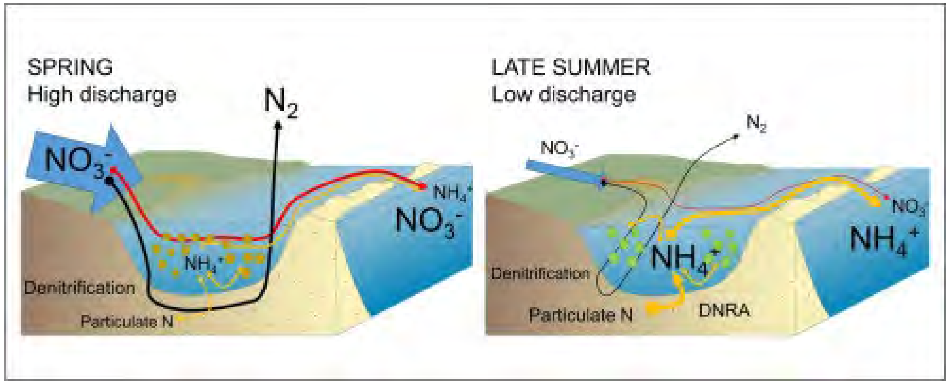
3. DO concentrations should be measured multiple times per day at different locations and depths. (T/F)

   True

8. TROUBLESHOOTING NITROGEN AND PHOSPHORUS PROBLEMS

6 Nitrogen Removal Pathways

1. Uptake by algae and bacteria
2. Sedimentation
3. Volatilization/stripping of ammonia to the atmosphere
4. Nitrification
5. Denitrification
6. Out with the effluent



Factors that Determine Rate of Nitrogen Removal

1. Retention time
2. Temperature
3. pH
4. Alkalinity
5. Dissolved Oxygen
6. Organic loading
7. Ammonia nitrogen concentration
8. NO3 & NO2 concentration
9. Species of algae, bacteria, protozoa, and higher life forms present
10. Mixing and quiescence:biomass suspension, mass transfer, and the ability of a pond to settle influent organic matter and biomass
11. Attachment sites

Nutrient Dynamics

- Waste stabilization lagoons can create their own nitrogen by atmospheric fixation of nitrogen
- High pH causes shift in NH_4 and NH_3 equilibrium, cause ammonia to volatilize, and phosphorus precipitation
- Stored N and P in sludge is released when temp rises, pH, declines, and DO levels drop
- Mixing, along with correct chemical and environmental conditions, cause uptake of N and P by bacteria and algae

Basics of Nutrient Transformations

- Organic nitrogen occurs in animal protein, urine urea, fecal matter, plant proteins, excreted extracellular compounds, or soluble material
- Particulate organic nitrogen occurs in the form of bacteria and algae
- Small amounts of N_2 gas comes from denitrification in sludge, typically at night when DO is low
- Ammonia-N results from biological decomposition of proteins and urea
- Small amounts of nitrate and nitrite produced from nitrification

Basics of Nutrient Transformations

Total N = Organic N + NH_4 + NH_3 + NO_2 + NO_3 + N_2

N = Organic nitrogen

NH_4 = Ammonia nitrogen (toxic)

NH_3 = Ammonia nitrogen (gas)

NO_2 = Nitrate nitrogen

NO_3 = Nitrite nitrogen

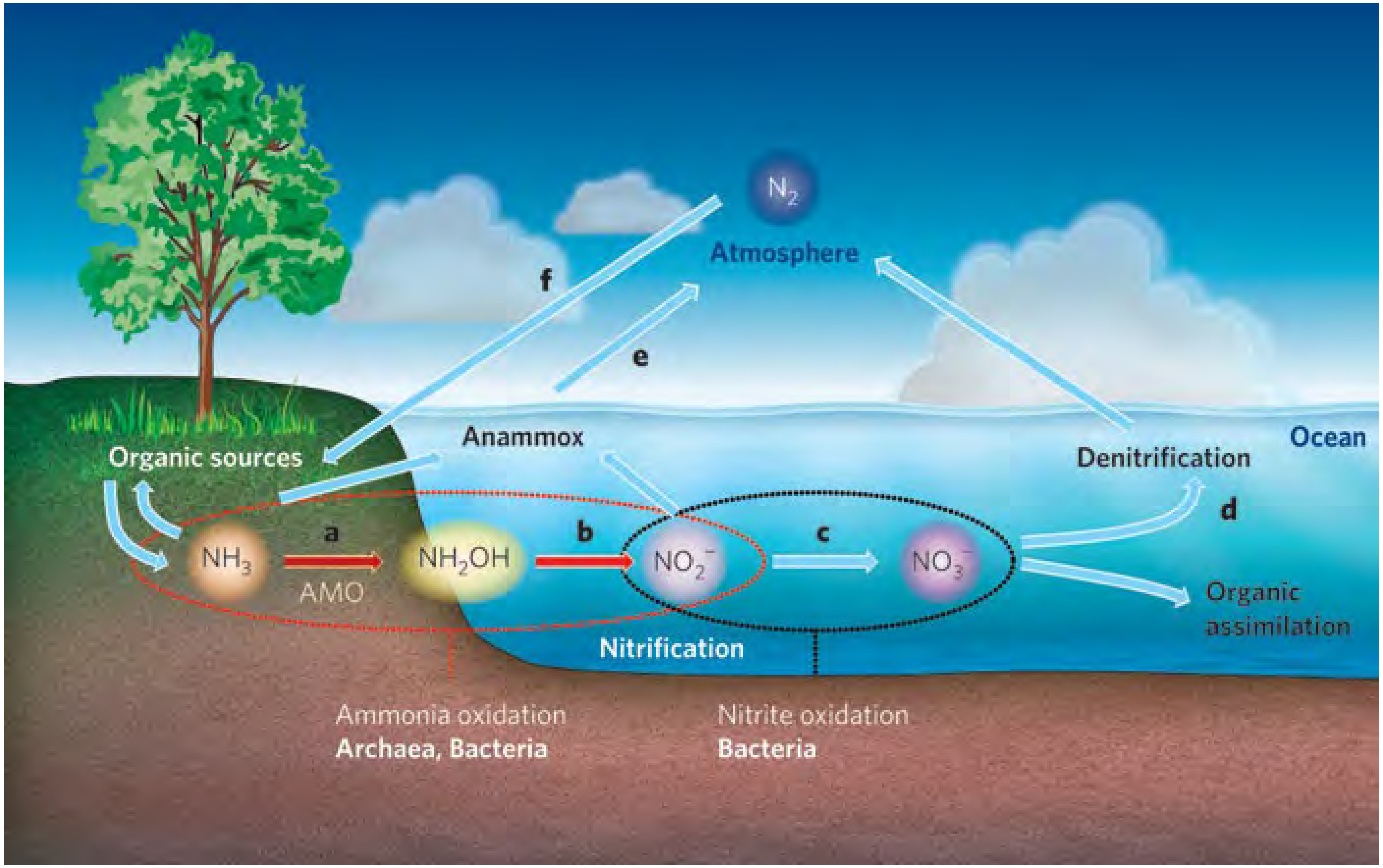
N_2 = Nitrogen gas

Total Kjeldahl nitrogen (TKN) = Organic nitrogen + ammonia nitrogen

Ideal Conditions for Nitrification

- DO concentration > 2.0 mg/L
- Optimum temperature 30°C (86°F)
- pH range 7.5 - 9.0
- No sulfide, heavy metals, or other toxicity
- Long retention times
- Good mixing
- Alkalinity > 250 mg/L as HCO_3
- Nitrifying bacteria present
- Surface floc, fixed film, or media for nitrifying bacteria to attach to
- Low organic loading
- Oxidation/reduction potential (ORP) +50 to +300
  - High ORP means high oxygen present

Nitrification



Denitrification

- Increases alkalinity and pH, and reduces NO_3

Ideal conditions

- Nitrates must be present
- Organic material must be present
- Little to no DO (anoxic)
- pH 7.0 - 8.5
- Temperature 30°C to 50°C (86°F to 122°F)
- ORP -50 to +50
- Works best in deep ponds with low oxygen

Troubleshooting Nutrient Removal Issues

- Monitoring and recordkeeping
- Testing
  - TBOD
  - CBOD

    TBOD - CBOD = NBOD
- NBOD represents nitrifying bacteria and O_2 demand
- NBOD indicates whether a lagoon has the potential to nitrify

Nitrogen Control

1. Loading - Organic
2. Retention time
3. Mixing
4. DO
5. Desludge the lagoon
6. pH
7. Pond maintenance
8. Baffles
9. Recirculation

Phosphorus Removal

Three naturally occurring biological and chemical phosphorus removal pathways:

1. Biological uptake of P by algae and bacteria
2. Sedimentation of organic P and inorganic P
3. Out with the effluent

Phosphorus Removal

Several factors important to the release of sediment bound phosphorus

1. Redox conditions
2. pH
3. Mixing
4. Temperature
5. Presence of Ca, Al, Mn, and Fe
6. Algae concentrations

Control Strategies for P Removal

- Growth of algae and bacteria help remove phosphorus
- Aerobic conditions slow the release of P
- Aerobic and facultative lagoons increase release rates of P
- Recirculating upper surface of high pH waters increase precipitation of phosphorus
- Sludge removal maintains low concentrations of P
- Iron salt or alum precipitation improves P removal
- Chemicals used in P removal:
  - Ferric chloride
  - Ferrous chloride
  - Ferrous sulfate
  - Alum
  - Sodium aluminate
  - Lime
  - Variety of polymers


QUIZ

Quiz

1. Denitrification and nitrification are nitrogen removal pathways. (T/F)

   True

Quiz

2. What is TKN?

Organic nitrogen and ammonia nitrogen

Quiz

3. Stored N and P in sludge is released when temperature rises, pH declines, and DO levels drop. (T/F)

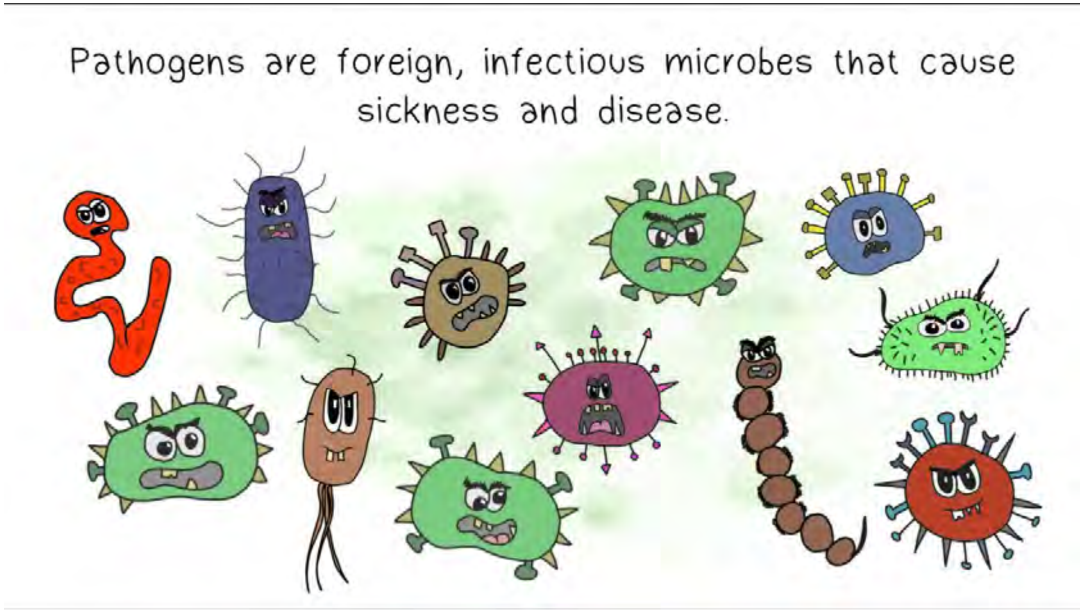
   True

9. PATHOGEN CONTROL

Pathogens

Fecal contaminated water can transmit diseases such as:

- Typhoid fever
- Dysentery
- Cholera
- Hepatitus
- Polio
- Gastroenteritic
  - Entamoeba
  - Giardia
  - Cryptosporidia
- Ascariasis and other intestinal diseases caused by parasites (e.g., tape worm, round worm, hook worm)



Pathogens in Lagoons

Natural environmental factors that effect pathogen die-off:

1. Solar radiation
2. Temperature
3. DO concentrations
4. Algae concentrations
5. Competitive bacterial populations
6. Protozoa and fungal populations
7. Duckweed or ice cover
8. Wind speed and direction

Pathogens in Lagoons

Physical factors effecting microbial die-off in ponds:

1. Pond depth
2. Retention time
3. Turbidity
4. Short-circuiting
5. Mixing
6. Pond geometry
7. Pond configuration (series vs parallel)
8. Shading
9. Position and number of influent and effluent structures
10. Surges in flow
11. Settling rate
12. Sludge accumulation

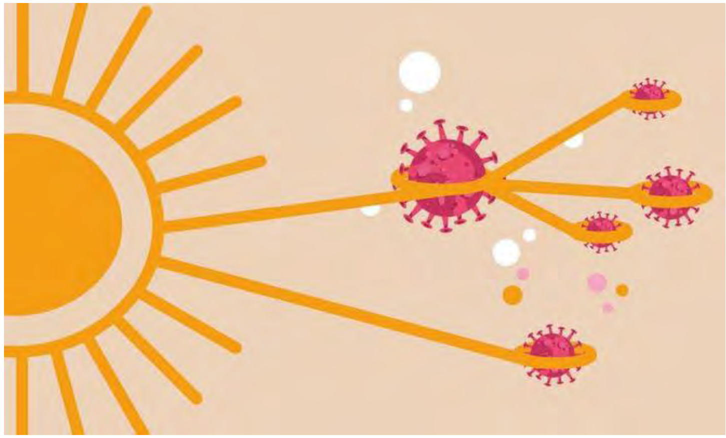
Pathogens in Lagoons

Chemical factors effecting die-off:

1. Antibiotics
2. Algal toxins
3. CO
4. pH
5. Nutrients
6. Concentrations of humic material
7. Loading
8. Redox potential
9. Salinity and conductivity

Maximizing Natural Disinfection Process

- Sunlight: Critical to inactivating pathogens
- Predation, sedimentation, starvation: Kills intestinal parasites
- Sunlight together with pH and DO: Disrupt microbial DNA
- Using sunlight for its disinfecting properties requires maintenance



Maintenance to Use Sunlight

- Keep surface clear
- Add shallow maturation pond
- Maximize retention time
  - Ponds in series
- Recirculate upper-surface pond water if high in pH
- Draw effluent from upper surface of final pond
- Discharge water in the afternoon
- Use baffles

Retention Time

Retention time is a function of:

1. Pond shape
2. Length to width ratio
3. Number of inlets and outlets
4. Position of inlets and outlets
5. Sludge accumulation
6. Sheer stress and pond bottom and sides
7. Wind speed and direction

Ultraviolet Disinfection

UV disinfection is proven to be very effective in pathogen control of lagoon effluents.

Sampling Procedures and Analysis

1. DO NOT touch the inside of the sample bottle
2. Use sterilized sample bottles
3. Run split samples and tap water sample blanks as a control
4. Samples older than 5 hours may give faulty results
5. Audit and review method of analysis and calculation the lab is using to determine number of microbes
6. Decaying vegetation may cause total coliform counts to rise, including fecal coliform


QUIZ

Quiz

1. Temperature effects pathogen die-off. (T/F)

True

Quiz

2. Sludge accumulation does not affect pathogen die-off. (T/F)

False

Quiz

3. Pathogen die-off is affected by pH. (T/F)

True

Quiz

4. Nutrients do not effect pathogen die-off. (T/F)

   False

10. MAINTENANCE

What EPA Inspectors Look for

1. Scheduled inspection of pond lining and levees
2. Weed control program
3. Insect control in the vicinity
4. Burrowing animal control
5. Regular site inspections of lagoons and facilities
6. Daily readings of aerator operating times
7. All non-operating equipment must be tested once a month

EPA’s recommended process control checklist: p. 166

Dike Maintenance

- Burrowing animals
- Check daily for seepage or leakage
- Erosion Prevention
  - Grass
  - Riprap
- Erosion causes
  - Asphalt
  - Limestone, sandstone
  - Tires
  - Chunks of concrete

Vegetation Control

Issues from overgrowth:

- Short-circuiting
- Poor circulation
- Excess sludge
- Insect problems
- Burrowing animal problems
- Damage to dikes and liners
- Odor problems
- Oxygen depletion

Scum, Debris, and Algae Mat

- Algae, sludge, and scum mats cause odor and insect problems
- Check and clean bar screen daily
- Check and clean effluent structure daily
- Work the valves and gates frequently to lubricate moving parts

Record Keeping

1. Preventive maintenance records (for each piece of equipment)
2. Preventive maintenance schedule
3. Service report cards
4. Where parts can be purchased
5. Spare parts inventory
6. Operation and maintenance instructions
7. Specifications on equipment from suppliers
8. Equipment inventory


QUIZ

Quiz

1. Burrowing animals can effect dike stability. (T/F)

   True

Quiz

2. Vegetation is a form of dike stability. (T/F)

   True

Quiz

3. Algae is bad for lagoons and should be removed immediately. (T/F)

False

Quiz

4. Vegetation overgrowth can cause poor pond circulation. (T/F)

   True

11. COLD WEATHER OPERATIONS

Profound Effects of Water Temperature

- Temperature directly affects the rate of biological activity
- Every 10°C reduction in temperature reduces microbial by 50%
- Can take 2 times longer to digest sludge at 25°C than 35°C

Profound Effects of Water Temperature

Water temperature directly affects the following:

1. Chemical and biological reactions (BOD/COD, sludge removal)
2. Reaction rate constant used in pond design
3. Bacterial mortality rate
4. Thermal stratification
5. Destratification
6. Density driven circulation
7. Oxygen solubility in water
8. CO_2 solubility in water
9. Algae, protozoa, and bacteria populations
10. Solids settleability

How Temperature Affects Pond Mixing

- Cooler fall temperatures
  - As air temp drops, surface water cools and becomes more dense displacing warmer water (densimetric mixing)
  - Microbial activity slows, BOD accumulates
- Cold winter temperatures
  - Surface freezes, DO doesn’t reaerate, denser cold water displaces warm
  - Some bacterial activity continues, CO_2 trapped, raises pH
- Spring thaw
  - Density driven mixing, stored up BOD may cause overloading, aeration is typically needed
- Warm summer weather
  - Upper surface high in DO, high pH, supports algae growth
  - Deeper layer colder, supports anaerobic activity, low DO, low pH

Cold Weather Operations

- Remove some aeration or reduce horse power
- Do not operate recirculation
- Maximize pond depth, liquid level
- Maximize retention time
- All cells should be operated

Pond Modifications for Cold Weather Operations

Anaerobic Ponds

- Deep digestion pits can be dug into existing lagoons, cell depth of 12 to 16 feet
- Digestion pits are warmed from influent
- Short retention times maximize heat storage (2 to 4 days)
- p. 180


QUIZ

Quiz

1. Temperature does not affect the rate of biological activity. (T/F)

False

Quiz

2. What is densimetric mixing, and when does it occur?

As temperatures drop, water cools; the cooler, denser, water falls to the bottom of the pond, displacing the warmer water.
This occurs in fall and winter.

Quiz

3. During the spring, stored-up BOD may cause overloading, and aeration is typically needed. (T/F)

   True

Quiz

4. During the summer, the upper layer of the pond is typically low in DO and the bottom layer is high in DO. (T/F)

   False

12. INDUSTRIAL LAGOON OPERATIONS


Industrial Lagoon Performance
Pre-treatment, Solids, Separation, Clarification
pH & Alkalinity
Loading, Flow Equalization
Toxicity
Anaerobic Treatment
Nutrient Deficiencies
Biomass Mortality
Temperature

Physical Pre-Treatment

Primary Clarification

- Remove 70% of BOD and 90% of TSS
- Effluent quality is a function of:
  - Raw influent characteristics, flow, concentration of non-settleable solids
  - Quality and quantity of solids returned from belt press or centrifuge
  - Clarifier hydraulics and efficiency
  - Polymer choice and polymer addition matched with pace of flow
  - Operational choices such as sludge blanket depth

Strategies to Improve Primary Clarifiers

1. Experiment with adding different types of polymers
2. Capture more solids at the belt press or centrifuge
3. Perform tracer study on clarifier to determine hydraulic efficiency
4. Monitor sludge blanket levels to determine optimum depth

Chemical Pre-Treatment

Industrial wastewater my need to be adjusted to:

- Control pH
- Supply nutrients
- Meet deficiencies in alkalinity
- Sequester metals, detoxify chemicals, or remove salts, ammonia, or H_2S

Nitrification Indicators

1. Low DO
2. Low pH
3. High concentrations of NH_4, NO_3, NO_2
4. Poor settling sludge
5. Loss of chlorine residual
6. Poor effluent BOD removal
7. Few to no protozoa

Nutrients

- Carbon
- Hydrogen
- Oxygen
- Nitrogen
- Iron
- Sulfur
- Potassium
- Copper
- Zinc
- Cobalt
- Manganese
- Magnesium
- Other trace nutrients

Nutrient Deficiencies

- When nutrient concentrations are out of balance, the biology of the system becomes metabolically and biologically out of balance
- Nutrients can be added to the system
- Ammonia is the preferred source of nitrogen

Anaerobic Lagoons

- Typically first followed by a series of aerated and facultative lagoons
- Used to handle loads heavy in BOD and TSS
- Can reduce BOD up to 80%
- Benefits:
  - Low sludge yield
  - Great at removing BOD and TSS
  - Small land requirements

Anaerobic Lagoons

Optimizing pond hydraulics:

- Baffled and mixed anaerobic reactors
- Increase mixing
- Eliminate short-circuiting
- Pond design:
  - Crosswise inlet/outlet
  - Length to width ratio 2:1
  - Two baffles positioned at 1/3 length and 2/3 length

Anaerobic Lagoons

Monitoring anaerobic lagoons

- Methane generation rates
- CO_2 concentrations
- pH and alkalinity
- BOD removal efficiency
- H_2S
- Volatile acid concentrations


QUIZ

Quiz

1. What percent of BOD and percent of TSS is removed during primary clarification?

   70% and 90%

Quiz

2. When nutrient concentrations are out of balance, the biology of the system becomes metabolically and biologically out of balance. (T/F)

   True

Quiz

3. Ammonia is the preferred source of nitrogen. (T/F)

True

¿Preguntas?

POST-

Post Quiz

1. What are the 3 different type of lagoons?
2. What is the difference between and anoxic and anaerobic environment?
3. What role do bacteria play in the WW process?
4. What role do algae play in the WW process?
5. What are negative impacts of algae?
6. What testing should be done to diagnose lagoon problems?
7. What does the ratio of VSS to TSS tell us?
8. How do you calculate the BOD removal efficiency?
9. What are the units for BOD loading?
10. What are some signs of pond overloading?

Post-Quiz

1. What are the 3 different type of lagoons?

- ✓ Aerobic
- ✓ Anaerobic
- ✓ Facultative

Post-Quiz

2. What is the difference between an anoxic and anaerobic environment?

   Both anoxic and anaerobic are without oxygen, but anaerobic is also without nitrogen.

   In the WW treatment process, the anoxic zone receives nitrate from a recycled zone with air (RAS).

Post-Quiz

3. What role do bacteria play in the WW process?

Bacteria decompose organic matter, assimilate nutrients, control disease-causing organisms, degrade pollutants and toxins, control odors, oxidize inorganic compounds (ammonia, H_2S, nitrate, sulfur), form floc particles (stabilization/settle ability).

Post-Quiz

4. What role do algae play in the WW process?

   Algae supply oxygen to aerobic bacteria and protozoa, assimilate nitrogen and phosphporus, elevate pH which kills pathogens and controls odors, precipitate metals and volatize ammonia, and help control odors by generating oxygen.

Post-Quiz

5. What are negative impacts of algae?

   Algae cause TSS and BOD problems, form mats and stink, and create toxins.

Post-Quiz

6. What testing should be done to diagnose lagoon problems?

   Testing for lagoon problems should include: total suspended solids (TSS), pH, dissolved oxygen (DO), ammonia, alkalinity, temperature, sludge depth, chlorophyll, fecal coliform, volatile suspended solids (VSS), and flow.

Post-Quiz

7. What does the ratio of VSS to TSS tell us?

VSS/TSS tells us the percentage of suspended matter that is organic and indicates if digested pond solids are leaving with effluent.

Post-Quiz

8. How do you calculate the BOD removal efficiency?

   BODin – BOD out/BOD in x 100

Post-Quiz

9. What are the units for BOD loading?

lb BOD/acre/per day

Post-Quiz

10. What are some signs of pond overloading?

Odor (rotten egg), color (gray to black), low pH, increase in BOD, drop in protozoa count