FLORIDA RURAL WATER ASSOCIATION

Wastewater

Certification Review

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Wastewater Operator Exam Review

Florida Rural Water Association

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Overview

- Collection Systems
- Rain Water Inflow & Infiltration
- Wastewater Flow Measurement
- Preliminary Treatment
- Grit Removal

2

Overview

- Bar Screens
- Activated Sludge Processes
- Clarification
- Microbiology Protozoans and Metazoans
- Filtration

3

Overview

- Digestion Aerobic and Anaerobic
- FDEP Rules
- Safety
- Laboratory
- Math

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Collection Systems

- *Purpose*: Collect and convey wastewater from homes and industries
- *Sanitary Sewer*: Household (domestic) wastewater
- *Storm Sewer*: Conveys stormwater to DRA's
- *Combined Sewer*: Collects both sanitary and storm water

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Collection System Components

- Sanitary Sewer Main—Velocity of flow must be at least 2' per second
- Manholes—Distance between manholes 300-500'
- Laterals—Connects house to sewer main
- Force Main—Pumps sewage from lift station to plant

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Collection System Problems

- Rainwater Inflow and Infiltration
- Flat Grades
- Bellies
- Tree Roots
- Manhole Deterioration
- Grease Accumulation
- Flushable wipes

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Collection System Problems

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Rain Water Inflow and Infiltration (I&I)

- Enters collection system through cracks and holes in pipes, open cleanouts, cross connections, manholes
- Can cause hydraulic overload at WWTF, decreased capacity due to sand and grit accumulation, lift station pump failures and overflows, increased operating costs

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Inflow

- Direct flow of water to sewer system

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Example of Inflow

Improperly located manholes and poorly sealed manhole covers can add to high flows.

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Infiltration

- Groundwater entering sewer pipes through cracks and openings

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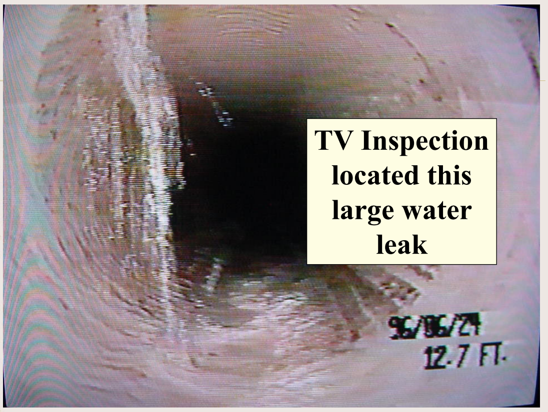

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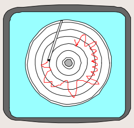
Is it Inflow or Infiltration?

- Record lift station run times and rainfall daily
- Compare rain event readings with dry weather readings to locate problem areas



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Rain Water I&I *(continued)*

- I&I studies include collection system inspection, smoke testing and televising sewer lines
- 10 three-inch open cleanouts adds up to a 30-inch hole in the collection system!
- A one-inch rainfall in one acre equals approximately 27,000 gallons of water!

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Smoke Blower

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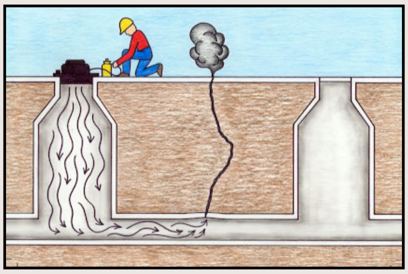
Smoke Testing

- Locates broken sewers
- Locates "lost" manholes



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Smoke testing is one way of locating broken sewer pipes, like this one in a ditch.

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Excessive Hydraulic Loading

Cause: Inflow

- Downspouts
- Yard drains
- Clean-outs

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Excessive Hydraulic Loading

Cause: Inflow

- Storm drains

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TV Inspection Equipment

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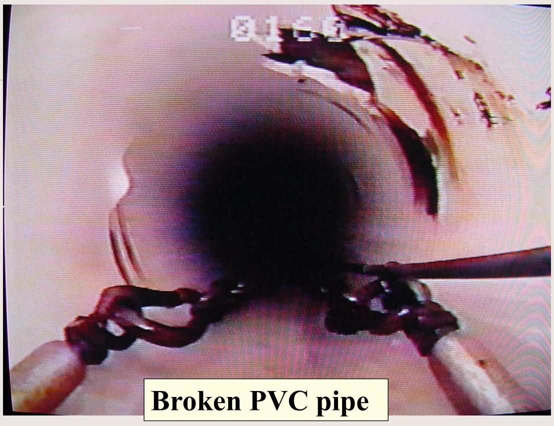

Broken PVC pipe

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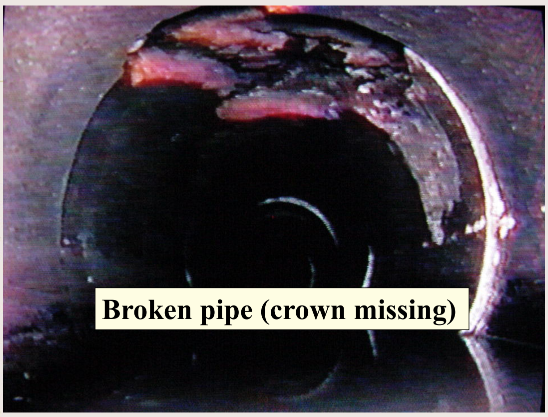

Broken pipe (crown missing)

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Crushed pipe

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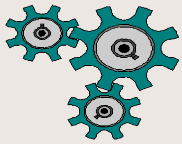
What effect does grit have?

- Excessive wear on plant equipment
- Grit takes up valuable volume in tanks
- Excessive solids handling for grit removal



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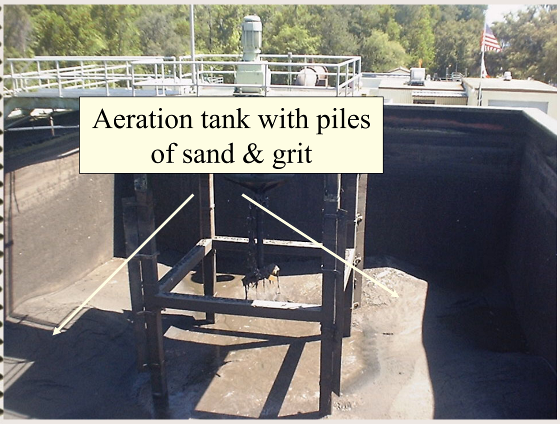

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Bellies and Flat Grade Sewers

- Allows septic conditions to develop
- Allows formation of Hydrogen Sulfide (H_2S)
- Can cause low influent pH
- Causes odors
- Can increase oxygen demand at plant
- Can contribute to sludge bulking
- H_2S causes deterioration of manholes, pipes and lift stations

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Wastewater Flow

- Flow is measured as a quantity (gallons) moving past a point (primary device) during a specific time interval
- Recording flow is required by DEP
- Recording flow @ plants 1 MGD are taken continuously.

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Flow Measurement

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Wastewater Flow

- Primary Devices: Weirs and Flumes
- *Secondary Devices*: Float Type, Ultrasonic, Bubbler, Magnetic, E.T. meters on pumps
- Secondary devices calibrated at least annually, a permit requirement of DEP

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Wastewater Types

- *Organic*- mainly plant and animal waste
- *Inorganic*- sand, grit, iron, calcium
- *Thermal*- heated wastewater from industrial sources
- *Radioactive*- hospitals, research labs, toxic disposal industries, nuke plants

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Wastewater Contents

- Domestic waste is 99.9% water
- Contains pathogenic (disease causing) bacteria, viruses, cysts that can cause Typhoid, Cholera, Dysentery, Polio and Hepatitis
- Floatable, settleable, suspended, dissolved, colloidal solids

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Raw Wastewater Solids Composition

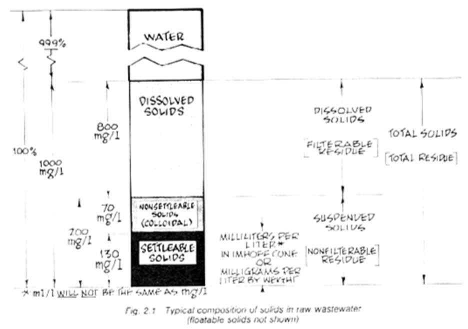

Fig. 2.1 Typical composition of solids in raw wastewater (floatable solids not shown)

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Preliminary Treatment

- Flow Equalization / Surge Basins
- Bar Screens and Racks
- Moving or Rotating Screens
- Grit Chambers / Channels

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Preliminary Treatment

36

Preliminary Treatment

Unit processes include:

- Odor control
- Screening
- Grit removal

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Odor Control

- Odor producing substances are small, mostly volatile molecules
- Most result from anaerobic decomposition of organic matter containing sulfur and nitrogen

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Odor Control, continued

Gases produced from wastewater decomposition:

- Hydrogen sulfide (H_2S)
- Ammonia (NH_3)
- Carbon dioxide (CO2)
- Methane (CH_4)

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Barscreens and Racks

- Influent is screened to remove debris that can clog and damage downstream equipment

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Barscreens and Racks

- Solids removed are referred to as screenings
- Consist of rags, roots, sticks, plastics and other large debris
- Must be placed in covered container and sent to approved landfill

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Hydroscreen in action

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Influent grinding

- Comminutors and Barminutors grind or chop large solids
- Returns chopped solids to influent flow
- Shredded rags adversely affect downstream processes
- Not very common, slowly being replaced

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Grit Removal

- Grit is removed to protect downstream equipment from its abrasive nature
- Grit consists of sand, gravel, pipe debris and eggshells
- Grit can plug pipelines, fill usable tank space, damage pumps and valves

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Volume of grit entering WWTP depends on following variables:

- Type of collection system (sanitary, combined)
- Material used in collection system construction
- Amount of street sand flushed into sewer
- Integrity of collection system
- Industrial waste containing grit from washing processes

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Grit removal

- A variety of equipment is used for grit removal
- Most grit removal techniques slow flow velocity to 1.0 fps to allow grit to settle

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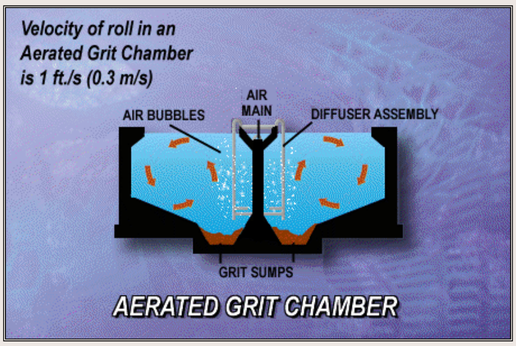
Aerated Grit Removal



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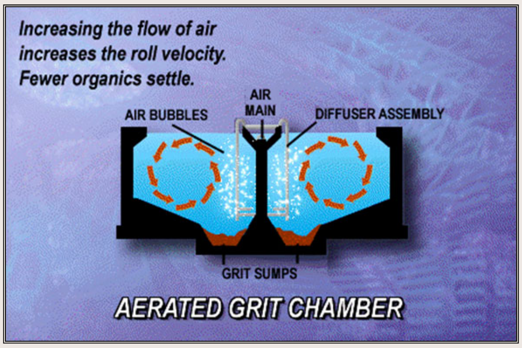
Aerated Grit Removal



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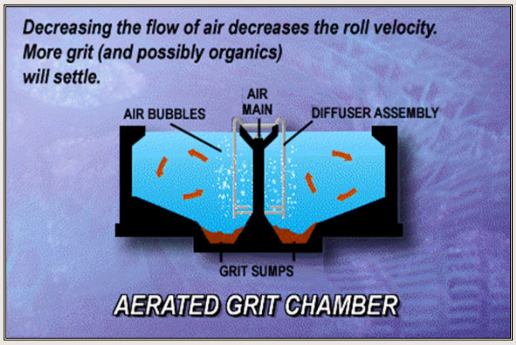
Aerated Grit Removal



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Aerated Grit Removal

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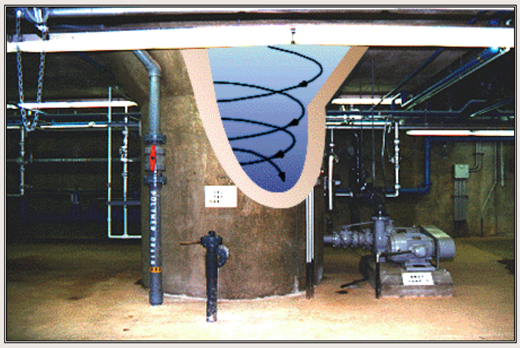
Aerated Grit Removal



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Grit Pumping

- Grit pumps are typically recessed impeller centrifugal pumps
- Pumps are usually timer controlled
- Grit is pumped to a cyclone degritter or dewatering screen

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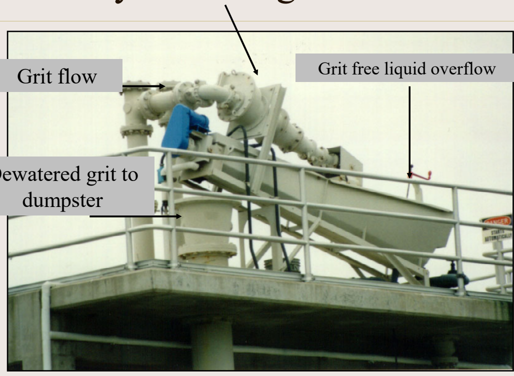
Cyclone Degritter



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Mechanically Cleaned Chambers

- Most are rectangular shaped
- Most use a chain and flight system to move grit to a sump
- A bucket elevator or inclined screw lifts grit to a classifier or washer

61

Mechanically Cleaned Chambers

- Collectors operate at low speed, only fast enough to collect grit as it settles
- Run times of collectors depends on rate of grit accumulation
- Additional grit chambers should be placed on-line if grit loading exceeds that of on-line units

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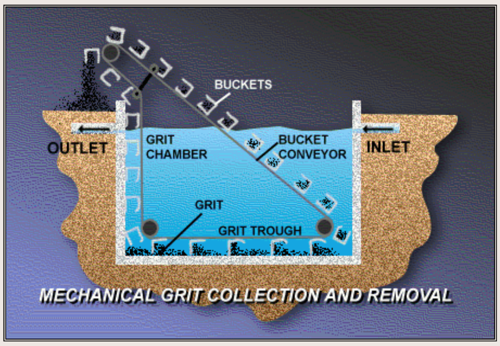
Mechanically Cleaned Chambers



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Grit channels

- Basically long channels that reduce flow velocity to 1.0 feet per second
- Use two or more channels
- One channel stays on-line, other channel off for draining and cleaning

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Grit Channels

- Grit is manually removed (armstrong method)
- May be found as a back-up to a mechanical grit removal system

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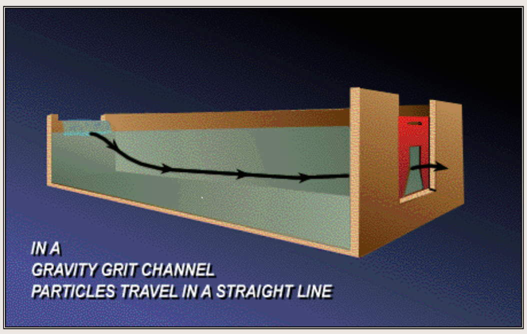
Grit Channels



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Grit Channels

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Grit Channels

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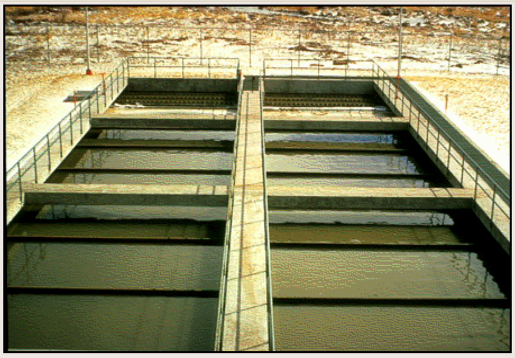
Primary Treatment



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Why Primary Treatment?

- Primary treatment lessens the solids burden on secondary treatment processes
- Trickling filters / RBC's
- Activated sludge processes

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Why Primary Treatment?

- Separates the settleable and floatable solids from waste stream

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Primary Sludge

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Primary Scum

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Primary Removal Stats

- Primary treatment can achieve 40-60% removal of influent TSS
- 25 –30% of influent BOD

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Primary Clarifier Design

- Primary clarifiers can be rectangular or circular
- Designed to decrease influent flow velocity to allow for solids settling

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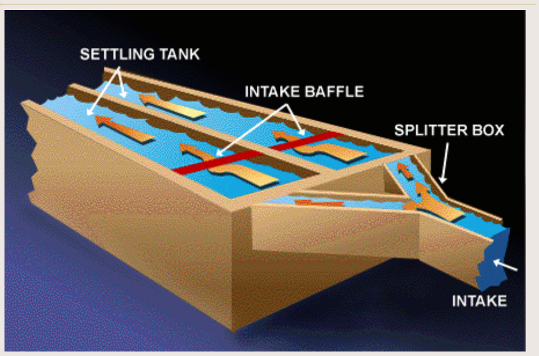
Slow the Flow



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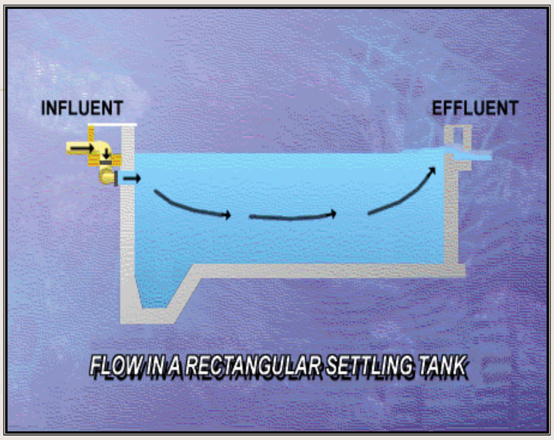

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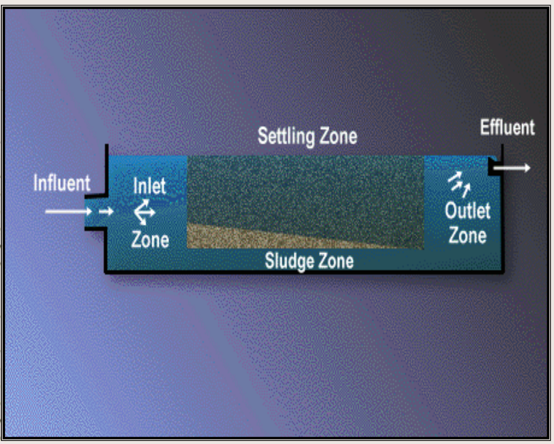

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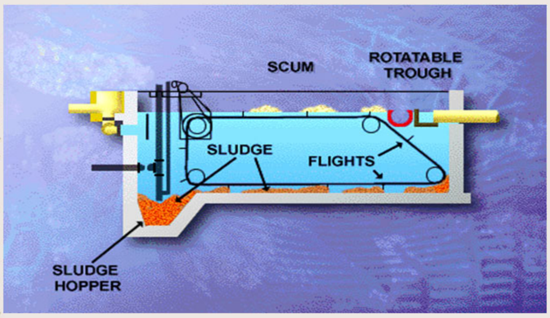
Rectangular Settling Tank



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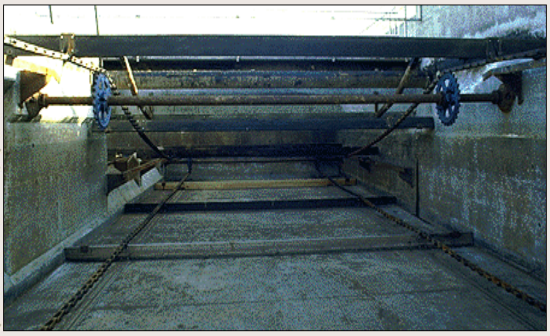
Chains and Flights



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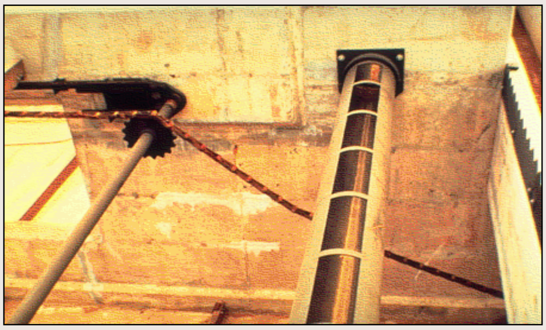
Scum Collection



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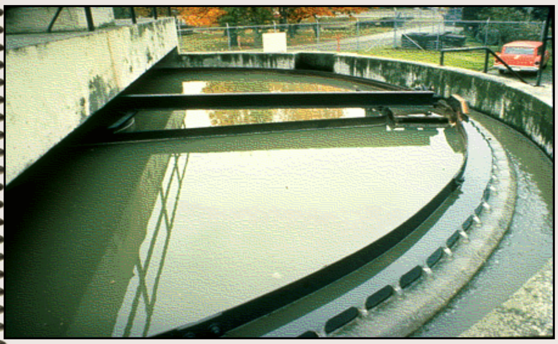
Circular Clarifier



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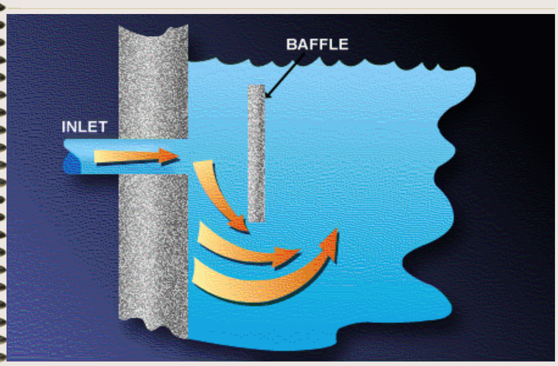
Slow the Flow



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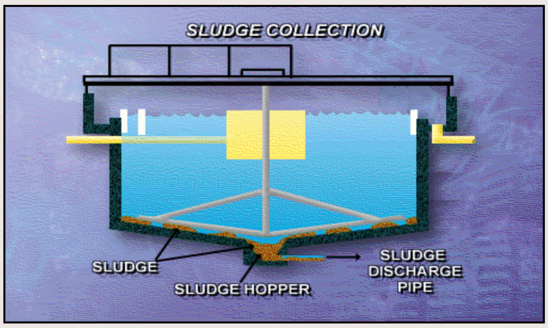
Circular Clarifier



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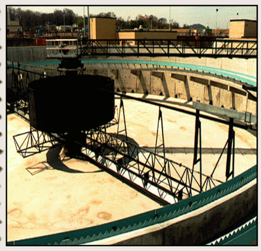
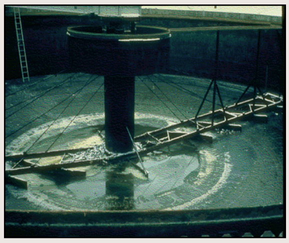
Circular Clarifiers





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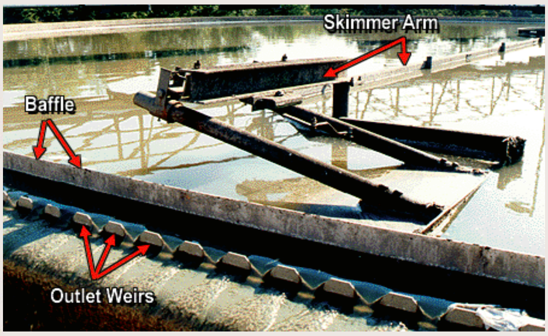
Scum Collection



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Factors Affecting Solids Removal

- Surface oveflow rates
- Detention time
- Tank configuration
- Wastewater characteristics
- Industrial contribution
- Temperature
- Particle characteristics

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Hydraulic Loading Parameters

Surface Overflow Rate

- Tank surface area governs overflow rate
- Overflow rate varies with flow, since tank sizes are fixed
- Range = 800-1000 gal/ft^2/day

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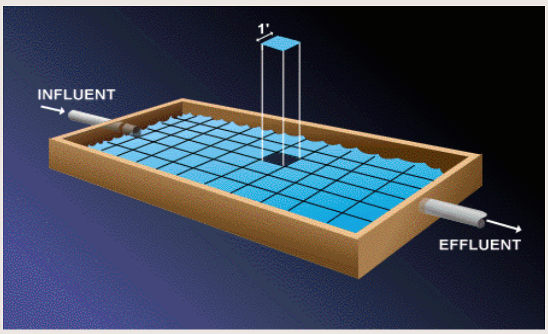
Surface Area, ft^2



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Surface Area

$$\text{Surface area, gpd/sq ft} = \frac{\text{flow, gpd}}{\text{tank surface area, sq. ft.}}$$

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Detention Time

- Time required for a unit of volume to pass entirely through the tank at a given flow rate.
- Should be sufficient to allow nearly complete removal of settleable solids
- Usually 1 to 2 hours

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Detention Time

$$\text{Detention time, hrs} = \frac{\text{tank volume, gal x 24 hours}}{\text{flow, gpd}}$$

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Particle Characteristics

- Dense particles settle faster than light ones
- Particles with large surface area:weight ratio settle slowly
- Irregularly shaped particles settle slowly

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Temperature

- Warm weather increases rate of biological degredation, increasing gasification
- Low viscosity of warm water tends to speed settling
- Cold temps slow settling

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Industrial Wastewater

Industries may contribute:

- Large, short term hydraulic surges
- Short term, high organic loading

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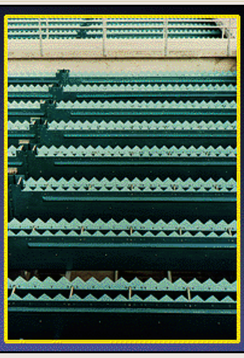
Effluent Weirs



Overflow weirs MUST be perfectly level to ensure good flow distribution and prevent short circuiting.

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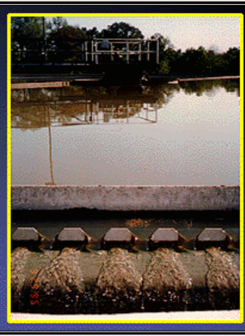
Effluent Weirs



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Primary Sludge Pumping

- Primary sludge should be withdrawn frequently, in small amounts
- Poor sludge pumping practice is most common operational error
- Can lead to septic conditions, high solids loading on secondary treatment units

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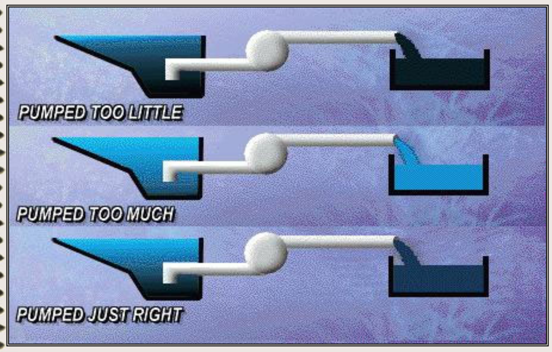
Primary Sludge Pumping



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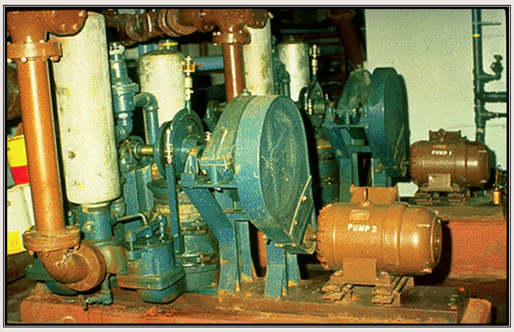
Primary Sludge Pumping



Positive displacement piston pumps

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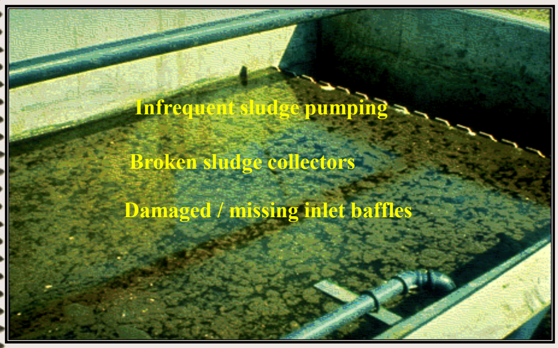
See Any Problems?



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Secondary Treatment

BIOLOGICAL PROCESSES

Rotating Biological Contactors (RBCs)

Trickling Filters

Activated Sludge Processes

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RBCs and Trickling Filters

- Rotating Biological Contactors (RBCs) and Trickling Filters use bacteria that grow on media to treat wastewater
- These processes are located after primary clarifiers

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Rotating Biological Contactor

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Rotating Biological Contactors

- RBC's can be ran in series or parallel

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RBC

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RBC

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Rotating Biological Contactors

- RBC's are designed to rotate approximately 1 rpm
- D.O. is maintained between 1-3 mg/l

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RBC

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RBC Media

- Color of biomass growing on RBC media can indicate operating conditions.
  - White media indicates hydrogen sulfide condition.
  - Black media can indicate septic conditions in tank, or high organic loading.

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Trickling Filters

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Trickling Filters

- Trickling filters use attached growth to treat wastes.
- Zoogleal (bacteria) growth continuously grows and sloughs off media.
- Sloughings flow to secondary clarifier.

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Trickling Filters

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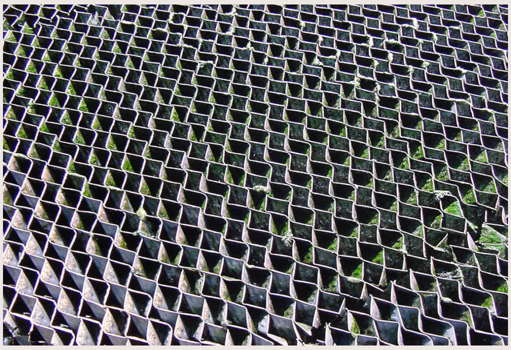
Trickling Filters



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Trickling Filters

- Wastewater is collected in underdrains
- Use rotary distributors or fixed nozzle distributors
- Can use rock or plastic media
- Have vents to allow air circulation

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Trickling Filters

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Trickling Filter Problems

- Ponding
- Filter Flies

Flood the Filter !

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Trickling Filters

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Trickling Filters

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Activated Sludge

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Activated Sludge

Most Common

- Conventional
- Complete Mix
- Step Feed
- Contact Stabilization
- Extended Aeration
- Oxidation Ditch

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Activated Sludge
Conventional Mode

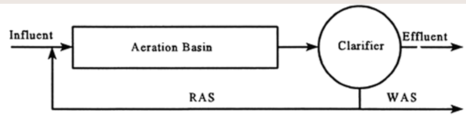

Figure 3-1: Conventional Activated Sludge

Plug flow design; 4-8 hour detention time;
F/M = 0.2-0.5 lb BOD/lb MLVSS;
1000-3000 mg/L MLSS;
5-15 day MCRT

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Activated Sludge
Complete Mix Mode

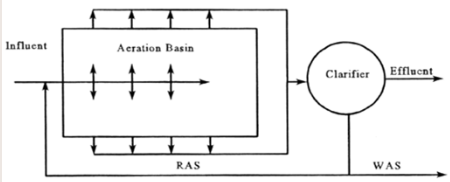

Figure 3-2: Complete Mix Activated Sludge

Not plug flow; 3-5 hour detention time;
F/M = 0.2-0.6 lbs BOD/lb MLVSS;3000-6000mg/L MLSS;
5-15 day MCRT

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Activated Sludge
Step Feed Mode

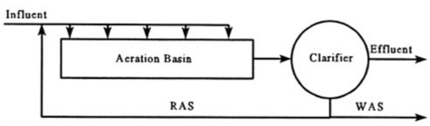

Figure 3-3: Step-feed Activated Sludge

Plug flow; 3-8 hour detention time;
F/M = 0.2-0.5 lbs BOD/lb MLVSS;
2000-3500 mg/L MLSS; 5-15 day MCRT

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Activated Sludge
Contact Stabilization Mode

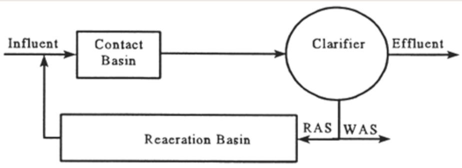

Figure 3-4: Contact Stabilization Activated Sludge

Plug flow pattern; 0.5-1.5 hr Detention time (contact);
F/M = 0.2-0.6 lbs BOD/lb MLVSS; 1000-3000 mg/L MLSS (contact); 5-15 day MCRT

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Activated Sludge
Extended Aeration Mode

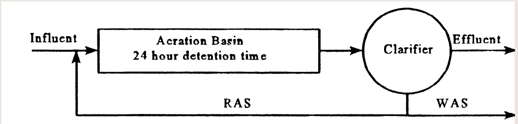

Figure 3-5: Extended Aeration Activated Sludge

Complete mix; 18-30 hour detention time;
F/M = 0.05-0.15 lbs BOD/lb MLVSS; 2000-6000 mg/L MLSS; 20-30 day MCRT

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Oxidation Ditch

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Activated Sludge

Other Modifications:
- Kraus Process
- High Rate
- Pure Oxygen
- Ludzack / Ettinger Process
- Wuhrman Process
- Sequencing Batch Reactor (SBR)
- Bardenpho process

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SBR's of Today




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Principles of SBR Operation

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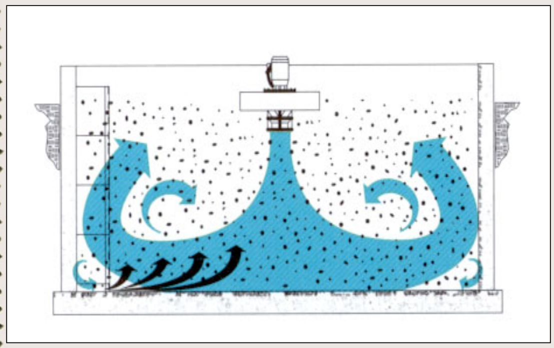
Fill Stage



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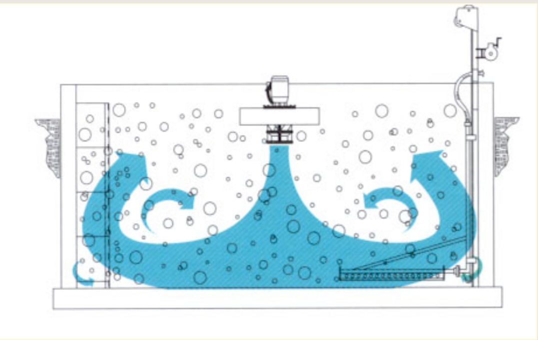
React Stage



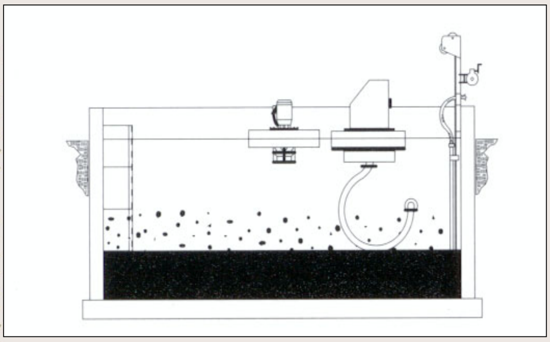
133

React Stage

- Influent flow is terminated
- Mixing and aeration continue
- Intermittent operation of aeration system may continue to complete the nitrification/de-nitrification process or to conserve energy

134

Settle Stage



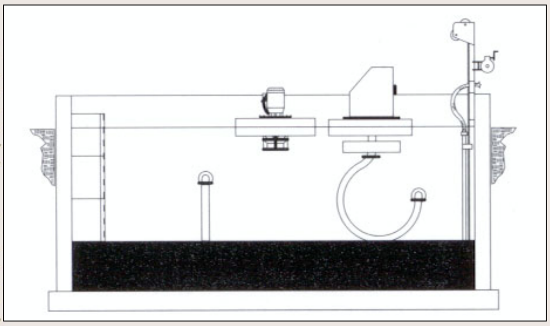
135

Settle Stage

- Mixing and aeration cease
- Solids/liquid separation takes place under quiescent conditions

136

Decant and Sludge Waste



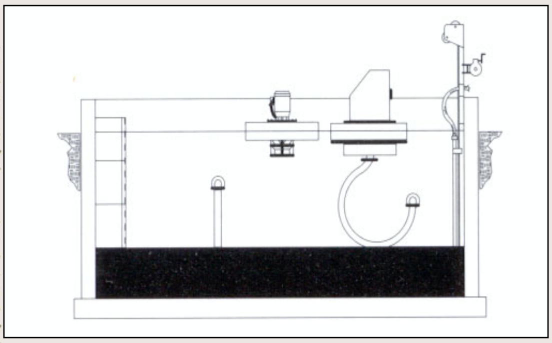
137

Decant and Sludge Waste

- The mixer and aeration remain off
- The decantable volume is removed by means of subsurface withdrawal
- A small amount of sludge is wasted each cycle
- The reactor is immediately available to receive the next batch of raw influent

138

Idle Stage



139

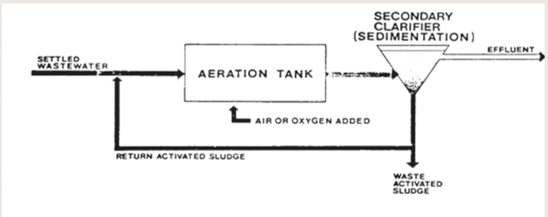
Idle Stage

- Occurs in multi-basin systems anytime that flow conditions are less than peak design flow
- Idle times will vary depending on actual flow conditions

140

Activated Sludge Control Methods

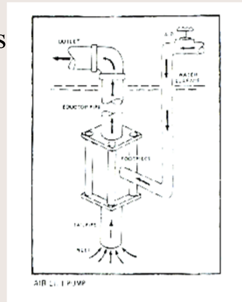
- Return Activated Sludge (RAS)
- Waste Activated Sludge (WAS)
- Dissolved Oxygen (DO)



141

Return Activated Sludge (RAS)

- Return microorganisms back to aeration basins from clarifiers
- Constant Rate
- Flow Percentage Rate



142

Return Sludge Eductor Pipe

- RAS flow can be reduced by rags, thick sludge, sticks, cans, blankets, bicycle rims, tools, bumpers, cinder blocks, buckets, pipes, etc …

If it can fall into the clarifier, it will clog the RAS piping!

143

Waste Activated Sludge (WAS)

The most important control of the activated sludge process

It affects the following:

- Effluent Quality
- Microorganism growth rate
- Oxygen uptake rate
- Settleability rates
- Nitrification rates
- Foaming / frothing

144

Waste Activated Sludge *(Continued)*

- Control Techniques: Constant MLSS/MLVSS F/M ratio, Sludge age (MCRT,SRT)
- Wasting can be intentional or unintentional.
- Wasting can be done from the aeration tank or a portion of the return sludge.
- Make waste changes gradually (10-15% per day) to avoid shock to system.

145

Dissolved Oxygen Requirements

- Aeration serves two purposes:
  1. Provides DO (1-3 mg/l)
  2. Mixes MLSS
- High DO (>5.0) can shear floc, waste energy.
- Low DO (<0.5) can lead to bulking, poor effluent quality.

146

Dissolved Oxygen Requirements

- 1.5 pounds of oxygen are required to convert 1 pound of BOD.
- 4.6 pounds of oxygen are required to convert 1 pound of ammonia.
- 2 approved methods of measuring DO are Winkler method & DO probe.

147

Aeration Methods

- Compressed air / Diffused aeration
  - Centrifugal blowers
  - Positive displacement blowers
- Mechanical aeration
  - Floating aerator
  - Fixed aerator

148

Brush rotors

149

Brush Rotors

150

Brush rotors

151

Diffusers

152

Diffusers

153

Diffusers

154

Activated Sludge Secondary Clarifiers

- Typical Loading Rates:
  - Detention Time - 2 to 3 hours
  - Hydraulic loading - 300 to 1200 gpd/sq.ft.
  - Solids loading - 20 to 30 lbs/day/sq.ft.
  - Weir overflow - 5,000 to 15,000 gpd/ft.

These are relative numbers, clarifiers vary between manufacturer and installation. Also, sludge quality changes these parameters.

155

156

157

158

159

Secondary Clarifiers *(continued)*

Monitor these parameters:

- Sludge levels (25% of total depth)
- MLSS concentrations
- Return sludge flows
- Turbidity of clarifier effluent
- DO in effluent
- Effluent pH

160

Understanding Activated Sludge Parameter Relationships

A look at how process parameters work together

161

Exam Preparation

- Important to know and understand how these parameters relate
- Applies to everyday operation of WWTP
- Simplifies troubleshooting

162

Floc Particles

- *Straggler floc*: As seen in settleometer or clarifier, about the size of half your pinky fingernail.
- Suspended, slow settling
- Large, irregularly-shaped, fluffy
- Young Sludge

163

Floc Particles

- *Pin-Floc:* As seen in settleometer or clarifier, small particles, about the size of a pin head.
- Leaves a turbid, cloudy appearance
- Sludge settles rapidly, rounded shape, grainy appearance
- Old Sludge

164

Foam Characteristics

- Young: White foam produced from low MLSS
- White, billowy, sudsy, crisp
- Large amounts of surfactants, plant start-up

165

Foam Characteristics

- Old: Dark foam produced from high MLSS
- Shiny, dark tan
- Dark and leathery as sludge gets older.
- Influent oil and grease contribute.

166

Indicator Organisms (bugs)

- Young: Amoebae and Flagellates
- Old: Rotifers and Worms
- Predominance of these bugs depends on sludge age

167

MLSS

- Young Sludge: Low mixed liquor
- Reasons
  - Plant start-up
  - Excessive solids washout
  - Excessive wasting
- Solutions
  - Stop or decrease waste rate
  - Control hydraulics through plant

168

MLSS

- Old Sludge: High mixed liquor
- Reasons
  - Poor sludge wasting practices
  - High organic and solids loading
- Solutions
  - Increase wasting
  - Haul sludge more frequently

169

Sludge Age / MCRT

- When MLSS is low, sludge age is young
- Reasons
  - Plant start-up
  - Solids washout
  - Excessive wasting
- Solutions
  - Slow or stop wasting

170

Sludge Age / MCRT

- When MLSS is high, sludge age is old
- Reasons
  - Poor wasting practices
  - Limited digester capacity
  - High organic/solids loading
- Solutions
  - Increase wasting

171

F/M Ratio

Amount of food, in pounds, available to a pound of MLVSS (bugs)

- High: Young Sludge
- Lots of food (CBOD) per pound of MLVSS (bugs)

172

F/M Ratio

Amount of food, in pounds, available to a pound of MLVSS (bugs)

- Low: Old sludge
- Limited amount of food (CBOD) per pound of MLVSS (bugs)

173

Sludge Volume Index (SVI)

- Young: High SVI (>300)
- Reasons
  - Plant start-up
  - Low MLSS
  - Excessive wasting
  - Solids washout

174

Sludge Volume Index (SVI)

- Old: Low SVI (<80)
- Reasons
  - Rapid-settling sludge
  - Small grainy particles

175

Sludge Settleability

- Young sludge: Slow settling
- Reasons
  - Supernate may be cloudy
  - Leaving stragglers
- Solutions
  - Reduce waste rate

176

Sludge Settleability

- Old sludge: Fast settling
- Supernate may be cloudy with pin point floc suspended
- Rapid settling leaves small stuff behind
- Increase sludge waste rate

177

Waste Activated Sludge (WAS)

- The key to controlling the activated sludge process
- Most facilities don't waste sludge properly

178

One more

- One of the most common causes of repeated sludge bulking is a high F/M ratio, low sludge age
- What waste rate change would you make?

179

Activated Sludge Troubleshooting

180

Typical Activated Sludge Problems

- Foams
- Excessive effluent suspended solids
- Excessive effluent BOD/NH_3
- Low effluent pH

181

Foam

182

Foaming Organisms

- Nocardia is hydrophobic and difficult to get rid of!
- Nocardia is the most common *SHORT* filament

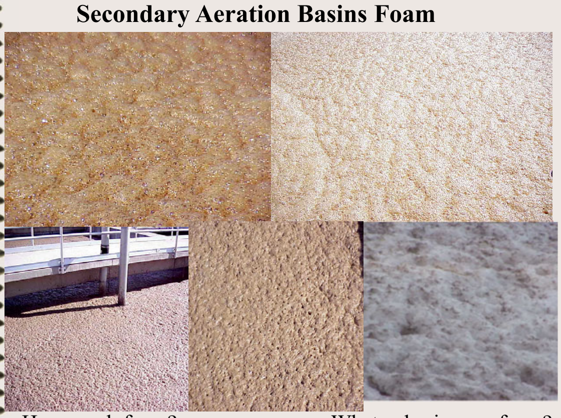
183

Foam Types

- Pumice-like foam
  - Solids return from sludge processing
- Gray, thick, slimy foam
  - Nutrient deficiency
- Dark brown, thick, scummy foam
  - Old sludge, Nocardia

184

Secondary Aeration Basins Foam



How much foam? What color is your foam?

185

Foam Types

- Billowy white foam – Young Sludge
  - Plant start up
  - High surfactant load

186

Foam Types

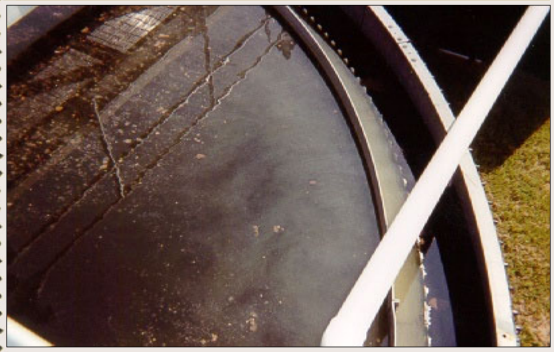
- Dark Brown, 'leathery' thick scummy foam
- High MCRT, low F/M Ratio, high MLSS
- Old sludge

187

188

189

Excess Effluent TSS



190

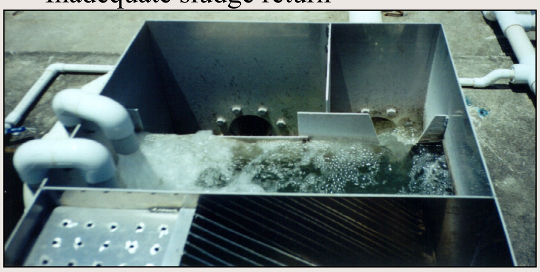
Blanket Washout

- Controllable settling ?
- Uncontrollable settling ?

191

Controllable Settling

- Hydraulic overload
- Inadequate sludge return



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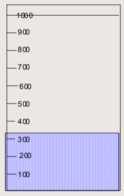
193

Controllable Settling

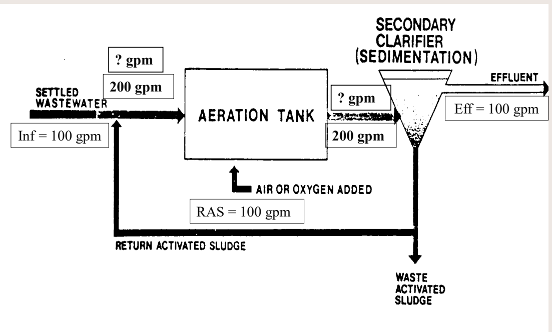


100 % MLSS

Good settling in an undiluted sample, but washout in clarifier, indicates hydraulic overload.

194

Controllable Settling



195

Diluted Settleability

- A modification of the settleability test
- Uses different dilutions to simulate how sludge would settle if some of the solids were wasted

196

Diluted Settleability

- Use clarifier effluent water for dilutions
- Don’t use the garden hose laying at the plant for dilution water
- Keep conditions consistent with actual operation

197

198

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200

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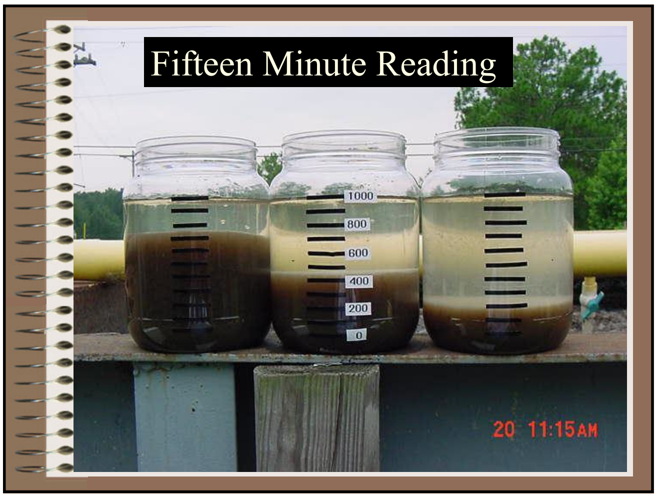

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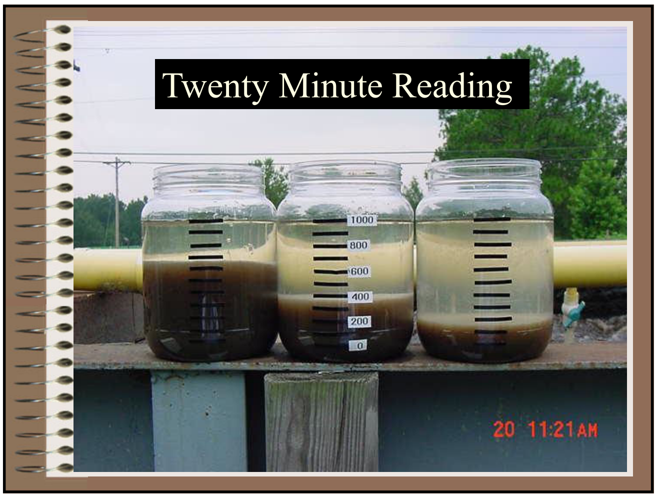

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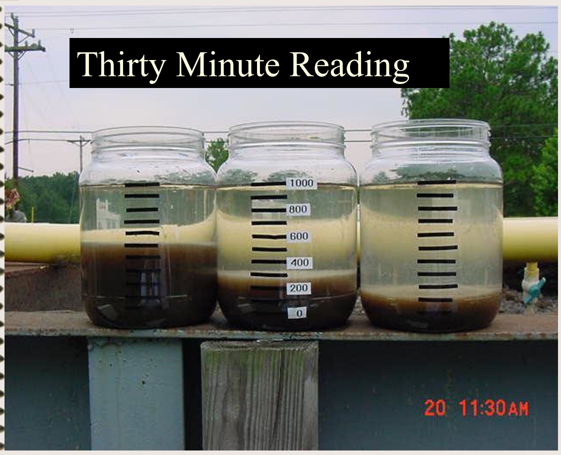
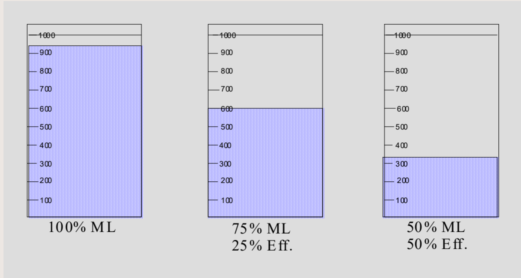


205

Good Settling with Diluted Settleometer



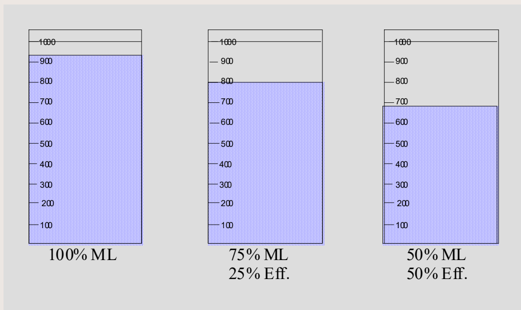
206

Good Settling with Diluted Settleometer

- Excess old sludge
- Glutted system
- Increase waste rates

207

Poor Settling with Diluted Settleometer



208

Poor Settling with Diluted Settleometer

- Slime Bulking
- Filamentous sludge (True Bulking)

209

Excess Effluent TSS

- Pop ups can wash out over weirs
- Reasons
  - Denitrification in clarifier
  - Septic sludge in clarifier

210

Excess Effluent TSS

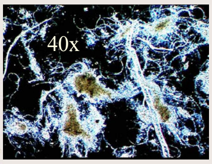
211

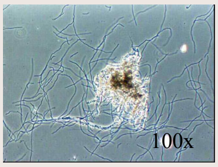
Filamentous

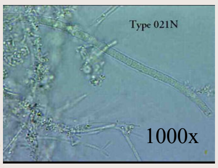
- Low DO
- Low F/M
- Nutrient deficiency
- Sulfides
- Readily metabolized substrate
- Slowly metabolized substrate
- Surface seeding

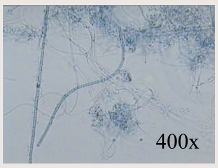
212

Magnification







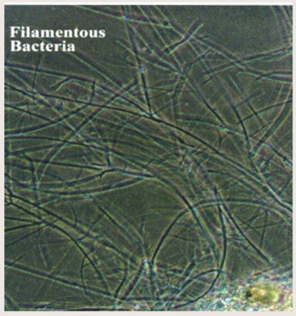


213

Filamentous

Low DO promotes low DO filaments:

1) Type 1701
2) *S. Natans*
3) *H. Hydrossis*
4) *M. Parvicella*



214

Individual Particle Washout

215

Individual Particle Washout

- Pin-floc
- Straggler floc
- Individual bacterial cells

216

Pin-floc

- High MCRT / Low F/M Ratio
  - Highly underloaded plant
  - Clarifier denitrification
- Solids recycle from solids processing
- Very small particles, about the size of a pin head

217

Pin-floc

- Pin floc can lead to 'ashing' on the surface of clarifiers
- MLSS getting high, sludge getting old
- Increase wasting

218

219

Straggler Floc

- Associated with Low MCRT or High F/M Ratio
- Filamentous
- Non-filamentous
- Larger particles, about the size of a half fingernail

220

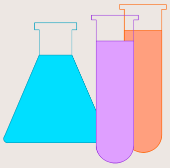
221

How Does Your WWTP Work?

222

Chemical Requirement for Treatment

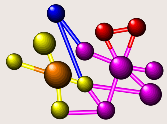
- DO, NO_3
- pH
- Alkalinity
- Nutrients



223

Nutrients

- Carbon
- Nitrogen
- Phosphorus
- Trace minerals



224

Ratio

BOD: Nitrogen: Phosphorus: Iron

100: 5: 1: 0.5

225

Types of Bugs, Critters & Microorganisms in *your* WWTP

- Bacteria
- Protozoa
- Metazoa
- Algae
- Fleas?
- Bears?!?

226

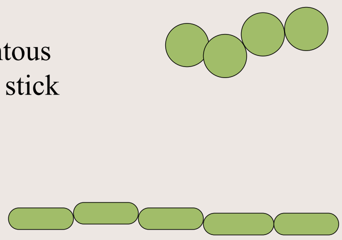
Bacteria: *The Workhorses of Treatment*

- Floc-forming (stick together)
- Filamentous (backbone of floc)
- Heterotrophic (utilize *organic* carbon)
- Autotrophic (utilize *inorganic* carbon)
- Aerobic (free dissolved oxygen)
- Anaerobic (fermentation)
- Facultative (free DO or bound Oxygen - NO_3 , SO_4)

227

Floc-Forming

- Non-filamentous bacteria that stick together



228

Filamentous Bacteria

- Form backbone of good floc
- Excessive filaments can cause a bulking sludge and settling problems

229

Heterotrophic Bacteria

- Carbon source is organic – BOD
- Fast growing under proper conditions
- Facultative - function with free DO or bound oxygen (NO_3, SO_4)

230

Autotrophic Bacteria

- Carbon source is inorganic - carbonate and carbon dioxide
- Slow growing
- Require O_2 as an electron acceptor

231

Environments

- Aerobic - Free dissolved oxygen present
- Anoxic - No free dissolved oxygen present, but nitrate present
- Anaerobic - No free dissolved oxygen or nitrate present

232

Facultative Bacteria

- Can reproduce under aerobic or anoxic conditions
- Can utilize free dissolved oxygen or bound oxygen (nitrate)
- Will utilize free dissolved oxygen first

233

The Indicator Organisms

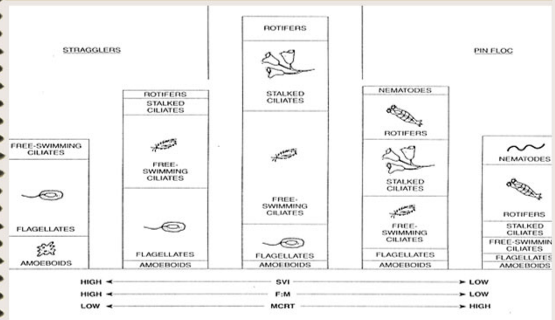


Fig. 11.38 Population predominance vs. operational guidelines (Bar graph taken from EPA PROCESS CONTROL MANUAL FOR AEROBIC BIOLOGICAL WASTEWATER TREATMENT FACILITIES, 1977)

234

Indicator Organisms

- While bacteria are performing the actual work of BOD and TSS reduction, we use certain protozoans as *indicators* to determine the degree of treatment.
  - Amoebae
  - Flagellates
  - Free Swimming Ciliates
  - Stalked Ciliates
  - Suctoria

235

Amoebae

- No distinct shape, since flow of cytoplasm continually changes shape
- Feed on bacteria and protozoa
- Found during plant start-up or toxic overload
- Poor biomass health when amoeba predominate
- Indicate young sludge

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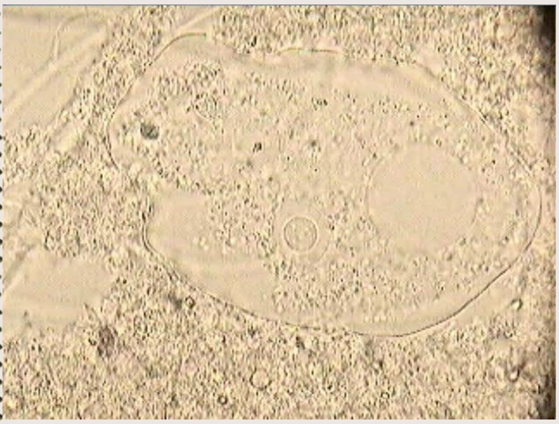

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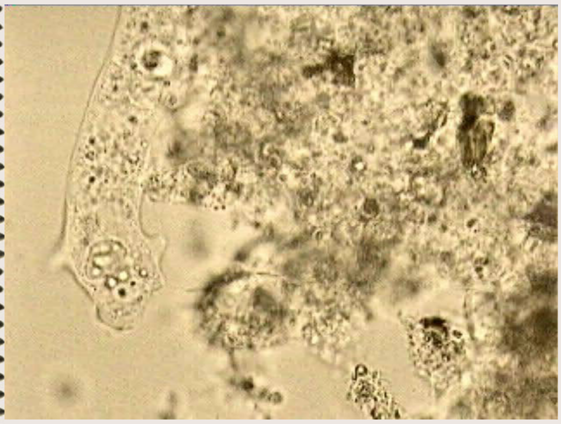

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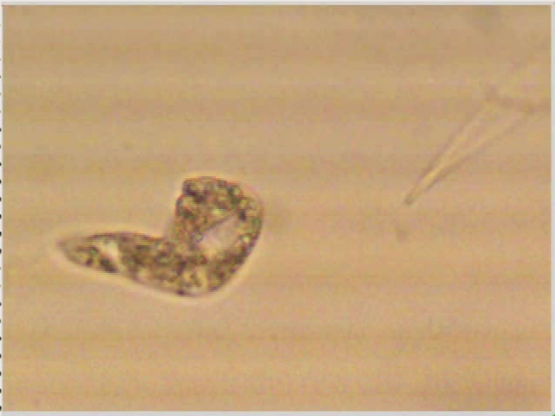
Flagellated Protozoa

- Use a flagellum (whip-like tail) for locomotion
- Present during start-up or plant upset
- Feed on specific strains of bacteria
- Indicate young sludge
- High energy requirement
- Elevated CBOD in effluent

240



241

Free Swimming Ciliates

- Present during start-up or plant upset
- Bulk Liquid - *Have large 'mouths' to collect food in liquid, high energy requirements, higher BOD*
- Crawler - *Smaller 'mouths', crawls over floc to scrape bacteria off, less energy required, decreasing BOD*
- Carnivorous - *BOD limited, specialized diets, least amount of energy used*



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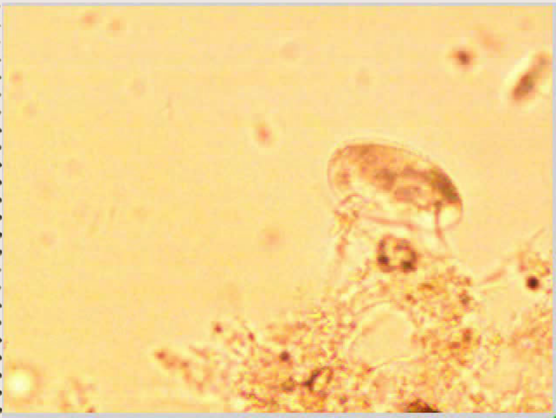

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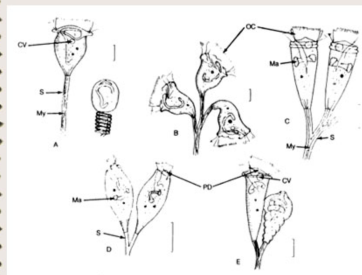
Stalked Ciliates

- Inverted bell shaped bodies mounted on a stalk which is attached to a substratum
- Conspicuous oral cililiation located in the oral region of the body
- Low energy requirements, BOD reduced, improves effluent quality

245

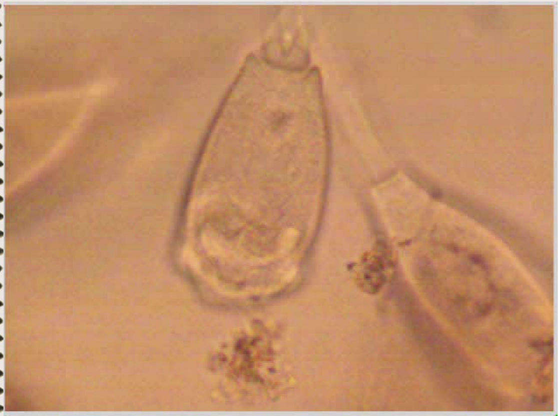
Stalked Ciliates



A Vorticella
B Carchesium
C Zoothanmium
D Opercularia
E Epistylis

246

247



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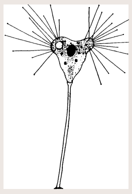
Suctoria

- Carnivorous protozoa
- Has hollow tentacles
- Feeds on small protozoa and bacteria
- Remains motionless
- Little energy exerted



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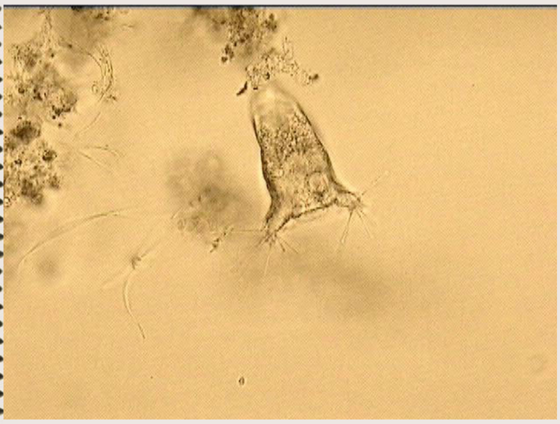

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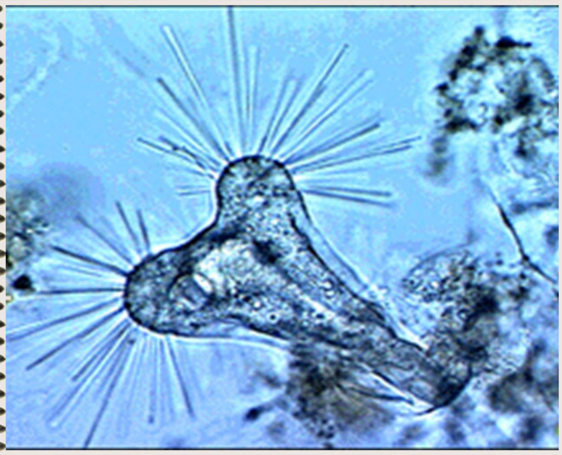

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Metazoa

As with the protozoans, we use these Metazoans to indicate process stability and age.

- Rotifer
- Nematode
- Copepod
- Water mites
- Ostracod (seed shrimp)
- Tardigrade (water bear)
- Water fleas (Ceriodaphnia)
- Annelid (bristle worm)

253

Rotifers

- Feed on bacteria and small protozoans
- Cilia on head resemble wheels
- Help keep bacterial population healthy
- Secrete mucus which aids in floc formation
- Strict aerobes
- Indicate process stability

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Rotifers

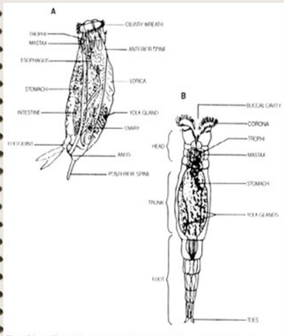
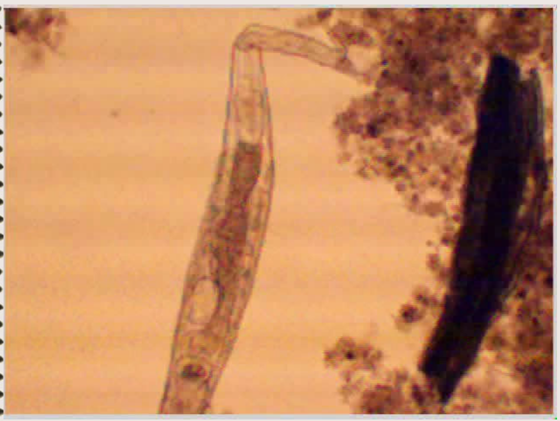


Figure 5.1 (A) Typical Monogononta rotifer; (B) Typical Digononta (bdelloid) rotifer.

- The phylum Rotifera is divided into two classes:
  - Monogononta
  - Digononta
- Rotifers range in size from 40 to 500 microns and have an average life of 6 to 45 days

255



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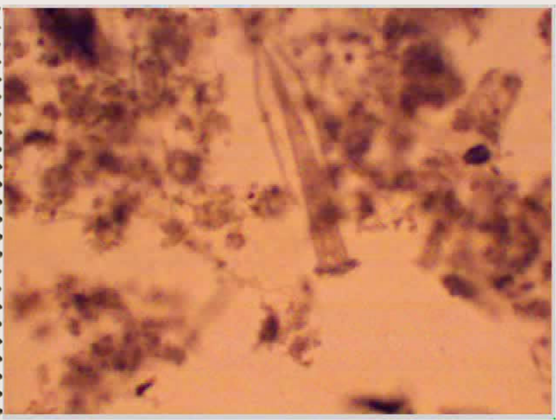

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Nematodes

- Infest soils
- Common in trickling filters and RBC's
- Indicate old, over-oxidized sludge
- Will eat protozoans, rotifers and decaying plant and animal matter
- Whip-like motion may cause floc to break-up

259

260

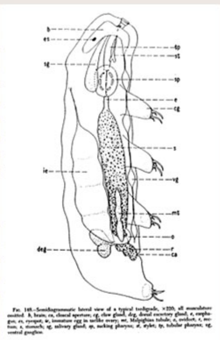
261

Tardigrades (Water Bears)

- Uncommon in most activated sludge systems
- Common in extended aeration systems
- Shed skin several times during lifetime
- Very sensitive to ammonia and other toxic substances
- Indicate a stable, well nitrified effluent

262

Tardigrades (Water Bears)



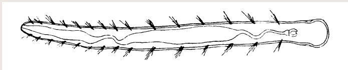
- Tardigrades are preyed upon by amoeboid protozoans, nematodes and each other.
- They have been discovered in lake bottoms 100 meters deep to mountain tops 6,000 meters high.

263

264

Annelids (Aeolosoma Worms)

- AKA Bristleworms
  - These aquatic earthworms feed on about anything including the MLSS solids used for secondary treatment. These can sometimes be seen as a red tint laying on the surface of the sludge blanket in a settleometer.



265

266

Other Metozoans

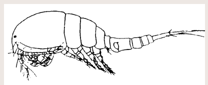
- Some other types of Metozoans are:
  - Ostracods
  - Copepods

Water Mites
Water Fleas

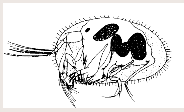
- These organisms are rare in activated sludge systems, but may be found in lagoon systems. If found in your system, they would indicate a stabile, non-toxic environment.

267

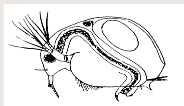
Other Metozoans



Copepod



Ostracod



Ceriodaphnia

268

How Do The Bacteria Eat?

- Adsorption
- Absorption
- Exocellular Digestion

269

Adsorption/Absorption

- Adsorption
  - Organisms contact and stick to food particles.
- Absorption
  - Dissolved nutrients are brought into the cell
  - Used for various growth and reproductive activities

270

Exocellular Digestion

- Exocellular Digestion
  - Organisms secrete enzymes though cell walls
  - Enzymes begin dissolving the adsorped food
  - These enzymes aid in floc formation

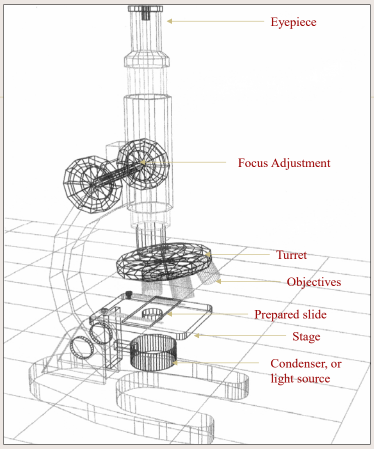
271

Microscopes

Types of microscopes:

- Compound
- Dark field
- Phase Contrast
- Interference contrast
- Electron
- Fluorescent microscopy

272



273

Summary Q & A

- Who are the "workhorses of treatment"?
- We call protozoans "_____" organisms.
- What organism has hollow tentacles?
- What is the "wheeled animal"?

274

Summary Q & A

- Who are the "workhorses of treatment"?
  - *Bacteria*
- We call protozoans "_____" organisms.
- What organism has hollow tentacles?
- What is the "wheeled animal"?

275

Summary Q & A

- Who are the "workhorses of treatment"?
  - *Bacteria*
- We call protozoans "_____" organisms.
  - *Indicator*
- What organism has hollow tentacles?
- What is the "wheeled animal"?

276

Summary Q & A

- Who are the "workhorses of treatment"?
  - *Bacteria*
- We call protozoans "_____" organisms.
  - *Indicator*
- What organism has hollow tentacles?
  - *Suctoria*
- What is the "wheeled animal"?

277

Summary Q & A

- Who are the "workhorses of treatment"?
  - *Bacteria*
- We call protozoans "_____" organisms.
  - *Indicator*
- What organism has hollow tentacles?
  - *Suctoria*
- What is the "wheeled animal"?
  - *Rotifer*

278

Summary Q & A

- Organisms contact and stick to food particles by ______.
- Enzymes producing and secreting to breakdown food particles is called ______?
- Dissolved nutrients are brought into cell by ______.

279

Summary Q & A

- Organisms contact and stick to food particles by ______. *Adsorption*
- Enzymes producing and secreting to breakdown food particles is called ______?
- Dissolved nutrients are brought into cell by ______.

280

Summary Q & A

- Organisms contact and stick to food particles by ______. *Adsorption*
- Enzymes producing and secreting to breakdown food particles is called ______? *Exocellular Digestion*
- Dissolved nutrients are brought into cell by ______.

281

Summary Q & A

- Organisms contact and stick to food particles by ______. *Adsorption*
- Enzymes producing and secreting to breakdown food particles is called ______? *Exocellular Digestion*
- Dissolved nutrients are brought into cell by ______. *Absorption*

282

DISINFECTION

283

Disinfection

- Disinfection - destroys pathogenic organisms
- Sterilization - destroys all organisms

284

Purpose of Disinfection

- Protect human beings and other animals from disease-causing pathogens
- These pathogens will threaten the quality of drinking water supplies, water-contact recreation areas and shellfish-growing areas

285

Disinfection Agents

- Heat energy
- Radiant energy – UV
- Chemical Agents

286

Choosing a Disinfectant

- Process should be
  - economical
  - operationally practical
  - reliable
  - environmentally acceptable

287

UV Disinfection

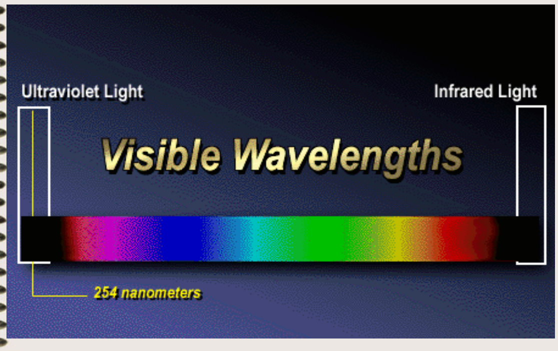
- High initial capital costs
- High O&M costs
- Must have low effluent TSS
- No residual to measure

288

UV equipment

289

Light Spectrum



290

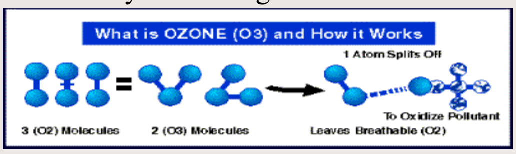
Chemical Agents

- Chlorine Gas or Liquid (Cl_2)
- Sodium or Calcium Hypochlorite
- Ozone (O_3)
- Chlorine Dioxide
- Paracetic Acid

291

Ozone

- Unable to measure residual
- Requires on-site generation
- Utilizes sensitive equipment which requires careful monitoring
- Instability - no storage



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Chlorine Dioxide

- Used to replace both Chlorine and Sulfur Dioxide in wastewater
- No disinfection by products

293

Paracetic Acid

- Requires shorter contact time
- Replaces Chlorine and Sulfur Dioxide
- No disinfection by products
- Currently under review for NSF certification for water.
- St. Augustine WWTP a 5 MGD plant

294

Choosing Chlorination

- Relatively low dosages
- Simple feed and control procedures
- Low cost compared to other substances

295

Chlorine in the United States

- Low cost can be contributed to the large total production of chlorine in the U.S.
- Water and Wastewater facilities use about 5% of total chlorine produced

296

Chlorine Disadvantages

- Lasting toxic effect on aquatic life
- Toxic effect on human life
- Regulatory agencies placing tightening restrictions on storage and use (Risk management plan req'd for 2500 lbs)

297

Chlorine

- Liquid/gas chlorine (Cl_2) - pressurized containers that keep the chlorine in a liquid state
- Calcium hypochlorite [$Ca(OCL)_2$] - white powder
- Sodium hypochlorite (bleach) (NaOCL) - a pale yellow liquid

298

Physical and Chemical Properties

- Under normal atmospheric pressure at room temperature, chlorine is a yellow-green gas
- 2.5 times heavier than air
- Chlorine gas becomes a liquid at - 30º F
- Liquid to gas expansion ratio=460:1

299

Physical and Chemical Properties

- Dry gaseous or liquid chlorine (less than 150 mg/L moisture) is 100% available chlorine
- Calcium hypochlorite 65 to 75% available chlorine

300

Physical and Chemical Properties

- Sodium hypochlorite is normally a 15% solution or 15% available chlorine - each 100 mL contain 15 grams of available chlorine or 150 g/L or 150,000 mg/L of available chlorine

301

Hazard

- Chlorine gas/liquid - extremely hazardous substance
- Calcium hypochlorite and sodium hypochlorite - hazardous substance
- Disinfection agents kill living organisms and tissue

302

Chlorination Methods

- Gas chlorination
- Liquid chlorination
- Hypochlorination

303

Chlorination Effectiveness

- Chlorine concentration and type
- Effluent pH
- Effluent temperature
- Contact time
- Effluent suspended solids

304

Reactions with Water

- When chlorine gas/liquid, sodium hypochlorite or calcium hypochlorite are added to water, hypochlorous (HOCl) or hydrochloric (HCl) acid is formed
- Higher pH makes Cl2 less effective

305

The Effect of Temperature on Disinfection Efficiency

- Disinfection happens quicker at higher water temperatures.
- However, disinfection strength is reduced at higher temperatures.

306

Contact Time

- Contact time is in many cases more important than dose
- For basic disinfection the State of Florida requires a minimum total chlorine residual of 0.5 mg/L after 15 minutes contact time at Peak Hourly Flow

307

Effluent Suspended Solids

- Effluent suspended solids normally consist of small nonsettleable or colloidal solids or settleable solids which have been hydraulically discharged
- Flocs consist of bacteria - some of these bacteria may be in the fecal coliform group or pathogenic
- The disinfectant may not penetrate the floc particle and may result in incomplete disinfection

308

Chlorine Demand

- Reducing agents (H_2S)
- Organic material
- Inorganic metals - Fe and Mn
- Nitrite (5:1 ratio)
- All react with chlorine and reduce it to the chloride ion
- No chlorine residual is realized

309

Forms of Chlorine

- Cl_2 existing in forms of hypochlorous acid and hypochlorite ion are defined as *free available chlorine*

310

Reactions of Hypochlorous acid with Ammonia

NH_3 + HOCl > NH_2Cl (monochloramine) + H_20

NH_2Cl + HOCl > NHCl2 (dichloramine) + H_20

NHCl2 + HOCl > NCl3 (nitrogen trichloride) + H_20

311

Formation of Combined Chlorine

- Monochloramine (NH_2Cl)
- Dichloramine ($NHCl_2$)
- Trichloramine (NCl_3)

312

Chlorine Residual

- Free Chlorine - aqueous chlorine, hypochlorite ion and hypochlorous ion
- Combined Chlorine - compounds formed by reactions of hypochlorous acid and ammonia (chloramines)
- Total Chlorine - sum of free and combined chlorine

313

Chlorine Relationships

- Chlorine Residual =

  Chlorine Dose - Chlorine Demand

314

Chlorine Demand

- The amount of chlorine that is not available because of side reactions
- The difference between chlorine dosage and chlorine residual

315

Feed Rate and Dosage

- Feed Rate - lb/day of Cl_2 applied
- Chlorine dose - the amount of chlorine that is added to the effluent
- Chlorine – expressed in mg/L

316

Chlorine Dosage (mg/L)

- Chlorine Dosage (mg/L) =

$$\frac{\text{Feed Rate (lb/day)}}{\text{Eff Flow, MGD} \times 8.34 \text{ lb/gal}}$$

317

Typical Chlorine Dosages *Wastewater*

- Trickling Filters - 3 to 10 mg/L
- Activated Sludge - 2 to 8 mg/L

318

Maximum Draw-Off Rates

150 lb cylinders - approximately 40 lbs/day

1-ton containers - approximately 400 lbs/day

- Temperature of remaining chlorine decreases as the rate of withdrawal increases
- When temperature of chlorine is low enough it will not evaporate

319

Chlorine Use Limit

- 40 lb/day from each 150-lb cylinder
- 400 lb/day from each 1-ton container
- Temperature of remaining chlorine decreases as the rate of withdrawal increases
- When temperature of chlorine is low enough it will not evaporate

320

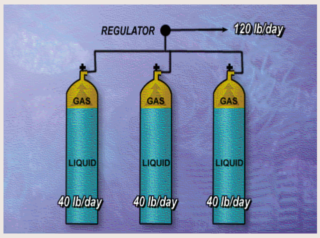
What happens when we try to feed more than these limits

CHLORINE ICING

321

Prevent Chlorine Icing

- When attempting to feed more than the allowable amount from any container, manifolding is required



322

Checks on Effectiveness

- Chlorine residual analysis - residual after a minimum contact time (i.e. for basic disinfection, 0.5 mg/L total chlorine residual after 15 minutes contact time at peak hourly flow)
- Concentration of Fecal Coliform Organisms
  - MPN -most probable number method
  - MF -membrane filter method

323

Effect on Treatment

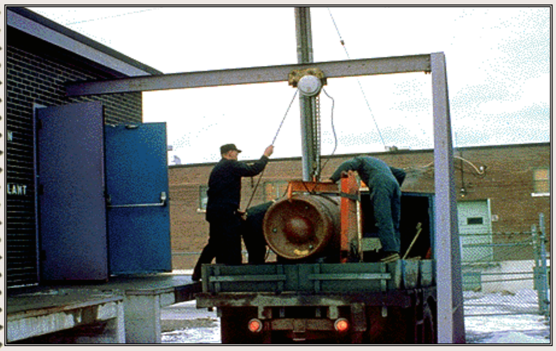
- Disinfection
- Oxidizes solids further reducing BOD
- Oxidation of ammonia-N

324

A Look at Chlorine Equipment

325

Hoisting a 1-Ton Container



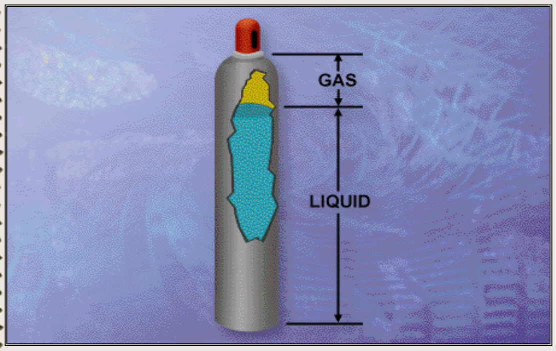
326

Chlorine Cylinders

- Fusible Plugs—designed to melt at 158-165 deg F.
- 6 Plugs on a ton cylinder
- 1 on a 150 lb cylinder

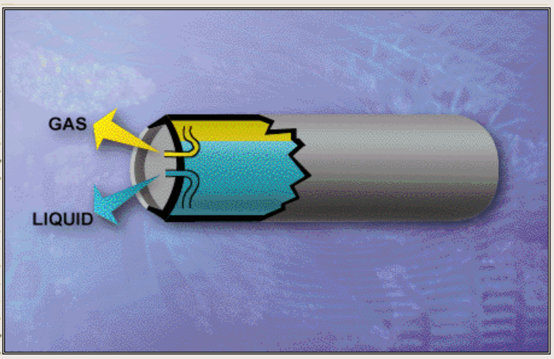
327

150 lb Chlorine Container



328

1-Ton Chlorine Container



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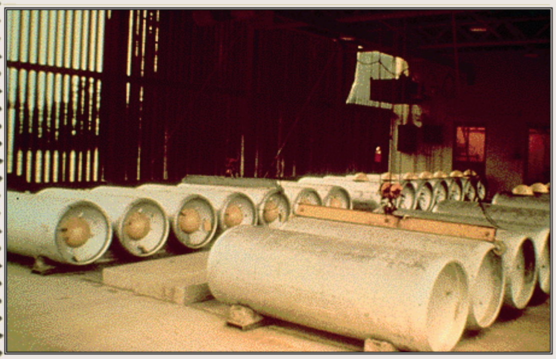
Ton Container Storage



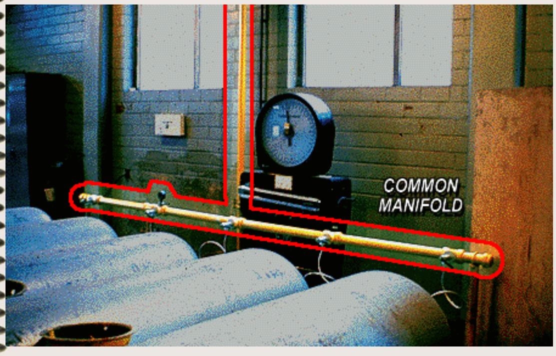
330

Chlorine Storage

- Storage is limited to 2500 pounds at one site
- If exceeded a Risk Management Plan is required

331

Manifolding More Than One

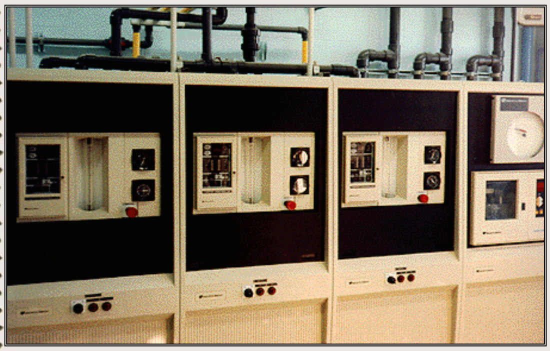


332

Chlorine Weights

333

Chlorine Feed Equipment



334

Disinfection Systems

Safety Hazards

335

Chlorine Safety

336

Detecting a Chlorine Leak

337

Effects of Chlorine on Humans

- Chlorine Concentrations

- 1 mg/l detectable by smell
  2-3 mg/L considered health haz
  25 mg/l immediate life hazard
- 1000 mg/l rapidly kills

338

Safe Handling of 1-Tons

339

Sludge Digestion

Principles of Operation

Troubleshooting and Correcting Problems

340

Purposes of Digestion

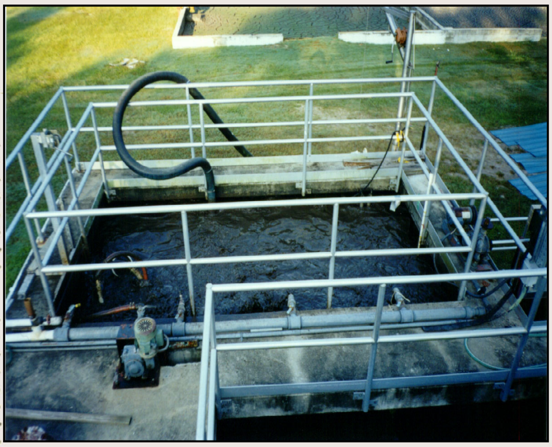
- Protect public health and the environment
  - Primary and secondary sludge both contain large amounts of biodegradable material, which must be stabilized before final disposal.
  - Digestion stabilizes biodegradable solids concentrated from wastewater.

341

Purposes of Digestion

- Protect public health and the environment *(continued)*
  - Reduces possibility of sludge becoming a food source and breeding ground for disease-causing insects and rodents (vectors).
  - Makes sludge relatively inert, reduces odor and bacteria.

342



343

Purposes of Digestion

- Reduces cost of disposal
  - Digestion reduces volume and weight of sludge

344

Aerobic Sludge Digestion

345

Aerobic Sludge Digestion

- Operates under Endogenous Respiration principle, similar to extended aeration.
- Sludge is aerated until volatile suspended solids are reduced to stable level, readily dewaters and does not create nuisance odors.
- "Digests" waste activated sludge, primary sludge and clarifier skimmings.

346

Aerobic Sludge Digestion

- Most common method of sludge digestion in Florida
- High Operating Costs (Energy)
- Easy operation
- No special training required by operators
- Covered in colder climates (Keep heat in)

347

Aerobic Sludge Digestion

- Supernating / Decanting
  - Aeration is ceased, sludge allowed to settle
  - Clear liquid (supernate) is drawn off, sent to aeration tank or head of plant
  - Aeration is restarted
  - Waste more sludge
  - Repeat process until sludge will not settle then haul sludge

348

349

350

Aerobic Sludge Digestion

- Operational Controls
  - DO should be maintained at 1.0 to 2.0 mg/L
  - pH should be around 7.0
  - Monitor waste sludge flow and digested sludge withdrawal rates
  - Reduce aeration after sludge is withdrawn to prevent over aeration that leads to foaming

351

Aerobic Sludge Digestion

- Operational Concerns
  - Supernatant is usually high in nitrate.
    - Return aerobic digester supernatant during day time flow
  - A drop in digester pH usually indicates an increase in nitrification.
  - May be accompanied by large amounts of foaming and high DO levels.
    - Try reducing DO in digester, and/or add lime or sodium hydroxide to raise pH.

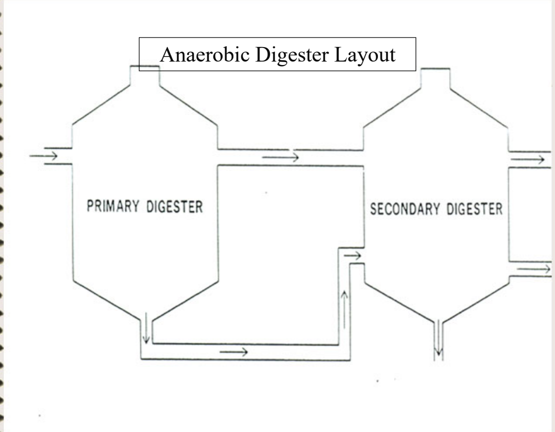
352

353

354

Anaerobic Sludge Digestion

355



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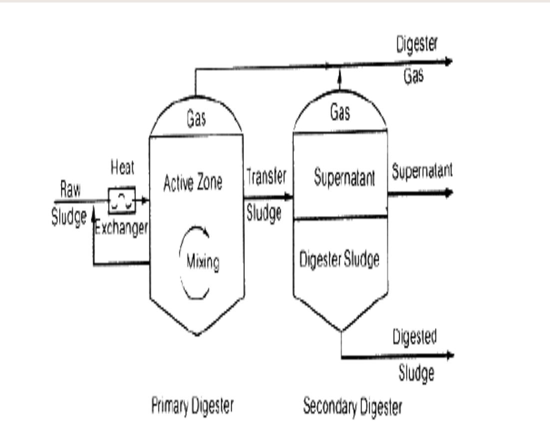


357

Anaerobic Sludge Digestion

A multistage process

- Anaerobic digestion is accomplished in two stages …

358

Stage One

- Complex organics, cellulose, proteins and lipids are broken down into soluble (liquid) forms.
- These forms include organic fatty acids, alcohols, carbon dioxide and ammonia.

359

Stage One

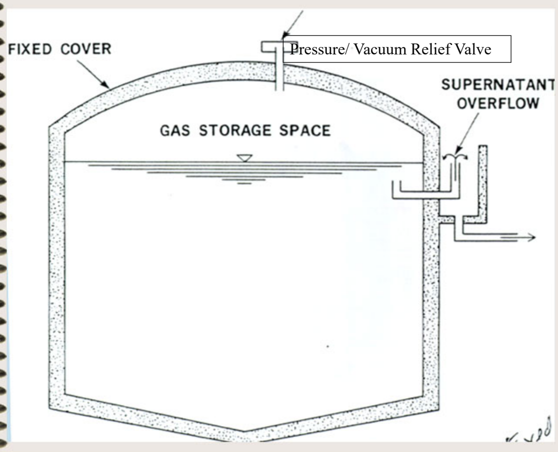
- Products of the first stage are converted to acetic acid, propionic acid, hydrogen, carbon dioxide and other organic acids.
- Microorganisms responsible for these conversions are referred to as acid formers (acetogenic bacteria).
- Acid formation phase

360

Stage Two

- Two groups of methane-forming bacteria begin work.
  - First group converts hydrogen and carbon dioxide to methane.
  - Second group converts acetate to methane and bicarbonate.
  - Methane formation phase

361



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Fixed Cover Anaerobic Digester

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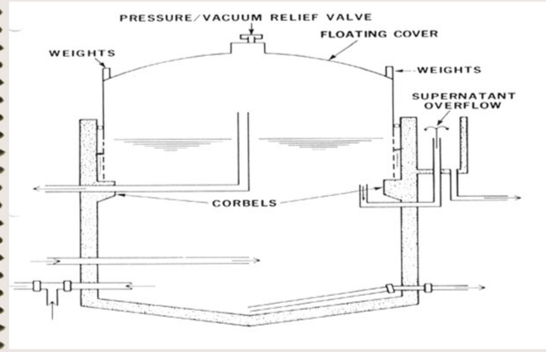
Floating Cover Digester



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Floating Cover Anaerobic Digester

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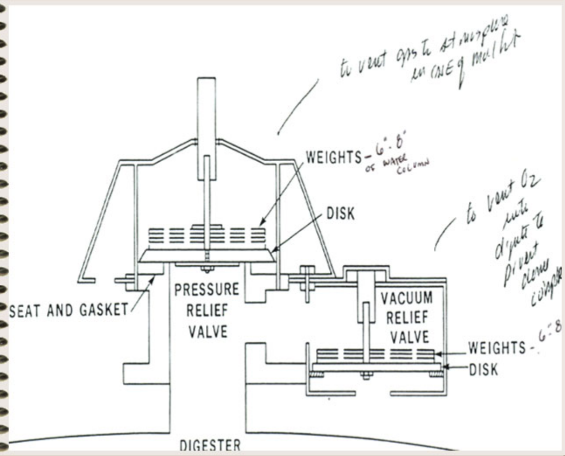

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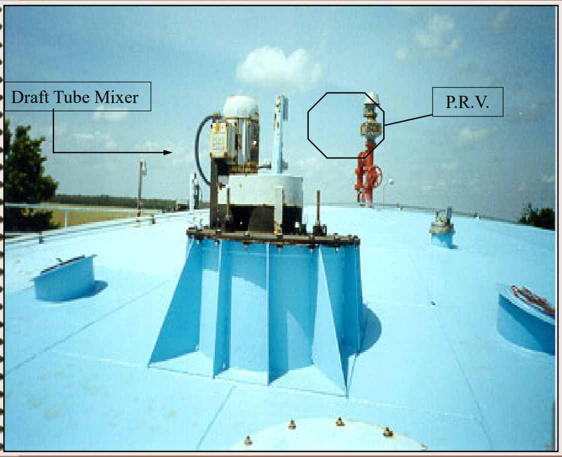

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Anaerobic Sludge Digestion

- Digester Mixing
  - Mixing serves three purposes:
    - Keeps solids in suspension
    - Keeps grit from accumulating and scum layer from forming
    - Keeps sludge temperature uniform
    - Mesophlic 85-105 Fahrenheit
    - Thermophlic 110-125 Fahrenheit

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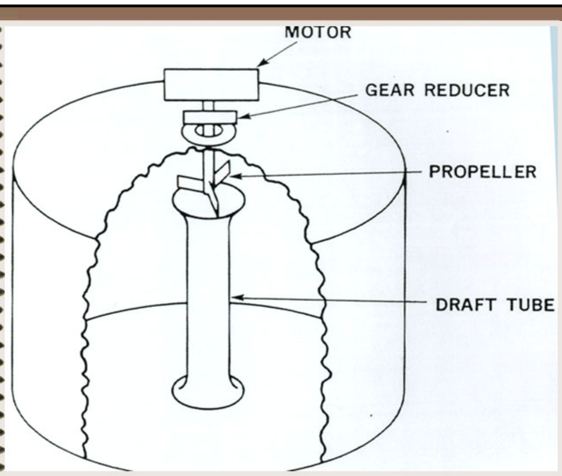

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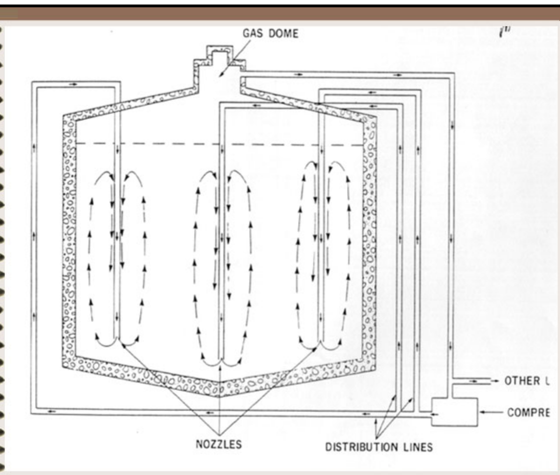

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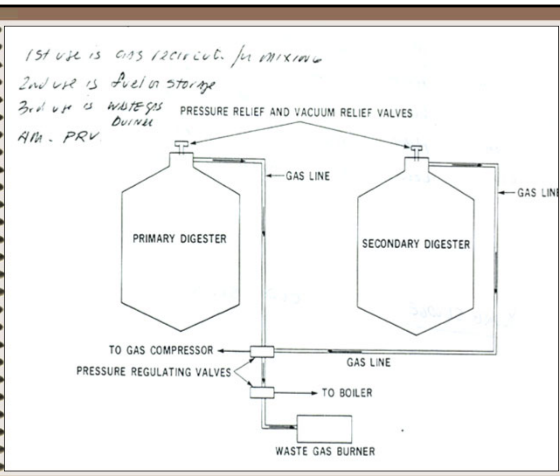

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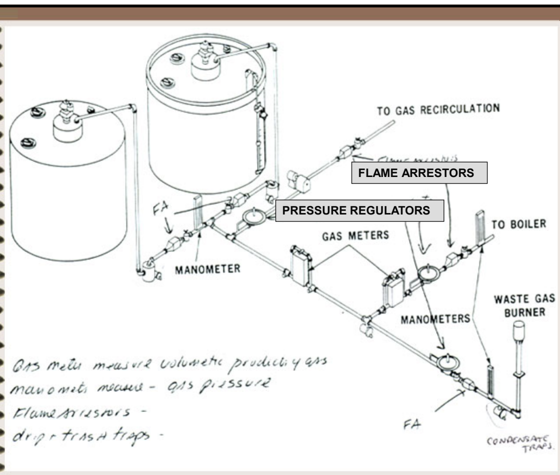

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Methane Gas Piping

373

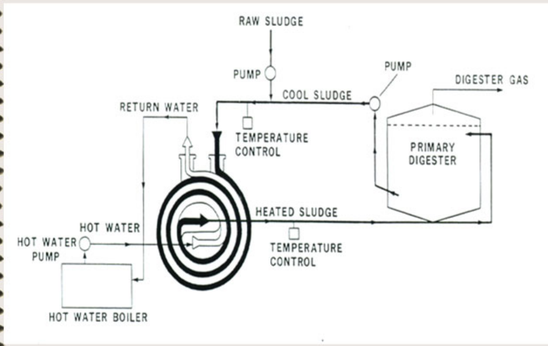
Methane Gas Piping

374

Methane Condensate Trap

375

Digester Sludge Heating



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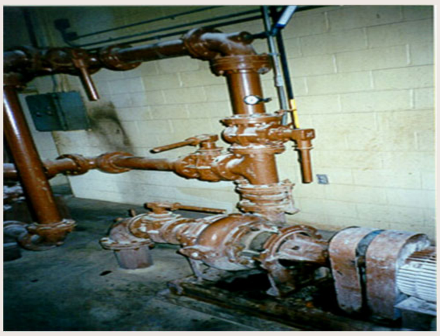
Sludge Heat Exchanger

377

Sludge Heat Exchanger

378

Sludge Recirculating Pump



379

Methane-Fueled Boiler

380

Digester Sludge Transfer Pumps

381

Sludge and Supernatant Ports

382

Anaerobic Sludge Digestion

- Operational Controls
  - Never change digester temperature more than one degree per day.
  - Digester gas is normally 70% methane and 30% carbon dioxide.
- Digester gas and oxygen is ***very*** explosive!!!

383

Anaerobic Sludge Digestion

- Volatile acid/Alkalinity ratio is key to operation
  - When VA/Alk ratio gets out of balance, upset (sour) digester occurs.
  - When VA/Alk ratio rises, digester gas may be unburnable.
  - When VA/Alk ratio finally gets too high, pH begins to drop.
  - If pH is only process control tool used, digester can sour before operator is aware.

384

Anaerobic Sludge Digestion

- Volatile acid/alkalinity ratio
  - 0.1:1 - considered good balance
  - 0.3:1 - needs attention, keep mixing slow feeding
  - 0.5:1 - stop feeding, keep mixing, add some seed sludge
  - 0.8:1 - gas unburnable, pH drops. Stop feeding, keep mixing, add alkalinity
  - 1.0:1- Too late!

385

Anaerobic Sludge Digestion

- Sour Digester Recovery
  - When digester becomes sour, several methods can be used to recover
    - Seed sludge from another digester can be used
    - Lime or soda ash can be added to raise pH

386

Anaerobic Sludge Digestion

- Digester Supernatant
  - Anaerobic digester supernatant is usually high in ammonia (NH_3) and BOD
  - Return anaerobic digester supernatant to head of plant during low flow periods

387

Rules

- In Florida, biosolids must meet either class A or B limits, as per EPA 40 cfr Part 503 and FDEP 62-640
- Must meet Pathogen Reduction requirements and Vector Attraction Reduction requirements
- Three methods to meet Pathogen limits, 10 ways to meet Vector Attraction Reduction limits

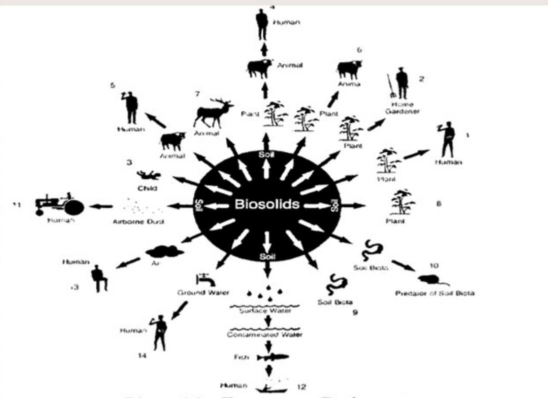
388

389

Pathogens and Vectors

- Fecal Coliform is the pathogen indicator
- Vectors are described as flies, mosquitoes, rats and other disease carrying organisms.
- All wastewater plants are considered generators of biosolids.

390



Biosolids Exposure Pathways

391

Sludge Analysis

- All plants must also perform sludge analysis testing at least annually.
- This includes metals testing, nitrogen, phosphorus, potassium, total solids and pH tests

392

Florida Department of Environmental Protection

Rules

393

Objective

- Overview of DEP Rules for Domestic Wastewater
- Rules of Concern for Certified Operators

394

Florida Administrative Code

- Chapter 62-4 - Permits
- Chapter 62-302 - Surface Water Quality Standards
- Chapter 62-600 - Domestic Wastewater Facilities

395

Florida Administrative Code

- Chapter 62-601 - Domestic WWTP Monitoring
- Chapter 62-602 - Drinking Water and Domestic Wastewater Treatment Plant Operators
- Chapter 62-604 - Collection Systems and Transmission Facilities

396

Florida Administrative Code

- Chapter 62-610 - Reuse of Reclaimed Water and Land Application
- Chapter 62-611 - Wetlands Application
- Chapter 62-620 - Wastewater Facility Permitting

397

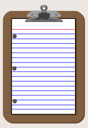
Florida Administrative Code

- Chapter 62-640 - Domestic Wastewater Bio-Solids
- Chapter 62-650 - Water Quality Based Effluent Limitations
- Chapter 62-699 - Treatment Plant Classification and Staffing

398

Chapter 62-4
Permits

- General Prohibition
  - Facility shall not be operated, maintained, constructed, expanded, or modified without the appropriate DEP permit
- Procedure to Obtain Permits
  - Application shall be certified by a Florida Professional Engineer
  - Permit fees
    - Collection System Construction
    - WWTF Operation
    - Modifications (Revision)



399

Chapter 62-4
Permits

- Surveillance Fees for Surface Water Discharge
  - Annual fee due by January 15
- Permit Application Renewals
  - At least 180 days before expiration of current permit
- Mixing Zones
  - Limited, defined area allows some relief for effluent limits
    - Calculated by dilution

400

Chapter 62-302
Surface Water Quality Standards

- Classification of Surface Waters
  - Class I - Potable water supplies
    - Lake Okeechobee, Hillsborough River, Upper St. Johns River
  - Class II - Shellfish propagation or harvesting
    - Indian River, Matanzas River, Tampa Bay
  - Class III - Recreation, propagation of a healthy, well-balanced population of fish and wildlife
    - Most other surface waters

401

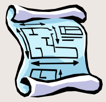
Chapter 62-302
Surface Water Quality Standards

- Outstanding Florida Waters, National Resource Waters
  - Receives highest protection
    - Surface waters in National Parks, Preserves, Memorials, Wildlife refuges and Wilderness Areas
      - Everglades National Park, Caloosahatchee Wildlife Refuge, Suwannee River
- Criteria for Surface Water Quality Classifications
  - Table of water quality limits

402

Chapter 62-600
Domestic Wastewater Facilities

- Definitions
  - General terms
  - Common parameters
  - Facility types
- Design Requirements
  - Fenced
  - Easy, dry, safe access for obtaining samples
- Planning for Expansion
  - Capacity Analysis Report
    - Must have accurate flow measurements



403

Chapter 62-600
Domestic Wastewater Facilities

- Operation and Maintenance Requirements
  - Operation by a certified operator
  - Equipment shall be maintained so as to function as intended
  - Permittee shall provide operating data to DEP
  - Permit, drawings, O&M manual and operating data shall be kept available for use by plant operators and inspection by DEP

404

Chapter 62-600
Domestic Wastewater Facilities

- Treatment Standards
  - Secondary/Advanced Treatment
    - Minimum treatment: 20mg/L $CBOD_5$ and 20 mg/L TSS
- Disinfection
  - Concentration and contact time at peak hourly flow
    - Minimum contact time 15 minutes at peak hourly flow
    - Minimum concentration
      - Basic disinfection - 0.5 mg/L
      - High-level disinfection - 1.0 mg/L, additional TSS control
      - 200 An. Avg Fecal 800 max sample

405

Chapter 62-600
Domestic Wastewater Facilities

- Operation and Maintenance Manual
  - Must be on-site and current
  - Provide the operator with information and description regarding design, operation and maintenance
  - Revise to reflect any facility alterations or reflect experience resulting from facility operation

406

Chapter 62-600
Domestic Wastewater Facilities

- O & M Performance Report
  - Included with new permit application
  - Evaluate physical condition and identify deficiencies
  - Prepared by engineer, operator and owner

407

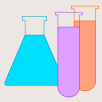
Chapter 62-600
Domestic Wastewater Facilities

- Reporting, Compliance and Enforcement
  - Violations
    - Release or disposal without proper permit
    - Failure to maintain equipment
    - Planned bypassing of critical components without DEP notification
    - Submission of misleading, false or inaccurate info either knowingly or through neglect
    - Owner shall not allow or encourage operator to violate rules

408

Chapter 62-601
Domestic WWTP Monitoring

- Definitions
  - Lead or chief operator
- General Requirements
  - Submit reports by 28th of month for previous month



409

Chapter 62-601
Domestic WWTP Monitoring

- Sampling and Testing Methods
  - Methods must be approved by DEP and EPA
    - Field testing, sample collection and preservation, and laboratory testing
  - Laboratory must be certified by DOH for specified test
  - On-site tests may be run under direction of certified operator

410

Chapter 62-601
Domestic WWTP Monitoring

- Sampling Schedules, Locations, Methodology
  - Minimum schedule for sampling – Table
  - Grab samples, composite samples
  - Flow-proportioned samples taken @ hourly intervals

411

Chapter 62-602
Drinking Water and Domestic Wastewater Treatment Plant Operators

- Qualifications for Operator License
  - Class D
    - High school diploma or equivalent
    - Minimum 3 months experience or complete training course and 1 hour experience
  - Class C, B and A
    - High school diploma or equivalent
    - Minimum 1 year, 3 year, 5 year experience
    - Complete required training course
    - Must have previous level license for A and B

412

Chapter 62-602
Treatment Plant Operators

- Qualifications for Operator License *(continued)*
  - Must meet qualifications and submit 90 days prior to requested exam date
  - Exam (70% or better passing grade)
  - Experience (2080 hours = 1 year)
  - Training courses - residence or correspondence

413

Chapter 62-602
Treatment Plant Operators

- *New* License Fees
  - A, B, or C level: $100
    - $50 application fee (non-refundable)
    - $50 license fee
    - $75 renewal fee
  - D level: $50
    - $25 application fee (non-refundable)
    - $25 license fee
    - $50 renewal fee

414

Chapter 62-602
Treatment Plant Operators

- Renewal of Operator Licenses
  - Requires renewal every two years
  - Renewal notices sent to last known address
    - Failure to receive notice does not excuse licensee from timely renewal

415

Chapter 62-602
Treatment Plant Operators

- Renewal of Operator Licenses *(continued)*
  - CEU (Continuing Education Unit) documentation
    - Required for next renewal cycle
    - One CEU equals 10 hours of continuing education contact time
    - Two CEUs required for Class A or B renewal
    - One CEU required for Class C renewal
    - 0.5 CEU for Class D

416

Chapter 62-602
Treatment Plant Operators

- CEU documentation for double license
  - A portion of the CEUs must apply to each type of license
    - must be identified on the certificate
    - table of license levels and <u>hours</u> needed for double license

417

Chapter 62-602
Treatment Plant Operators

- Suspension and Revocation of Licenses
  - Suspension for up to 2 years
    - Submitting false data in license application
    - Cheating on exam
    - Incompetence in treatment plant operation
    - No re-test required to resume license

418

Chapter 62-602
Treatment Plant Operators

- Suspension and Revocation of Licenses *(continued)*
  - Permanent revocation
    - Fraud in the submission of documents for license
    - Falsified or misrepresented reports, logs, lab sheets
    - Negligence in treatment plant operation
    - Suspension of license more than twice
    - Short term revocation - complete course and take exam

419

Chapter 62-602
Treatment Plant Operators

- Duties of Operators
  - Submit required reports to permittee
  - Report to permittee and Department within 24 hours any:
    - Unsafe treatment plant operation
    - Unpermitted discharge
    - Major interruption in service

420

Chapter 62-602
Treatment Plant Operators

- Duties of Operators *(continued)*
  - Perform responsible and effective on-site management
  - Maintain operation and maintenance logs on site
    - Hard bound books with consecutive page numbers
    - Contain a minimum of three months of data
    - Partial electronic logging acceptable if approved by DEP

421

Chapter 62-602
Treatment Plant Operators

- Duties of Operators *(continued)*
  - O & M logs shall include the following:
    - Identification of plant
    - Signature and license number of operator
    - Signature of the persons making any entries
    - Date and time in and out
    - Specific operation and maintenance activities
    - Tests performed, samples taken (unless documented on lab sheet) and repairs made
    - Preventive maintenance and repair requests

422

Chapter 62-604
Collection Systems and Transmission Facilities

- Prohibitions
  - Deliberate introduction of stormwater
  - Acceptance of discharges without pretreatment
- Operation and Maintenance
  - Provide uninterrupted service
- Abnormal Events
  - Verbal notification within 24 hours, written report within 72 hours

423

Chapter 62-610
Reuse of Reclaimed Water and Land Application

- Rapid-Rate Land Application Systems
  - Rapid infiltration basins, absorption fields (percolation ponds, drainfields)
  - Effluent Nitrate limit = 12 mg/L
  - maintain ponds to control vegetation

424

Chapter 62-610
Reclaimed Water and Land App.

- Slow-Rate Land Application Systems - *Public Access*
  - Golf course, residential and food crop irrigation
  - TSS limit = 5 mg/L
  - 15 days for food crops
- Slow-Rate Land Application Systems - *Restricted Public Access*
  - Spray irrigation (hay field)
  - TSS limit = 10 mg/L

425

Chapter 62-610
Reclaimed Water and Land App.

- Ground Water Recharge and Indirect Potable Reuse
  - Injection wells
  - Surface water augmentation for public water supply
- Overland Flow Systems
  - Sod farms, fodder crops
- Industrial Uses
  - Cooling water, wash-water or process water

426

Chapter 62-611
Wetlands Application

- Discharge Limits
  - Treatment wetland
    - Secondary treatment with nitrification
  - Receiving wetland
    - High level treatment 5-5-3-1
  - Total ammonia < 2 mg/L

427

Chapter 62-611
Wetlands Application

- Man-made Wetlands
  - Exempted from wetlands rule
  - Discharge must meet requirements
- Monitoring Requirements
  - Baseline monitoring
  - Nutrient monitoring
  - May request modification after 3 years

428

Chapter 62-620
Wastewater Facility Permitting

- General Prohibitions
  - Must have a permit to operate, construct or modify
- Renewals
  - Application must be submitted 180 days prior to expiration
- Recordkeeping
  - Maintain all records on site for 3 years

429

Chapter 62-620
Wastewater Facility Permitting

- Signatories to Permit Applications and Reports
  - Corporate officer
  - General partner or proprietor
  - Executive officer (city manager, public works director)
  - Authorized representative (must be documented)

430

Chapter 62-620
Wastewater Facility Permitting

- General Conditions for All Permits
  - All results must be reported and included in calculations
  - Must use certified laboratory for all tests
    - On-site tests for DO, Temperature, Turbidity, pH and Cl2 may be performed under the direction of a certified operator

431

Chapter 62-640
Domestic Wastewater Bio-Solids

- Provisions adopted from 40 CFR Part 503
- Applicability
  - domestic wastewater treatment facilities
  - residuals management facilities
  - septage management facilities
    - >10,000 gpd monthly average or 20,000 gpd in a single day

432

Chapter 62-640

Domestic Wastewater Bio-solids

- Permit Requirements
  - Valid permit and approved agricultural use plan
  - Responsibility for treatment and proper use
    - Permittee - unless applier has legally agreed
- Nutrient Management Plan (NMP)
  - Shall consider nutrient content of all residuals, reclaimed water, and other sources

433

Chapter 62-640

Domestic Wastewater Bio-Solids

- Pathogen Reduction - Class A
  - Specific density requirements for fecal coliform or Salmonella in addition to one of six alternatives
  - Six alternatives
    - Examples: Thermal treatment, High pH - high temperature
- Pathogen Reduction - Class B
  - Three alternatives
    - Examples: Fecal coliform density, Process to Significantly Reduce Pathogens (PSRP), Equivalent PSRP

434

Chapter 62-640

Domestic Wastewater Bio-Solids

- Vector Attraction Reduction
  - Ten options
    - Examples: Volatile solids reduction, SOUR test, lime addition, moisture reduction, soil injection or soil incorporation
- Monthly Distribution and Marketing Report
  - Class AA only
  - Sent to Tallahassee
  - Residuals monitoring report still applies

435

Chapter 62-640

Domestic Wastewater Bio-Solids

- New Site
  - NMP along with permit application
  - Aerial maps
  - Soil conservation information
  - Pending site inspection
  - Liability agreement
  - Other pertinent information may be required (i.e. setbacks)
  - Cumulative metals loading rates
  - Site life determination
  - Nitrogen loading rate, Plant Available Nitrogen (PAN) determination, etc.

436

Chapter 62-640

Domestic Wastewater Bio-Solids

- Site Requirements
  - Inspection
    - Piezometer
      - At least 2" in diameter, 36" deep and 24" above ground
      - Located at area where it is easy to see
      - Maintain water table readings ready for inspection
    - Aerial Maps
      - Scale zones
      - Crop type
      - Area of zone
      - Zone ID

437

Chapter 62-640

Domestic Wastewater Residuals

- Site Requirements
  - Setback Distances
    - To buildings - 300 feet if occupied
    - To water bodies - 1000 feet to Class I, 200 feet all other
    - To potable water wells - private is 300 feet, public is 500 feet

438

Chapter 62-640
Domestic Wastewater Residuals

- Site Requirements
  - Soil/residuals mixture must be pH 5.0 or greater
  - Runoff prevention
    - No application during rain that causes runoff or when soil is saturated
    - Topographic grades less than 8%
    - Topographic grades greater than 2% require a conservation plan. Contact the Soil Conservation Service at (904) 328-6522

439

Chapter 62-640
Domestic Wastewater Residuals

440

Chapter 62-650
Water Quality Based Effluent Limitations

- WQBEL Level I Process
  - Water body meets standards
- WQBEL Level II Process
  - Insufficient water quality data
  - Available assimilative capacity of water body is utilized

441

Chapter 62-699
Treatment Plant Classification and Staffing

- Classification and Staffing of Plants
  - Permittee shall employ certified operator as required

442

Chapter 62-699
Plant Classification and Staffing

- Additional Classification and Staffing Requirements
  - Operator shall be on call when plant is unattended
  - Daily checks shall be performed
  - Electric surveillance
  - Lead/chief operator shall be on duty each duty day

443

For More Information …

- www.dep.state.fl.us
  - For DEP Rules check side bar under Resources
- www.epa.gov
- contact your local district office:
  - Your Local District – Domestic Waste Section

444

Safety at WWTFs

445

Types of Hazards at the WWTF

- Physical injuries
- Infections/infectious diseases
- Confined space
- Oxygen deficiency
- Toxic or suffocating gases or vapors

446

Types of Hazards at the WWTF

... continued

- Explosive gas mixtures
- Electrical shock
- Noise
- Dusts, fumes, mists, gases, and vapors

447

Physical Injuries

Most common:

Cuts - Strains
Bruises - Sprains

Can be caused by improper lifting techniques or slippery surfaces

Falls from or into tanks, wet wells, or catwalks

448

Infections and Infectious Diseases

- General Definitions
  - Infection: The invasion of a host by an infectious microorganism.
  - Pathogenicity: The ability of an infectious agent to cause disease and injure the host.
  - Pathogenic organisms or “Pathogens”: Bacteria, viruses, or cysts which can cause disease *(such as typhoid, cholera, dysentery)* in a host *(such as a human)*.

449

Infections and Infectious Diseases

- Personal hygiene is the best protection against the risk of infections and disease.
- *Types:* Typhoid fever, Dysentery, Hepatitis and Tetanus
- Immunization shots are a necessity against Tetanus, Polio, and Hepatitis B.

450

Infections and Infectious Diseases

- There are many "Modes of Transmission" of infectious agents:
  - *Person-to-person:* This is the most common mode. By direct person-to-person contact, coughing, or sneezing.
  - *Waterborne:* From consumption of contaminated water.
  - *Foodborne:* Food contaminated from unsanitary practices during production or preparation.

451

Infections and Infectious Diseases

- Modes of Transmission *(continued)*
  - *Airborne:* Transmission of biological aerosols generated by WWTFs or by spray irrigation of wastewater effluents.
  - *Vector-borne:* Transmission by arthropods (fleas, insects) or vertebrates (cats, dogs)
  - *Fomites:* Pathogens transmitted by nonliving objects or fomites (clothes, utensils, toys).

Reference summary chart of some diseases associated with wastewater environments.

452

Infections and Infectious Diseases

- Pathogenic Bacteria Infections Include:
  - *Salmonella spp*: Acute Gastroenteritis, Typhoid Fever, Paratyphoid Fever, Salmonellosis.
  - *Shigella spp*: Shigellosis (bacillary dysentery)
  - *Vibrio spp*: Asiatic Cholera
  - *Clostridium spp*: Tetanus

453

Infections and Infectious Diseases

- Pathogenic Bacteria Infections Include:
  - *Mycobacterium*: Tuberculosis
  - *Yersinia*: Acute Gastroenteritis
  - *Escherichia coli (E-coli)*: Usually considered nonpathogenic, several strains may cause Gastroenteritis.

454

Infections and Infectious Diseases

- **Personal Protection**
  - *Gloves* Always wear a good, heavy duty rubber glove when cleaning bar racks, weirs, or while conducting any other scrubbing duty. Be sure there are no holes in them. Always wear gloves if your hands may come in direct contact with wastewater or sludge.
  - *Footwear* If you have to walk in sewage, wear rubber boots. Rubber boots will not soak up sewage fluids.

455

Infections and Infectious Diseases

- Personal Protection *(continued)*
  - *Hygiene* If you smoke or break for a snack, clean your hands first. Be sure to use a disinfectant soap.
  - Spray your shoes with a disinfectant or change your shoes before going home. Don't mix your work clothes with the family wash, and wash them in hot water.

456

Infections and Infectious Diseases

- Safety At The Plant Site
  - *DO NOT* store your lunch in the same refrigerator as sludge or any other wastewater samples. Freezing will not kill viruses, *only extremely high heat.*
  - When cleaning with a high pressure water hose (hose with nozzle), wear a full face shield and apron to stop any splash back.

457

Infections and Infectious Diseases

- Safety At The Plant Site *(continued)*
  - While conducting lab work, or when wearing latex gloves while sampling, consider doubling or tripling the glove. Latex is laced with five micron channels, the HIV virus is .1 micron in size and Hepatitis B is 1.5 microns in size.

458

Infections and Infectious Diseases

- Safety At The Plant Site *(continued)*
  - Bandages covering wounds should be changed frequently.
  - You should always wear long pants when climbing on or around a WWTF.

459

Confined Space

- Space that is large enough and configured so that an employee can enter and perform assigned work.
- Space that has limited or restricted means for entry or exit.
- Space that is not designed for continuous employee occupancy.

460

Confined Space

Examples of Confined Spaces

- Tanks
- Vessels
- Storage Bins
- Hoppers
- Vaults
- Pits
- Manholes
- Lift Stations

461

Oxygen Deficiency

- Low oxygen levels may exist in poorly ventilated areas where gases, such as hydrogen sulfide, gasoline vapor, carbon dioxide and chorine, may be produced or accumulated.
- *Hydrogen Sulfide and Chlorine* collect in low places because they are heavier than air.
- The weight of a gas is indicated by its specific gravity as it is compared to an equal volume of air.

462

Oxygen Deficiency

- The specific gravity of air is 1.0.
- Therefore, any gas with a specific gravity of >1 will sink to low lying places.

(Methane rises out of manholes because it's specific gravity is < 1. Therefore, it is lighter than air.)

463

Chlorine Facts

- When changing chlorine cylinders or handling chlorine, ALWAYS do the following
  - Have a standby person present with a respirator available.
  - Remove the old lead washer from the pig-tail or chlorinator, use one new lead washer.
  - Have an emergency repair kit on-site and be familiar with how to use if BEFORE the need arises. Make sure the kit is complete and no tools or parts are missing.

464

Toxic or Suffocating Gases

- They originate from industrial waste dischargers, process chemicals, or decomposition of domestic wastewater.
- Become familiar with waste dischargers in your system.

465

Toxic or Harmful Chemicals

- Strong acids, bases, and liquid mercury are types of harmful chemicals that operators may encounter.
- All hazardous chemicals should be clearly labeled
- Health and safety data (MSDS) about the specific chemicals should be read before handling.

466

Explosive Gas Mixtures

- *Explosive Gases* develop in areas where air and methane, natural gas, manufactured fuel gas, hydrogen, or gasoline vapors mix.
  - Explosion-proof electrical equipment and fixtures should be used in these areas.
  - Explosions can be avoided by eliminating sources of ignition in these type areas. *(examples: influent/bar screen rooms, gas compressor areas)*

467

Explosive Gas Mixtures

- Also, adequate ventilation should be provided

***Note:* Methane and oxygen combined are highly explosive.**

Always use Non-Sparking tools when working around anaerobic digesters.

468

Electrical Shock

- *DO NOT* attempt electrical repairs unless you are qualified and know what you are doing.
- Ordinary 120 Volt electricity may be fatal.
- 12 Volts can cause injury.

469

Electrical Shock

- Any electrical system should be considered dangerous unless you know *for sure* it has been de-energized.
- Always use a lock-out tag-out procedure to prevent accidental re-energizing of power.

470

Noise

- Some WWTF equipment produce high noise levels. Ex: blowers
- Hearing protection devices should be used if you have to shout or cannot hear someone talking to you in a normal tone of voice.

471

Dust, Fumes, Mists, Gases, and Vapors

- The ideal way to control diseases from breathing air contaminated with harmful dusts, fumes, mists, gases, and vapors is to prevent the atmospheric contamination from occurring.
- This can be achieved through *engineering control measures*. It is not always economically feasible, therefore *respirators should be provided/used* in these atmospheres.

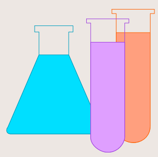
472

References

- Operation of Wastewater Treatment Plants California State University, Sacramento, Volume II, Third Edition 1998.
- Wastewater Microbiology, University of Florida, Gainesville, Gabriel Bitton, 1994.
- Wastewater Engineering Treatment, Disposal, and Reuse, Metcalf and Eddy, Inc., Third Edition, 1991.

473

Laboratory Procedures and Chemistry



474

Agenda

- **Sample Collection**
  - Terminology
  - Procedures
- **Laboratory**
  - Safety
  - Terminology
  - Measurements

475

Sample Collection

- The result of any testing method can be no better than the sample on which it is performed.
- **Objective -** to collect a portion of material small enough in volume to be transported conveniently and handled in the laboratory while still accurately representing the material being sampled to demonstrate compliance with regulatory requirements.

476

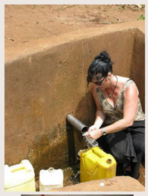
Sample Collection

- **Why?**
  - Used to control wastewater processes
    - Find problems before they become problems
    - Used for basic wastewater operations parameters
  - Used to monitor treatment effectiveness
    - Tests required by regulation
    - For determining effectiveness for budget issues

477

Sample Collection Terminology

- **Grab Sample -** a single sample collected at a particular time and place which represents the composition only at that time and place



- **Composite Sample -** a collection of individual samples obtained at regular intervals

478

Sample Collection Terminology

- **Flow Proportioned Sample -** a collection of individual samples obtained at regular intervals. Sample size based upon flow
- **Representative Sample -** a sample portion of material that is as nearly identical in content and consistency as possible to that in the larger body of material being sampled

479

Sample Collection Procedures

- **Most errors occur due to**
  - Improper sampling
  - Poor preservation
  - Lack of mixing during compositing and testing

480

Sample Collection Procedures

- **Proper sampling technique**
  - Have access to safe sampling location
  - Use clean and proper sampling equipment and containers
  - Collect a representative sample
    - Approved location and sample type (grab or composite)
    - Appropriate collection time and frequency

481

Sample Collection Procedures

- **Automatic samplers -** clean sample lines and verify proper programming
- **Sample containers & preservation**
  - Use type of container specified in method
  - Preserve as specified in method
  - Keep refrigeration $\leq$ 4 degrees C
  - Properly label all sample containers
  - Record sample collection time

482

Laboratory Safety

- Chemical hygiene plan
- Safety Data Sheets (SDSs)
- Blood borne pathogens
- Never pipet by mouth
- Always add acid to water
- PPE

483

Laboratory Safety

- **Corrosive Chemicals**
  - H_2SO_4 (Sulfuric Acid)
  - HNO_3 (Nitric Acid)
  - HCl (Hydrochloric Acid)
  - NaOH (Sodium Hydroxide)
  - KOH (Potassium Hydroxide)
  - Phenylarsine oxide

484

Laboratory Safety

- **Safety equipment in the laboratory**
  - Fume hood
  - Spill clean up kits
  - Safety eyewash and shower
  - Fire extinguisher
  - Fire blanket
  - First aid kit

485

486

Laboratory Terminology

- **Aliquot -** portion of a sample, usually an equally divided portion
- **Aseptic -** free from living germs, sterile
- **Buffer -** a solution or liquid that neutralizes acids or bases with minimal change in pH

487

Laboratory Terminology

- **Chain-of-Custody -** the ability to trace possession and handling of the sample from the time of collection through analysis and final disposition
- **Compound -** a pure substance composed of two or more elements
- **Element -** a substance which cannot be separated into its parts

488

Laboratory Terminology

- **Gram Molecular Weight -** molecular weight of compound in grams
- **Meniscus -** the curved surface of a column of liquid in a small tube
- **Molar (M) -** solution consists of one gram molecular weight of a compound dissolved in enough water to make 1 liter

489

Laboratory Terminology

- **Molecular weight -** the sum of the atomic weights of the elements in a compound
- **Normal (N) -** solution contains one gram equivalent weight of a compound per liter of solution

490

Laboratory Terminology

- **Quality Assurance** - a set of operating principles that, if strictly followed during sample collection and analysis, will produce data of known and defensible quality
- **Quality Control** - ability to produce credible results

491

Laboratory Terminology

- **Reagent** - a pure chemical substance that is used to make new products or is used in chemical test to measure, detect, or examine other substances
- **Solution -** a liquid mixture of dissolved substances
- **Titrate** - a chemical solution of known strength is added drop by drop until a change in the sample is observed (end point)

492

Laboratory Terminology

- **Volatile -** capable of being evaporated or changed to a vapor. In solids analysis, materials lost at 550 deg. C for 60 minutes in a muffle furnace.
- **Volatile acids -** fatty acids produced during digestion that are soluble in water and can be steam distilled at atmospheric pressure.

493

Laboratory Measurements

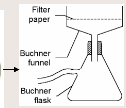
- **Metric**
  - Liter (volume) - L
  - Gram (weight) - g
  - Meter (length) - m
    - micro(□) = 1/1,000,000 or 0.000001 X
    - milli (m) = 1/1000 or 0.001 X
    - centi (c) = 1/100 or 0.01 X
  - Temperature
    - $C^o = 5/9 (F^o - 32)$
    - $F^o = C^o(1.8) + 32$

494

Laboratory Equipment

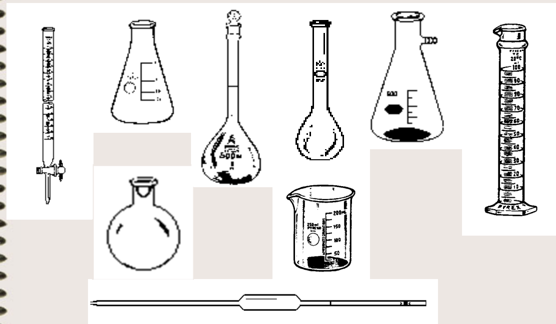
- Use of class "A" labware
- Burets
- Graduated cylinders
- Flasks
- Beakers
- Pipettes (Most Accurate)
- Crucibles
- Funnels (Buchner Funnel is used for TSS)



495

Laboratory Equipment



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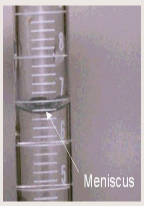
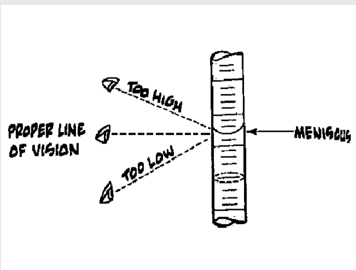
Laboratory Equipment





497

Laboratory Equipment

- Hot Plate
- Magnetic Stirrer
- Dessicator
- Drying Oven
- Muffle Furnace
- Water Bath
- Incubator
- Petri dishes

498

Laboratory Equipment

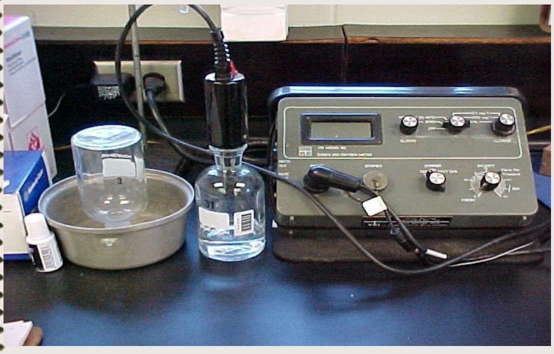
499

Laboratory Equipment

- Analytical balance
- Triple beam balance
- Ion meter (pH)
- Spectrophotometer
- D.O. meter
- Microscope
- Autoclave
- Fume hood

500

Laboratory Equipment



501

Laboratory Records

- **Bench sheets and notebooks**
  - Bench sheets must have all information required by DEP
    - Name of laboratory
    - Name of sampler(s)
    - Date & time of analysis
    - Date, time & location of sample
    - Method used
    - Name of technician performing analysis
    - Calculations used

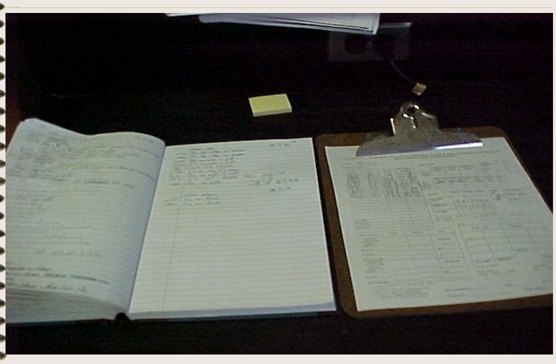
502

Laboratory Records

- **Accurate, complete records are a must!**
  - Used to record data and arrange in orderly manner
  - All information must be recorded
  - If you make a mistake, one line & initial, no white out!
  - Keep accurate calibration and temperature logs
  - Make sure information is legible!

503

Laboratory Records



504

Laboratory Records

- **Quality Assurance/ Quality Control**
  - All certified labs must have a DEP approved QA Plan
  - Without good QA/QC, data is not considered reliable

505

Laboratory Analyses

- **Titrations**
  - Adding one solution to another until end point
- **Gravimetric**
  - Using weight to determine concentration

506

Laboratory Analyses

- **Electrode**
  - Using ion selective electrodes to measure
- **Spectrophotometer or Colorimeter**
  - Measure intensity of color at particular wavelength

507

Laboratory Analyses

- Carbonaceous Biochemical Oxygen Demand
- Total Suspended Solids
- Chlorine Residual
- pH
- Fecal Coliform

508

Laboratory Analyses

- **Carbonaceous BOD**
  - Disadvantage- results take 5 days to obtain
  - Bioassay
  - 5 day test at 20 deg. C
  - Nitrification inhibitor
  - Initial dissolved oxygen
  - Oxygen five days later
  - Calculate CBOD
  - Rate of oxygen-use expressed as mg/L

509

Laboratory Analyses

510

Laboratory Analyses

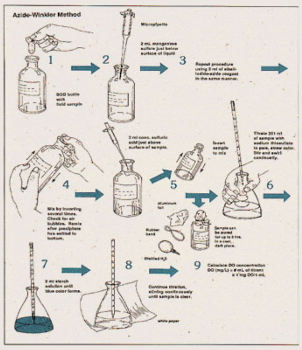
- **Total Suspended Solids (Total Non-Filterable Solids)**
  - Gravimetric method
  - Use fine filter to capture solids
  - Weigh clean filter
  - Pour sample through filter
  - Dry in drying oven at 103-105 C
  - Weigh again to determine mg/L

511

Dissolved Oxygen Analysis

DO Meter

Winkler Method



512

Laboratory Analyses

- **Chlorine residual** (Chlorine must be read immediately)



  - DPD Spectrophotometric
    - Use standards to calibrate meter
    - Add DPD reagent. Color intensity corresponds to residual chlorine
      (For Total Chlorine this takes 3 minutes)

  - Amperometric Titration
    - Uses electronic value to read chlorine level

513

Laboratory Analyses

- **pH**
  - Meter or ion meter
  - Calibrate with at least 2 buffer solutions that bracket the expected range
  - Take reading immediately, pH can change quickly (Immediately means within 15 min.)

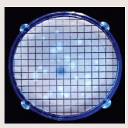

514

Laboratory Analyses

515

Laboratory Analyses

- **Fecal coliform**
  - Membrane Filter Method
    - Uses very fine porous filter to capture bacteria
    - Maintain sterile conditions during sampling and testing
    - Pour samples through filter
    - Place filter in petri dish with broth
    - Incubate 24 hours at 44.5 deg. C



516

Laboratory Analyses

- **Fecal coliform**
  - MPN Method (Most Probable Number)
    - Inoculate tubes of broth with several dilutions of sample
    - Calculate density based on number of tubes gas-negative and gas-positive

517

Additional Terminology

- **Bioassay -** measuring effect of biological process. Determining toxic effects by using live organisms.
- **Biomonitoring -** measuring effects of toxic substances
- **Biosurvey** - site survey upstream and down. Used to determine effect downstream

518

Additional Terminology

- **Facultative -** can survive in aerobic or anaerobic conditions
- **Oxidation -** addition of oxygen, removal of hydrogen (aerobic)

519

Additional Terminology

- **Reduction -** addition of hydrogen, removal of oxygen (anaerobic)
- **Surfactant** - surface active agent. Agent in detergents that has good cleaning ability.

520

WATER AND WASTEWATER MATH

521

CONVERSION FACTORS

- VOLUME :

522

CONVERSION FACTORS

- VOLUME :

7.48 gal = 1 cu ft

7.48 gal/cu ft

1 cu ft / 7.48 gal

523

CONVERSION FACTORS

- **DENSITY OF WATER**

524

CONVERSION FACTORS

- **DENSITY OF WATER**

8.34 LBS = 1 GAL

8.34 LBS / GAL

1 GAL / 8.34 LBS

525

CONVERSION FACTORS

- **CONCENTRATION**

526

CONVERSION FACTORS

- **CONCENTRATION**

CONCENTRATION MAY ALSO BE REFERED TO AS DOSAGE.

1 ppm = 1 mg/l

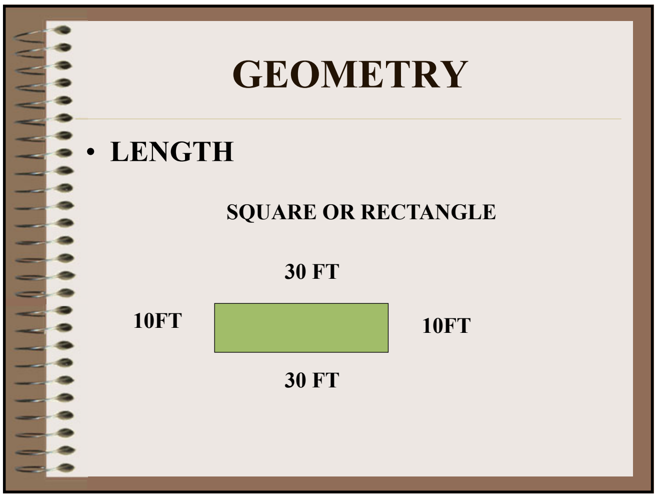
1% = 10,000 mg/l

527

GEOMETRY

- **LENGTH**

528



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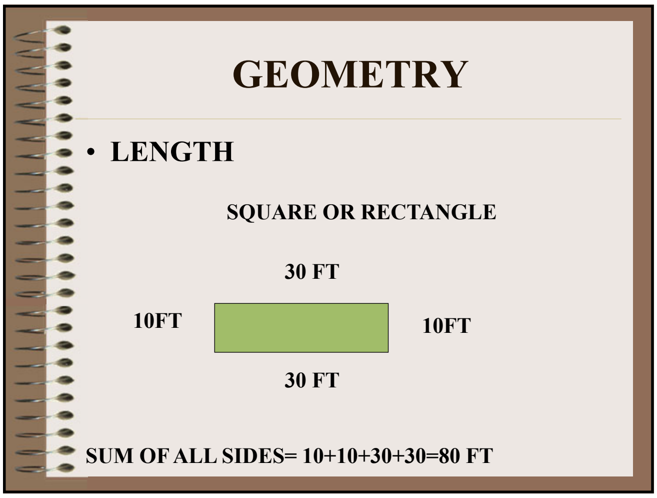

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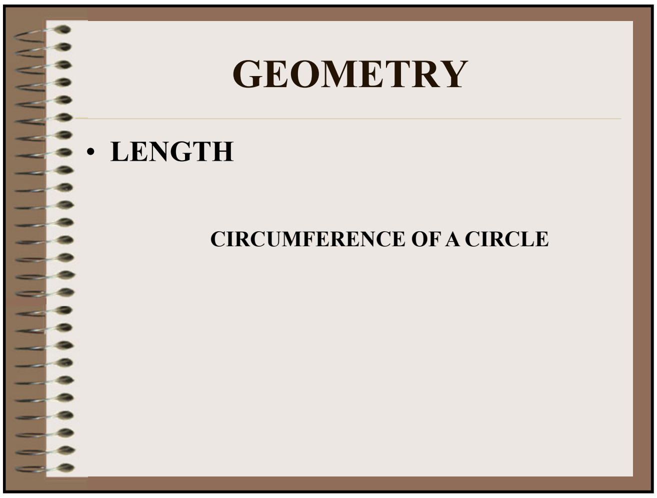

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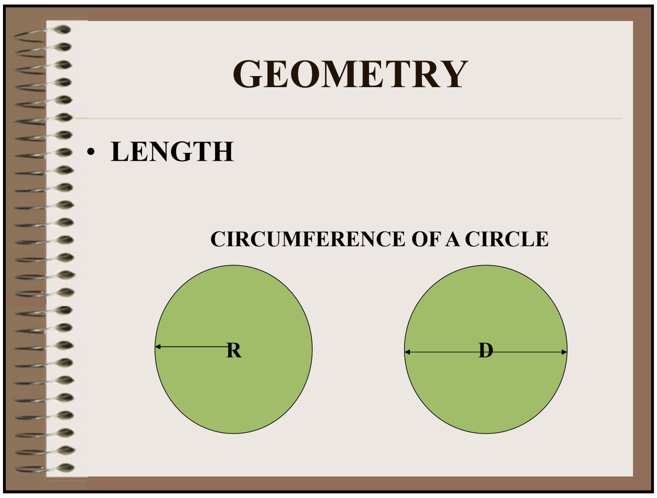

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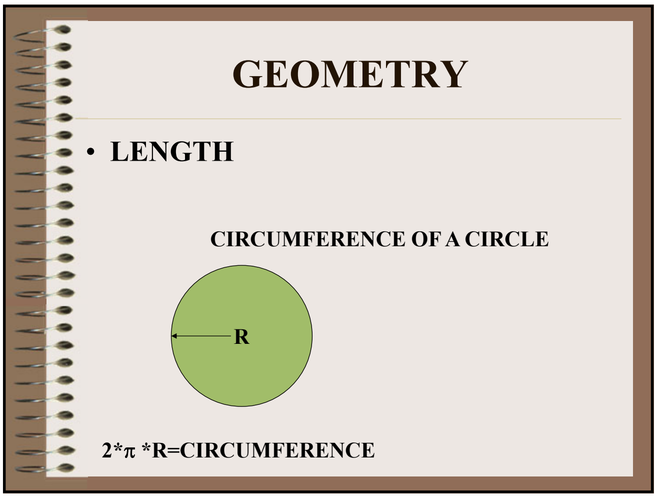

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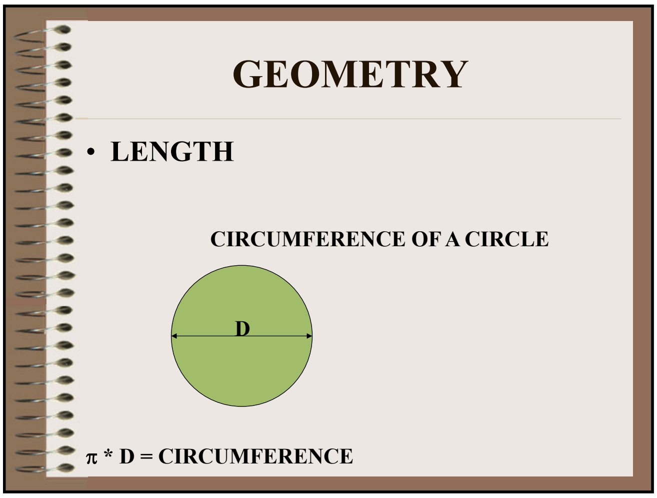


534

GEOMETRY

- AREA

FT² OR SQ FT

535

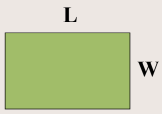
GEOMETRY

- AREA

FT² OR SQ FT

AREA OF A RECTANGLE:

L * W= AREA



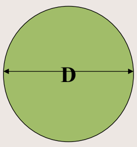
536

GEOMETRY

- AREA

FT² OR SQ FT

AREA OF A CIRCLE



(π * D²) /4
or
D x D x 0.785

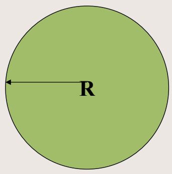
537

GEOMETRY

- AREA

FT² OR SQ FT

AREA OF A CIRCLE



AREA= π * R²

538

GEOMETRY

- VOLUME

FT³ OR CU FT

539

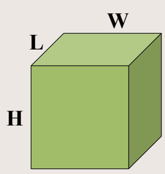
GEOMETRY

- VOLUME

FT³ OR CU FT

VOLUME OF A RECTANGLE

L * W * H = VOLUME



540

GEOMETRY

- VOLUME

FT³ OR CU FT

VOLUME OF A CYLINDER

$= [(\pi * D^2)/4] * H$

or

D x D x 0.785 x H

$= \pi * R^2 * H$

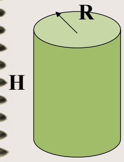
541

GEOMETRY

- VOLUME

FT³ OR CU FT

VOLUME OF A CYLINDER



$= [(\pi * D^2)/4] * H$

or

D x D x 0.785 x H

$= \pi * R^2 * H$

542

AREA AND VOLUME PROBLEMS

CALCULATE THE AREA OF THE RECTANGLE

10 FT

20 FT

543

AREA AND VOLUME PROBLEMS

CALCULATE THE AREA OF THE RECTANGLE

10 FT

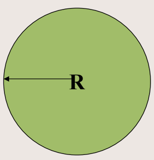
20 FT

L * W OR 10 * 20 = 200 SQ FT

544

AREA AND VOLUME PROBLEMS

CALCULATE THE AREA OF THE CIRCLE

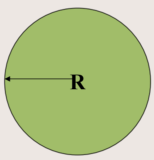


RADIUS = 20 FT

545

AREA AND VOLUME PROBLEMS

CALCULATE THE AREA OF THE CIRCLE



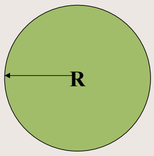
RADIUS = 20 FT

$= \pi * R^2$

546

AREA AND VOLUME PROBLEMS

CALCULATE THE AREA OF THE CIRCLE



RADIUS = 20 FT

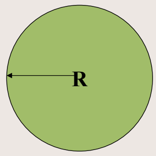
$= \pi * R^2$

= 3.14 * 20 * 20

547

AREA AND VOLUME PROBLEMS

CALCULATE THE AREA OF THE CIRCLE



RADIUS = 20 FT

$= \pi * R^2$

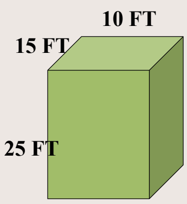
= 3.14 * 20 * 20

= 1256 SQ FT

548

AREA AND VOLUME PROBLEMS

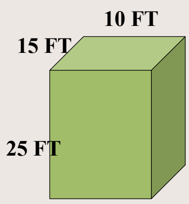
CALCULATE THE VOLUME OF THE RECTANGULAR TANK



549

AREA AND VOLUME PROBLEMS

CALCULATE THE VOLUME OF THE RECTANGULAR TANK

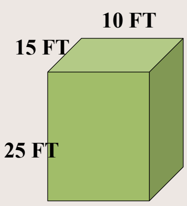


L * W * H

550

AREA AND VOLUME PROBLEMS

CALCULATE THE VOLUME OF THE RECTANGULAR TANK



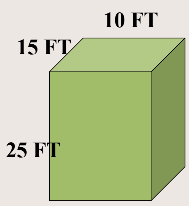
L * W * H

15 * 10 * 25

551

AREA AND VOLUME PROBLEMS

CALCULATE THE VOLUME OF THE RECTANGULAR TANK

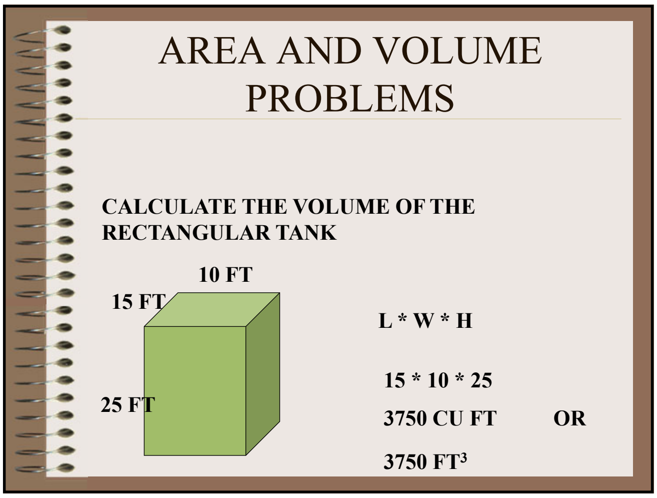


L * W * H

15 * 10 * 25

3750 CU FT

552



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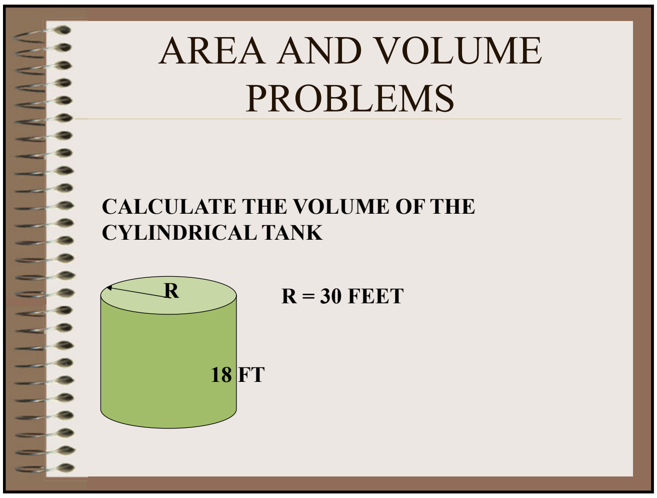

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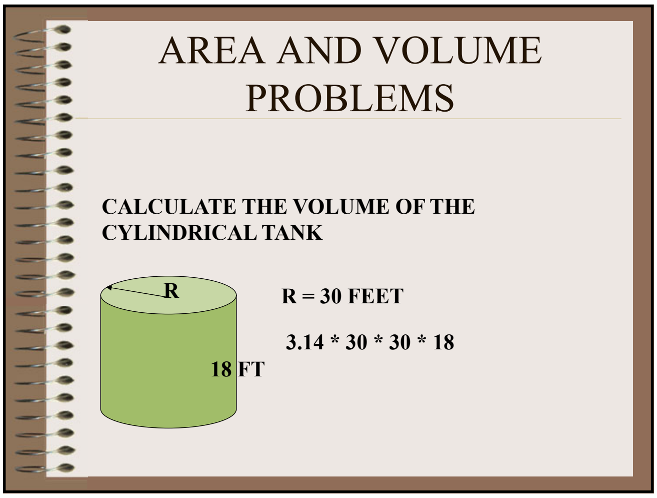

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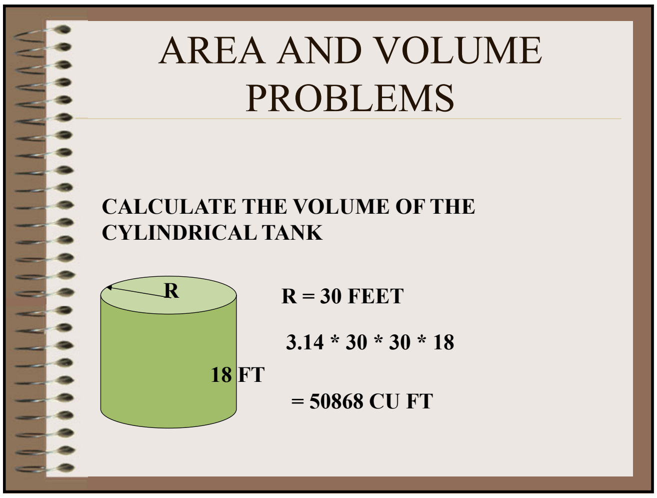

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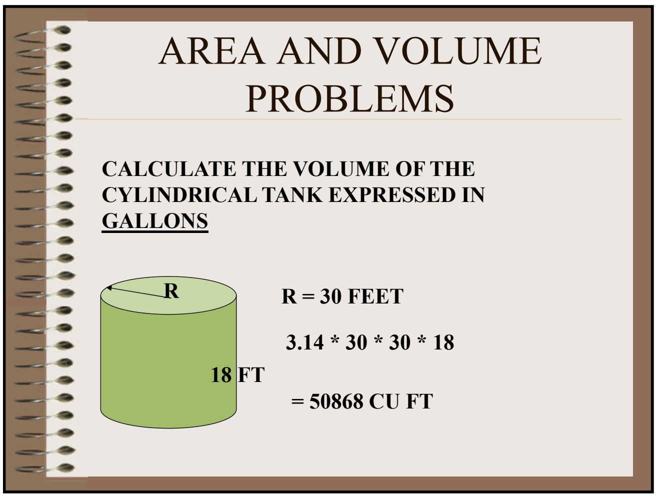

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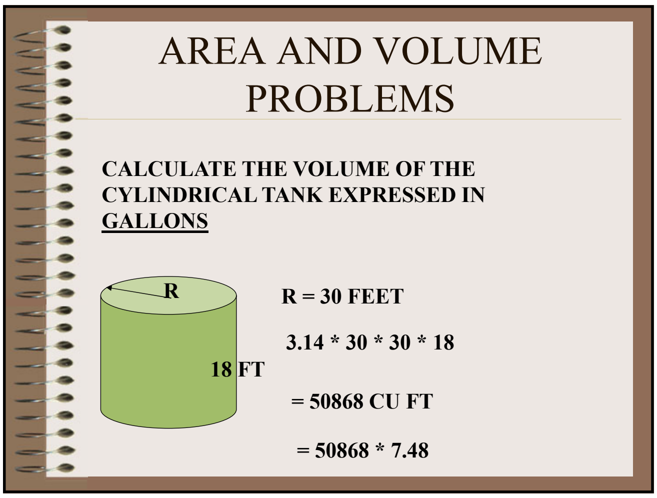
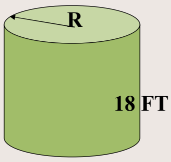


558

AREA AND VOLUME PROBLEMS

CALCULATE THE VOLUME OF THE CYLINDRICAL TANK EXPRESSED IN <u>GALLONS</u>



R = 30 FEET

3.14 * 30 * 30 * 18

= 50868 CU FT

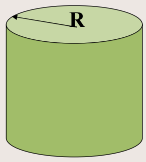
= 50868 * 7.48

= 380493 GALLONS

559

AREA AND VOLUME PROBLEMS

CALCULATE THE WEIGHT OF THE CYLINDRICAL TANKS CONTENTS IF IT IS WATER

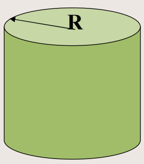


= 380493 GALLONS

560

AREA AND VOLUME PROBLEMS

CALCULATE THE WEIGHT OF THE CYLINDRICAL TANKS CONTENTS IF IT IS WATER



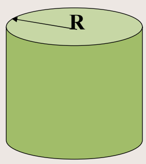
= 380493 GALLONS

= 380493 * 8.34

561

AREA AND VOLUME PROBLEMS

CALCULATE THE WEIGHT OF THE CYLINDRICAL TANKS CONTENTS IF IT IS WATER



= 380493 GALLONS

= 380493 * 8.34

= 3173312

LBS

562

GENERAL FORMULAS

DETENTION TIME,hr

<u>= (TANK VOLUME, FT^3) * (7.48 GAL/ FT^3) * (24 HR/DAY)</u>

(FLOW, GAL/DAY)

563

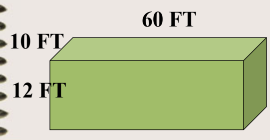
GENERAL FORMULAS

DETENTION TIME,hr

<u>= (TANK VOLUME, FT^3) * (7.48 GAL/ FT^3) * (24 HR/DAY)</u>

(FLOW, GAL/DAY)

USING THIS FORMULA CALCULATE THE DETENTION TIME OF THIS TANK, WITH A DAILY FLOW OF 20,000 GAL/DAY.



564

GENERAL FORMULAS

DETENTION TIME,hr

$$= \frac{(\text{TANK VOLUME, FT}^3) * (7.48\ \text{GAL/FT}^3) * (24\ \text{HR/DAY})}{(\text{FLOW, GAL/DAY})}$$

$$\frac{(10 * 60 * 12) * 7.48 * 24}{20{,}000} = \frac{7200\ \text{FT}^3 * 7.48 * 24}{20{,}000}$$

= 64.6 HRS

565

GENERAL FORMULAS

PLANT EFFICIENCY

$$\text{PLANT EFFICIENCY, \%} = \frac{(\text{IN - OUT}) * 100\%}{\text{IN}}$$

566

GENERAL FORMULAS

PLANT EFFICIENCY

$$\text{PLANT EFFICIENCY, \%} = \frac{(\text{IN - OUT}) * 100\%}{\text{IN}}$$

EXAMPLE: RAW WATER COMING INTO THE PLANT HAS A TSS OF 120 MG/L, LEAVING THE PLANT AFTER FILTRATION IT IS 5 MG/L. WHAT IS THE EFFICENCY OF THE FILTER?

567

GENERAL FORMULAS

PLANT EFFICIENCY

$$\text{PLANT EFFICENCY, \%} = \frac{(\text{IN - OUT}) * 100\%}{\text{IN}}$$

EXAMPLE: RAW WATERCOMING INTO THE PLANT HAS A TSS OF 120 MG/L, LEAVING THE PLANT AFTER FILTRATION IT IS 5 MG/L. WHAT IS THE EFFICENCY OF THEFILTER?

$$\frac{(120 - 5) * 100\%}{120} = 95.8\%$$

568

GENERAL FORMULAS

PLANT EFFICIENCY

$$\text{PLANT EFFICENCY, \%} = \frac{(\text{IN - OUT}) * 100\%}{\text{IN}}$$

CAN ALSO BE USED FOR MANY OTHER APPLICATIONS:

BOD
TSS
REMOVAL OF CHEMICALS

569

GENERAL FORMULAS

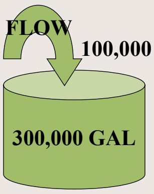
$$\text{DETENTION TIME} = \frac{\text{TANK CAP. (GAL.)}}{\text{RATE OR FLOW (GAL/TIME)}}$$

570

GENERAL FORMULAS

DETENTION TIME = <u>TANK CAP. (GAL.)</u>
RATE OR FLOW (GAL/TIME)

FLOW
100,000 GAL/HR

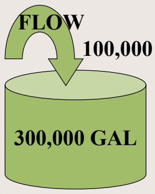


571

GENERAL FORMULAS

DETENTION TIME = <u>TANK CAP. (GAL.)</u>
RATE OR FLOW (GAL/TIME)

FLOW
100,000 GAL/HR



<u>300,000 GAL.</u> = 3 HOURS
100,000 GAL/HR

572

GENERAL FORMULAS

PARTS PER MILLION

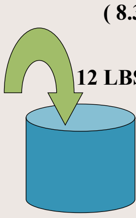
Mg/L = <u>POUNDS OF CHEMICAL</u>
(8.34 LBS/ GAL * MG)

573

GENERAL FORMULAS

PARTS PER MILLION

Mg/L = <u>POUNDS OF CHEMICAL</u>
(8.34 LBS/ GAL * MG)



12 LBS CL2

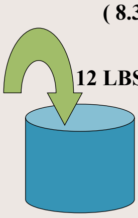
.750 MG

574

GENERAL FORMULAS

PARTS PER MILLION

Mg/L = <u>POUNDS OF CHEMICAL</u>
(8.34 LBS/ GAL * MG)



12 LBS CL2

.750 MG

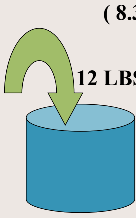
<u>12 LBS</u>
8.34* .750

575

GENERAL FORMULAS

PARTS PER MILLION

MG/L = <u>POUNDS OF CHEMICAL</u>
(8.34 LBS/ GAL * MG)



12 LBS CL2

0.750 MG

<u>12 LBS</u> = 1.9 mg/L
8.34* 0.750

576

GENERAL FORMULAS

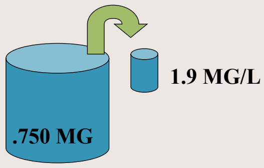
POUNDS

LBS = 8.34 LBS/ GAL * mg/L * MG

577

GENERAL FORMULAS

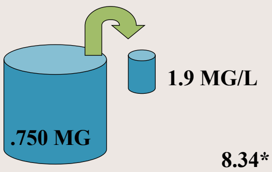
POUNDS
LBS = 8.34 LBS/ GAL * mg/L * MG



578

GENERAL FORMULAS

POUNDS
LBS = 8.34 LBS/ GAL * Mg/L * MG

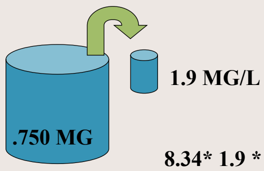


8.34* 1.9 * .750 =

579

GENERAL FORMULAS

POUNDS
LBS = 8.34 LBS/ GAL * Mg/L * MG



8.34* 1.9 * .750 = 11.88 OR 12 LBS

580

ACTIVATED SLUDGE

SOLIDS INVENTORY or
POUNDS UNDERAERATION

581

ACTIVATED SLUDGE

SOLIDS INVENTORY, LBS

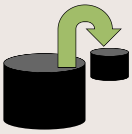
SI , LBS = (TANK CAP. MG) * (MLSS, Mg/L) * (8.34LBS/GAL)

582

ACTIVATED SLUDGE

SOLIDS INVENTORY, LBS

SI , LBS = (TANK CAP. MG) * (MLSS, mg/L) * (8.34LBS/GAL)



2800 mg/L MLSS

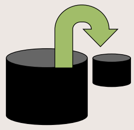
.500 MG

583

ACTIVATED SLUDGE

SOLIDS INVENTORY, LBS

SI , LBS = (TANK CAP. MG) * (MLSS, mg/L) * (8.34LBS/GAL)



2800 Mg/L MLSS

.500 MG

.500 MG * 2800 Mg/L * 8.34 LBS/GAL= 11676 LBS

584

ACTIVATED SLUDGE

SLUDGE AGE

SLUDGE AGE, DAYS= SOLIDS UNDER AERATION, LBS / SOLIDS ADDED, LBS / DAY

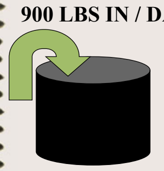
585

ACTIVATED SLUDGE

SLUDGE AGE

SLUDGE AGE, DAYS= SOLIDS UNDER AERATION, LBS / SOLIDS ADDED, LBS / DAY

900 LBS IN / DAY



11676 LBS

586

ACTIVATED SLUDGE

SLUDGE AGE

SLUDGE AGE, DAYS= SOLIDS UNDER AERATION, LBS / SOLIDS ADDED, LBS / DAY

900 LBS IN / DAY

11676 LBS UNDER AERATION / 900 LBS ADDED / DAY

11676 LBS

587

ACTIVATED SLUDGE

SLUDGE AGE

SLUDGE AGE, DAYS= SOLIDS UNDER AERATION, LBS / SOLIDS ADDED, LBS / DAY

900 LBS IN / DAY

11676 LBS UNDER AERATION / 900 LBS ADDED / DAY =12.97 OR 13 DAYS

11676 LBS

588

ACTIVATED SLUDGE

- INFLUENT FLOW 0.500 MGD
- INF TSS 200 Mg/L
- INF CBOD 250 Mg/L
- AERATION TANK VOL. 0.300 MG
- MLSS 2800 Mg/L
- EFF TSS 20 Mg/L
- EFF CBOD 12 Mg/L
- MLVSS 2600 Mg/L
- WAS CONC. 5500 Mg/L
- WAS 10,000 gal.

589

ACTIVATED SLUDGE

F/M

F = FOOD OR CBOD, MEASURED IN LBS.

590

ACTIVATED SLUDGE

F/M

F = FOOD OR CBOD, MEASURED IN LBS.

M = MICROORGANISMS MEASURED IN LBS.

MLVSS ARE THE BUGS

591

ACTIVATED SLUDGE

F/M =

<u>(INF CBOD, Mg/L) * (FLOW, MGD) * (8.34 LBS/GAL)</u>
(AERATION TANK CAP.,MG) * (MLVSS,mg/L) * (8.34LBS/GAL

592

ACTIVATED SLUDGE

F/M =

<u>(INF CBOD, Mg/L) * (FLOW, MGD) * (8.34 LBS/GAL)</u>
(AERATION TANK CAP.,MG) * (MLVSS,Mg/L) * (8.34LBS/GAL

<u>250 Mg/L * 0.500 MGD * 8.34 LBS/ GAL</u>
0.300 MG* 2600 Mg/L * 8.34 LBS/GAL

593

ACTIVATED SLUDGE

F/M =

<u>(INF CBOD, Mg/L) * (FLOW, MGD) * (8.34 LBS/GAL)</u>
(AERATION TANK CAP.,MG) * (MLVSS Mg/L) * (8.34LBS/GAL

<u>250 Mg/L * 0.500 MGD * 8.34 LBS/ GAL</u> **= .16**
0.300 MG* 2600 Mg/L * 8.34 LBS/GAL

594

ACTIVATED SLUDGE

MCRT: MEAN CELL RESIDENCE TIME

595

ACTIVATED SLUDGE

MCRT: MEAN CELL RESIDENCE TIME

•MCRT= SOLIDS INVENTORY , LBS / (EFF SOLIDS, LBS) + (WAS SOLIDS, LBS)

596

ACTIVATED SLUDGE

•MCRT= SOLIDS INVENTORY , LBS / (EFF SOLIDS, LBS) + (WAS SOLIDS, LBS)

SI, LBS = TANK CAP MG * MLSSMg/L * 8.34 LBS GAL

EFF SOLIDS, LBS = FLOW MG * EFF TSS Mg/L * 8.34LBS/GAL

WAS SOLIDS, LBS = WAS Q * WAS CONC. Mg/L * 8.34 LBS/GAL

597

ACTIVATED SLUDGE

•MCRT= SOLIDS INVENTORY , LBS / (EFF SOLIDS, LBS) + (WAS SOLIDS, LBS)

0.300 MG * 2800 mg/L * 8.34 LBS/GAL

0.500 MG * 20 mg/L * 8.34 LBS/ GAL +

0.010 MG * 5500 mg/L * 8.34 LBS/GAL

598

ACTIVATED SLUDGE

•MCRT= SOLIDS INVENTORY , LBS / (EFF SOLIDS, LBS) + (WAS SOLIDS, LBS)

0.300 MG * 2800 mg/L * 8.34 LBS/GAL = 7005.6

0.500 MG * 20 mg/L * 8.34 LBS/ GAL + = 83.4 +

0.010 MG * 5500 mg/L * 8.34 LBS/GAL = 458.7

599

ACTIVATED SLUDGE

•MCRT= SOLIDS INVENTORY , LBS / (EFF SOLIDS, LBS) + (WAS SOLIDS, LBS)

0.300 MG * 2800 mg/L * 8.34 LBS/GAL = 7005.6

0.500 MG * 20 mg/L * 8.34 LBS/ GAL + = 83.4 +

0.010 MG * 5500 mg/L * 8.34 LBS/GAL = 458.7

$\frac{7005.6}{83.4 + 458.7}$ $\frac{7005.6}{542.1}$ = 12.92 OR 13 DAYS

600

Sprayfield Zones

You operate an extended air plant with a permitted capacity 750,000 gallons per day. Your average daily flow is 400,000 gallons per day. You discharge to a spray field that has 7 zones. Each zone is 5 acres. You are allowed to apply 3 inches to a zone. One acre is 43,560 sq. ft.

How long can you spray to a zone before switching zones?

601

Sprayfield Zones

You operate an extended air plant with a permitted capacity 750,000 gallons per day. Your average daily flow is 400,000 gallons per day. You discharge to a spray field that has 7 zones. Each zone is 5 acres. You are allowed to apply 3 inches to a zone. One acre is 43,560 sq. ft.

How long can you spray to a zone before switching zones?

3 inches/12 inches = 0.25 ft.

602

Sprayfield Zones

You operate an extended air plant with a permitted capacity 750,000 gallons per day. Your average daily flow is 400,000 gallons per day. You discharge to a spray field that has 7 zones. Each zone is 5 acres. You are allowed to apply 3 inches to a zone. One acre is 43,560 sq. ft.

How long can you spray to a zone before switching zones?

3 inches/12 inches = 0.25 ft.

43,560 X 0.25ft= 10,890cubic ft. X 7.48 = 81,457 gallons

603

Sprayfield Zones

You operate an extended air plant with a permitted capacity 750,000 gallons per day. Your average daily flow is 400,000 gallons per day. You discharge to a spray field that has 7 zones. Each zone is 5 acres. You are allowed to apply 3 inches to a zone. One acre is 43,560 sq. ft.

How long can you spray to a zone before switching zones?

3 inches/12 inches = 0.25 ft.

43,560 X 0.25ft= 10,890cubic ft. X 7.48 = 81,457 gallons

81,457 X 5 acres = 407,286 gallons/400,000 = 1 day

604

Sprayfield Zones

You operate an extended air plant with a permitted capacity 750,000 gallons per day. Your average daily flow is 400,000 gallons per day. You discharge to a spray field that has 7 zones. Each zone is 5 acres. You are allowed to apply 3 inches to a zone. One acre is 43,560 sq. ft.

How long can you spray to a zone before switching zones?

3 inches/12 inches = 0.25 ft.

43,560 X 0.25ft= 10,890cubic ft. X 7.48 = 81,457 gallons

81,457 X 5 acres = 407,286 gallons/400,000 = 1 day

Answer: Daily

605

Positive Displacement Pump

You have a positive displacement pump that has a 9 inch bore and a 6 inch stroke. The pump runs at 89 RPM. How many gallons per stroke does it pump? How many gallons per minute does it pump?

How long will it take to raise the level of a digester 20%, if it has a diameter of 20 feet and a height of 10 feet?

606

Positive Displacement Pump

- You have a positive displacement pump that has a 9 inch bore and a 6 inch stroke. The pump runs at 89 RPM. How many gallons per stroke does it pump? How many gallons per minute does it pump?
- How long will it take to raise the level of a digester 20%, if it has a diameter of 20 feet and a height of 10 feet?
- 9 inches/12 = 0.75 feet and 6 inches/ 12 = 0.5 feet

607

Positive Displacement Pump

- You have a positive displacement pump that has a 9 inch bore and a 6 inch stroke. The pump runs at 89 RPM. How many gallons per stroke does it pump? How many gallons per minute does it pump?
- How long will it take to raise the level of a digester 20%, if it has a diameter of 20 feet and a height of 10 feet?
- 9 inches/12 = 0.75 feet and 6 inches/ 12 = 0.5 feet
- 0.75X0.75X0.785= .44 X 0.5 = 0.22 cubic feet X 7.48 = 1.65 gallons

608

Positive Displacement Pump

- You have a positive displacement pump that has a 9 inch bore and a 6 inch stroke. The pump runs at 89 RPM. How many gallons per stroke does it pump? How many gallons per minute does it pump?
- How long will it take to raise the level of a digester 20%, if it has a diameter of 20 feet and a height of 10 feet?
- 9 inches/12 = 0.75 feet and 6 inches/ 12 = 0.5 feet
- 0.75X0.75X0.785= .44 X 0.5 = 0.22 cubic feet X 7.48 = 1.65 gallons
- 1.65 X 89 = 147 gallons per minute

609

Positive Displacement Pump

- You have a positive displacement pump that has a 9 inch bore and a 6 inch stroke. The pump runs at 89 RPM. How many gallons per stroke does it pump? How many gallons per minute does it pump?
- How long will it take to raise the level of a digester 20%, if it has a diameter of 20 feet and a height of 10 feet?
- 9 inches/12 = 0.75 feet and 6 inches/ 12 = 0.5 feet
- 0.75X0.75X0.785= .44 X 0.5 = 0.22 cubic feet X 7.48 = 1.65 gallons
- 1.65 X 89 = 147 gallons per minute
- 20 X 20 X .785 X 2 = 628 cubic feet X 7.48 = 4697 gallons

610

Positive Displacement Pump

- You have a positive displacement pump that has a 9 inch bore and a 6 inch stroke. The pump runs at 89 RPM. How many gallons per stroke does it pump? How many gallons per minute does it pump?
- How long will it take to raise the level of a digester 20%, if it has a diameter of 20 feet and a height of 10 feet?
- 9 inches/12 = 0.75 feet and 6 inches/ 12 = 0.5 feet
- 0.75X0.75X0.785= .44 X 0.5 = 0.22 cubic feet X 7.48 = 1.65 gallons
- 1.65 X 89 = 147 gallons per minute
- 20 X 20 X .785 X 2 = 628 cubic feet X 7.48 = 4697 gallons
- 4697/147 gpm = 32 minutes

611

Drying Bed Rehab

- You have a drying bed that measures 40 feet wide and 60 feet long. You are going to rehab the bed. You need to replace 6 inches of sand in the bed. The sand cost is $60.00 per cubic yard. How much will it cost to rehab the drying bed?

612

Drying Bed Rehab

You have a drying bed that measures 40 feet wide and 60 feet long. You are going to rehab the bed. You need to replace 6 inches of sand in the bed. The sand cost is $60.00 per cubic yard. How much will it cost to rehab the drying bed?

40 X 60 = 240 sq. feet

613

Drying Bed Rehab

You have a drying bed that measures 40 feet wide and 60 feet long. You are going to rehab the bed. You need to replace 6 inches of sand in the bed. The sand cost is $60.00 per cubic yard. How much will it cost to rehab the drying bed?

40 X 60 = 240 sq. feet

6”/12” = 0.5’

614

Drying Bed Rehab

You have a drying bed that measures 40 feet wide and 60 feet long. You are going to rehab the bed. You need to replace 6 inches of sand in the bed. The sand cost is $60.00 per cubic yard. How much will it cost to rehab the drying bed?

40 X 60 = 240 sq. feet

6”/12” = 0.5’

240 X 0.5 = 120 cubic feet

615

Drying Bed Rehab

You have a drying bed that measures 40 feet wide and 60 feet long. You are going to rehab the bed. You need to replace 6 inches of sand in the bed. The sand cost is $60.00 per cubic yard. How much will it cost to rehab the drying bed?

40 X 60 = 240 sq. feet

6”/12” = 0.5’

240 X 0.5 = 120 cubic feet

120/27=4.4 cubic yards

616

Drying Bed Rehab

You have a drying bed that measures 40 feet wide and 60 feet long. You are going to rehab the bed. You need to replace 6 inches of sand in the bed. The sand cost is $60.00 per cubic yard. How much will it cost to rehab the drying bed?

40 X 60 = 240 sq. feet

6”/12” = 0.5’

240 X 0.5 = 120 cubic feet

120/27=4.4 cubic yards

4.4 X $60= $264

617

Water Horse Power

You have an effluent pump that pumps 250 gpm at 75 feet of head.

What is the Water Horse Power of the pump?

618

Water Horse Power

You have an effluent pump that pumps 250 gpm at 75 feet of head.

What is the Water Horse Power of the pump?

250gpm X 75ft of head

3960

619

Water Horse Power

You have an effluent pump that pumps 250 gpm at 75 feet of head.

What is the Water Horse Power of the pump?

250gpm X 75feet of head

3960

4.73 WHP

620

Brake Horse Power

You have an effluent pump that pumps 150 gpm at 55 feet of head. The pump efficiency is 85%

What is the Brake Horse Power of the pump?

621

Brake Horse Power

You have an effluent pump that pumps 150 gpm at 55 feet of head. The pump efficiency is 85%

What is the Brake Horse Power of the pump?

150gpm X 55feet of head

3960 X .85

622

Brake Horse Power

You have an effluent pump that pumps 150 gpm at 55 feet of head. The pump efficiency is 85%

What is the Brake Horse Power of the pump?

150gpm X 55feet of head

3960 X .85

2.5 Brake Horse Power

623

Motor Horse Power

You have an effluent pump that pumps 300 gpm at 45 feet of head. The pump efficiency is 80 percent and the motor efficiency is 85 percent.

What is the Motor Horse Power of the pump?

624

Motor Horse Power

You have an effluent pump that pumps 300 gpm at 45 feet of head. The pump efficiency is 80 percent and the motor efficiency is 85 percent.

What is the Motor Horse Power of the pump?

<u>300gpm X 45feet of head</u>

3960 X .8 X .85

625

Motor Horse Power

You have an effluent pump that pumps 300 gpm at 45 feet of head. The pump efficiency is 80 percent and the motor efficiency is 85 percent.

What is the Motor Horse Power of the pump?

<u>300gpm X 45feet of head</u>

3960 X .8 X .85

5.0 MHP

626