Wastewater Treatment Technology

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I. Goal and objectives

- Gain familiarity with basic wastewater treatment unit processes
- Highlight some common advantages, and/or disadvantages of each unit process
- Recognize the need to use qualified professionals in selection, design and operation of treatment processes
- Recognize need for properly trained and certified operators

II. Wastewater Definition

May be defined differently in various laws and rules, check definition in the specific laws/rules applicable to your industry and circumstances, contact DEQ's Compliance Assistance Programs or local DEQ office for assistance

Definition in the Michigan Manufacturer's Guide, Chapter 3, Wastewater:
"Wastewater" is liquid waste that results from industrial and commercial processes and municipal operations, including liquid or water-carried process waste, cooling and condensing waters, and sanitary sewage. "Waste" means any waste, wastewater, waste effluent, or pollutant, including any of the following: dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, industrial, municipal, and agricultural waste.

Wastewater includes storm water that comes into contact with industrial activities or material, or which runs off a construction site that disturbs an acre or more.

III. Waste Characterization

- Important to know what is in the waste water, what needs to be removed, and to what extent
- Characterize waste, identify pollutant parameters
- Examples:
    - Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)
    - Solids, suspended or dissolved
    - Oils/Grease
    - Temperature
    - Phosphorous & Nitrogen Compounds
    - pH
    - Metals
    - Other chemical elements, compounds, additives…

- Definitions "Organics"
    - ***Organic compound:*** large class of chemical compounds whose molecules contain carbon
    - ***Organic matter:*** plant and animal, "organisms"

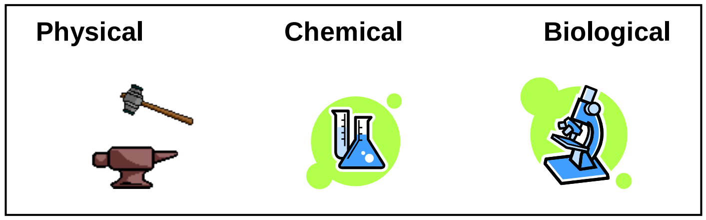
- Metals
    - Iron, Lead, Mercury, Chromium, Copper etc…

- Other chemical elements, compounds, additives, and substances
    - Arsenic, Chlorine compounds/chlorides, sulfur compounds, sodium, cyanide
    - (BTEX) benzene, toluene, ethylbenzene, and xylene and other volatile organic compounds
    - Chlorinated solvents, Perchloroethylene, trichloroethylene and methylene chloride

IV. Wastewater Treatment

Basic Process Categories:

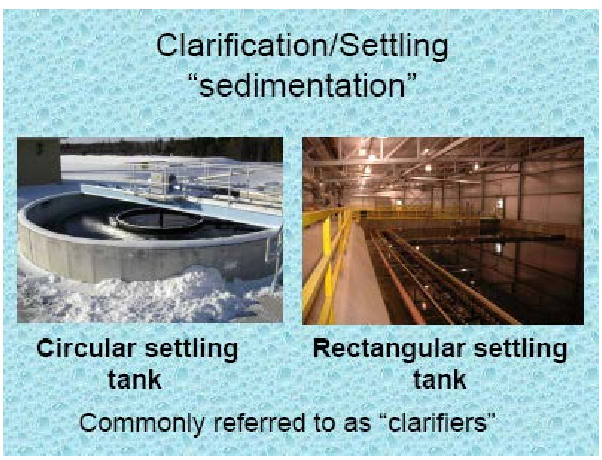
Some processes may consist of more than one type; combination of Physical, Chemical and/or Biological

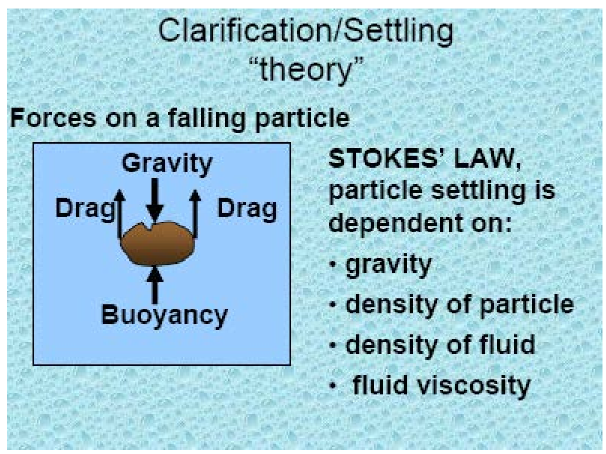


V. "Rearrangement & Residuals"

- The processes discussed in this presentation do not destroy matter, due to basic principles of physics. The pollutant is physically separated, and/or chemically rearranged to (or exchanged for) other chemical elements or compounds that generally are less harmful to the receiving water than the original element or compound
- Most all of the following processes result in a "residual", a solid substance, commonly known as "sludge" consisting of the target pollutant(s) or containing the target pollutant(s).
- The sludge or solids must often receive additional treatment and ultimate disposal. These processes are not covered in this presentation

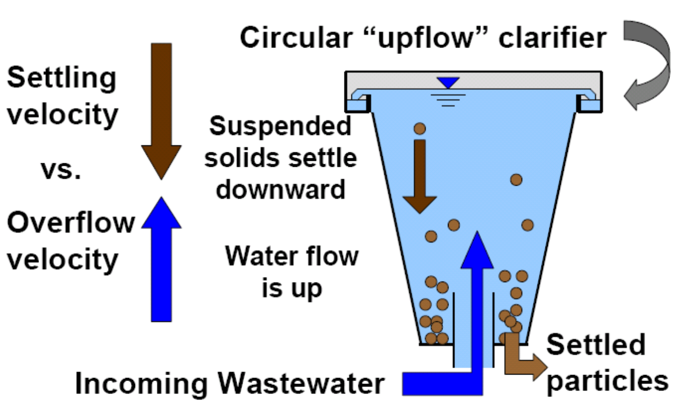
VI. Physical Processes -- Clarification/Settling

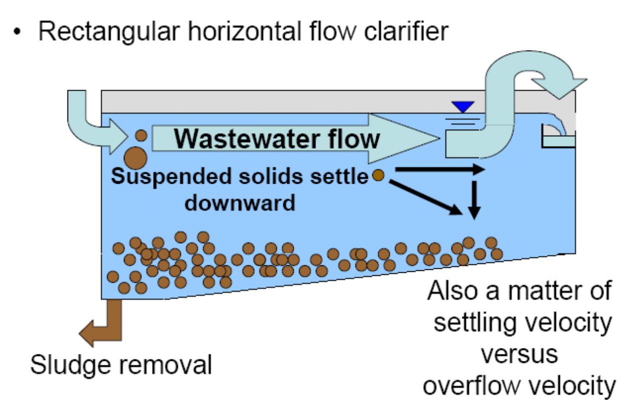


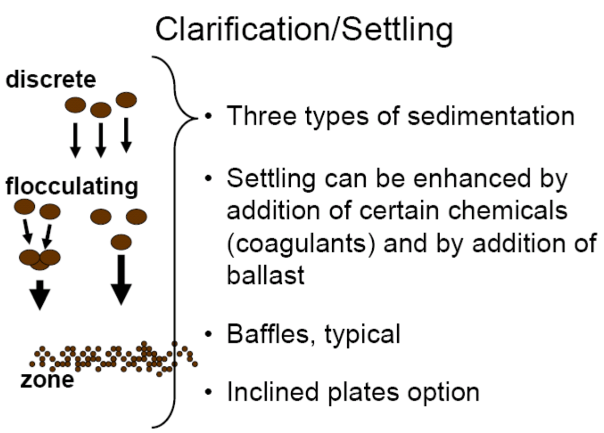


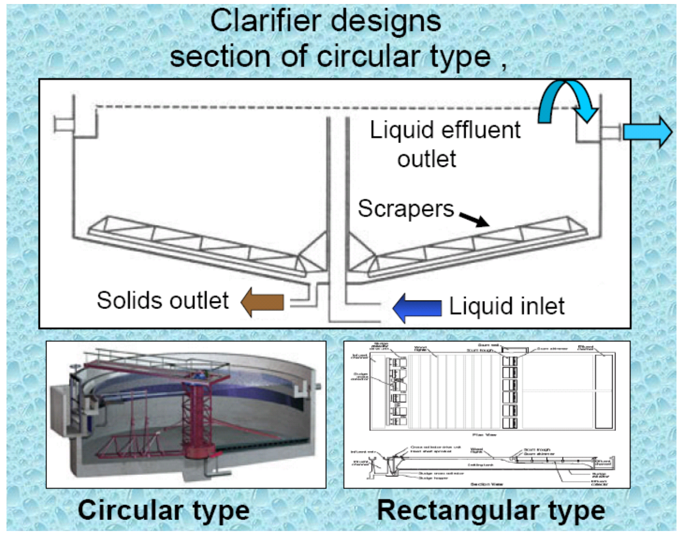
Primary Design Parameters:

- Surface Overflow Rate: gallons per day per square foot
- Solids Loading Rate: pounds per day per square foot





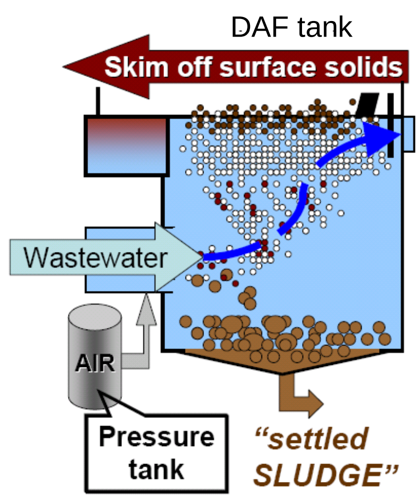




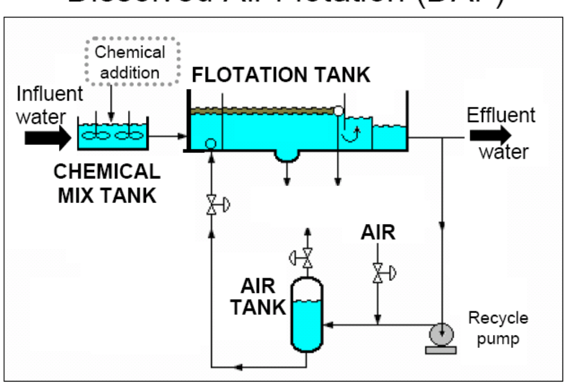
- Notable issues/concerns
  - o Will only address "setteable" solids
  - o Impaired settling "bulking sludge"

VII. Physical Processes -- Air flotation, Dissolved Air Flotation (DAF)

- A process of removing suspended solids, oils and other contaminants via the use of air bubble flotation.
- The dissolved air comes out of solution, producing millions of microscopic bubbles which attach to the solids, increase their buoyancy, and float them to the surface.
- At the surface the solids are mechanically skimmed and removed from the tank.



Dissolved Air Flotation (DAF)



DAF Example, with recycle

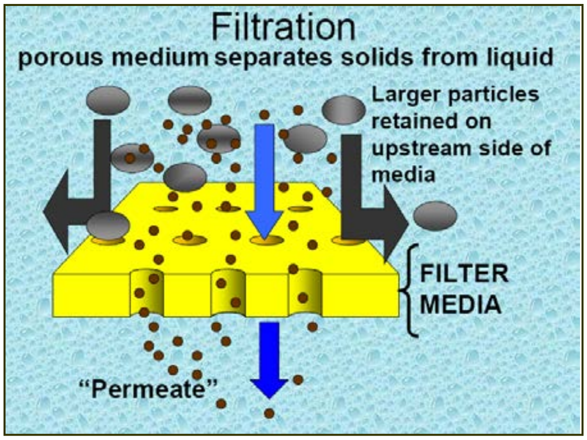
Primary design parameters:

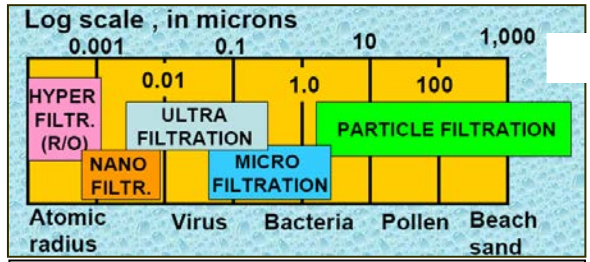
- Air/solids ratio
- Solids and hydraulic loading rates
- Coagulant dosage
  - o Typically requires use of certain chemical flocculating aids or coagulants and mixing ahead of DAF unit
- Typical applications in industry: refineries, paper products, food processing, chemical-petrochemical and natural gas processing plants

Benefits: Can remove lighter particles faster, provide better treated-water quality, more rapid startup, and thicker sludges than standard clarifier type settling or sedimentation.

Issues/concerns: Significant mechanical equipment involved, more complex, more maintenance, and high-energy consumption compared to standard clarifier type settling or sedimentation.

VIII. Physical Processes -- Filtration (including activated carbon, membrane filters/bioreactors and reverse osmosis)

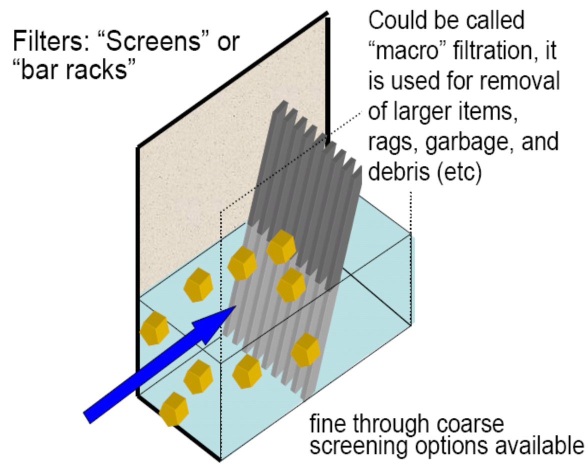




Size of particle removed dependent on "pore" size of media typically expressed micrometers (symbol µm) or one thousandth of a millimeter. It is also commonly known as a micron

Filter Media

- "Screens"
- Sand
- Diamataceous earth
- Granular/multi-media
- Activated carbon
- Membrane
- Fabric



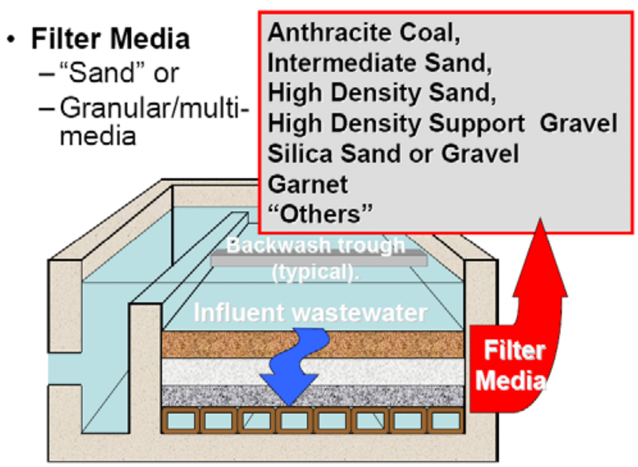
Filter types, defined by force driving fluid through the filter

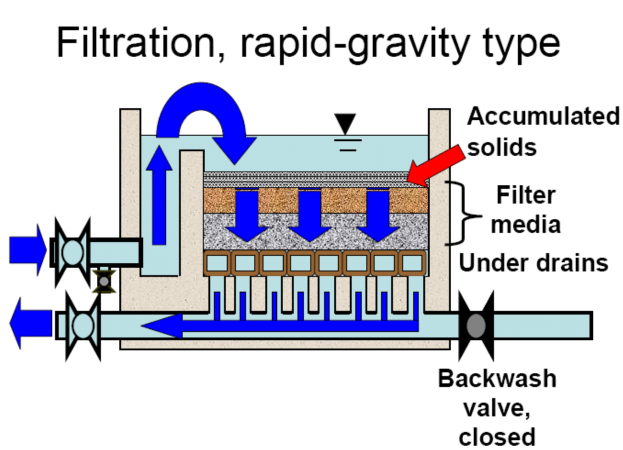
- Gravity
- Pressure
- Centrifugal force
- Vacuum

Filter rates

- Rapid infiltration
- Slow infiltration

Moving or fluidized bed filters (another type)

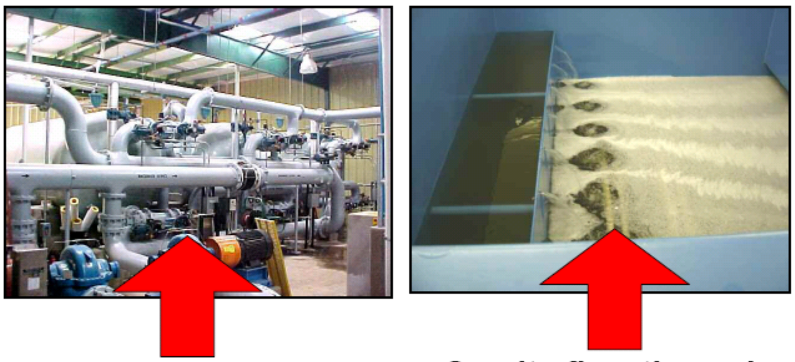




Filtration Issues and Concerns

- Influent water characteristics to the filters are critical
- Filters are subject to routine plugging and biofouling
- Filters require frequent cleaning, most often accomplished through “backwashing”
  - o Filters backwash with “clean” water to re-suspend the sediment.
  - o Cleaning/operation are most often mechanized and are typically very dependent on automated and/or computer controls.
  - o Secondary cleaning methods often employed such as chemicals or air scour
- Periodic replacement of filter media needed

Pressure type **“Fabric” type**



Filter media in pressure vessel

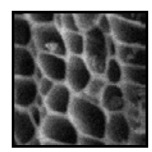
Gravity flow through submerged cloth filter disk

“Fabric” type

Filter disks shown when tank is empty or out of service

Filter Media -- Activated carbon, Granular Activated Carbon (GAC)

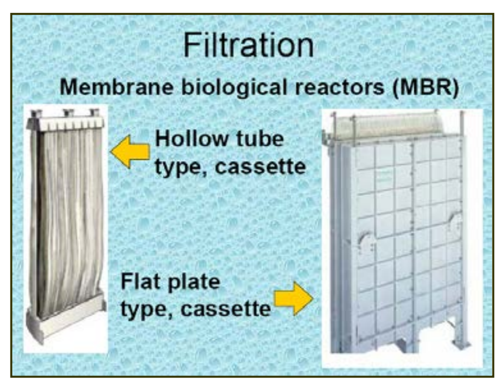
GAC particle and magnified GAC surface



- Adsorption: Through a type of attractive force between molecules, activated carbon has a natural affinity for certain high molecular weight organic pollutants (and some other types), which bind to its surface.
- GAC also acts as filter media but with enhanced “attraction” to certain substances

IX. Filtration -- Membrane biological reactors (MBR)

- MBRs combine biological treatment with a membrane liquid-solid separation process.
- Low pressure microfiltration or ultra filtration through synthetic membranes that are typically immersed in an aeration tank
- Benefits:
  - o Eliminates need for clarification & tertiary filtration
  - o Comparably small land area; has small “footprint”
- Issues/concerns
  - o Higher building and operating cost than conventional wastewater treatment
  - o Highly dependent on computer control technology



X. Filtration: Reverse osmosis (RO)

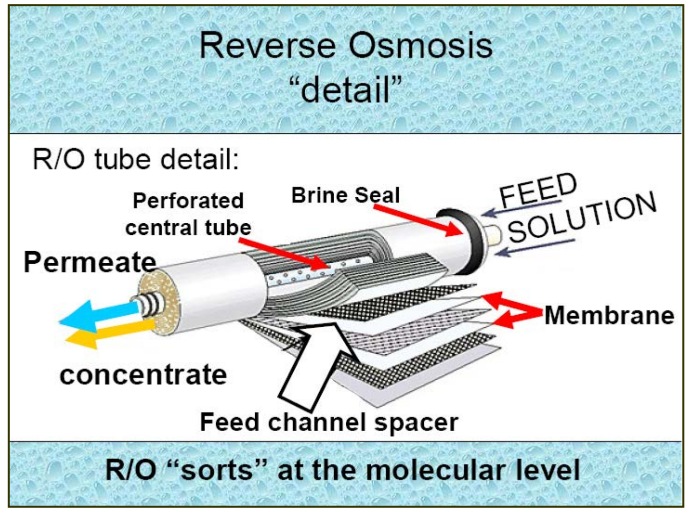
- RO is a filter separation process using pressure to force a solution through a semi-permeable membrane; the solute remains on one side and the pure solvent passes to the other side of the membrane.
- RO process requires that high pressure be exerted on the membrane
- Process is best known for removing salt from water

Benefits

- Removes a wide range of pollutants, significantly reduces nitrate, sulfate, sodium and total dissolved solids, most other inorganic material present in the water, and some organic compounds

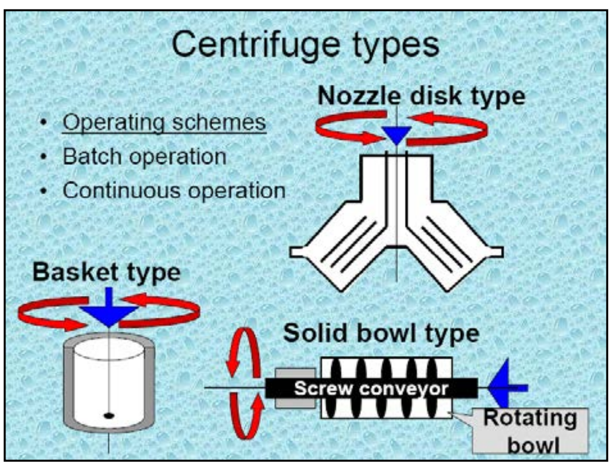
Issues/concerns

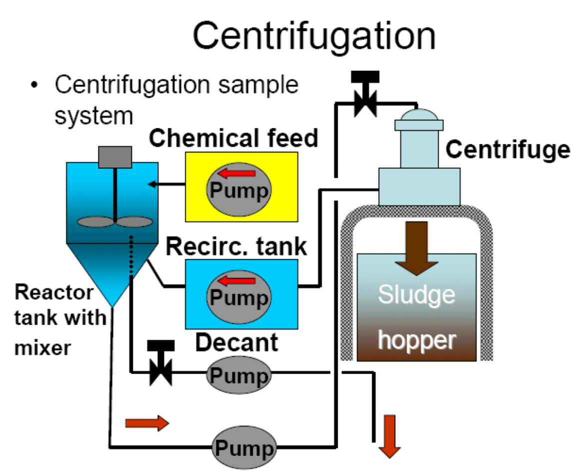
- Pretreatment: The feed water usually needs to be pretreated to remove particulates, influent turbidity
- Scaling, fouling, and degradation of membranes
- Ineffective in removing the lighter, low molecular weight volatile organics such as THM's, TCE, vinyl chloride, carbon tetrachloride.
- Disposal of reject water



XI. Physical Processes -- Centrifugation

- Used in industry for separating liquids of different size, shape, density, viscosity density, for thickening slurries or removing solids; also used to dewater wastewater sludges.
- Centrifuges utilize the separation resulting from a high-speed circular G-force. The machines spin in order to separate materials from one another as denser materials separate from those less dense.
- Centrifuges have been used to replace sedimentation as a means of performing many tasks, such as: Clarification, Dewatering, Extraction, Recovery, Recycling, and Separation





Centrifugation:
Often need to precondition the influent to the centrifuge, and a support or upstream process is required, such as chemical addition/mixing etc.

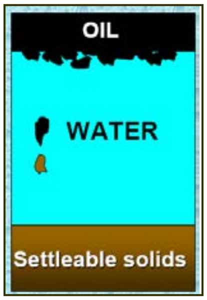
Advantages:

- The typical sedimentation process is slow and fine particles will remain suspended in the liquid.
- Compact, small size

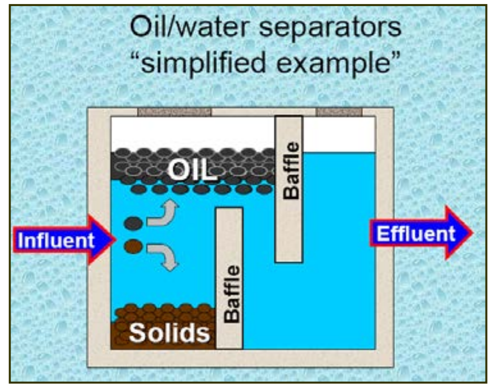
Disadvantages

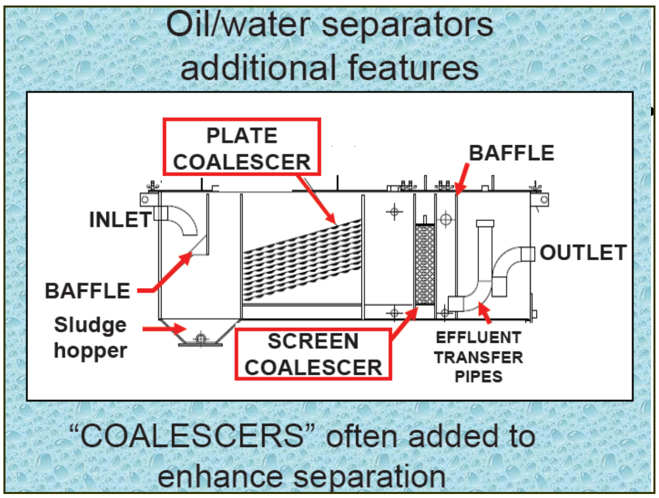
- Centrifuges require lots of energy and substantial maintenance
- Abrasive wear

XII. Physical Processes -- Oil/water separation



- A gravity separation device
- Oil droplets rise based on their density and size.
- Design is based on the difference in specific gravity between the oil and water.
- Standardized criteria by the American Petroleum Institute (API)
- Above and below ground types
- Rectangular or circular types





Common Limitations: Both emulsified and dissolved oils cannot be removed in physical oil/water separators.

Emulsions are fine oil droplets which cannot be separated from water physically because of other chemicals in the water, such as soap.

Relatively simple to operate but the effluent water must often be sent on for further treatment, such as a dissolved air flotation unit, for removal of any residual oil, and then to a biological treatment unit for removal of dissolved compounds.

Maintenance! Solids and oils must be removed and properly disposed. Clean out must be frequent enough to prevent baffles from being overcome.

XIII. Physical Processes -- Cooling

Refineries, steel mills, petrochemical industries, power plants and paper mills all typically generate heat in their processes and often need cooling water systems. The cooling water itself gets hot

Normally reuse or recycle this water, but if a discharge to natural waters or a public sewer system is needed then cooling will likely be required first.

Cooling water systems

- Non-evaporative or evaporative
- Non-evaporative systems include once-through cooling and closed loop systems

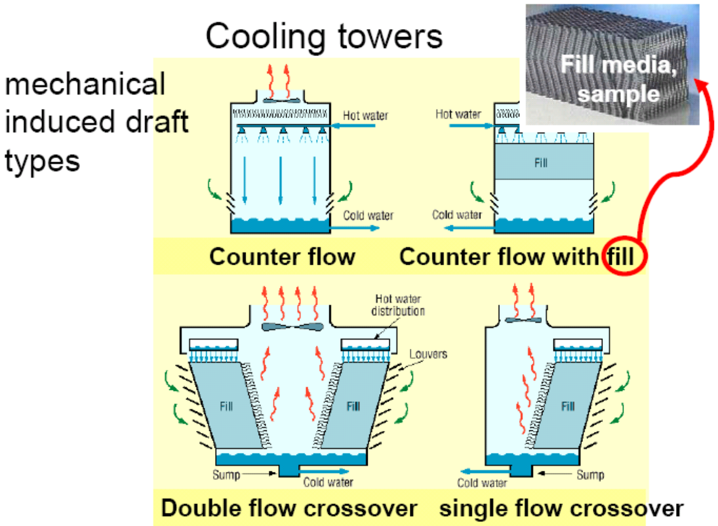
Non Contact Cooling Water is water used for cooling which does not come into direct contact with any raw material, product, byproduct, or waste.

Contact Cooling Water does come into direct contact with materials, products and/or waste.

Evaporative cooling systems include

- cooling towers
- evaporative condensers
- spray ponds
- cooling ponds

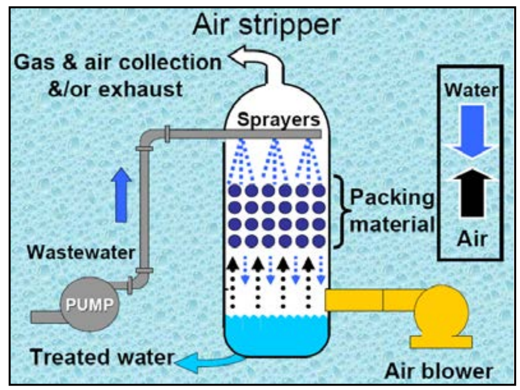
Reduce temperature of waste water through simple thermodynamic process, transferring heat from the wastewater to another fluid or to the atmosphere.



Issues/Considerations

- Ponds
  - o Large land area required
  - o Algae/bacteria growth
  - o Liners
- Towers
  - o Power and maintenance requirements
  - o Makeup water contains minerals, solids, debris, bacteria and other impurities resulting in scale, corrosion, and fouling
  - o Water additives may be needed to address scale, corrosion, and fouling which may complicate suitability for discharge; additives require special approval from DEQ

XIV. Chemical Processes -- Air Stripping



Air stripping is the transfer of volatile components of a liquid into an air stream.

Volatile compounds with certain properties can be economically stripped from water.

- Includes BTEX compounds and certain solvents
- Ammonia also, typically with pH and temperature adjustment to waste stream

Air strippers are usually towers

- “Packed” or “tray” towers of packing media

Air Stripping -- Packed towers

- Engineered or random plastic packings used
- Design criteria for packed towers
  - o surface area provided by the packing
  - o column height and diameter
  - o air to water flow rates

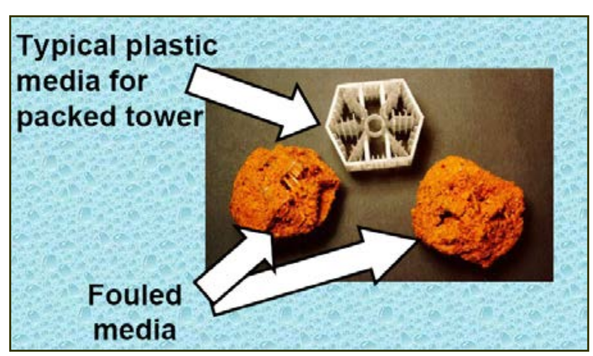
Air Stripping -- Low profile units, typically use “trays”

Benefits

- Air strippers are simple and generally easy to construct, operate, and maintain.

Issues/concerns

- Noise, can be very loud
- Air stripping cannot remove metals, PCBs, or other chemicals that do not evaporate.
- Air stripping transfers pollutants to the air
  - o If stripping results in elements or compounds that are air pollutants, then the air exiting the stripper will require emissions control and permits
- Subject to fouling with deposits of minerals, solids, biological films



XV. Chemical Processes -- Precipitation

Chemical precipitation: for removal of metals, other inorganic, suspended solids, fats, oils, greases, and some other organic substances from wastewater.

Dissolved or suspended contaminants in a solution settle out of the solution as a solid "*precipitate"*.

Precipitate is then separated from the liquid by clarifiers, filters or centrifuging etc.

Assisted through the use of a coagulants and polymers

Coagulants cause smaller particles suspended in solution to gather into larger aggregates

Polymers contain electrically charged molecules which allow the polymers to act as connecters between particles suspended in solution, or to neutralize particles in solution

Common Uses

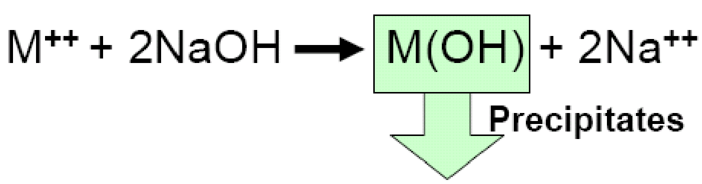
- Water softening
- Heavy metal removal from metal plating wastes
- Oil and grease removal from emulsified solutions
- Phosphate removal from wash-waters and other wastewater

Common Chemicals Used

- Lime (Calcium Oxide) -- CaO
- Ferrous Sulfate – $Fe(SO_4)_3$
- Alum– $Al_2(SO_4)_3$-$14H_2O$
- Ferric Chloride – $FeCl_3$
- Sodium Hydroxide Na(OH)
- Sodium sulfide Na_2S
- Sodium carbonate Na_2CO_3,
- Acids, Sulfuric H_2SO_4 and phosphoric H_3PO_4
- Polymers, synthetic

Because the hydroxides of most metals are insoluble, often use chemical precipitation to convert them to an insoluble hydroxide

Example reaction mechanism for a divalent metal:



Note: Metal precipitation, solubility is dependent on pH -- need to optimize pH for each metal

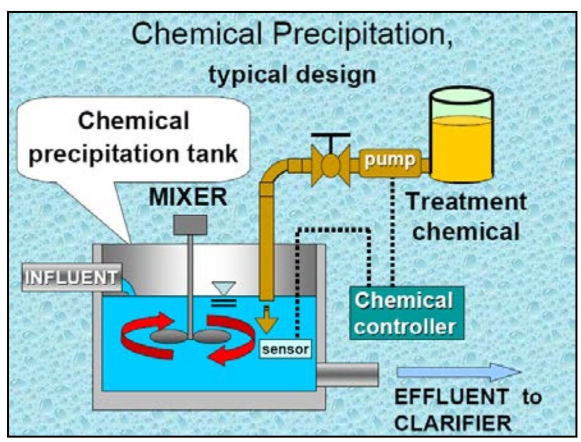
For some metals use sulfide precipitation instead

Benefits:

- Well-established technology, readily available
- Some treatment chemicals are very inexpensive.
- Some systems can be self-operating with low maintenance

Issues/Concerns:

- Competing reactions, pH, alkalinity, temperature, mixing effects, and other factors can make precipitation delicate and frustrating
- Some chemicals are hazardous and corrosive, increasing operator safety concerns.
- Large amounts of chemicals may be needed to be transported to the treatment location.
- Some polymers can be expensive.



XVI. Chemical Processes -- Ion Exchange

A common process employed to remove heavy metals from relatively low–concentration waste streams

- An ion is an atom or molecule which has lost or gained one or more valance electrons, making it positively or negatively charged

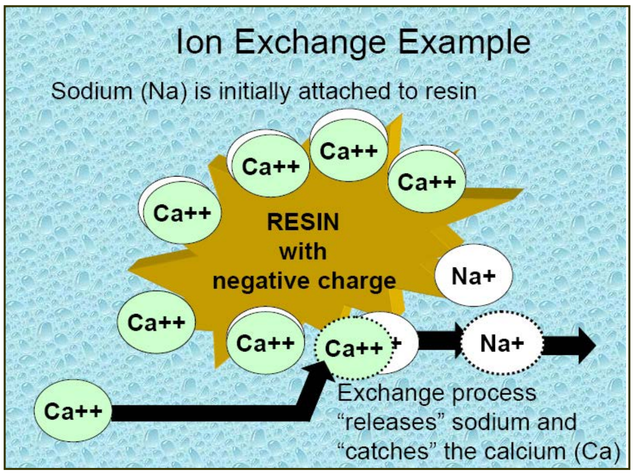
The wastewater is passed through a bed of resin containing bound groups of ionic charge on its surface, which are exchanged for ions of the same charge in the wastewater.

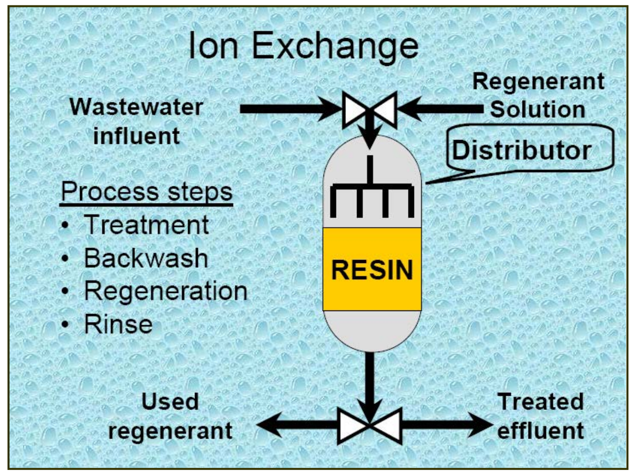
- Resins are classified by type, either cationic or anionic, choice depends upon the contaminant to be removed.
- Resins: typically based on cross linked polystyrene

Example application: Ion exchange resins are used to remove copper or lead ions from solution, replacing them with less offensive ions, such as sodium and potassium.

Process: The Ion Exchange Process involves 4 steps:

1. Treatment: apply wastewater to the resin bed
2. Backwash: clean bed once removal capacity is expended, also known as "break through"
3. Regeneration: apply a chemical solution to the resin bed which re-establishes the original ion and concentrations
4. Rinse: removes excess regeneration solution





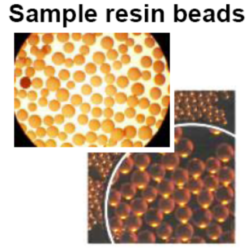
Benefits:

- Metal contaminants can be recovered and reused.
- Selective, may be designed to remove certain metals only

Issues/Concerns:

- Resins may be fouled by some organic substances, oils, & polymers
- Wash water disposal

Sample resin beads



Bead material has a structure of pores on the surface which accommodate easily trapped and released ions

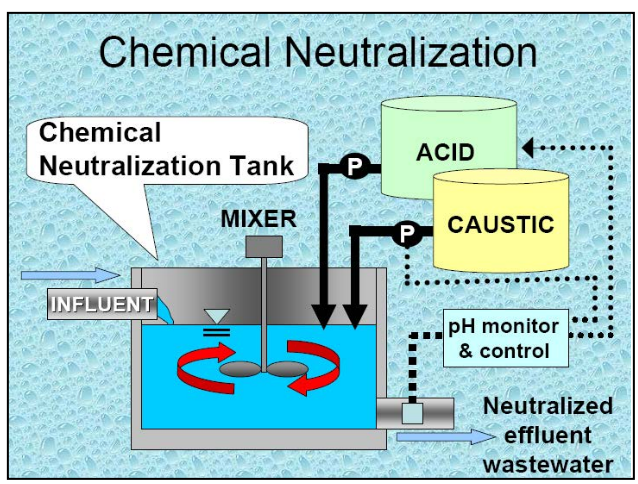
XVII. Chemical Processes -- Chemical Neutralization

Eliminate either high or low pH values

- to meet discharge limits
- or prior to biological or other chemical treatment processes where pH adjustment is needed to optimize treatment efficiencies.

Basic Process

- Add acids, such as sulfuric or hydrochloric acid, to reduce pH
- Add alkalies, such as sodium hydroxides, to raise pH values
- Typically performed in a holding tank, rapid mix tank, or an equalization tank



Control pH to between 6.5 and 9 in order to meet typical discharge limitations.

Benefits:

- Relatively simple

Issues/Concerns:

- Typically involves handling hazardous chemicals.

Typical chemicals

ACIDS	BASES
Sulfuric Acid (H_2SO_4)	Caustic (NaOH)
Carbonic Acid (H_2CO_3)	Calcium Hydroxide ($CaOH_2$)
Hydrochloric Acid (HCl)	Calcium Carbonate ($CaCO_3$)-Lime
Phosphoric Acid (H_3PO_4)	Ammonium Hydroxide (NH_4OH)
Nitric Acid (HNO_3)	

XVIII. Chemical Processes -- Oxidation/Reduction

Oxidation: The loss of electrons by a molecule, atom or ion
Reduction: The gain of electrons by a molecule, atom or ion

- Can remove ammonia, cyanide, residual organics, chromium etc.
- Achieved by chemical addition such as chlorine, permanganate, hydrogen peroxide, & ozone
- Often precedes another process which completes removal
- Can have secondary benefit of disinfection in some cases

Example: Cyanides & Chromium; common in the electroplating industry

- For wastewater containing cyanide, an alkaline chlorination process is sometimes used to oxidize cyanides to carbon dioxide (or carbonate) and nitrogen. This occurs prior to metals removal.
- For wastewater containing hexavalent chromium the chemical reduction process involves adding sulfur dioxide, sodium bisulfite or ferrous sulfate to the wastewater and an acid to lower the pH to 3.0 or less. This process converts hexavalent chromium to trivalent chromium which can then be treated similar to other metals.

Cyanide destruction by alkaline chlorination

STAGE 1

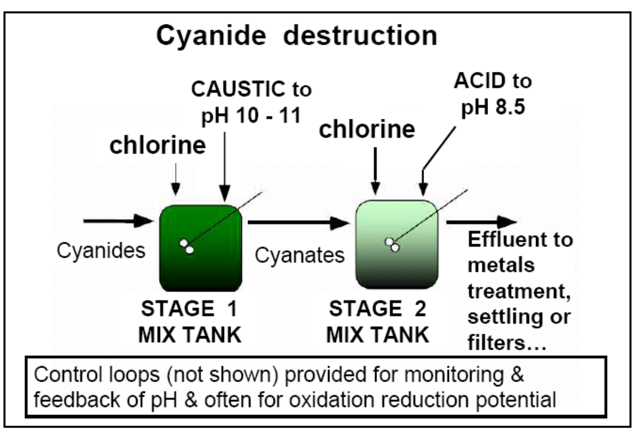
$NaOCl + CN^- \rightarrow NaCNO + Cl^-$

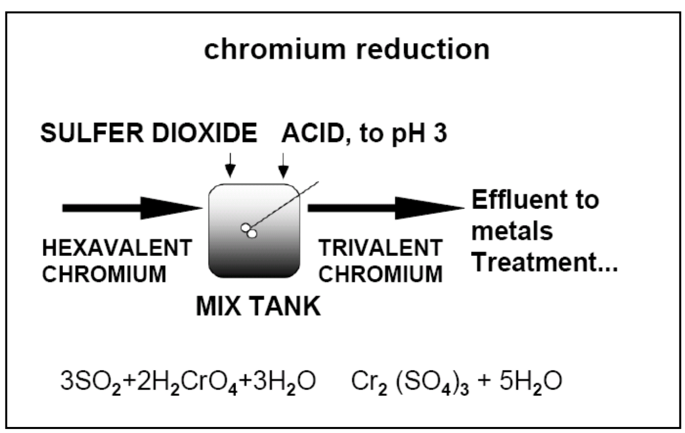
STAGE 2

$2NaCNO + 3NaOCl + H_2O \rightarrow 2NaHCO_3 + N_2 + 3NaCl$

Caustic added in first stage to increase pH, acid added in second stage to decrease pH

pH controls must have fail-safe design, as pH levels below certain values can produce very toxic hydrogen cyanide or cyanogen chloride under certain conditions in each stage



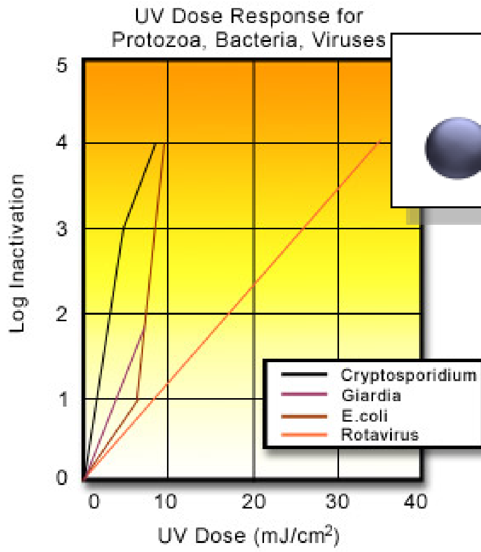


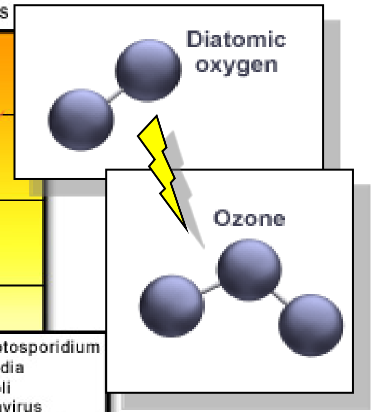
Issues/Concerns:

- Interference from other chemicals in the wastewater
- Dependent on pH and often on catalyst
- Often needs prolonged detention time 30 minutes - 2 hours
- Transport and handling of hazardous chemicals often required, strong oxidizers have certain dangerous properties and strong acids/caustics are required for certain processes.

XIX. Chemical Processes -- Disinfection

Reduce or eliminate the number of microorganisms in the water to be discharged back into the environment.





Common methods:

- Chlorine
- Ultraviolet light
- Ozone

Chlorination: gas or liquid chemical storage & feed, mixing, and a tank/chamber for contact & detention.

Ultraviolet (UV) light: pass the water near lamps in channel or pipe

Ozone (O_3): generated on site by passing oxygen O_2 through a high voltage, O_3 gas fed to a detention/contact basin.

Benefits:

- Chlorine has a residual, a positive if need to minimize microbial growth in a downstream pipeline etc.
- UV uses no chemicals
- Ozone, can add dissolved oxygen to effluent as a positive, secondary effect

Issues/Concerns:

- All of the noted disinfection types have safety issues
- Chlorination
  - o Chlorination of residual organic material can generate some harmful, carcinogenic by-products.
  - o Chemical dechlorination required for discharge to environment.
- UV disinfection
  - o Frequent lamp maintenance and replacement needs
  - o Needs highly treated effluent so target organisms are not shielded from the (UV)radiation
- Ozone disinfection
  - o High cost of the ozone generation equipment and requires highly skilled operators
  - o The off-gases, if any, from the contact chamber must be treated to destroy any remaining ozone before release to the atmosphere.

XX. Biological Processes – Common Concepts & Lagoons/Stabilization Ponds

Common Background & Definitions

- Applies to industrial waste waters containing organic pollutants that are subject to biological degradation
- Some oils can also be treated biologically
- Biological treatment systems use microbes to consume organics
- ***Aerobic*** microbes require oxygen (O_2) to grow
- ***Anaerobic*** microbes will grow only in the absence of O_2.
- ***Facultative*** microbes can grow with or without O_2
- ***Aeration*** is the process by which air (or oxygen) is added to, dissolved in, circulated and/or mixed in wastewater.

- ***Microorganisms:*** commonly referred to as "bugs"

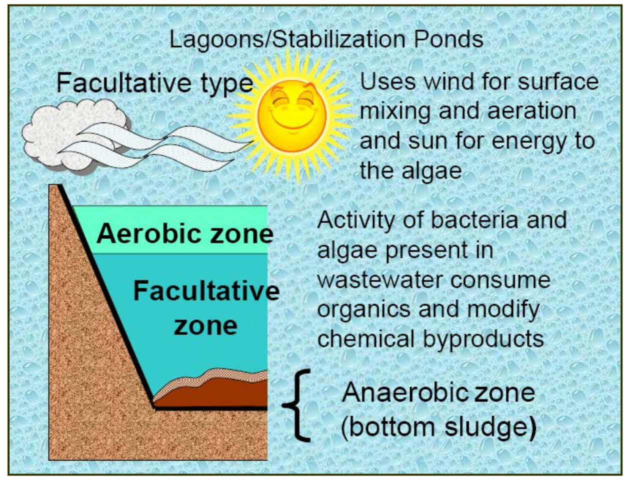
  The organisms see organic compounds and matter as food/energy and degrade or break down these materials in metabolic processes. Products include carbon dioxide and water and other "smaller" compounds

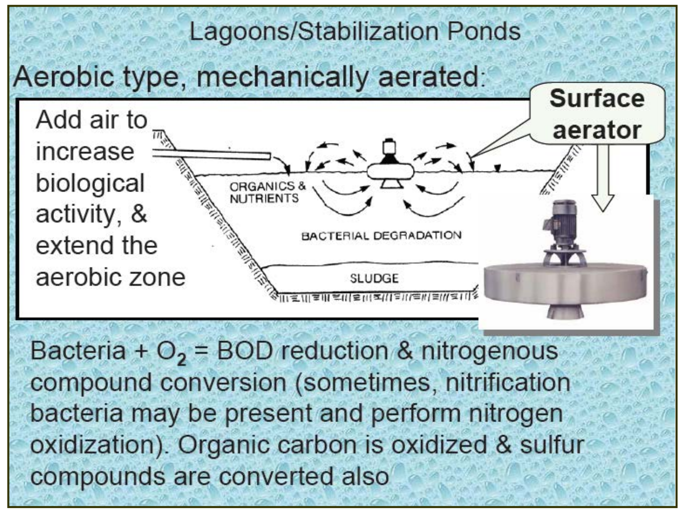
  The "bugs" generally need oxygen but anaerobic organisms do this without the presence of oxygen. Some use nitrate, sulfate, iron, manganese, and carbon dioxide as their electron acceptors, and break down organic chemicals into smaller compounds, often producing carbon dioxide and methane as the final products.

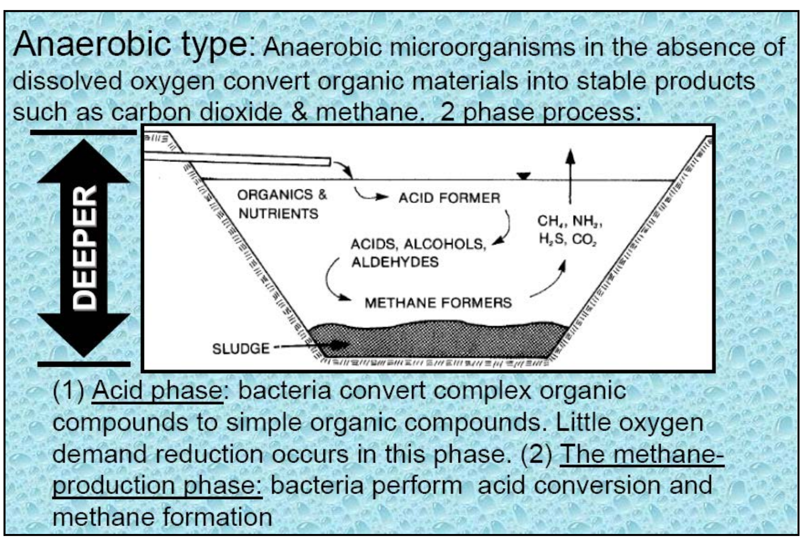
- Even though lagoons are generally considered to be simple treatment systems, the biology and biochemistry involved are very complex, involving many forms of biological reactions.

- Different types of lagoons can be combined into multiple-stage lagoons to achieve the best treatment

- Operated at ambient temperature, only function well only in mild or warm climates.







Issues and Concerns (common to all lagoon types)

- Removal of settled sludge's & grit
- Sludge reduction limited in cold climates
- Emergent vegetation, insects & burrowing animals
- Need for composite liners, (expensive)

Facultative type lagoons

Benefits:

- Fairly effective in removing settleable solids, BOD, pathogens, fecal coliform & ammonia.
- Easy to operate & requires little energy

Issues/Concerns:

- Effluent ammonia difficult to manage
- Need large areas of land.
- Strong odors occur during seasonal turnovers.
- Often limited to seasonal discharge

Aerobic type lagoons

Benefits:

- Can require less land than facultative ponds
- Continuous discharge
- Sludge & grit removal can be less than facultative

Issues/Concerns:

- Some aerated ponds are not as effective as facultative ponds in treating ammonia or phosphorous, (unless designed for nitrification)
- Surface ice formation
- Requires energy input

Anaerobic type lagoons

Benefits:

- Effective & rapid stabilization of strong organic wastes, higher influent organic loading possible
- Produce less sludge, reduced sludge removal & disposal costs.
- Little energy needed
- Less costly to operate than other lagoon types

Issues/Concerns:

- Longer detention time needed (slow growth rate of the methane formers)
- Undesirable odors

XXI. Biological Processes -- Conventional Biological Treatment

Two categories:

- Suspended Growth
- Attached Growth

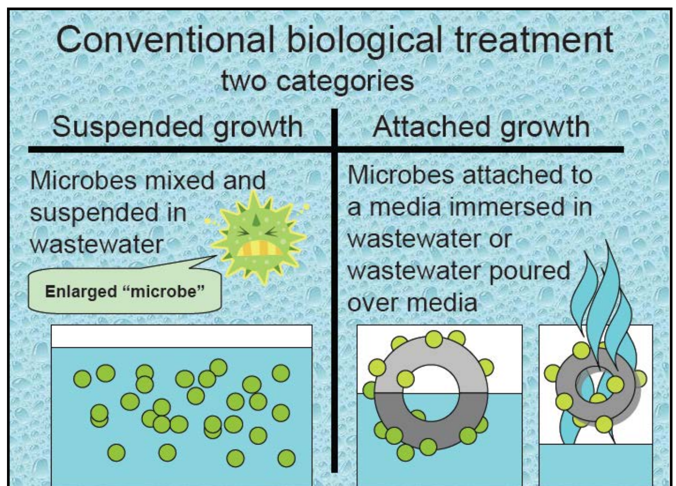
Suspended growth process variations

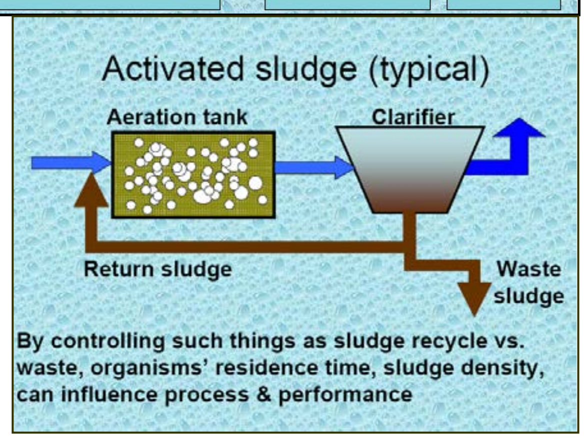
- Activated sludge
- Oxidation ditches
- Sequencing Batch Reactors (SBRs)

These processes speed up the work of aerobic bacteria and other organisms by providing a highly aerobic environment to increase their efficiency

Removes or break down bio-degradable organic material & converts organic nitrogen-compounds

Air is pumped in the water or the water is agitated to provide oxygen to the suspended microbial growth





Benefits:

- Treatment units are relatively small, requiring less space than attached growth processes.
- Good process control features and options.
- Process is generally free of odors.
- Process flexibility, has many options.

Issues/Concerns:

- Can be costly to operate compared to attached growth types, high energy use to run the aeration system
- Process can be impacted by elevated levels of toxic compounds in the wastewater

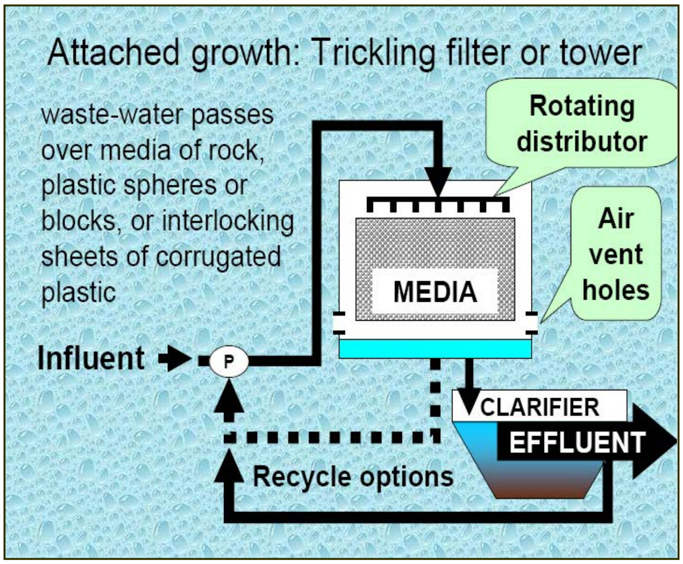
XXII. Biological Processes -- Attached Growth

Attached growth variations:

- Trickling filters or towers
- Rotating Biological Contactors (RBC)

Microbial growth occurs on the surface of stone or plastic media, a "film" of microbes

Wastewater passes over the media along with air to provide oxygen <u>or</u> the media is rotated into and then out of the wastewater to provide oxygen.



Attached Growth: Trickling filter or tower

Benefits:

- Can be effective in treating high concentrations of organics
- Rapidly reduce soluble BOD
- Efficient nitrification
- Durable with low power requirements

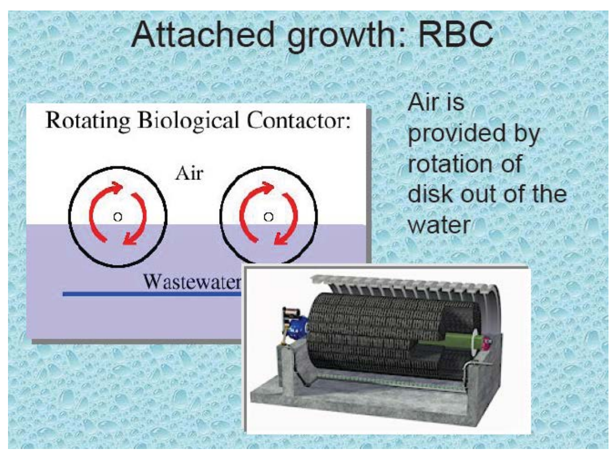
Issues/Concerns:

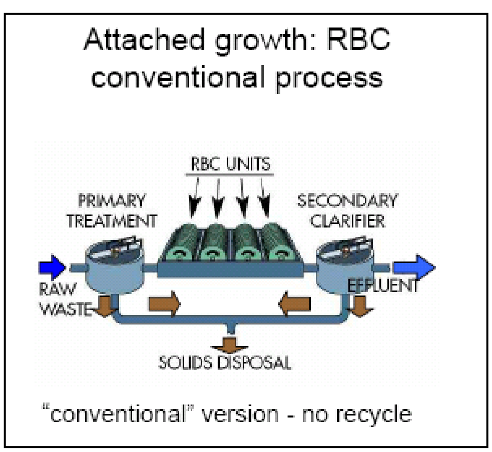
- Additional treatment often needed
- Accumulation of excess biomass can impair performance
- Clogging
- Flexibility and control are limited in comparison with activated-sludge processes

Attached Growth: RBC

Benefits:

- Short contact periods & retention time
- Withstands hydraulic & organic shock loads & fluctuations
- Biomass settles well
- Low operating costs & power requirements
- Easily nitrify





Attached Growth: RBC

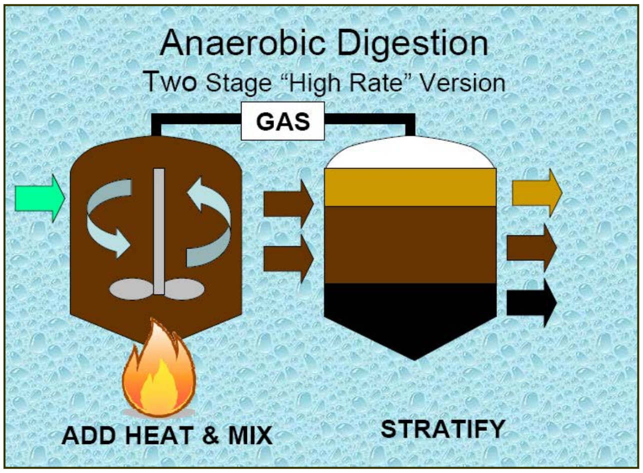
Issues/Concerns:

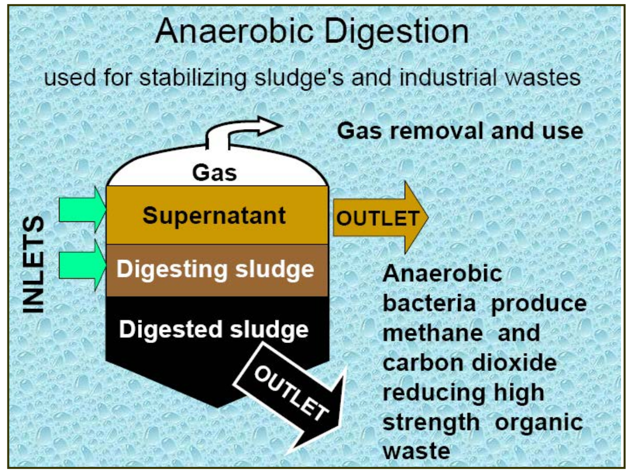
- RBC units must be indoors or covered in northern climates to protect against freezing
- Shaft bearings and mechanical drive units require frequent maintenance.

Biological Processes -- Common Issues and Concerns

- In certain waste stream supplemental nutrients or carbon may be needed in order for the process to work properly if the waste is deficient in carbon or nutrients.
- Inconsistent waste type and loading can reduce effectiveness (of some types more than others)
- Toxics can kill biomass

XXIII. Biological Processes -- Anaerobic Digestion





Benefits:

- Low energy required compared to aerobic versions
- Less biological sludge produced
- Smaller reactor volume required
- End product can be saleable products such as biogas (methane production), soil conditioner and a fertilizer
- Process can effectively reduce pathogens
- Anaerobic digestion is suitable for high-strength industrial wastes

Issues/Concerns:

- Longer start-up time to develop necessary biomass inventory
- May require further treatment with an aerobic treatment process
- Reaction rates sensitive to lower temperatures, heating achieve adequate reaction rates
- Increased potential for production of odors and hazardous and corrosive gases

XXIV. Biological Processes - Constructed Wetlands

- Man-made wetlands only
- Lengthy contact time, 30 days +
- Organic waste naturally attenuate and degrade, metals are adsorbed by plant root systems
- Best suited as "polishing" process

Issues/Concerns:

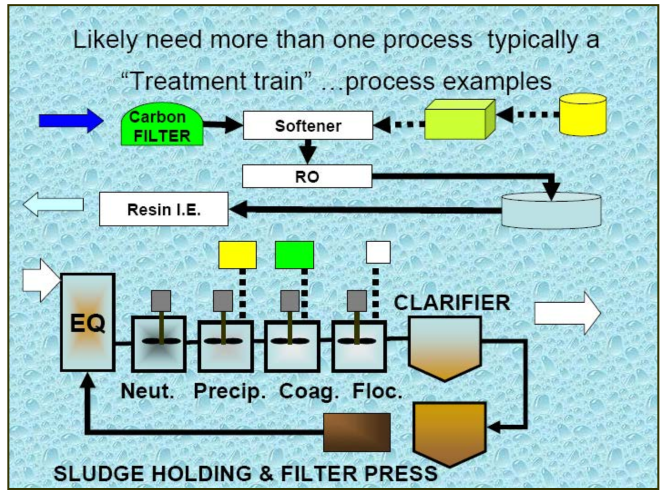
- Climate constraints
- Often fail to meet performance criteria
- Harvest and disposal of vegetation

XXV. Considerations

Likely need more than one process typically a “Treatment train” of processes

Selection of technologies:

Use a qualified consultant



- Use DEQ staff (will not design or select systems but can offer feedback based on experience)
- Consider capital and operation costs
- Consider complexity of testing and reporting requirements
- Consider complexity of operation, operator qualifications
- Operator training and training requirements

XXVI. Additional Resources

- Industrial/Commercial Wastewater Treatment Plant Operator Certification

  Go to www.michigan.gov/deq for information under the Wastewater Operator Certification Program.
  Useful information on training and certification for wastewater operators

  Certification is offered in a variety of classifications, each relating to a unit process

  RULES AND REGULATIONS:
  Part 31 of Act 451, Industrial Rules for Industrial Wastewater Operator Certification

- DEQ’s “Michigan Manufacturer’s Guide…” contains a discussion of Wastewater Treatment Technology
- DEQ Staff, contact district staff, statewide specialist
- Consulting engineers
- Similar facilities