



WASTE WATER TREATMENT



INDUSTRIAL CHEMISTRY
CLASS : XIII
SEMESTER : 8

Overview



- ❖ **Wastewater Engineering**
- ❖ **Wastewater Characteristics**
- ❖ **Wastewater Treatment Considerations**
- ❖ **Wastewater Treatment Plant Design**
- ❖ **Physical, Chemical and Biological Processes**

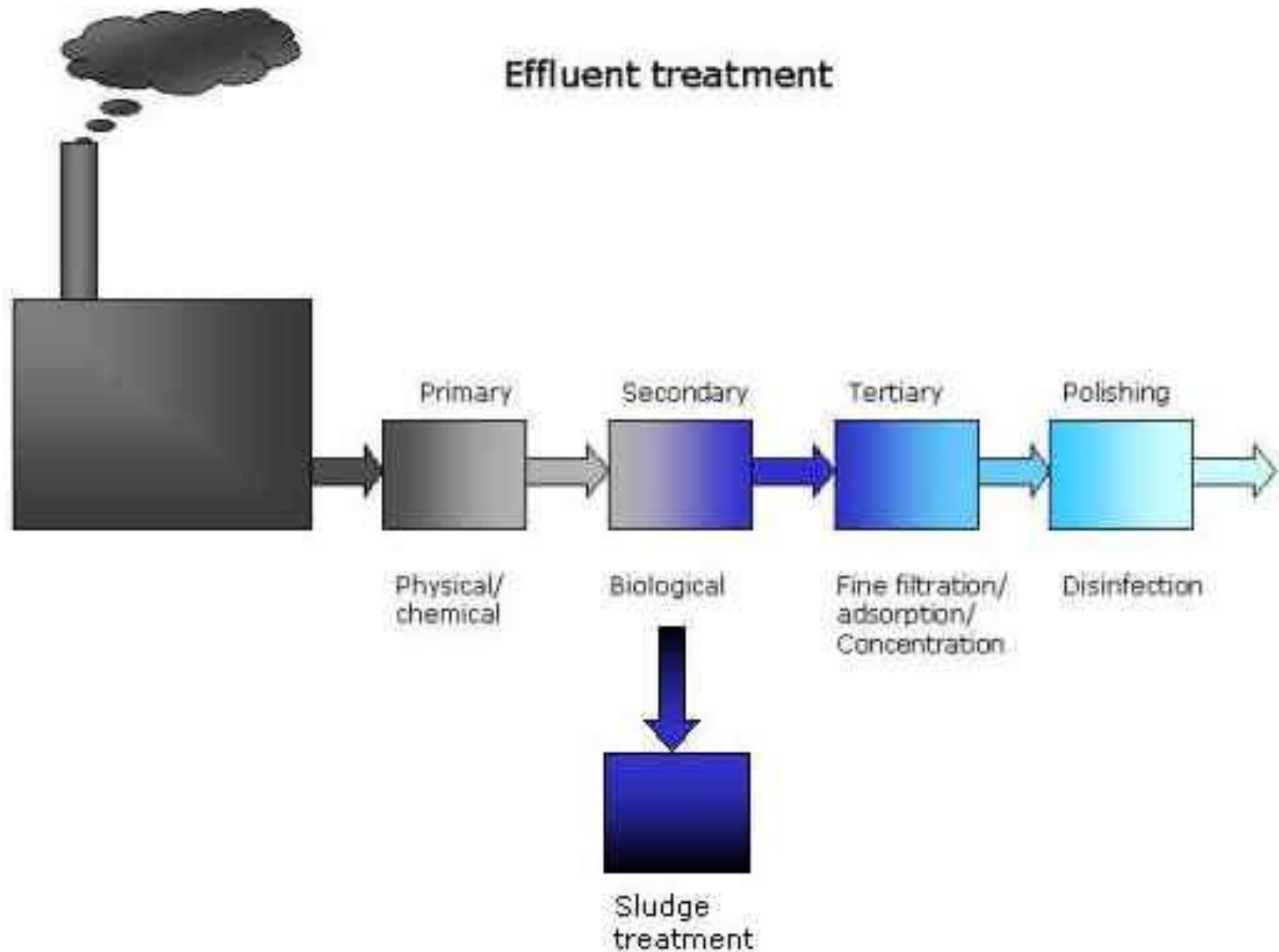
Wastewater Engineering

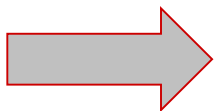
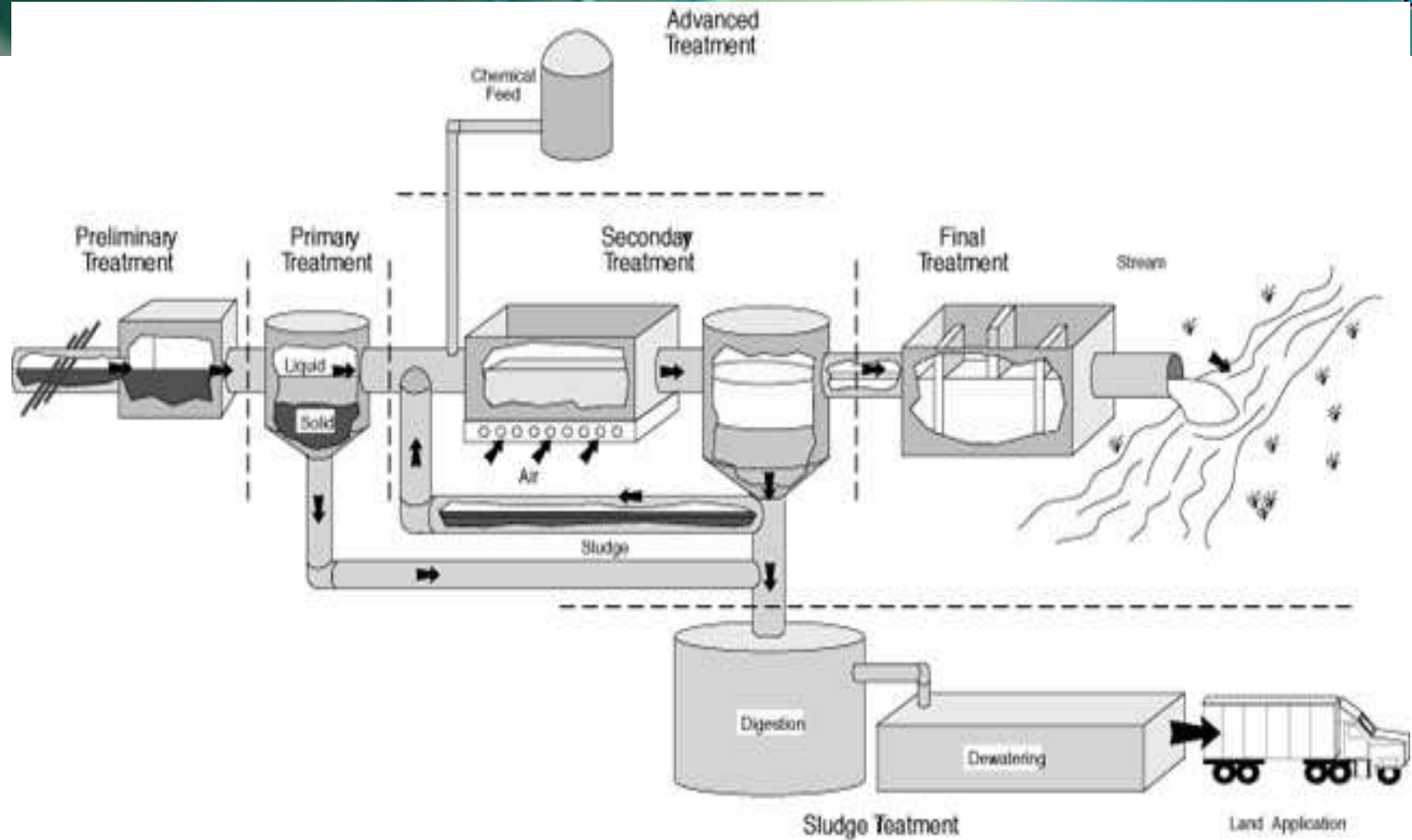


❖ Wastewater Treatment

- Wastewater is the water used by a community
- Collected and treated prior to discharge
- Standards of treatment vary but are generally becoming more stringent
- Treatment is a process of removal of smaller and smaller particles
- The goal is to reduce or remove organic matter, solids, nutrients, disease-causing organisms and other pollutants from wastewater

Effluent treatment





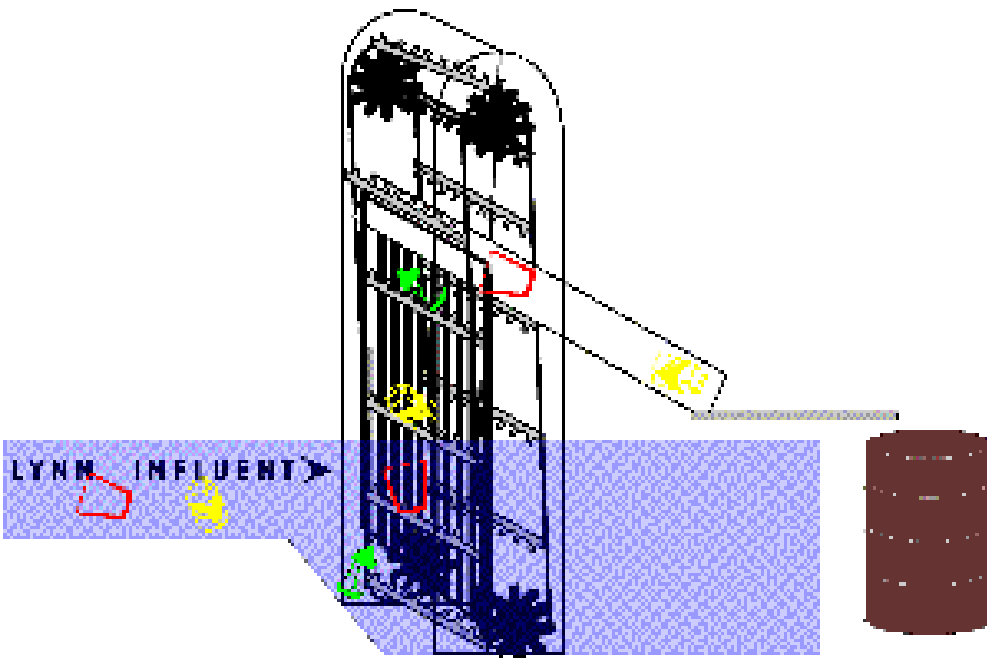
Preliminary Treatment



- ❖ **Preliminary treatment to screen out, grind up, or separate debris is the first step in wastewater treatment. Sticks, rags, large food particles, sand, gravel, toys, etc., are removed at this stage to protect the pumping and other equipment in the treatment plant. Treatment equipment such as bar screens, a large version of a garbage disposal, and grit chambers are used as the wastewater first enters a treatment plant. The collected debris is usually disposed of in a landfill.**



MECHANICAL BAR SCREENS



Waster Water Treatment
Animation\barscr1.gif



Barscreen Room, Barscreens in blue

Primary Treatment

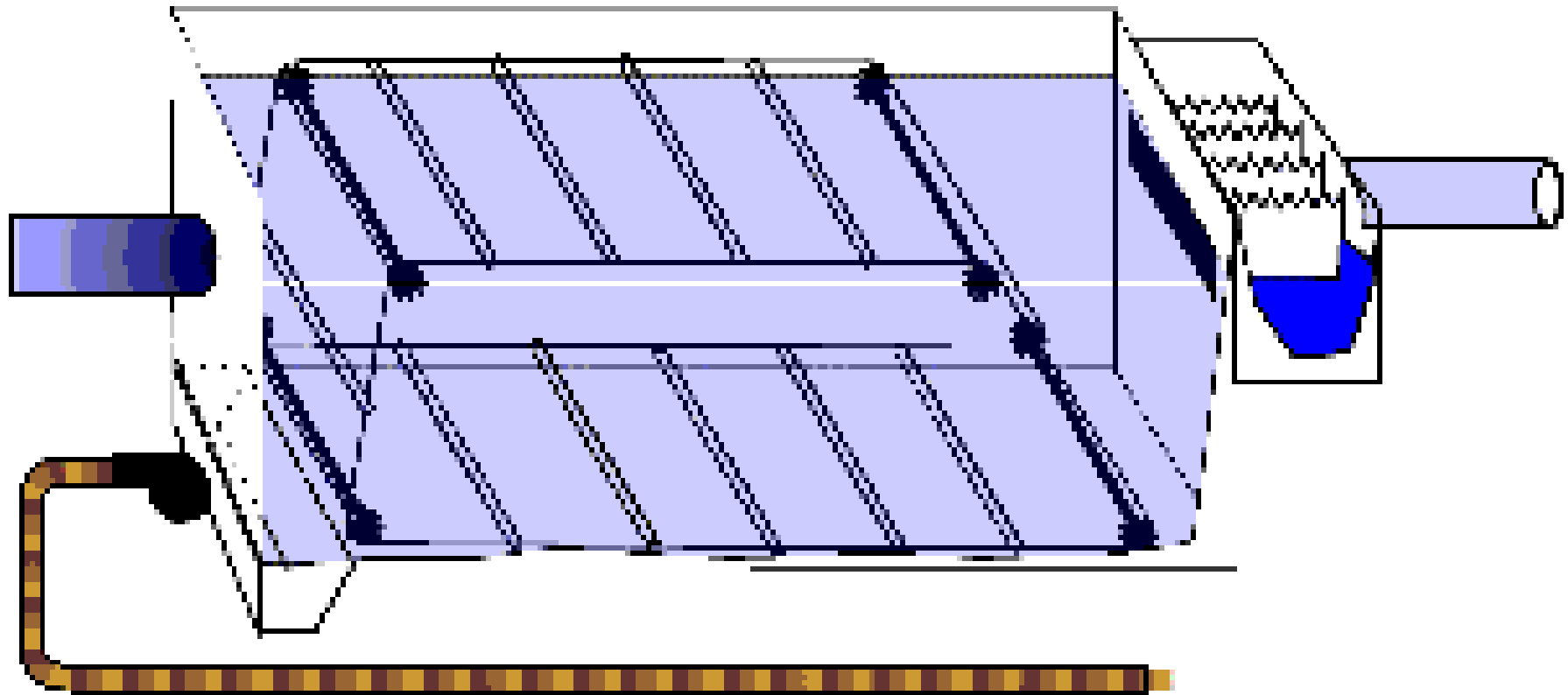


❖ **Primary treatment is the second step in treatment and separates suspended solids and greases from wastewater. Waste-water is held in a quiet tank for several hours allowing the particles to settle to the bottom and the greases to float to the top. The solids drawn off the bottom and skimmed off the top receive further treatment as sludge. The clarified wastewater flows on to the next stage of wastewater treatment. Clarifiers and septic tanks are usually used to provide primary treatment.**



- ❖ **The wastewater flows from the preliminary treatment grit chambers to the primary treatment process which removes Settleable and floatable materials from the wastewater. This occurs in the primary clarifiers which provide a quiescent zone for the sludge to settle and be collected into hoppers by a traveling flight and chain system. Primary sludge is pumped out of the clarifier and on to the Solids Handling process.**
- ❖ **Baffles were installed in the clarifiers to increase removal efficiencies**

PRIMARY CLARIFIER





Secondary Treatment



- ❖ **Secondary treatment is a biological treatment process to remove dissolved organic matter from wastewater. Sewage microorganisms are cultivated and added to the wastewater. The microorganisms absorb organic matter from sewage as their food supply. Three approaches are used to accomplish secondary treatment; fixed film, suspended film and lagoon systems**

Fixed Film Systems



- ❖ **Fixed film systems grow microorganisms on substrates such as rocks, sand or plastic. The wastewater is spread over the substrate, allowing the wastewater to flow past the film of microorganisms fixed to the substrate. As organic matter and nutrients are absorbed from the wastewater, the film of microorganisms grows and thickens. Trickling filters, rotating biological contactors, and sand filters are examples of fixed film systems.**

Suspended Film Systems



- ❖ **Suspended film systems stir and suspend microorganisms in wastewater. As the microorganisms absorb organic matter and nutrients from the wastewater they grow in size and number. After the microorganisms have been suspended in the wastewater for several hours, they are settled out as a sludge. Some of the sludge is pumped back into the incoming wastewater to provide "seed" microorganisms. The remainder is wasted and sent on to a sludge treatment process. Activated sludge, extended aeration, oxidation ditch, and sequential batch reactor systems are all examples of suspended film systems**

Lagoon Systems



- ❖ **Lagoon systems are shallow basins which hold the wastewater for several months to allow for the natural degradation of sewage. These systems take advantage of natural aeration and microorganisms in the wastewater to renovate sewage**



❖ **Pollutants dissolved in the wastewater or that would not settle in the primary clarifiers flow on in the wastewater to the Secondary treatment process. Secondary treatment further reduces organic matter (BOD₅) through the addition of oxygen to the wastewater which provides an aerobic environment for microorganisms to biologically break down this remaining organic matter. This process increases the percent removals of BOD and TSS to a minimum of 85 percent to meet the standards required in newer standard discharge permit**



❖ **The secondary treatment facilities are comprised of Oxygenation Tanks, Pure Oxygen Generating Plant, Liquid Oxygen Storage Tanks, Secondary Clarifiers, Return Sludge Pumping Station and Splitter Box, Sludge Thickeners and Pumping Station, Sludge Dewatering Building Addition and modifications to the existing Service Water Pumping Station.**



The Pure Oxygen Generation System incorporates a pressure swing adsorption (PSA) system oxygen generating system. PSA system is capable of providing 27 tons per day of pure oxygen to the oxygenation system.



PSA Compressors



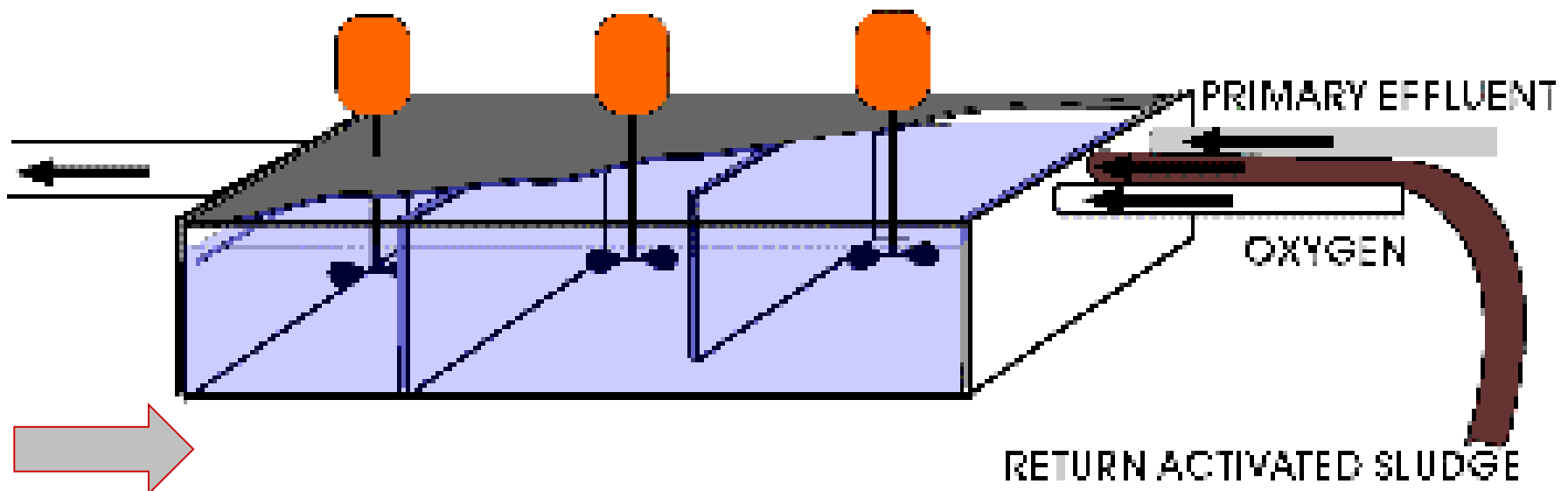
PSA Molecular Sieve

Oxygenation System



The oxygenation system is comprised of three covered oxygenation tanks, mechanical mixing system, and pressure-controlled oxygen feed and oxygen purity-controlled venting system. The primary effluent enters the head end of the tanks where it mixes with return activated sludge which consists of microorganisms "activated" by the organic matter and oxygen. This combination of primary effluent and return sludge forms a mixture known as "Mixed Liquor". This mixed liquor is continuously and thoroughly mixed by the mechanical mixer in each tank. The oxygen gas produced in the PSA system is introduced into the first stage of each tank and then remains in contact with the mixed liquor throughout the oxygenation system

AERATION REACTORS





Once the mixed liquor goes through the complete oxygenation process, it flows to four secondary clarifiers where the biological solids produced during the oxygenation process are allowed to settle and be pumped back to the head of the system. These settled solids being pumped, called return activated sludge, mix with the primary effluent to become mixed liquor.



❖ Since the population of microorganisms is growing some microorganisms in the return activated sludge are removed from the system. This solids waste stream is called waste activated sludge (WAS) and flows to the secondary gravity thickener for Solids Processing. The cleaned wastewater flows over the weir of the secondary clarifier and on to the disinfection (chlorination) process

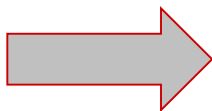
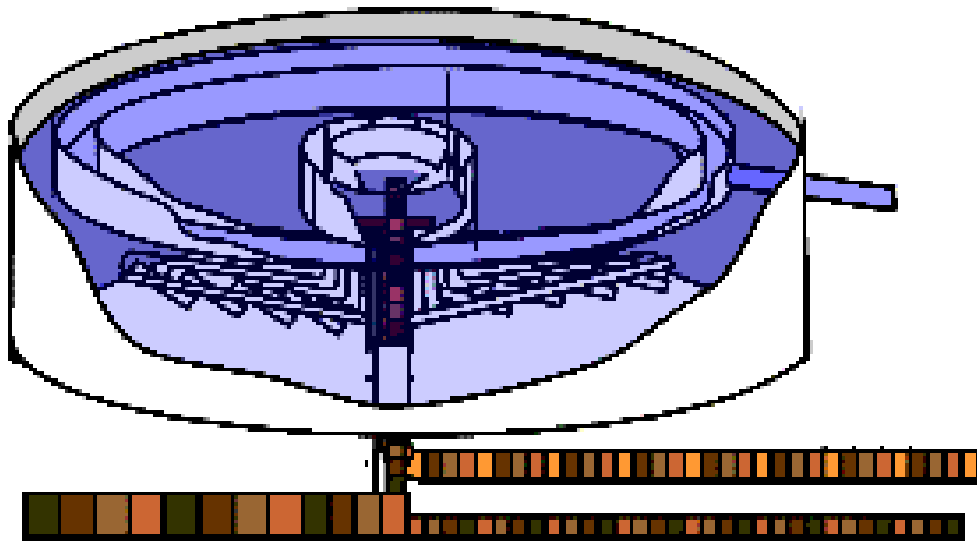


❖ **The activated sludge process is an aerobic, suspended growth, biological treatment method. It employs the metabolic reactions of microorganisms to produce a high quality effluent by oxidation and conversion of organics to carbon dioxide, water and biosolids (sludge).**



- ❖ **Basically the system speeds up nature and supplies oxygen so the aquatic environment will not have to. High concentrations of microorganisms (compared to a natural aquatic environment) in the activated sludge use the pollutants in the primary treated wastewater as food and remove the dissolved and nonsettleable pollutants from the wastewater. These pollutants are incorporated into the microorganisms bodies and will then settle in the secondary clarifiers. Oxygen needs to be supplied for the microorganisms to survive and consume the pollutants**

SECONDARY CLARIFIER



Final Treatment



- ❖ **Final treatment focuses on removal of disease-causing organisms from wastewater. Treated wastewater can be disinfected by adding chlorine or by using ultraviolet light. High levels of chlorine may be harmful to aquatic life in receiving streams. Treatment systems often add a chlorine-neutralizing chemical to the treated wastewater before stream discharge**

Advanced Treatment



- ❖ **Advanced treatment is necessary in some treatment systems to remove nutrients from wastewater. Chemicals are sometimes added during the treatment process to help settle out or strip out phosphorus or nitrogen. Some examples of nutrient removal systems include coagulant addition for phosphorus removal and air stripping for ammonia removal.**

Sludges



- ❖ **Sludges are generated through the sewage treatment process. Primary sludges, material that settles out during primary treatment, often have a strong odor and require treatment prior to disposal. Secondary sludges are the extra microorganisms from the biological treatment processes. The goals of sludge treatment are to stabilize the sludge and reduce odors, remove some of the water and reduce volume, decompose some of the organic matter and reduce volume, kill disease causing organisms and disinfect the sludge.**

Levels of Treatment



Primary

- removal by physical separation of grit and large objects (material to landfill for disposal)

Secondary

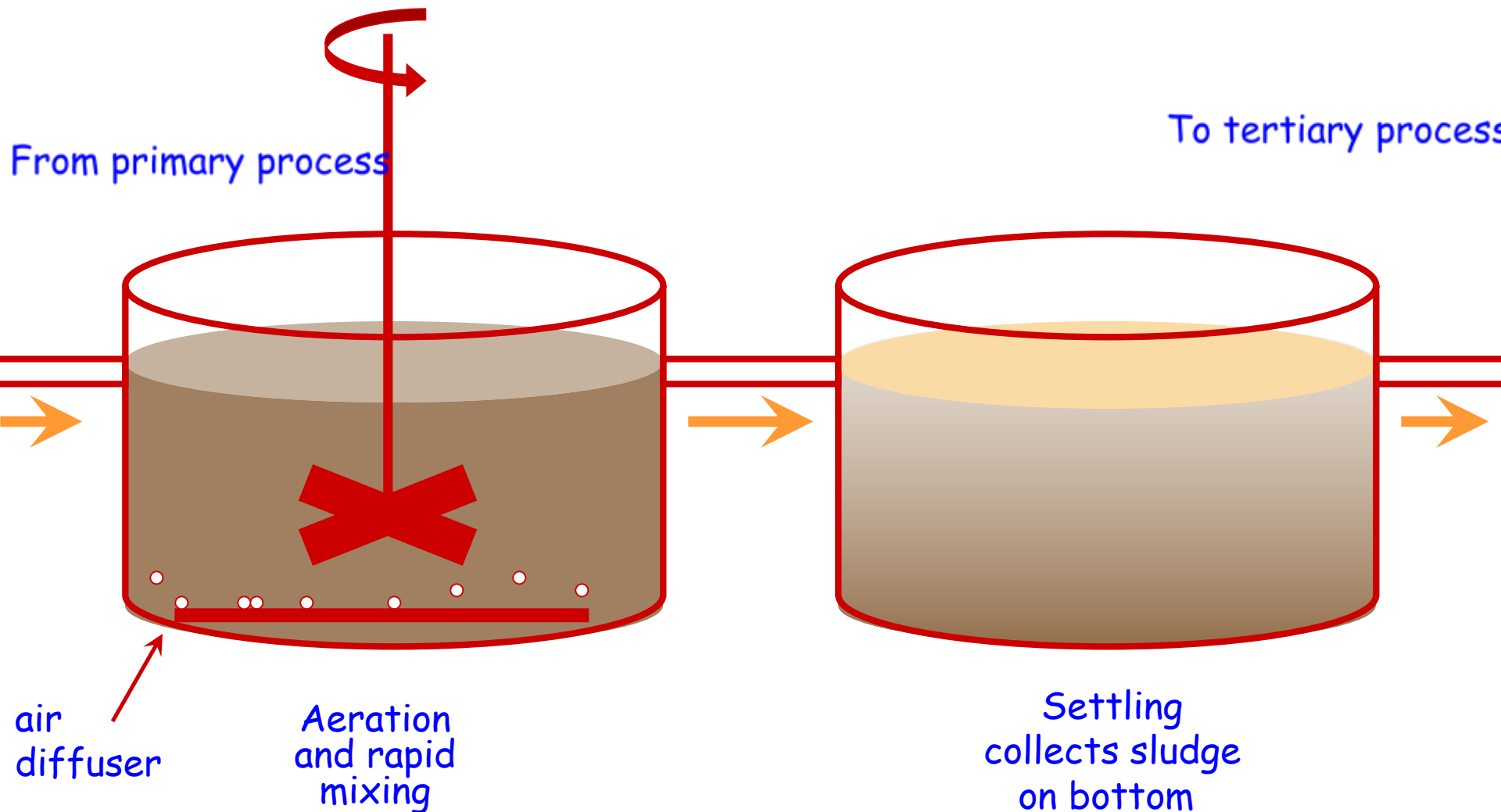
- aerobic microbiological process (sludge)



Mostly dead
microbes

- lowers suspended solids content (into sludge)

Secondary process



Levels of Treatment continued



Tertiary (advanced)

- anaerobic microbiological process with a different microbe where O_2 is toxic (more sludge)

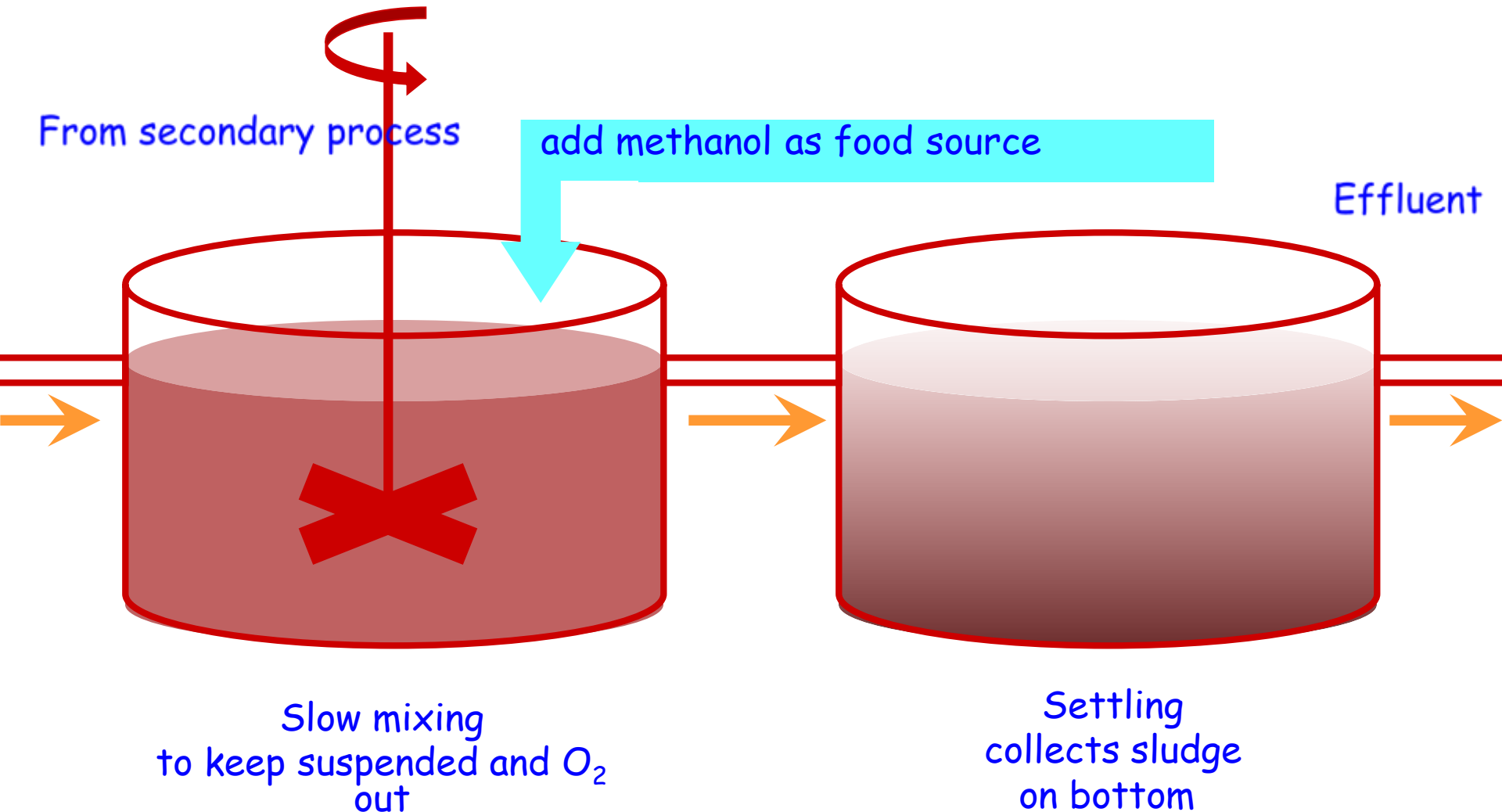


- PO_4^{3-} if not removed in sludge in secondary process



- aeration to strip N_2 and re-oxygenate (add DO)

Tertiary process



When the treatment is done...



- ❖ **Effluent back to stream after**
 - a final carbon filtration and
 - chlorination/dechlorination

- ❖ **Sludge – very nutrient rich**
 - applied directly to land as fertilizer
 - incinerated (good fuel after drying)
 - composted (Compro® from WSSC)

Note - Leafgro® is composted leaves and grass
from MES

Wastewater Engineering



❖ **Sludge Treatment**

- Sludges are the product of biological treatment of wastewater
- Sludges comprise solids found in wastewater plus organisms used in the treatment process
- Disposal is a major issue
- Various disposal techniques are used but each has advantages and disadvantages

Wastewater Engineering



❖ **Water Disposal and Re-Use**

- Wastewater treatment generates a *Cleaned Water Stream*
- Cleaned water is often discharged to a larger body of water for dilution
- Alternatively, cleaned water may be re-used for irrigation or rarely drinking water production

Wastewater Characteristics



Characteristics are normally estimated by empirical methods

❖ **Wastewater Flows**

- **Flows arise from households, industry, infiltration and storm flows**
- **Flows are considered in both hydraulic and process design**
- **Levels of treatment may vary for different flow rates**

Wastewater Characteristics



❖ Wastewater Flows

- There is a variety of methods for estimating flowrates
- However there may be great variability in the factors which affect flow rates from region to region
- Different multiples of the Dry Weather Flow will receive each level of treatment

Wastewater Characteristics



❖ **Wastewater Composition**

- **Key design issues:**
 - **Solids: density, particle size, level of Volatile Suspended Solids**
 - **Biochemical Oxygen Demand**
 - **Temperature**
 - **Ammonia**
 - **Nutrient levels**

Wastewater Characteristics



❖ Wastewater Treatment Considerations

- Objective: to maintain or improve the quality of the receiving body of water
- Treatment stages:
 - Preliminary
 - Primary
 - Secondary
 - Tertiary

Wastewater Characteristics



Classification of Methods

Physical Processes	Chemical Processes	Biological Processes
Screening Sedimentation Filtration	Precipitation Chlorination	Aerobic Anaerobic

Wastewater Characteristics



❖ **Applicability and Selection of Methods**

- Different processes are used to treat wastewater depending on the contaminants present
- Similarly, different processes are used to treat sludges, depending on the objective of treatment

Wastewater Treatment Plant Design



❖ **Flow rate and Mass Loading**

- Wastewater feed is not specified, therefore the plant must be able to treat whatever the wastewater contains
- **Plant design will take account of historical flows and loadings, but must also be able to deal with expansion**
- **Plant must also be able to deal with a range of flow and load conditions, plus peak upstream flow conditions (eg storms)**

Wastewater Treatment Plant Design



❖ Selection of Design Flowrates

- **Domestic:** based on a flow per head. Varies between countries
- **Industrial:** Based on records of discharge consents and of metered supplies
- **Infiltration/Exfiltration:** based on a % of the domestic flow
- **Peaking Factors:** Depends on size of community

Wastewater Treatment Plant Design



❖ **Selection of Design Flowrates**

■ **Upstream Flow Equalisation**

- **Plants are not normally designed to treat total peak arisings**
- **Instead, hydraulic controls will direct flows above plant capabilities to storm system on larger works**

Wastewater Treatment Plant Design



❖ Selection of Design Flowrates

- Upstream Flow Equalisation
 - UK maximum flow to treatment plant is determined by Formula A:
 - Formula A = $PG + E + I + 1360P + 2E$ l/d

P=population

G=average daily consumption per head l/h/d

E=Industrial & commercial discharges to sewer l/d

I=infiltration l/d

Wastewater Treatment Plant Design



❖ Selection of Design Flowrates

- Upstream Flow Equalisation
 - For larger works with storm tanks, only “Full Treatment Flow” (FTF) will receive full treatment.

$$\text{FTF} = 3\text{PG} + 3\text{E} + \text{I}$$

- Formula A-FTF will pass to storm tanks

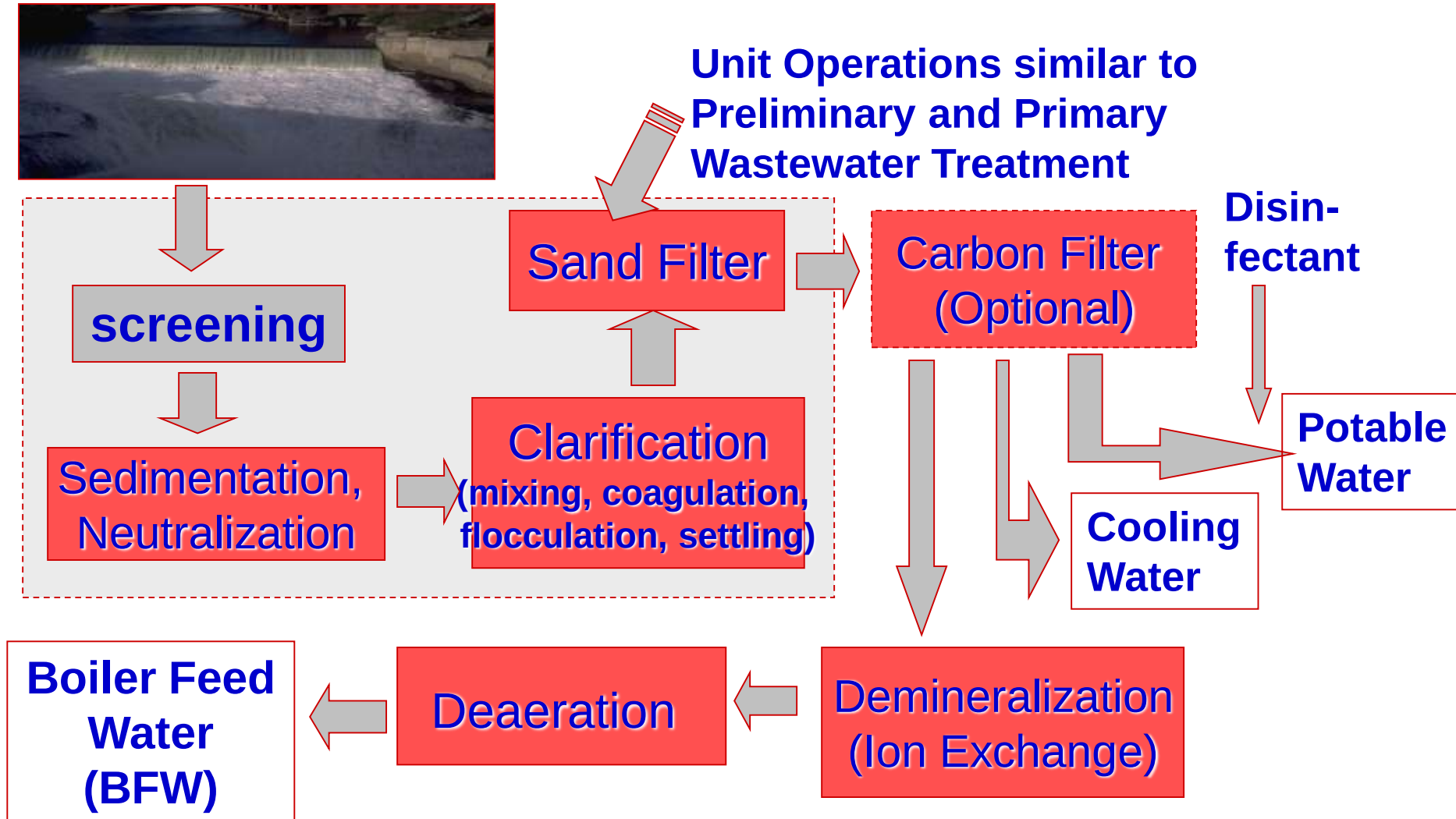
Wastewater Treatment Plant Design



❖ Selection of Design Mass Loadings

- Average mass loadings for BOD and Suspended Solids are commonly determined by Population Equivalent (PE)
- Design mass loadings are more complex and must take account of seasonal, diurnal and industrial load variations

INDUSTRIAL WATER CONDITIONING (SURFACE WATER, RIVER WATER)



Coagulation



The *chemical alteration* of the colloidal particles to make them stick together

- Hydrophilic particles – water loving – absorbs to water
- Hydrophobic particles – water hating – does not absorb to water
 - Hydrophobic particles are negatively charged and do not like to aggregate and are hydrophobic
 - A positively charge coagulant destabilizes the negatively charged particles and brings them together.
- Coagulants lower the negative repulsion force of colloid.

Sedimentation of suspended solid



To separate large size suspended solids from the water.

Sedimentation process usually takes longer time. To avoid flowrate and contaminant fluctuations, water is flown into an equalization basin/tank prior to sedimentation process.

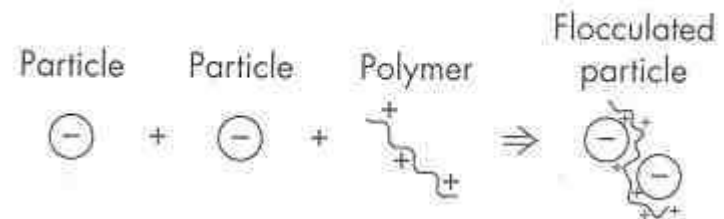
Some coagulants to assist floc formation:



Aluminum ions: Al^{+3}
Alum $\text{Al}_2(\text{SO}_4)_3 \cdot X \text{H}_2\text{O}$

Ferric Ions: Fe^{3+}
Ferric Sulfate $\text{Fe}_2(\text{SO}_4)_3$
Ferric Chloride FeCl_3

Calcium Ions: Ca^{2+}
Lime $\text{Ca}(\text{OH})_2$



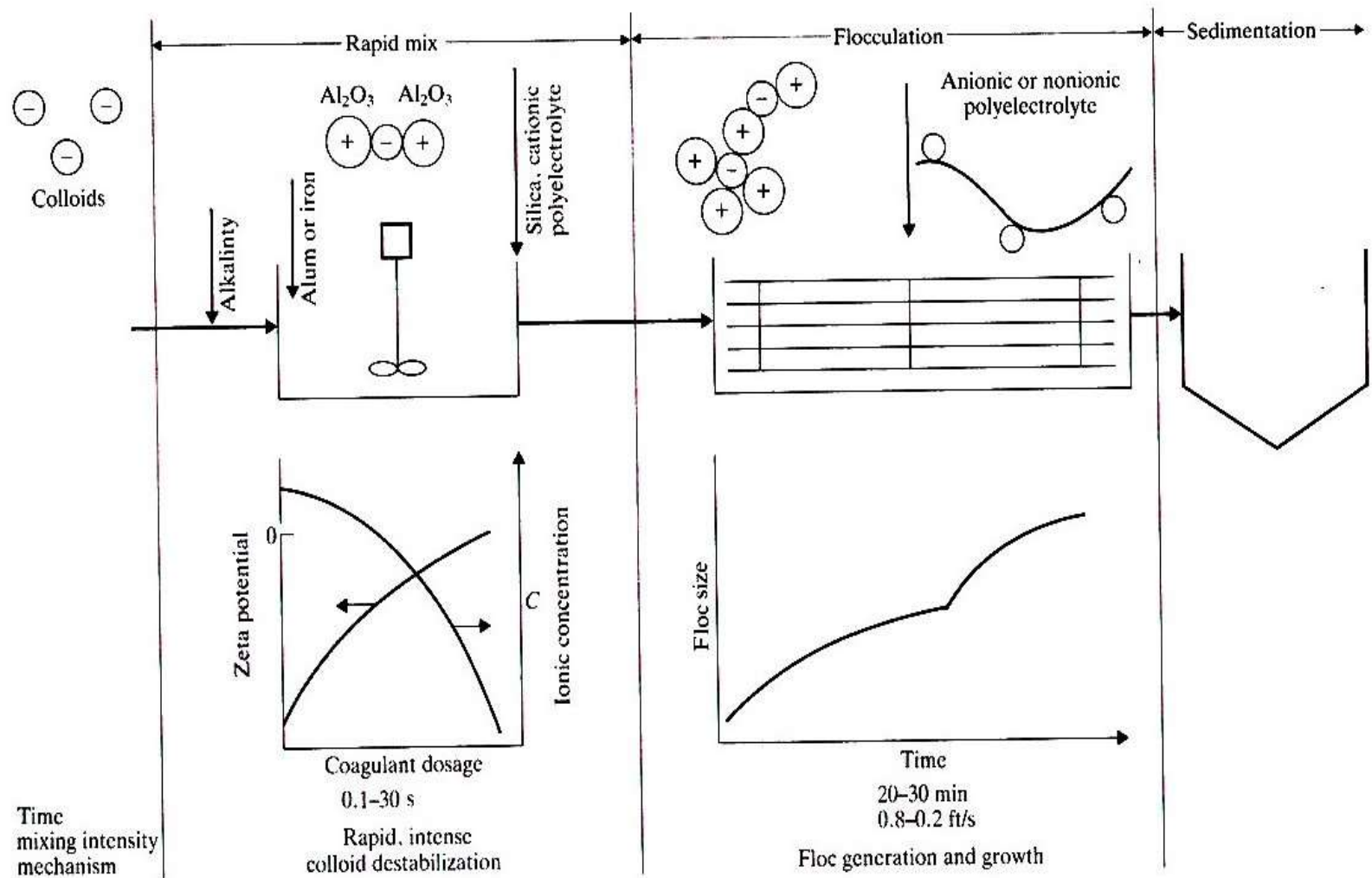
Coagulant aids:

Poly-electrolytes: to accelerate 'bridging' process between particle

Lime alkalinity addition – for $\text{Al}(\text{OH})_3$ formation.

pH correction: lime, sulfuric acid – for optimum floc formation

Coagulation Mechanism



Note: ft/s = 30.48 cm/s

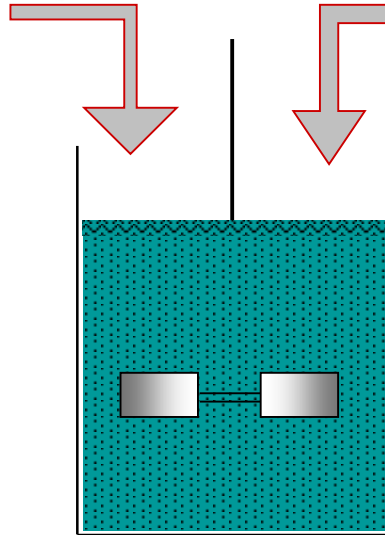
Mechanisms of coagulation.

Coagulation-Clarification Units

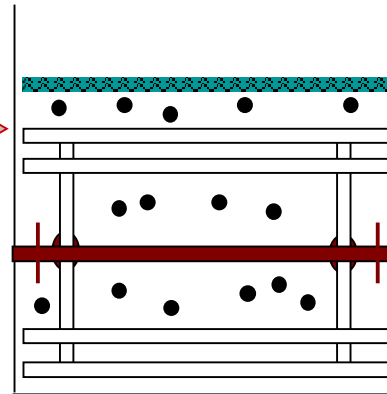


Water, contains
colloid particles

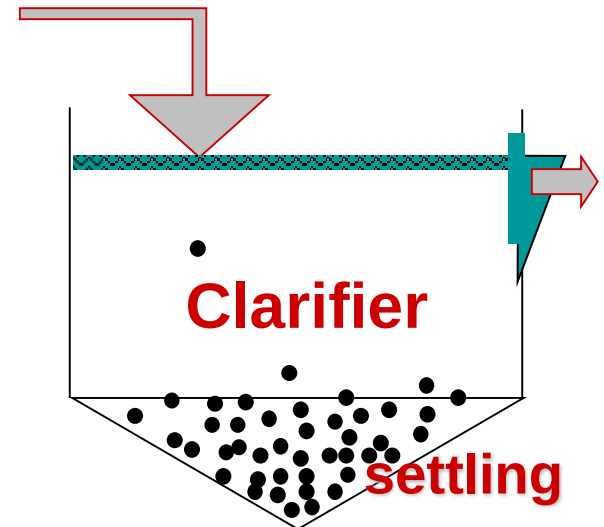
coagulant



Mixing Tank
(rapid mix)



Flocculator



Clarifier

Sludge

Clarification



Clarifier is used for reducing turbidity by reducing smaller suspended solids (colloids) in the water. A clarifier contains 3 type of processes, i.e. *mixing*, *flocculation* of smaller solids and *settling*.

Colloid matters need long time to settle or often impossible to settle by themselves due to gravity force. To settle down, colloids matters need to be coagulated to form larger particles by chemical (coagulant). Addition of coagulant is usually done in the *rapid mixing tank (pre-mix tank)* that work under fast and intensive agitation.

Clump of larger solids are then settled down in a clarifier and is blown-down from the bottom of the clarifier.