Industrial Waste Water Treatment

Unit 5

Outline – Levels of treatment methods

- Biological wastewater treatment
- Caste study
- Heavy metals

Treatment Methods employed – *Biological*

- Except possibly for chemical oxidation-reduction, the previously described processes do not actually destroy the wastes; they only change the volume occupied by the waste or the medium in which it is located.

- The only destructive technologies for industrial wastes that are commonly used are biodegradation and thermal destruction (incineration).

Treatment Methods employed – *Biological*

- Industrial wastewaters containing organic materials can be treated biologically either as the terminal treatment step before discharge to a receiving stream
- Most of the treatment is done by bacteria, which use the organics as substrate for energy and as a source of carbon for new bacterial cell growth.
- Biological treatment processes mimic the natural biodegradation of organics in the environment but are designed to speed the process so that degradation that may take days or weeks in nature can be accomplished in hours in the treatment plant.

Treatment Methods employed – *Biological*

- Microorganisms require a variety of nutrients for growth. These include the major nutrients carbon, hydrogen, oxygen, and nitrogen; the minor nutrients phosphorus, potassium, sulfur, and magnesium; and many trace nutrients. These nutrients are used in the synthesis of new microbial cells or to maintain those that exist.

- In addition to nutrients for microbial growth, microorganisms also need a source of energy.

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Treatment Methods employed – *Biological*

- For chemotrophs, energy is obtained by redox reactions in which electrons (and energy) are transferred from the organic molecule to an electron acceptor.

- The electron acceptor can be oxygen, in which case the process is considered to be *aerobic* to an oxygen-containing molecule such as nitrate or sulfate, in which case it is deemed to be an *anoxic* or *facultative* process; or to another more oxidized organic compound, in which case it is called an *anaerobic* process.

Aerobic process : Organic + $O_2 \rightarrow CO_2$ + Water + Energy
Anerobic process : Organics $\rightarrow$ Organic acids + CH_4 + CO_2 + Energy

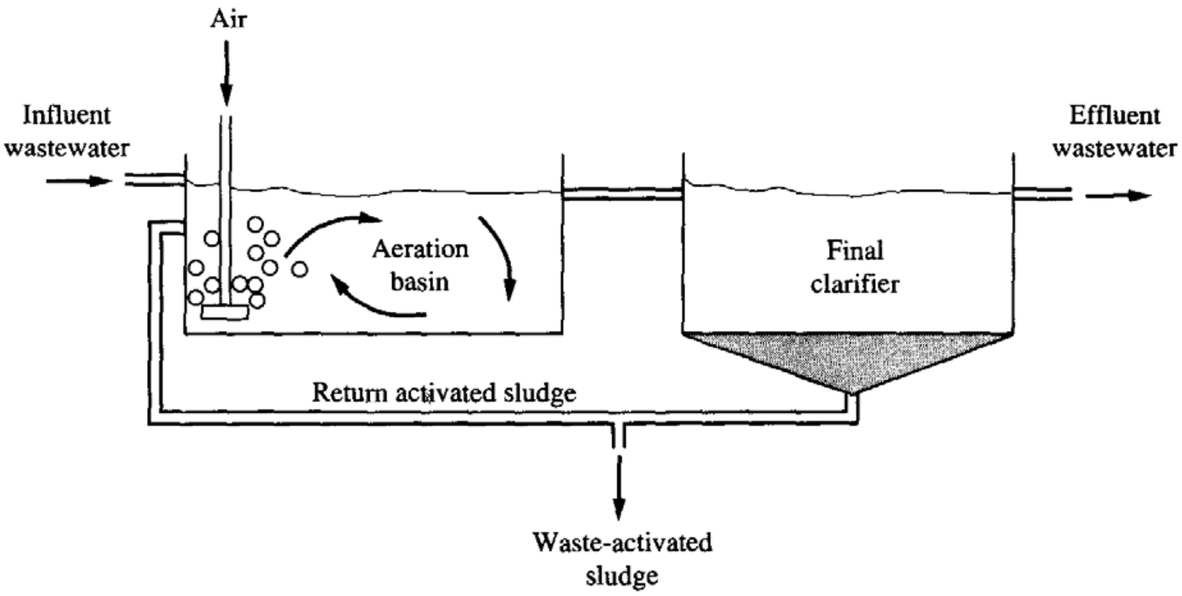
Treatment Methods employed – *Biological*

Activated Sludge Systems

- Activated sludge systems are designed to maintain intimate contact among the wastewater, a large population of bacteria, and oxygen.
- The large population of bacteria will allow for rapid biodegradation of the organics in the wastewater.
- An air supply is needed to ensure that there is sufficient oxygen to keep the system aerobic under the high-growth-high-oxygen utilization conditions.
- Finally, adequate mixing must be supplied to ensure good contact between the bacteria and the wastewater organics.

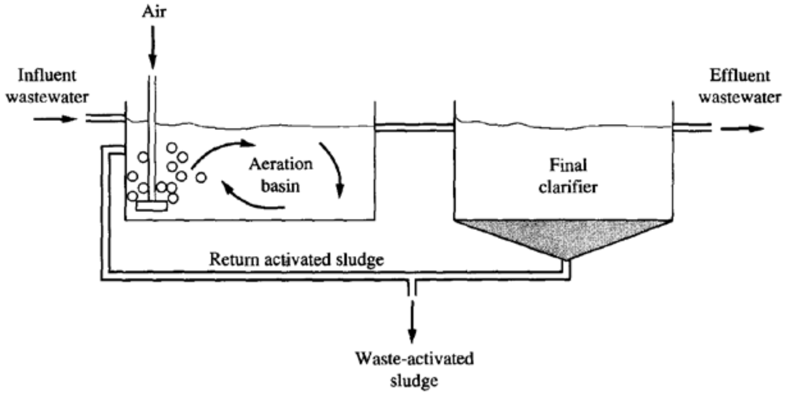
Treatment Methods employed – *Biological*

Schematic representation of a *activated sludge* system



Treatment Methods employed – *Biological*

- The wastewater must be pre-settled to remove settleable solids before entering the aeration tank.
- The bacteria in the aeration tank transform the wastewater organics into new bacterial cells.
- The microbes usually stick together, forming small *floc* particles.



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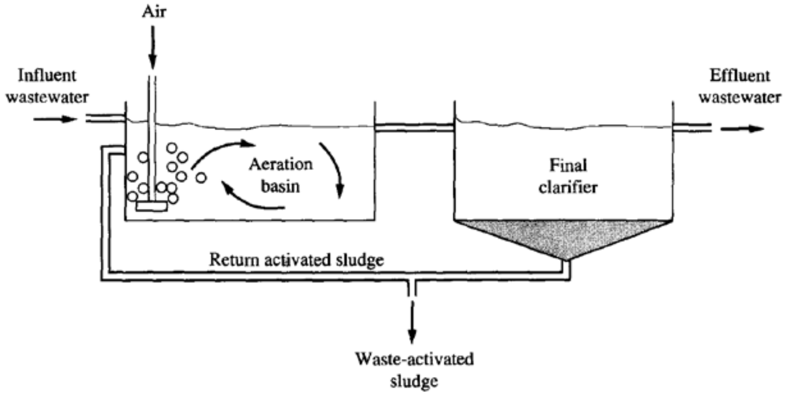
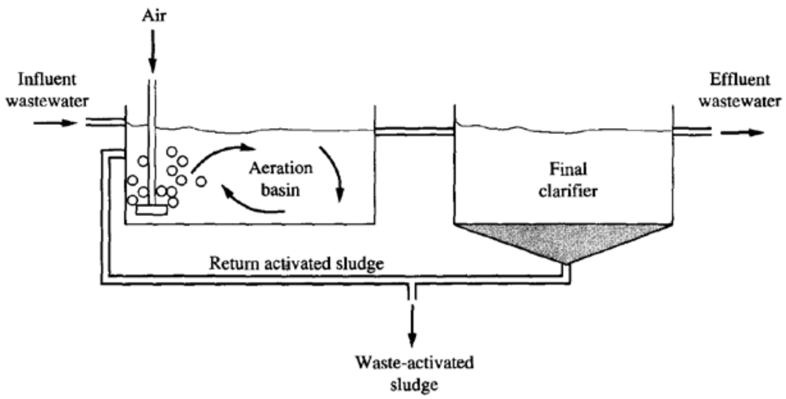


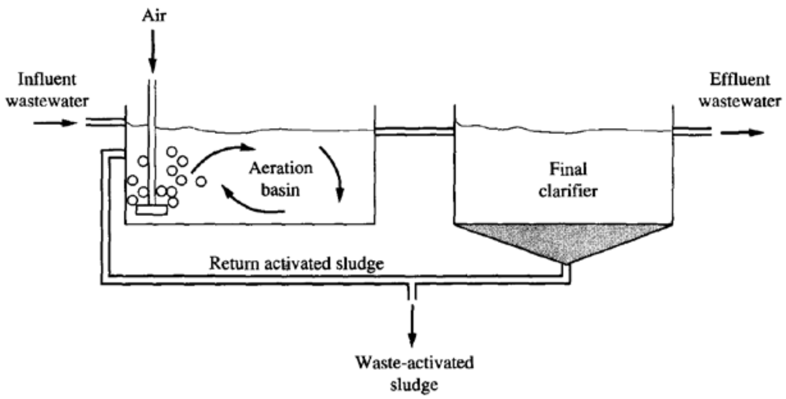
Treatment Methods employed – *Biological*

- The microbial mass can be removed from the wastewater in a secondary clarifier, leaving a clarified wastewater with little remaining organics.
- The high bacterial population necessary in the aeration tank is achieved by recycling biomass removed from the treated wastewater in the final clarifier.
- The primary settled wastewater usually contains very little bacteria (only about 10 mg/L or less), but bacterial populations of 2000-3000 mg/L are commonly used in the aeration tank.



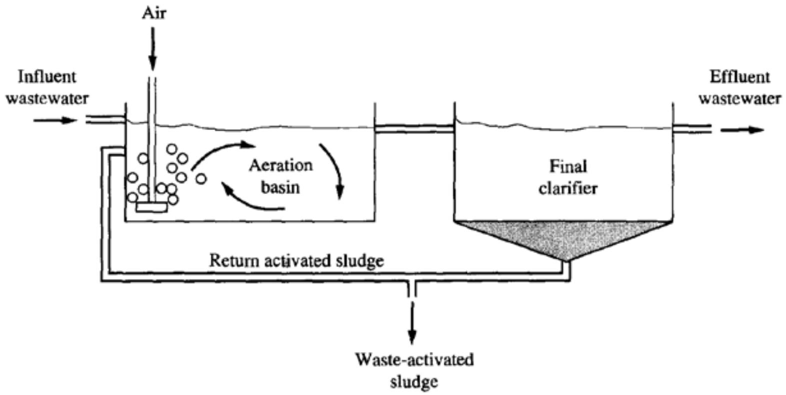
Treatment Methods employed – *Biological*

- Thus treatment will be much more rapid in the aeration tank than if the organics were degraded in the natural environment.
- By the time the biomass is returned to the head end of the aeration tank, it has biodegraded essentially all of the available substrate from the wastewater and it is hungry for more substrate.
- The microorganisms are "activated" for rapid uptake of new substrate, thus the term *activated sludge.*



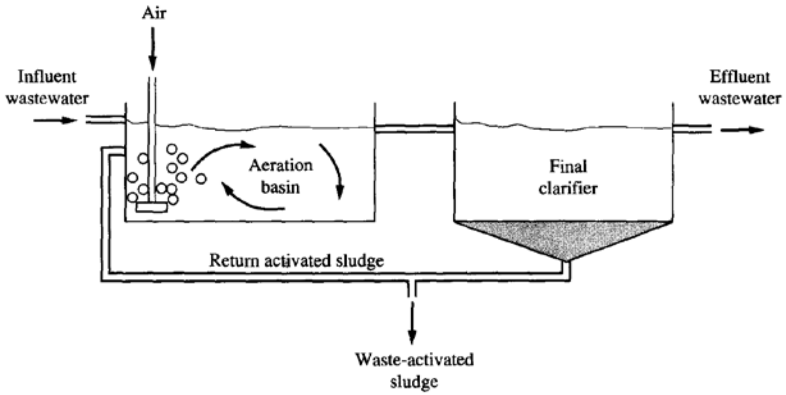
Treatment Methods employed – *Biological*

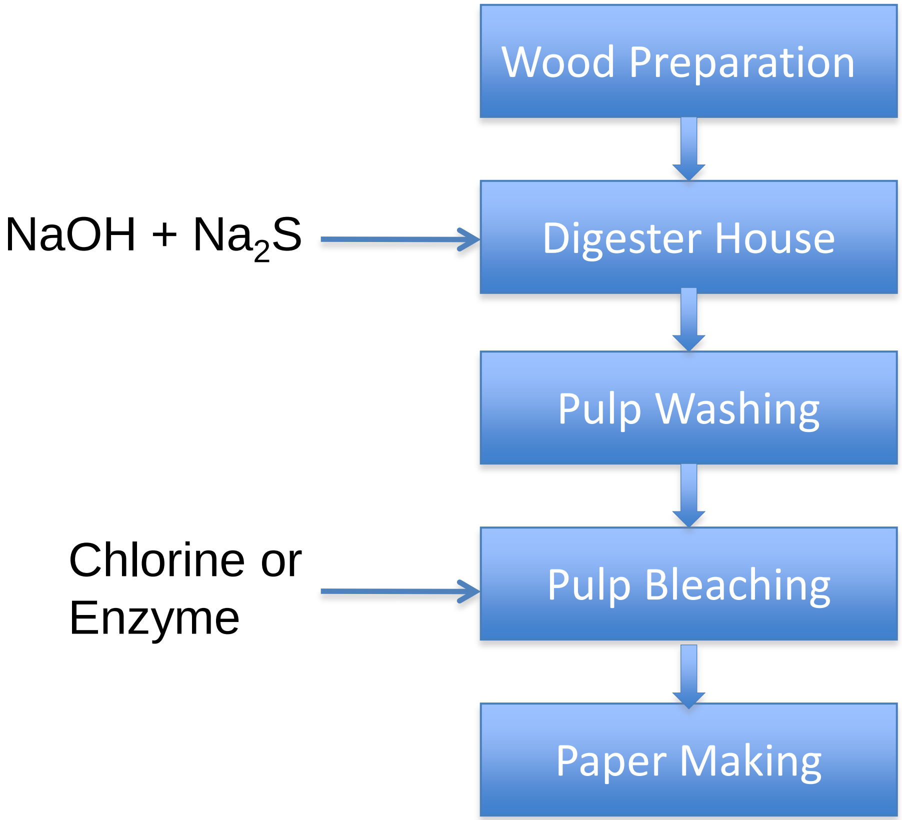
- The activated sludge process should be operated with a constant biomass population (termed *mixed liquor suspended solids,* or MLSS) in the aeration tank.
- Because the microorganisms are growing due to biodegradation of the waste organics, the population will increase unless some of the biomass is continually wasted.
- This *waste activated sludge* must be processed and disposed of safely, an expensive and difficult operation.



Treatment Methods employed – *Biological*

- The amount of sludge that must be wasted per day is equal to the amount of biomass produced per day; it can be determined based on the cell yield, or mass of new cells produced per unit of substrate biodegraded.





Major Steps involved in *paper making* from wood

Table. 1 Volume of individual liquid effluent discharged from a modern kraft mill producing 200t of bleached printing and writing paper per day.

Sources of liquid effluent	Volume US gallons (10^6) per day
Chipper House	2.42
Pulp Mill – Digester and	
Chemical Recovery house	1.10
Chlorination	
Caustic Extraction	3.16
Paper Machine	2.43
Recausticisation	1.90
	0.40
Combined Sources	**11.41**

Table. 1 Characteristics of different liquid effluent from a modern kraft mill.

(All values expect pH expressed as mg/L)

Sources of liquid effluent	pH	Color	Alkalinity	Total Solids	Suspended Solids	COD	BOD
Chipper House	7.0	Muddy	-	891	529	450	49
Pulp Mill – Digester and Chemical houses	11.1	Dark Brown	1,143	2,756	944	1,220	469
Chlorination	2.2	Pale Yellow	434	2,609	147	701	177
Caustic Extraction	9.2	Dark Brown	368	1,328	110	905	121
Paper Machine	7.6	White	150	1,170	778	745	131
Recausticisation	12.4	Light green	57,000	76,140	72,921	563	-
Combined Sections	**9.0**	**-**	**-**	**3,285**	**3,285**	**758**	**176**

Table. 2 Comparison of kraft mill effluent with environmental standards set by Central Pollution Control Board (CPCB), India

Effluent data	pH	Suspended Solids mg/L	COD mg/L	BOD mg/L
Combined Sections of Kraft mill	9.0	3,285	758	176
CPCB Environmental Standard	6.5-8.5	100	350	30

Case Study – Industrial wastewater treatment

Treatment Level	Method
Primary	Physiochemical Sedimentation, Flotation Coagulation and Flocculation Chemical Oxidation Adsorption
Secondary	Biological Aerobic Sludge Process Aerobic biological reactors Anaerobic treatment Aerated lagoons
Tertiary and Advanced	Physiochemical Membrane Filteration Integrated Treatment Process - Coagulation and Wet oxidation Ozonation and Coagulation Ozonation and Adsorption

Heavy metals removal

Metals of importance in wastewater management

Metal	Symbol
Arsenic	As
Cadmium	Cd
Calcium	Ca
Chromium	Cr
Cobalt	Co
Copper	Cu
Iron	Fe
Lead	Pb
Magnesium	Mg
Manganese	Mn
Mercury	Hg
Molybdenum	Mo
Nickel	Ni
Potassium	K
Selenium	Se
Sodium	Na
Tungsten	W
Vanadium	V
Zinc	Zn

Heavy metals removal - Typical industries , commercial and agricultural activities that produces heavy metals

Name	Formula	Use	Concern
Arsenic	As	Alloying additive for metals, especially lead and copper as shot, battery grids, cable sheaths, boiler tubes. High-purity (semiconductor) grade	Carcinogen and mutagen. *Long-term*—sometimes can cause fatigue and loss of energy; dermatitis
Barium	Ba	Getter alloys in vacuum tubes, deoxidizer for copper, Frary's metal, lubricant for anode rotors in x-ray tubes, spark-plug alloys	Flammable at room temperature in powder form. *Long-term*—Increased blood pressure and nerve block
Cadmium	Cd	Electrodeposited and dipped coatings on metals, bearing and low-melting alloys, brazing alloys, fire protection system, nickel-cadmium storage batteries power transmission wire, TV phosphors, basis of pigments used in ceramic glazes, machinery enamels, fungicide, photography and lithography, selenium rectifiers, electrodes for cadmium-vapor lamps and photoelectric cells	Flammable in powder form. Toxic by inhalation of dust or fume. A carcinogen. Soluble compounds of cadmium are highly toxic. *Long-term*—concentrates in the liver, kidneys, pancreas, and thyroid; hypertension suspected effect

Case Study – Industrial wastewater treatment

Heavy metals removal - Typical industries , commercial and agricultural activities that produces heavy metals

Name	Formula	Use	Concern
Chromium	Cr	Alloying and plating element on metal and plastic substrates for corrosion resistance, chromium-containing and stainless steels, protective coating for automotive and equipment accessories, nuclear and high-temperature research, constituent of inorganic pigments	Hexavalent chromium compounds are carcinogenic and corrosive on tissue. *Long-term*—skin sensitization and kidney damage
Lead	Pb	Storage batteries, gasoline additive, cable covering, ammunition, piping, tank linings, solder and fusible alloys, vibration damping in heavy construction, foil, babbitt and other bearing alloys	Toxic by ingestion or inhalation of dust or fumes. *Long-term*—brain and kidney damage; birth defects
Mercury	Hg	Amalgams, catalyst electrical apparatus, cathodes for production of chlorine and caustic soda, instruments, mercury vapor lamps, mirror coating, arc lamps, boilers	Highly toxic by skin absorption and inhalation of fume or vapor. *Long-term*—toxic to central nervous system, may cause birth defects

Heavy metals removal - Treatment methods

- The technologies available for the removal of heavy metals from waste water include chemical precipitation, carbon adsorption, ion exchange and reverse osmosis

- Of these technologies chemical precipitation is commonly employed for most of the metals present in wastewater

- Common precipitants include hydroxide (OH) and sulfide (S_2^{-})

Heavy metals removal - Treatment methods

- The technologies available for the removal of heavy metals from waste water include chemical precipitation, carbon adsorption, ion exchange and reverse osmosis as we discussed in chemical treatment methods in lecture 5 slides.
- Of these technologies chemical precipitation is commonly employed for most of the metals present in wastewater
- Common precipitants include hydroxide (OH) and sulfide (S_2^{-})

References

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