Unit III

WASTEWATER TREATMENT

WHAT IS WASTEWATER TREATMENT

- This is the process of removing contaminants from wastewater, both industial and domestic
- Usually refer to sewage treatment, or domestic wastewater treatment

- Two types of waste water
  1. Domestic Sewage
  2. Industrial Sewage

WHERE DOES WASTEWATER COME FROM? (SOURCE)

- Residences and Commercial institution

Physically, **domestic wastewater** is usually characterised by a grey colour, musty odour and has a solids content of about 0.1%. The solid material is a mixture of faeces, food particles, toilet paper, grease, oil, soap, salts, metals, detergents, sand and grit.

- Industrial institution (usually require specialized treatment process)

pH	6-10
Temperature	40 C
Suspended solids	400 mg/l
Total toxic metals	10 mg/l
Cadmium	0.1 mg/l
Cyanide	2 mg/l
Sulphate	1000 mg/l
Oil, grease	100 mg/l


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- Sewage is primarily the liquid waste but usually gets mixed with industrial wastes, ground water and storm water.

- Sewage contain so many different substances, both suspended and dissolved matter such as food waste, oil, soaps dirt, rags paper, sand grains, human and animal waste or excreta.

- The total amount of organic materials is related to the strength of the sewage. This is measured by the BOD.

- Another important parameter related to the strength of the sewage is Total Suspended Solids (TSS).
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- Sanitary sewage contains BOD 200 mg/l

- TSS of about 240 mg/L

Waste water or sewage treatment

Objectives

1. To eliminate hardness of water
2. To eliminate the bad smell
3. To remove the solid wastes in the sewages
4. To kill and remove the disease producing micro organisms.

The basic purpose of sewage treatment is to destroy pathogenic microorganism and to remove most suspended and dissolved biodegradable organic materials. It is also necessary to recover precious water for recycling.

TARGETS

- To produce waste stream (effluent)
- To produce solid waste (sludge)
- To discharge or reuse them back into the environment

1. Aim of the treatment process

- ❑ Pathogen free
- ❑ Chemically safe
- ❑ Without dirt solid matter
- ❑ Aesthetically acceptable

HOW CAN IT BE TREATED?

- collected and transported via a network of pipes and pump stations to a municipal treatment plant

TYPES OF TREATMENT

- **Mechanical treatment**
  - Influx (Influent)
  - Removal of large objects
  - Removal of sand and grit
  - Primary Sedimentation
- **Biological treatment**
  - Trickling bed filter
  - Activated sludge
- **Chemical treatment**
  - Disinfection

STEPS INVOLVED IN WASTE WATER TREATMENT

- Preliminary treatment
- Primary treatment
- Secondary treatment
- Tertiary treatment
- Sludge digestion

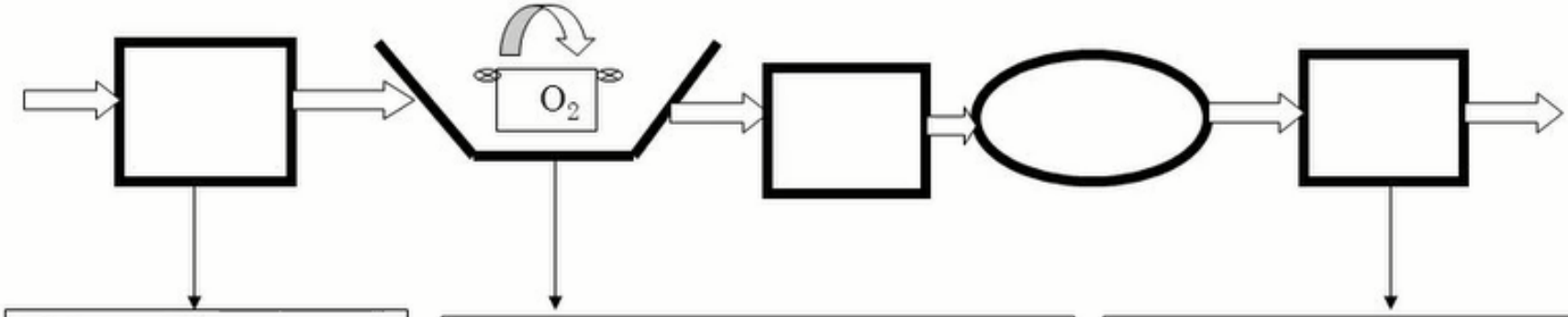
PRELIMINARY TREATMENT

- Solids and suspended impurities are removed by passing the waste water through bar and mesh screens

- Screening: Bar or mesh screens hold floating debris, bulky objects, etc. that could block pipes or damage mechanical equipment in the rest of the water treatment plant.

- Grit Removal: A grit chamber where small particles like sand, stones, etc. are allowed to settle.

Wastewater Treatment Processes



Primary treatment

- screening
- grit removal
- removal of oil
- sedimentation

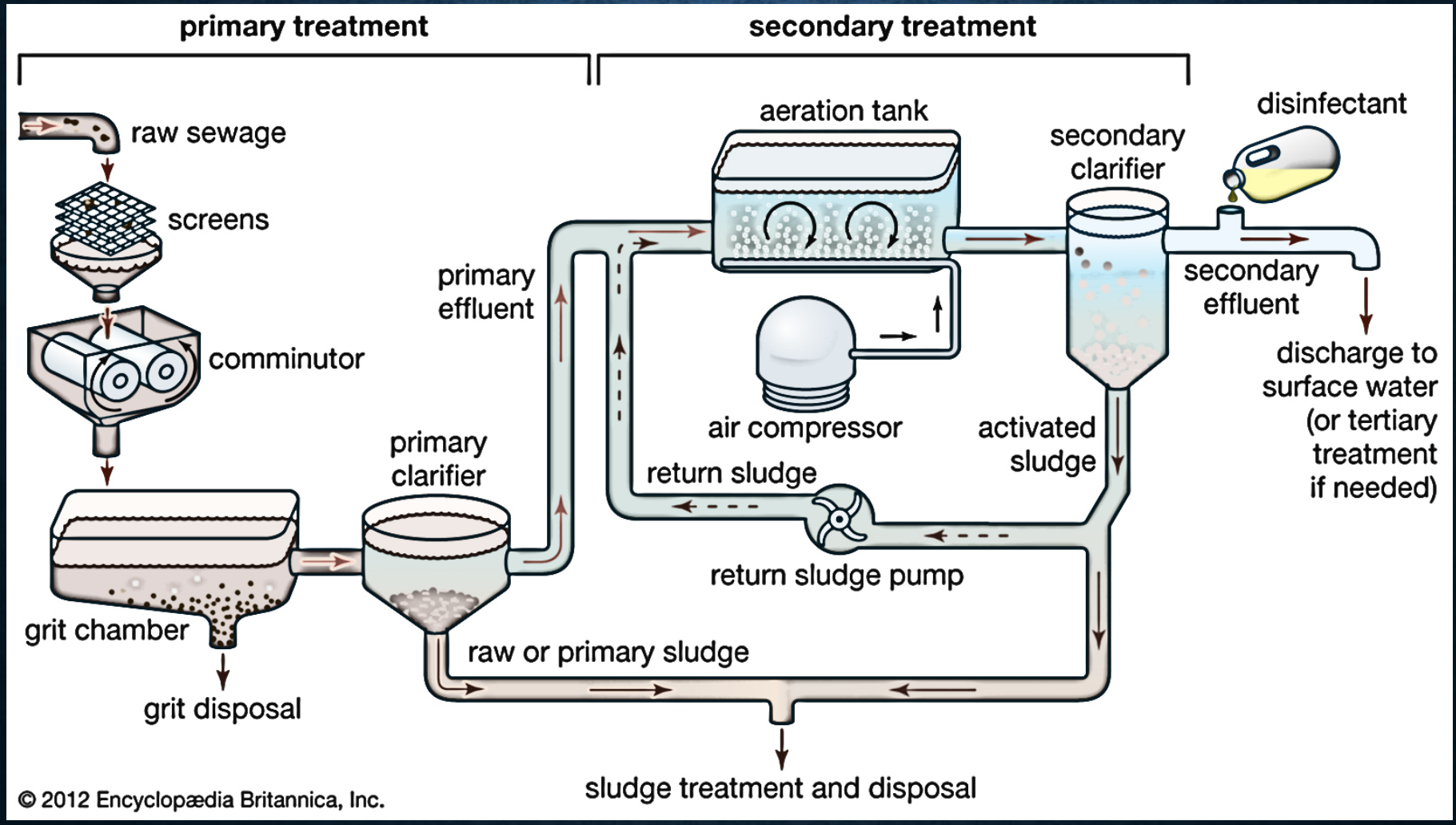
Secondary treatment

- Aerobic, anaerobic lagoons
- Trickling filter- activated sludge-oxidation ditch
- Mostly BOD removal technology

Tertiary treatment

- Nitrate removal
- Phosphorus removal
- Disinfection

WASTE WATER TREATMENT



Grit Removal in Grit Chamber

Preliminary Treatment

- Racked screen
- Remove large objects
- Ex: sticks, rags and toilet paper
- Avoid blocking equipment in sewage treatment plant

The Racked Screen is perfectly suited to both municipal and industrial wastewater and process water screening. The cleaning elements, attached to the chain system, can easily be adjusted to suit different requirements.

PRIMARY TREATMENT

-Solids are separated

- Suspended organic solids are removed by sedimentation in primary treatment.
- Sludge that settles down is removed and oil/grease is skimmed off from the top.
- Coagulants are added to remove tiny particles.
- About 60% of suspended solids and 30% of organic materials are removed.

TREATMENT STAGES - PRIMARY TREATMENT

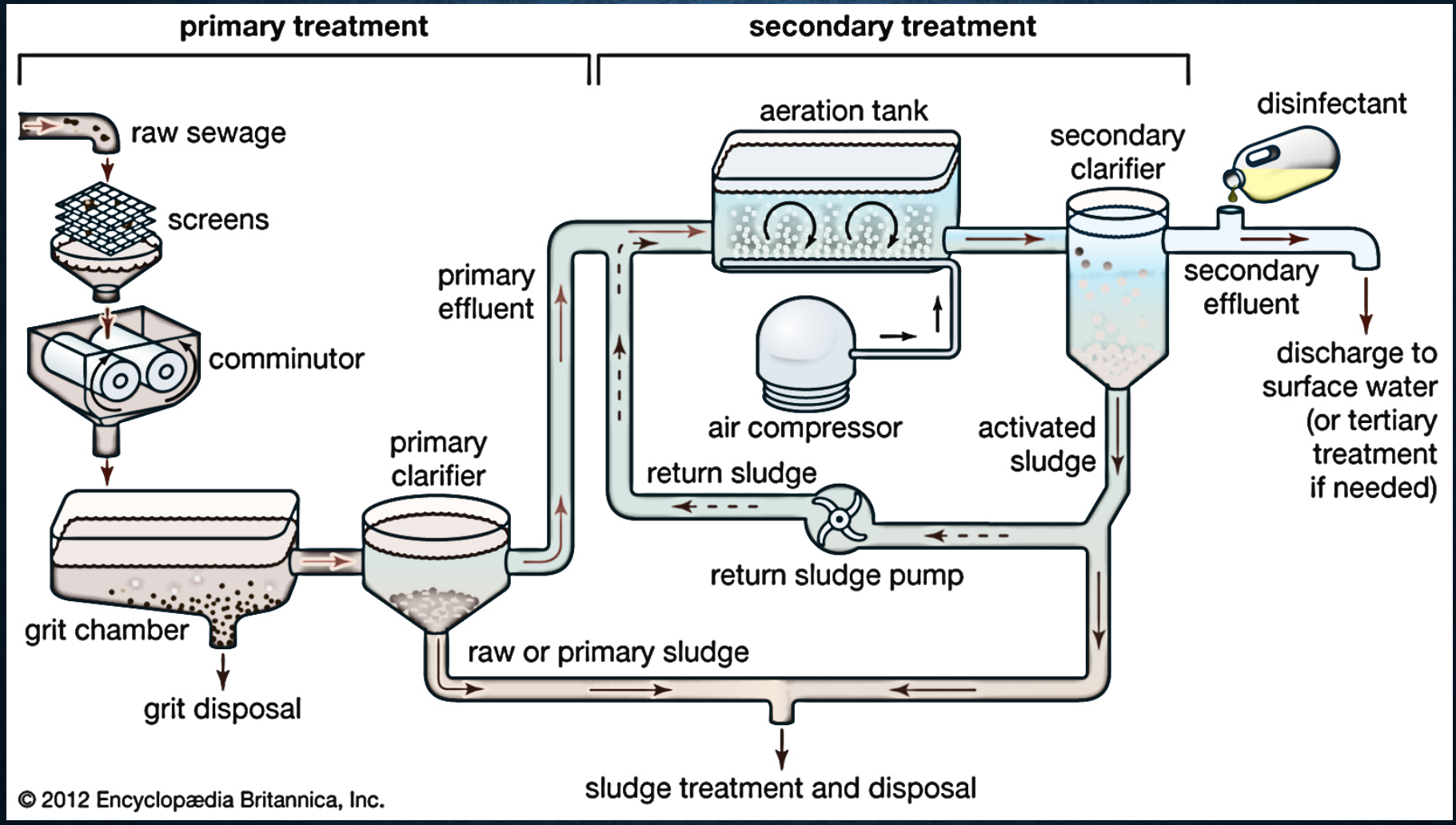
- typical materials that are removed during primary treatment include
  - fats, oils, and greases
  - sand, stones and rocks
  - larger settleable solids including human waste, and floating materials

METHODS USED IN PRIMARY TREATMENT

- Sand catcher
  - Remove sand, stones and grit
  - Control wastewater velocity
    - Sand grit and stone settle
    - Keep suspended organic matter in water
  - Prevent the damage equipment in the remaining treatment stage
  - Landfill

- Primary Sedimentation Tank
  - Remove grease, oil
  - Fecal solid settle, floating material rise to the surface
  - Produce a homologous liquid for later biological treatment
  - Fecal sludge are pumped to sludge treatment plant

WASTE WATER TREATMENT



SECONDARY TREATMENT METHODS

Secondary treatment of wastewater works on a deeper level than primary and is designed to substantially degrade the biological content of the waste through aerobic biological processes.

Two of the most common biological treatment systems are

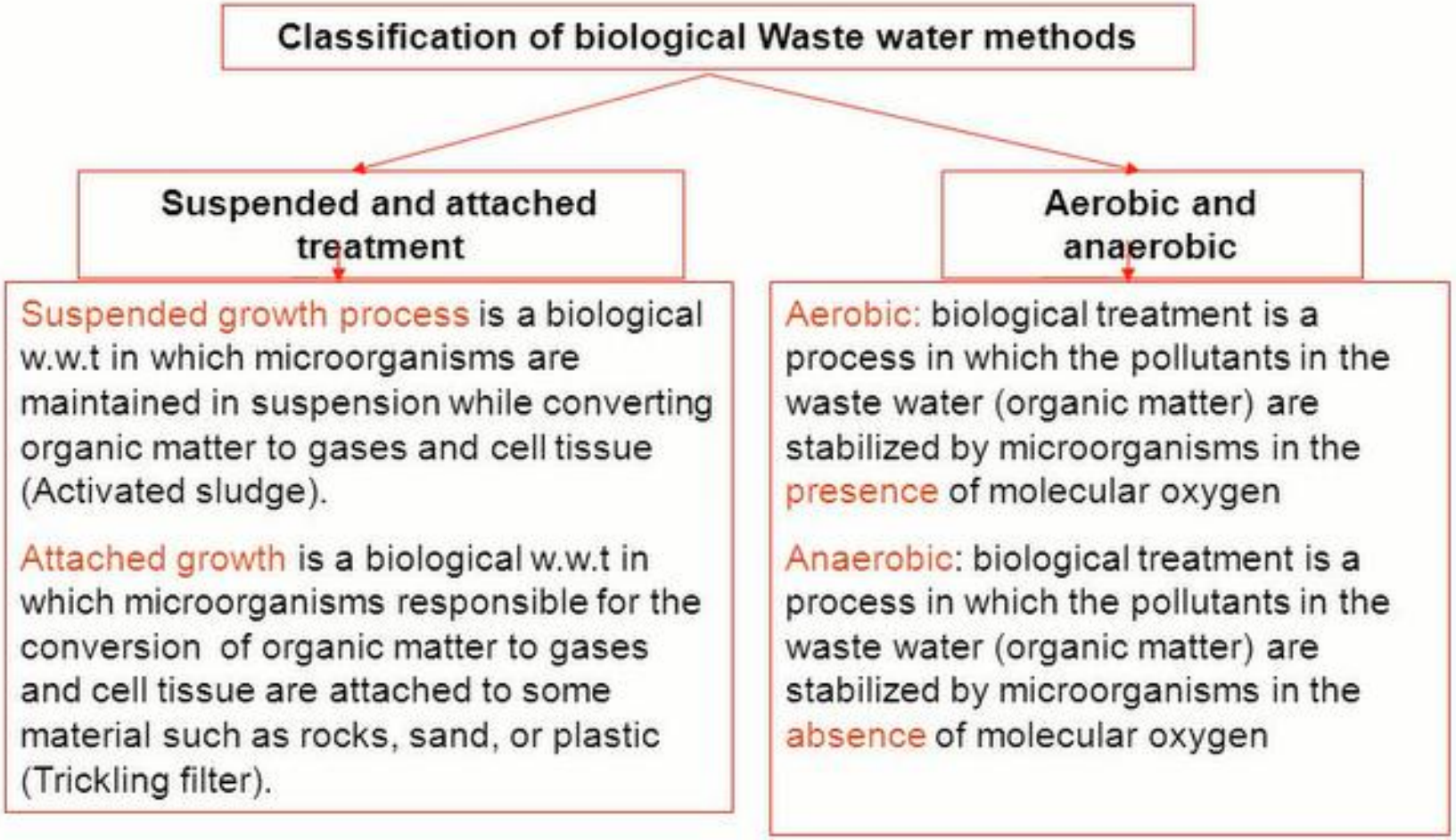
- Trickling filter
- Activated Sludge

Completing secondary wastewater treatment allows to safer release into the local environment, reducing common biodegradable contaminants down to safe levels.

These remove about 85% Biological oxygen demanding waste and total suspended solid (TSS).

Biological waste water treatment

1. **It is a type of waste water treatment in which microorganisms such as bacteria are used to remove pollutants from waste water through bio-chemical reaction.**



ACTIVATED SLUDGE SYSTEM

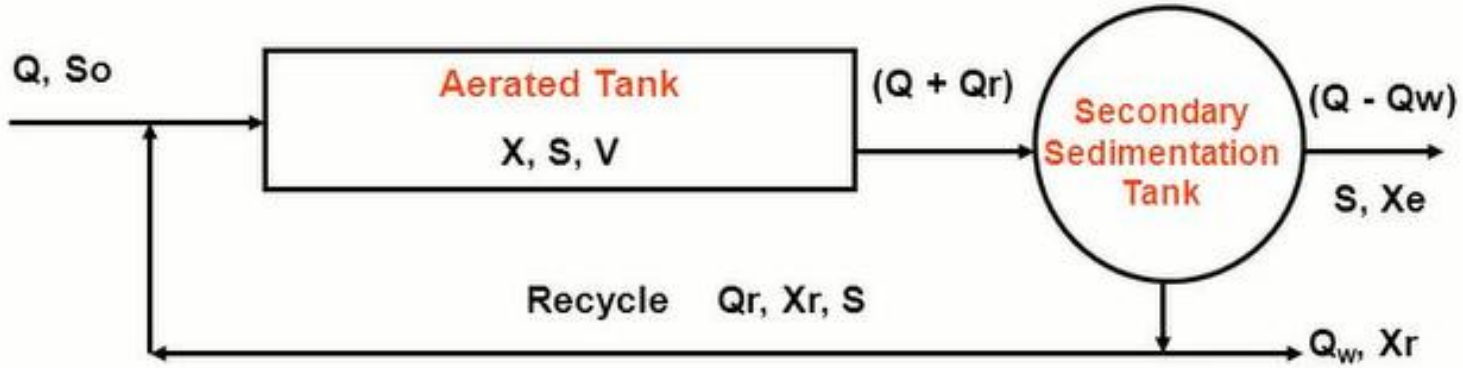
Process Description:

- It is aerobic suspended growth biological wastewater treatment method in which dissolved organic and inorganic matter can be removed.

- This treatment is achieved in tanks called aeration tanks. Oxygen is supplied to these tanks to allow aerobic biochemical reaction to occur.

- In the aeration tank, the microorganisms feed on dissolved solids mainly organic matter and produce large amounts of bacteria (colonies). This means that microorganisms convert dissolved solids into suspended solids (the bacterial colonies).

PRINCIPLE OF ACTIVATED SLUDG



Q = waste water flow rate

X = the mixed liquor suspended solids concentration (MLSS) bacteria concentration

Xr = concentration of recycled activated sludge

Xe = effluent suspended solids concentration

Qw = waste sludge flow rate

Qr = return sludge flow rate

So = concentration of pollutants such as BOD

S = concentration of dissolved pollutants in the aerated tank and the effluent

V = volume of the aerated tank

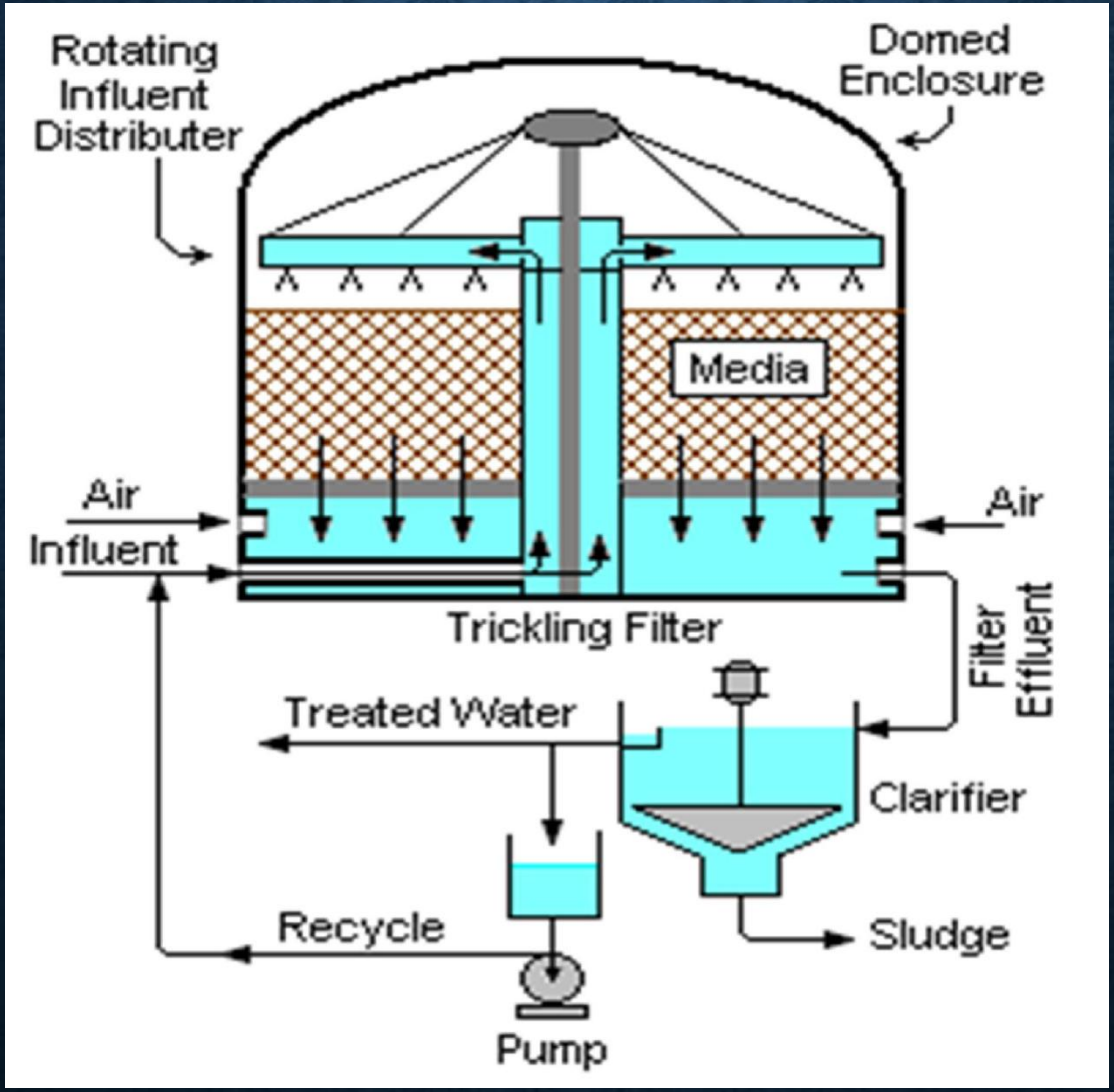
TRICKLING FILTERS BED

- Spread wastewater over microorganism
- made of coke (carbonised coal), limestone chips or specially fabricated plastic media
- Optimize their thickness by insect or worm grazing

TRICKLING FILTER PROCESS

1. It is a circular tank.
2. Sewage is sprayed over crushed rocks
3. Slow rotating arm sprayer is used.
4. When sewage moves downwards microorganisms grow on rocks surface.
5. Food for the microorganisms is organic matters in sewage.
6. After aerobic oxidation sewage goes to settling tank
7. In settling tank sludge are removed.
8. By this process 85% of BOD removed.

Trickling filter: The microbes remain attached to a surface while the waste water flows over them. It is a fixed growth system.



- Suspended Film Systems
  - stir and suspend microorganisms in wastewater
  - settled out as a sludge
  - pumped back into the incoming wastewater
  - Ex: Activated sludge, extended aeration

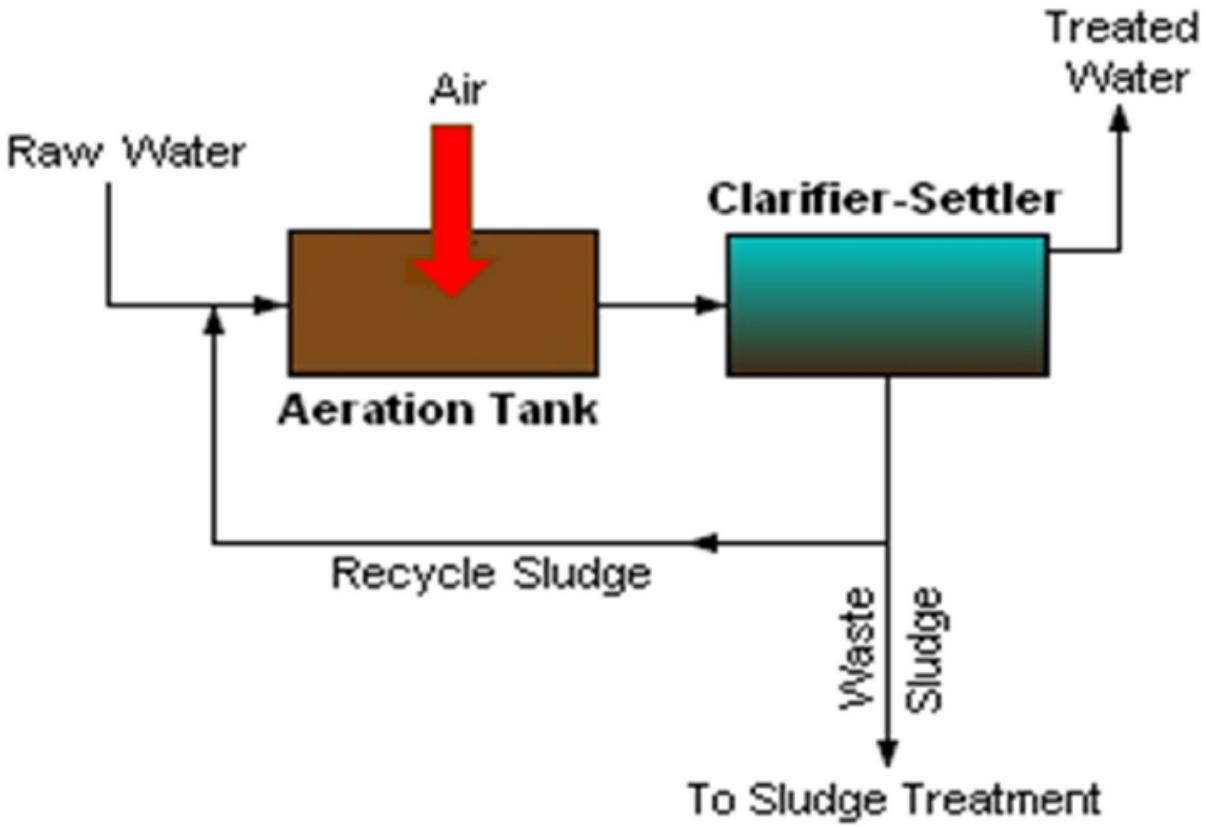
ACTIVATED SLUDGE

- mixed community of microorganisms
- Both aerobic and anaerobic bacteria may exist
- Biological floc is formed

Activated sludge process

1. Activated sludge is biologically activated sewage
2. Sewage from primary treatment mixed with activated sludge
3. It is aerated in aeration tank
4. Here oxidation of organic impurities takes place
5. Sludges settle down in the sedimentation tank.
6. This process removes 95% of BOD

Activated Sludge: It is a suspended growth system because the microbes are thoroughly mixed and suspended in the waste water.

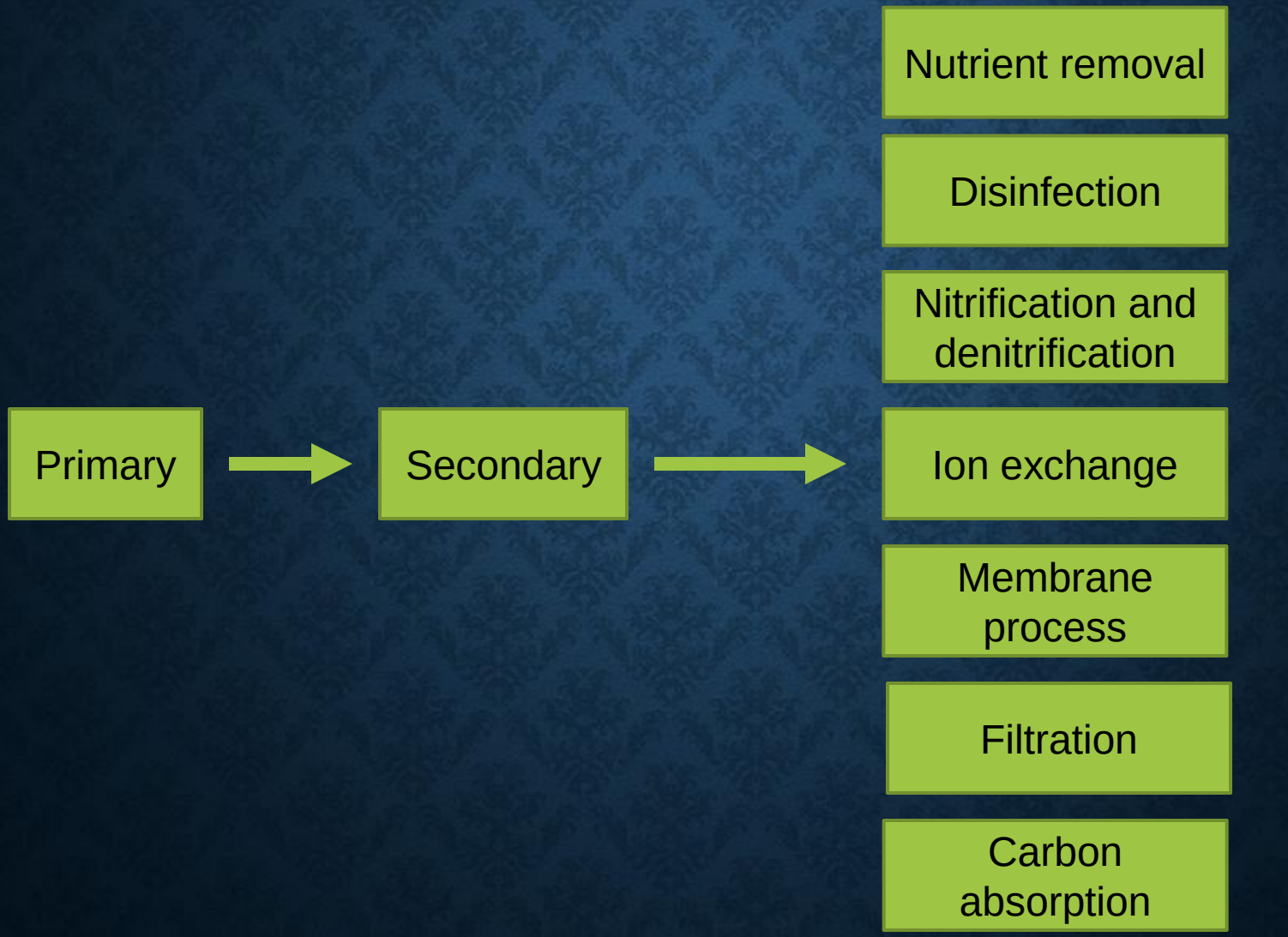


TERTIARY TREATMENT METHODS

The aim of tertiary wastewater treatment is to raise the quality of the water to domestic and industrial standards, or to meet specific requirements around the safe discharge of water. In the case of water treated by municipalities, tertiary treatment also involves the removal of pathogens, which ensures that water is safe for drinking purposes.

Tertiary Treatment
Filtration: Physical / Chemical
Wastewater leaving the Secondary Clarifiers looks as clean as drinking water! Depending on conditions, this water can go directly to the Disinfection process to produce recycled water, or it can go the Filtration Building.
The Filtration Building contains a series of sand filters that are 27 feet tall, and can filter almost 14,000 gallons of water per hour. The filters remove very tiny solids (“suspended solids”) from the wastewater before it moves on to disinfection. Polymers are added at this step to cause the suspended solids to clump together, making them easier to filter out.

TERTIARY TREATMENT METHODS



Phosphorus Removal

A) Physical:

- a) filtration for particulate phosphorus
- b) membrane technologies

B) Chemical:

- a) precipitation

C) Biological:

- a) enhanced biological phosphorus removal (EBPR)

Ammonia removal

- The most common processes for removal of ammonia from wastewater are
- i) Air stripping
- ii) Biological nitrification and denitrification.

Air Stripping

- It consists of converting ammonium to gaseous phase and then dispersing the liquid in air, thus allowing transfer of the ammonia from wastewater to the air

- The most important and efficient reactor for air stripping is counter current spray tower.

TERTIARY TREATMENT METHODS

Biological Nitrification

Conversion of Ammonia to Nitrite *(Nitrosomonas)*

$$NH_4^+ + 2\ O_2 \rightarrow NO_2^- + 2\ H^+ + H_2O$$

Conversion of Nitrite to Nitrate *(Nitrobacter)*

$$NO_2^- + 0.5\ O_2 \rightarrow NO_3^-$$

Biological Denitrification

- Denitrifying bacteria obtain energy from the conversion of NO_3^- to N_2 gas, but require a carbon source

$$NO_3^- + CH_3OH + H_2CO_3 \rightarrow C_5H_7O_2N + N_2 + H_2O + HCO_3^-$$

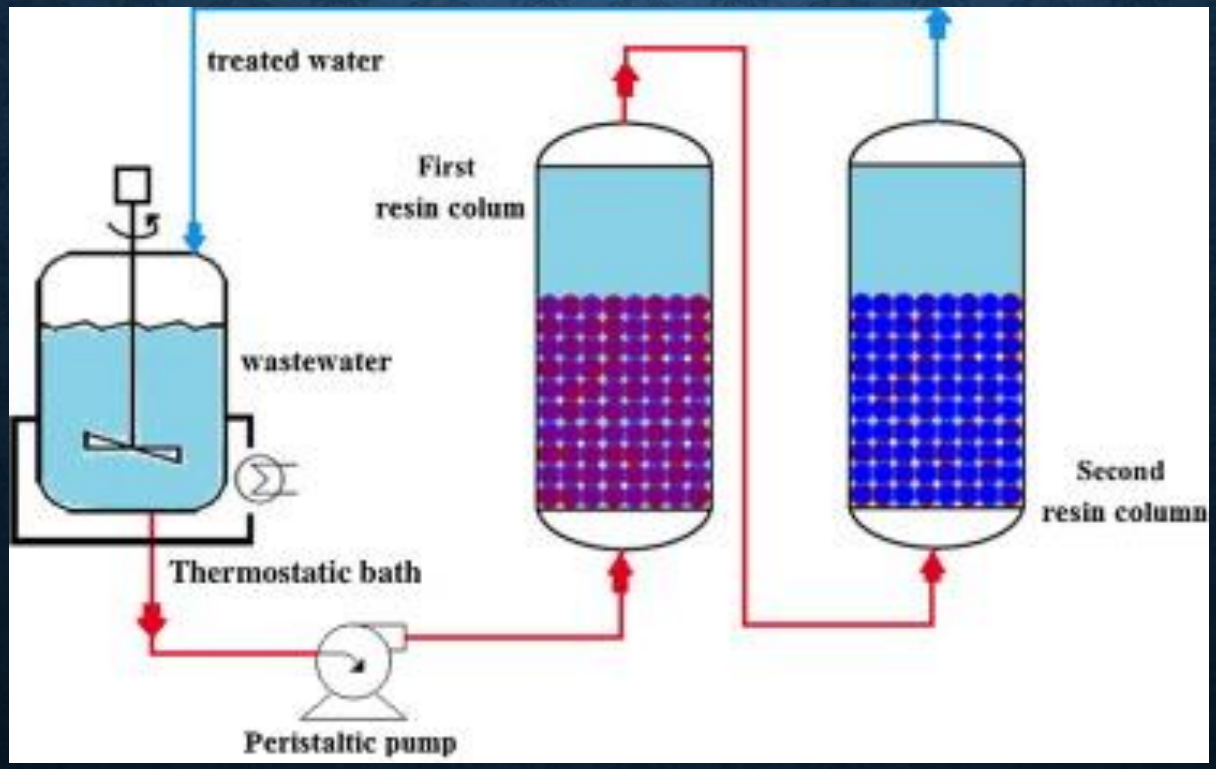
Organic matter *Cell mass*

Denitrification

- Need low (no) oxygen (< 1 mg/L)
- Need carbon source (BOD in Wastewater)
- Neutral pH (pH 7)
- Conc of nitrate

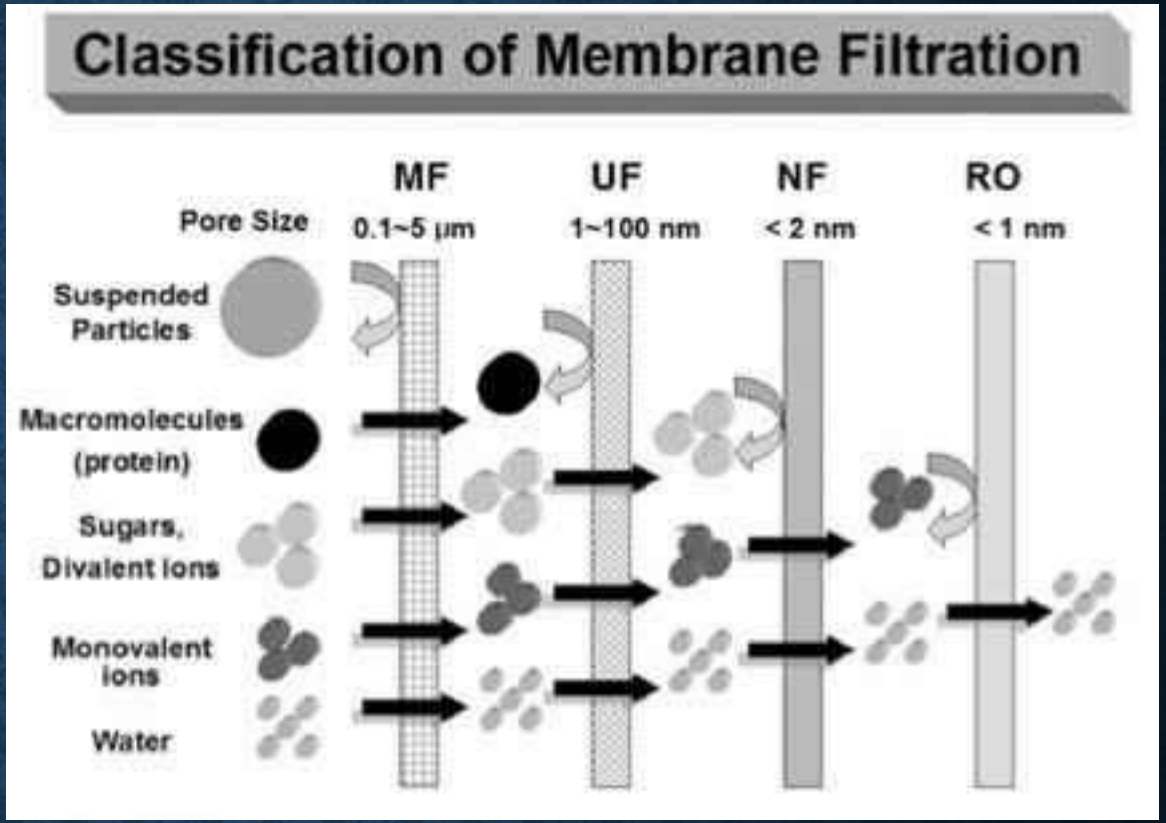
Ion exchange

- Ion Exchange can be used in wastewater treatment plants to swap one ion for another for the purpose of demineralization. The widest application of this process is in domestic water softening



MEMBRANE PROCESS

- microfiltration (MF)
- ultrafiltration (UF)
- nanofiltration (NF)
- reverse osmosis (RO)



Membrane	Driving force	Mechanism of separation	Membrane structure	Phases in contact
Microfiltration (MF)	pressure	Sieve	Macropores	Liquid-liquid
Ultrafiltration (UF)	pressure	Sieve	Mesopores	Liquid-liquid
Nanofiltration (NF)	pressure	Sieve + solution + diffusion + exclusion	Micropores	Liquid-liquid
Reverse Osmosis	pressure	Solution/diffusion + exclusion	Dense	Liquid-liquid

Microfiltration (MF)

- Microfiltration (MF) membranes are having 0.1 µm or more pore size. It is generally used for particulate matter removal. The pressure used in this process is similar to that of UF.

Ultrafiltration (UF)

- It is a clarification and disinfection membrane operation. UF membranes are porous and allow only coarser solutes (macromolecules) to be rejected. All types of microorganisms as viruses and bacteria and all types of particles can be removed by this process.
- operating pressure is kept low as 50- 500 KPa.

Nanofiltration (NF)

- Nanofiltration (NF) is a rapidly advancing membrane separation technique for water and wastewater treatment as well as concentration/separation of antibiotics and pharmaceuticals due to its unique charge-based repulsion property and high rate of permeation.
- This process is also called as low pressure RO or membrane softening.
- The operating pressure used in NF is typically 0.5 to 1.5 MPa.

Reverse Osmosis

- Reverse osmosis removes many types of large molecules and ions from effluents by applying pressure to the effluents when it is on one side of a selective membrane.
- RO is used to remove specific dissolved organic constituents from wastewater remaining after advanced treatment with depth filtration or MF.
- RO system can operate at 90 % efficiency.
- Normally pressure of 5 -8 MPa is used in practice

Classification of membranes

According to separation mechanism:

- Sieve effect: In this mechanism, separation is based on difference in pore size e.g. MF, UF.
- Solution-diffusion mechanism: In this mechanism, separation is based on difference in the solubility and diffusivity of materials in the membrane e.g. RO.
- Electrochemical effect: In this mechanism, separation is based on difference in the charges of the species to be separated e.g. ED (electrodialysis).

The classification based on separation mechanism leads to two main classes of membranes.

- Porous membranes
- Non-Porous membranes

Porous membranes

- Fixed pores are present in these membranes. These pores are sub-divided into three types-

- Macropores: Theses are larger than 50 nm
- Mesopores- These are in the range of 20 to 50 nm
- Micropores- These are in the size less than 2 nm.

MF and UF are porous membranes while, NF could be classified in an intermediate class between porous and non porous membranes.

Non Porous membranes

- These are dense media membranes. The diffusion of species takes place in the free volume which is present between the macromolecular chains of the membrane material.

- RO is non porous membrane.