Waste Water Management III.

NUTRIENT REMOVAL PROCESSES

Nutrient = compounds of nitrogen and phosphorus which are responsible for eutrophication

Nutrient removal = reducing the concentrations of phosphorus and nitrogen in the waste water so as to prevent algal and other photosynthetic aquatic plant growth in the receiving waters

BIOLOGICAL NITRIFICATION AND DENITRIFICATION

Nitrification	**Denitrification**
Ammonia, NH_3	Nitrate, NO_3^-
↓	↓
Nitrite, NO_2^-	Nitrite, NO_2^-
↓	↓
Nitrate, NO_3^-	Nitric oxide, NO
	↓
	Nitrous oxide, N_2O
	↓
	Nitrogen, N_2

CHEMICAL PRECIPITATION

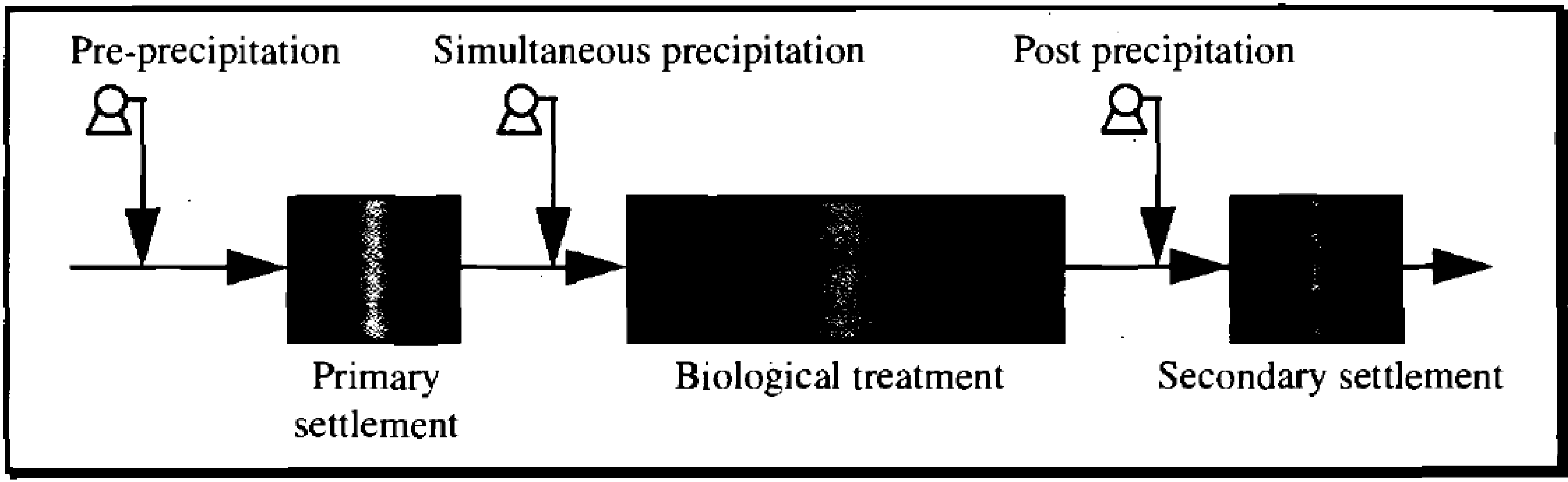
Chemical precipitation is a method of wastewater treatment. Wastewater treatment chemicals are added to form particles which settle and remove contaminants.

CHEMICAL PHOSPHORUS REMOVAL

Metal salts are generally used for the precipitation of phosphate according to the reaction:

$$M^{3+} + P0_4^{3-} \rightarrow MPO_4$$

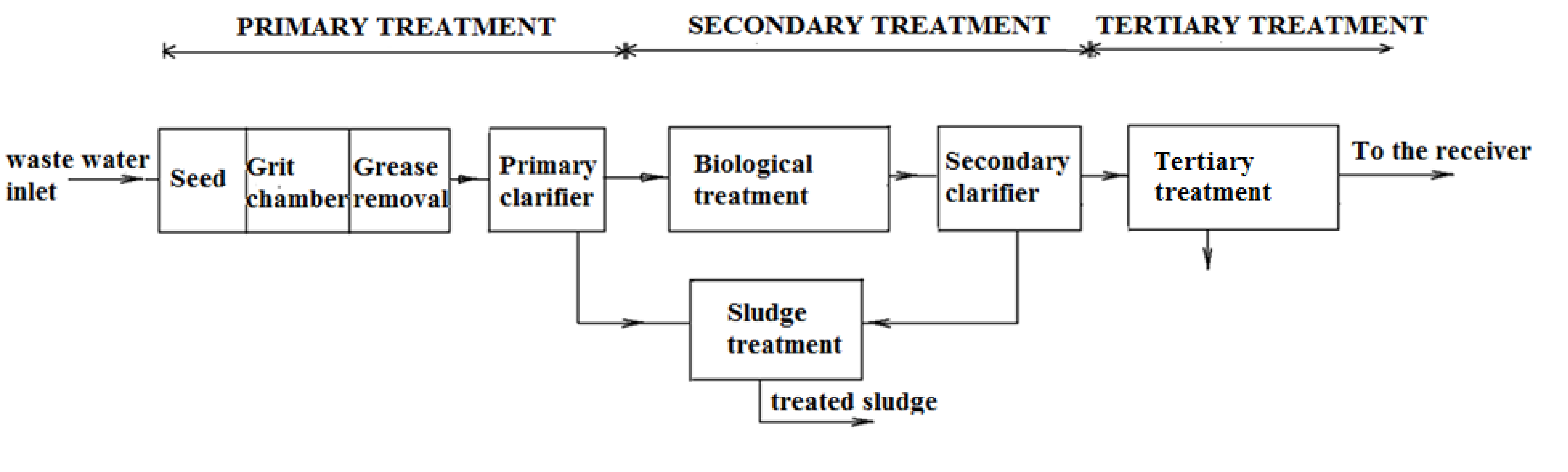
DOSING POINTS FOR THE CHEMICAL PRECIPITATION OF PHOSPHORUS



CHEMICAL PHOSPHORUS REMOVAL

Result of phosphorus effluent in receiving water: Eutrophication

Generalized layout of a waste water treatment plant



Processes in tertiary treatment can be

- Disinfection
- Chemical treatment (precipitation, neutralization etc.)
- Adsorption
- Membrane technology
- Distillation
- Evaporation

Disinfection of Wastewater

- Disinfection is treatment of the effluent for the destruction of all pathogens.
- Disinfection procedures applied to wastewaters will result in a substantial reduction of all microbes so that bacterial numbers are reduced to a safe level.
- (Sterilization is the destruction of **all** microorganisms.)

Disinfection Techniques of Wastewater

- Chemical;
- Physical;
- Irradiation.

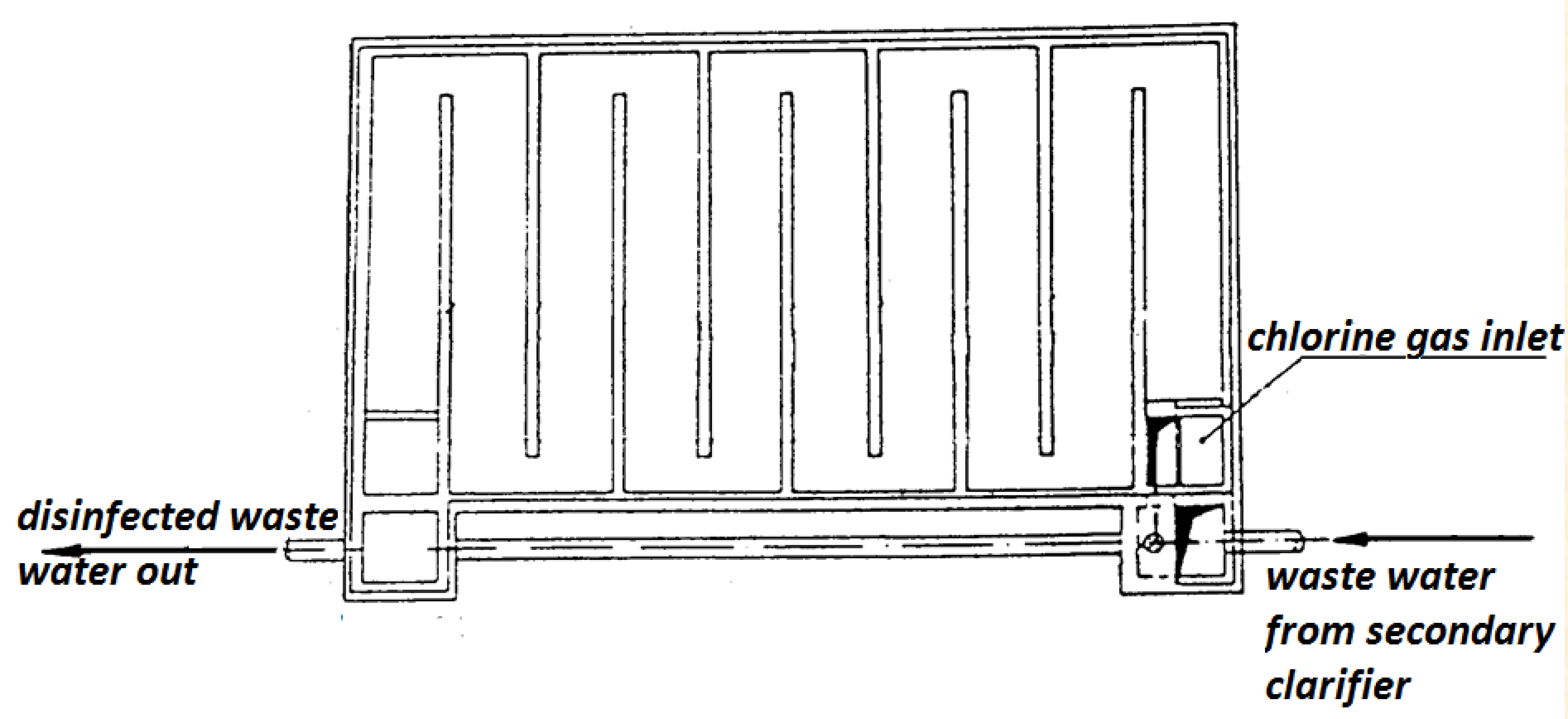
Chemical disinfectants

- Chlorine
- Ozone
- Hydrogen peroxide

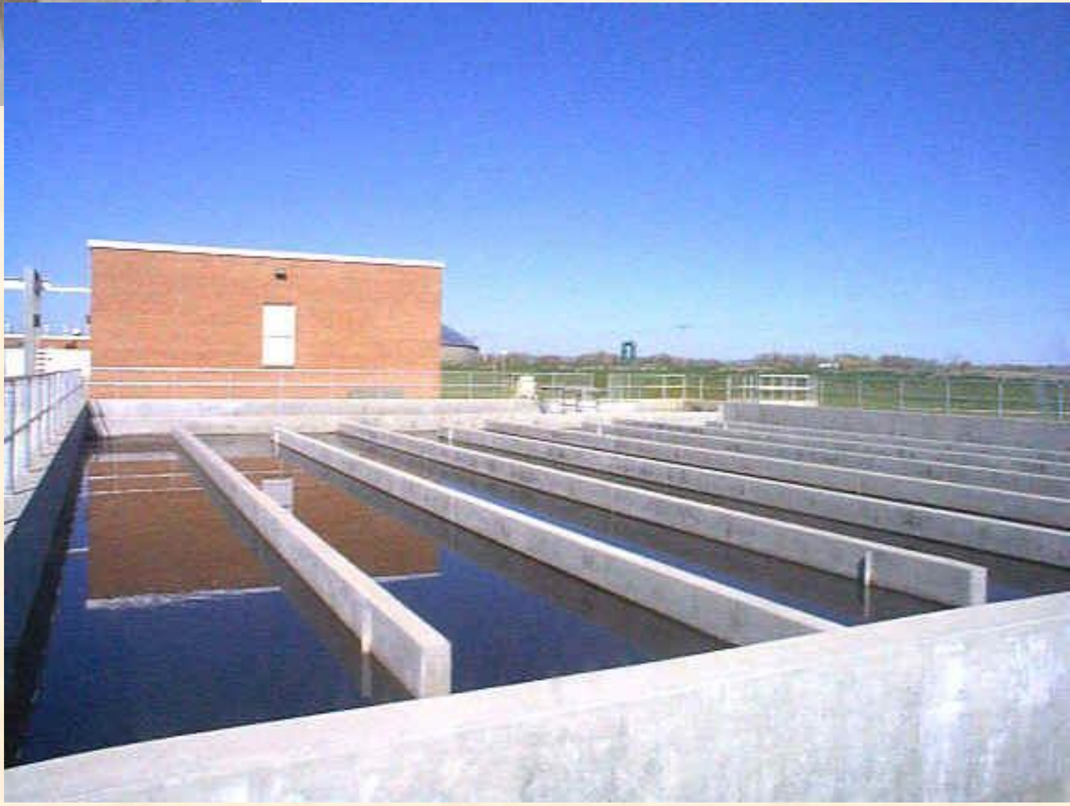
The factors influencing the performance of chemical disinfection

- contact time,
- the efficiency of mixing,
- the type and concentration of chemicals
- the residual remaining,
- the pH (measure of acidity or alkalinity),
- the concentration of interfering substances.

Chlorine contact basin



Chlorine contact basin



OZONE DISINFECTION

advantages:

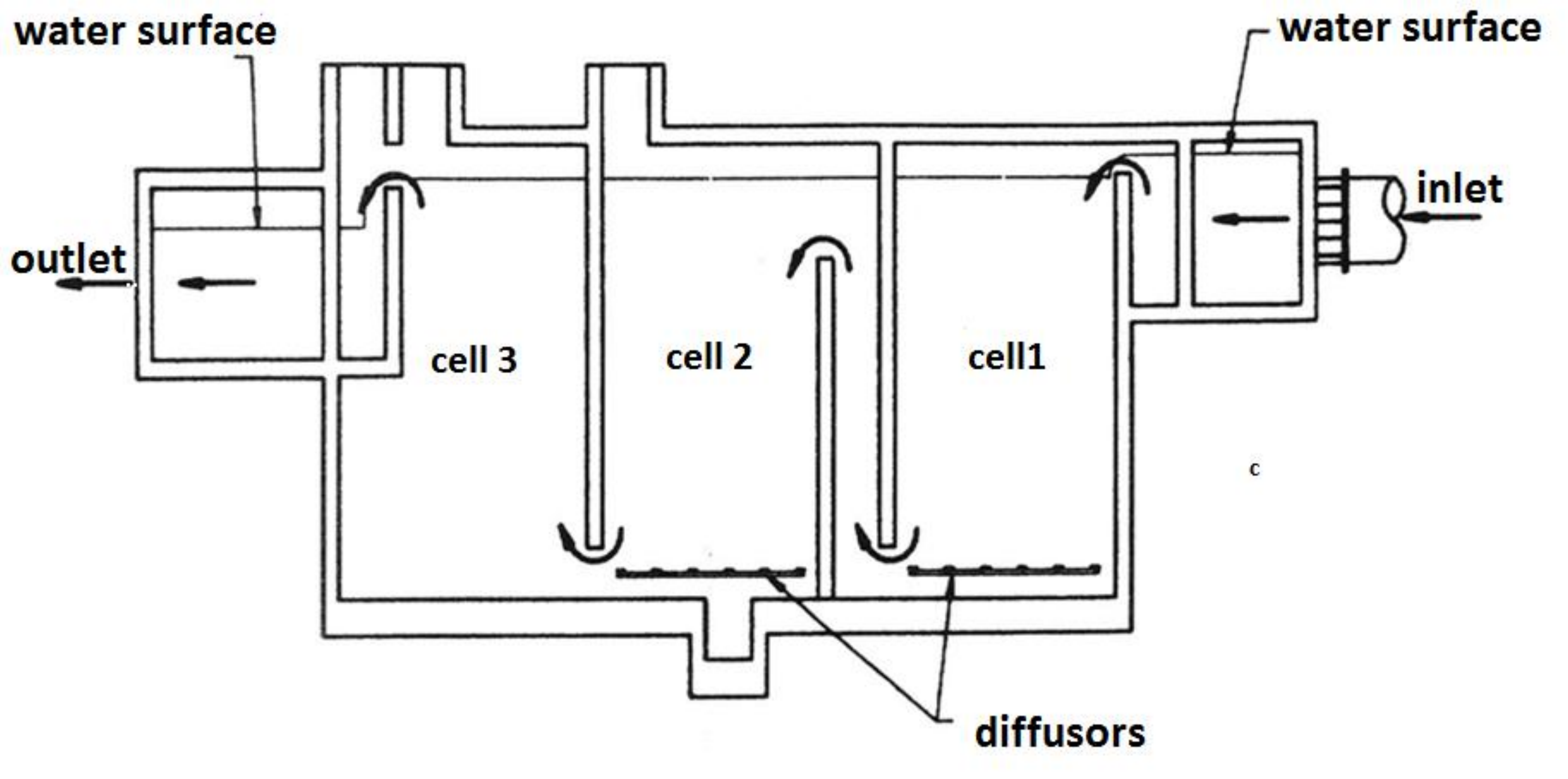
- elimination of odors;
- oxidation of residual organic compounds;
- ozone can be generated from air, making its supply dependent only upon a source of power.

OZONE DISINFECTION

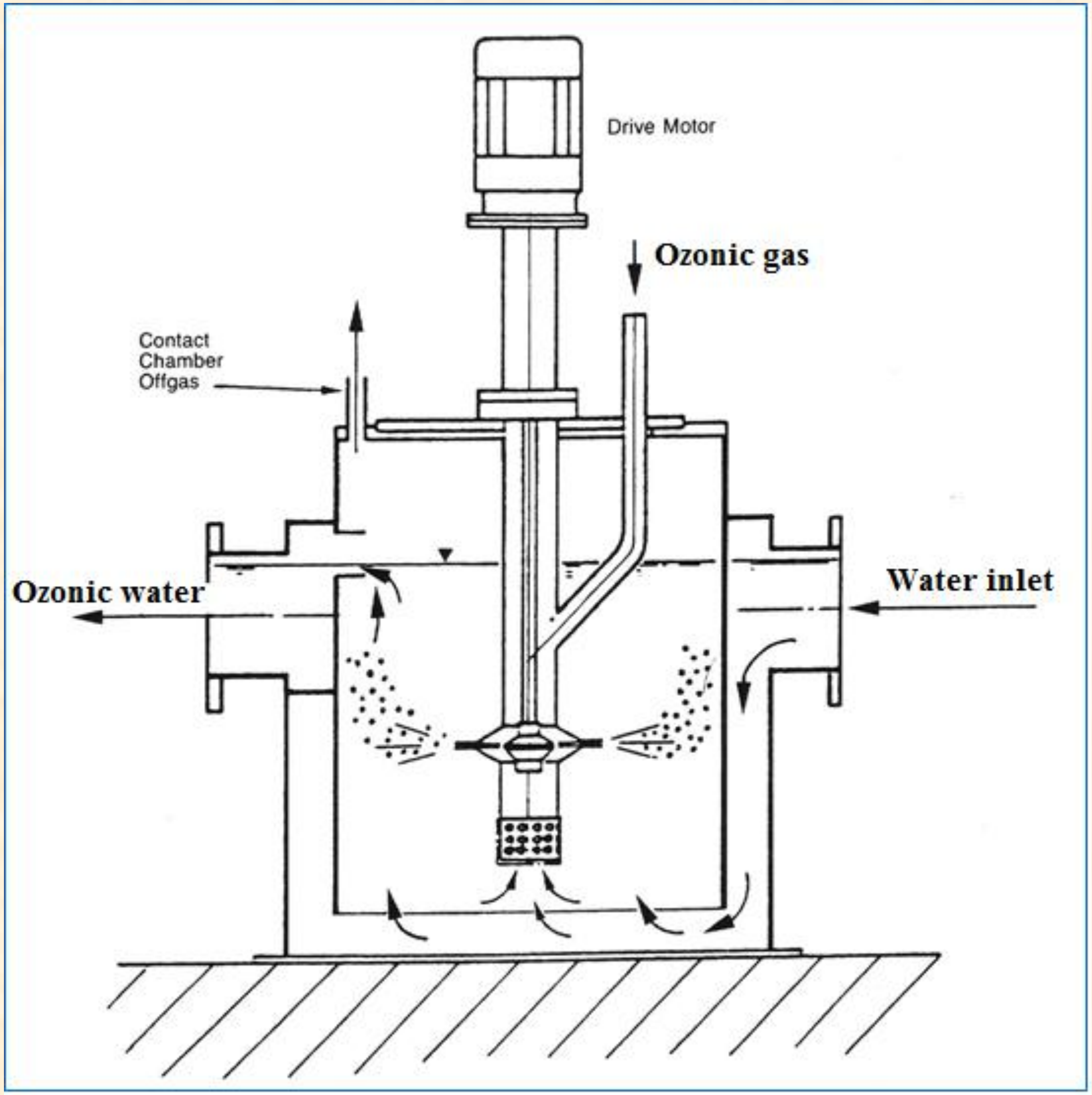
disadvantages:

- high cost of production;
- potential to cause localized air pollution.

OZONE DISINFECTION



OZONE DISINFECTION



Forrás: Langlais

UV DISINFECTION

1878	Microbial inactivation with UV from the sun was discovered by Downes & Blunt
1910	First full scale UV disinfection system for pre-filtered water from the river Durance (Marseille, France)
1916	First full-scale application of UV in the US (Henderson, Kentucky)
1940s	With the invention of neon tubes, low pressure Hg lamps became available for UV disinfection

ULTRA-VIOLET DISINFECTION

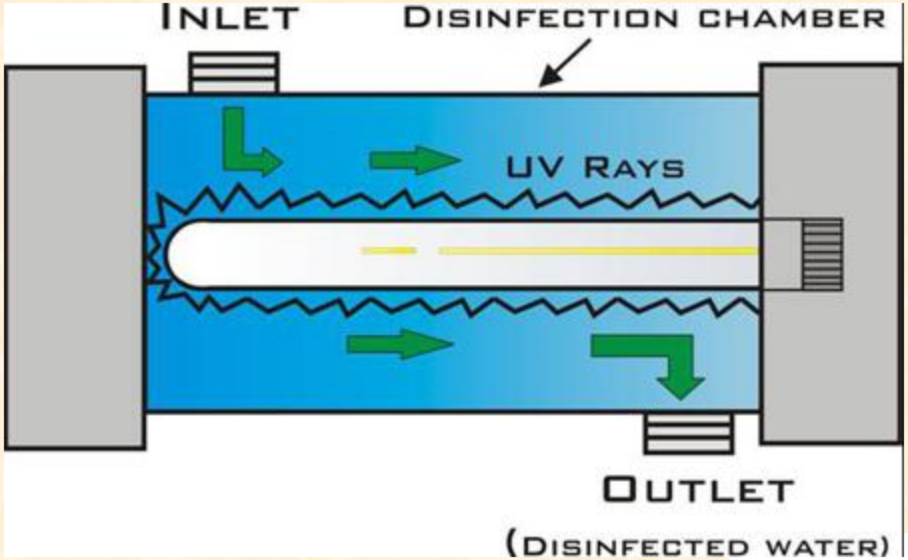
Ultra-violet light is produced by a special mercury discharge lamp. The effectiveness of UV radiation depends on the dose received by the micro-organisms and this depends on:

- the intensity of the radiation (the most effective wavelength is 254nm);
- the path length from the source to the microorganisms;
- the contact time at the required dose;
- the quality of the waste water (particularly with regard to turbidity).

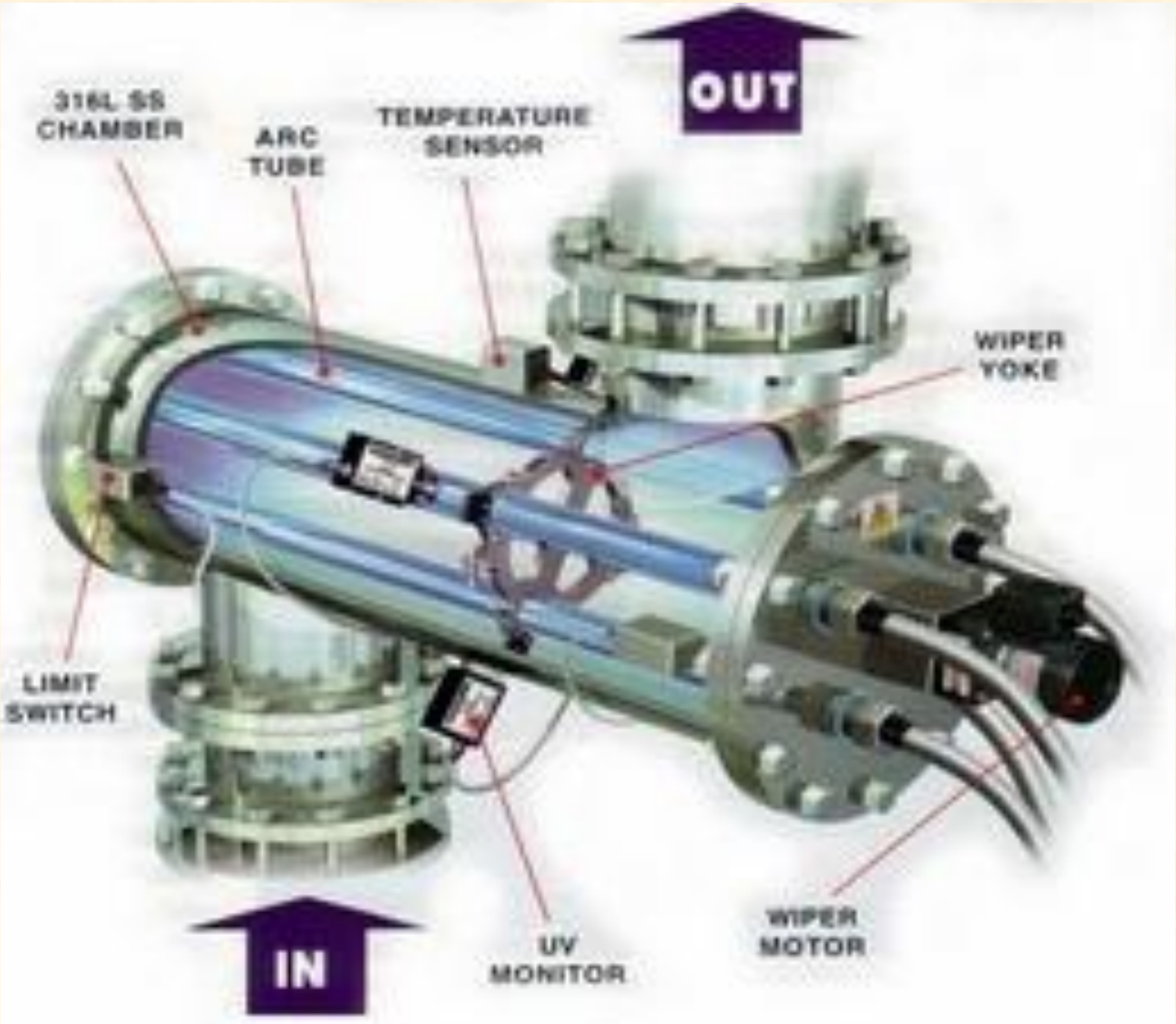
Lamps are prone to interference from chemical constituents of the waste water such as ferric and hardness salts.

Periodic cleaning of the lamps is therefore required.

ULTRA-VIOLET DISINFECTION



ULTRA-VIOLET DISINFECTION



CHEMICAL TREATMENT:

Chemical treatment has to be used:
- for industrial waste water treatment;
- for acidic and caustic waste water (if $pH \neq 7$ a measure of acidity or alkalinity);
- if contaminants can be well precipitated;
- to improve settling properties,
- to remove heavy metals
- for phosphorus removal.

ADSORPTION

is the adhesion of atoms, ions, molecules of gas, liquid, or dissolved solids to a solid surface. This process creates a film of the adsorbate (the molecules or atoms being accumulated) on the surface of the adsorbent.

Industrial adsorbents

- Oxygen-containing compounds – Are typically hydrophilic and polar, including materials such as silica gel and zeolites.

- Carbon-based compounds – Are typically hydrophobic and non-polar, including materials such as activated carbon and graphite.

- Polymer-based compounds

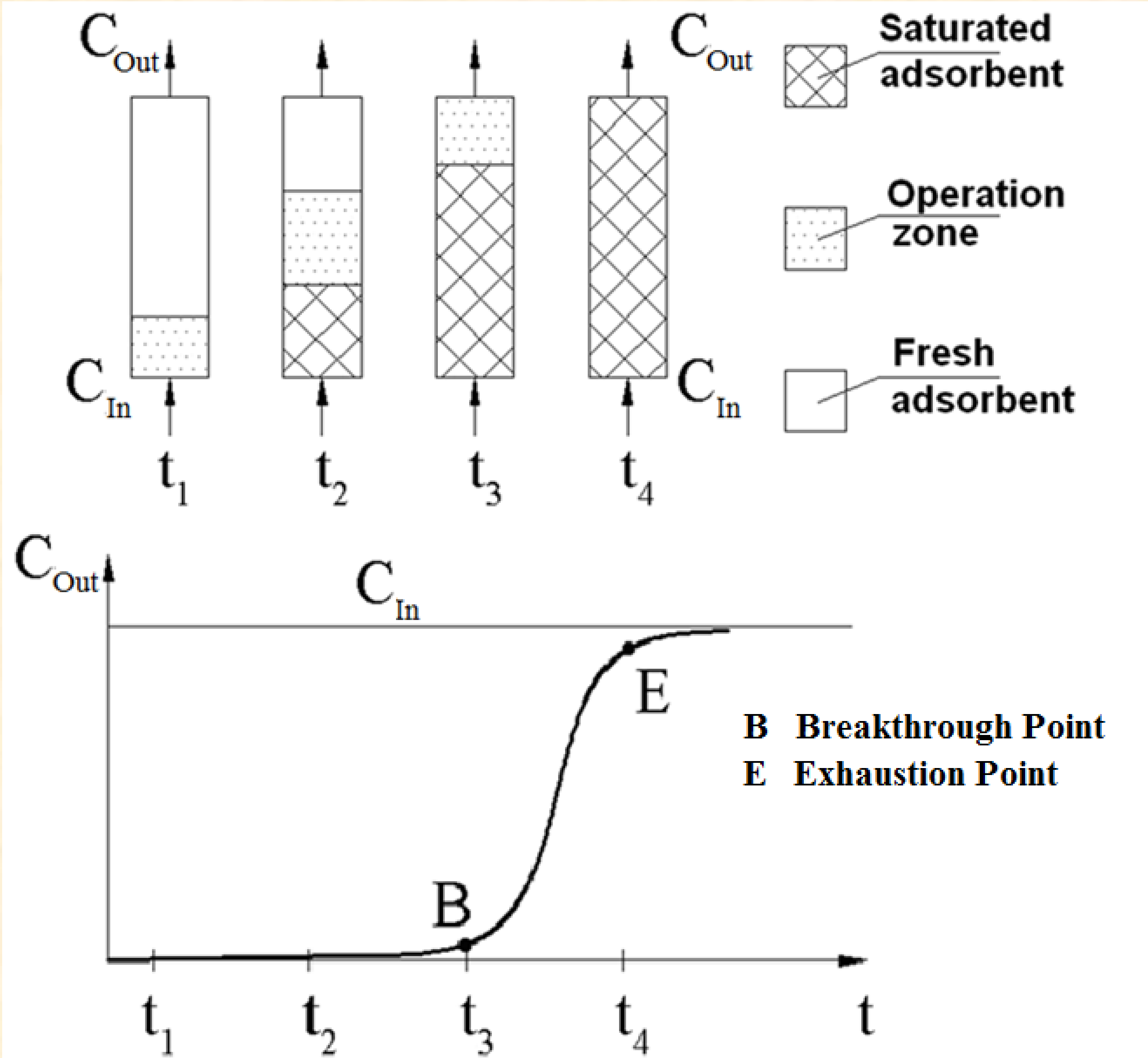
Fixed Bed Adsorbers

A part of the bed is saturated at inlet point of water and reaches adsorption equilibrum.
This part of the bed is not able to further adhesion so moves towards the outlet zone of the water. Zones in the bed are:

- saturated zone
- adsorption or operation zone
- free zone

Water flow to be cleared into the adsorber has to be turned off at breakthrough point or exhaustion point, and let into another adsorber column.
Saturated adsorber has to be regenerated (desorbed.)

Fixed Bed Adsorbers

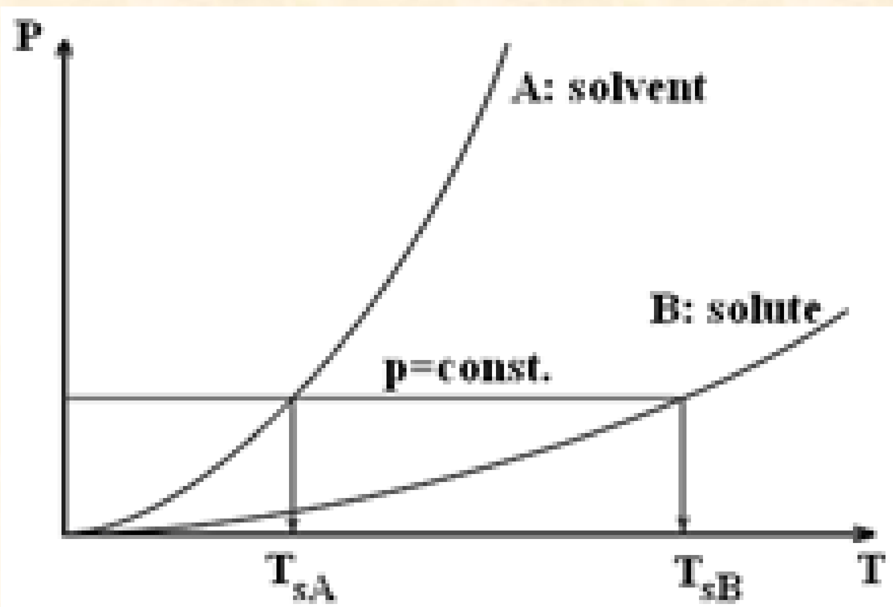


EVAPORATION

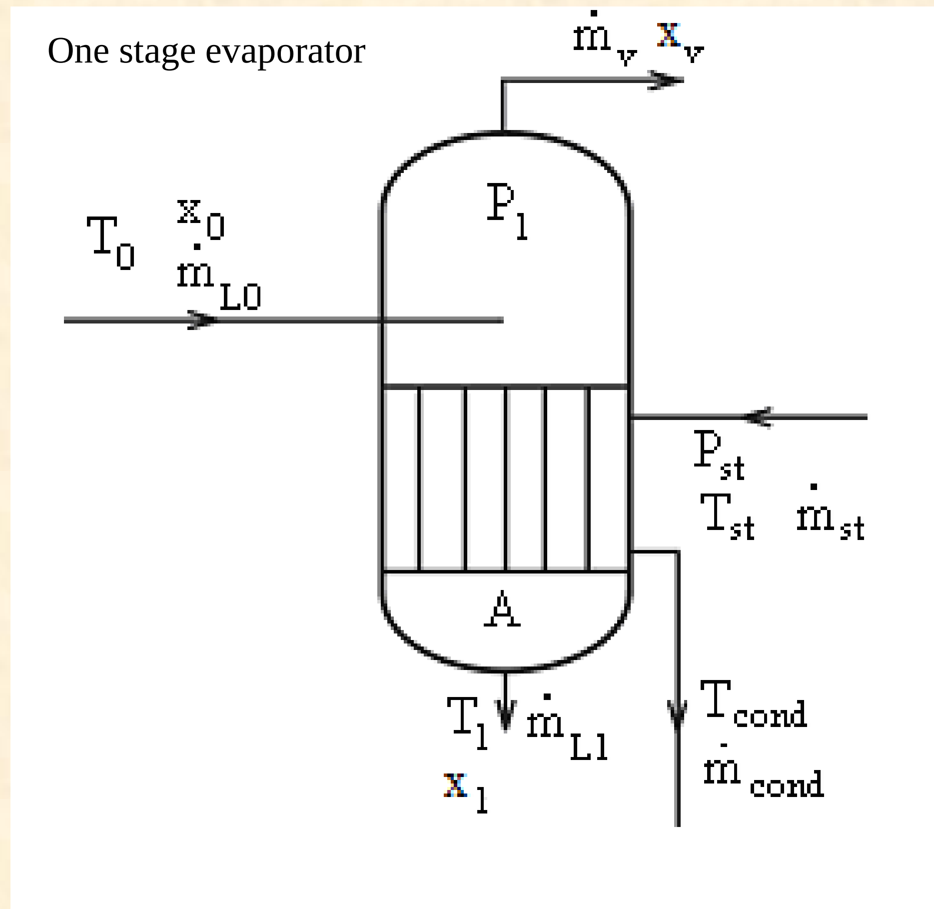
Evaporation is a thermal process, widely used for concentrating solutions, suspensions, and emulsions.

Concentration is accomplished by boiling out one part of the solvent, normally water, from the liquid phase.

Applicability of evaporation process



One stage evaporator



EVAPORATION

At two-component systems mass of the total solution (m_L) is equal with sum of solvent mass (m_A) and solute mass (m_S): $m_L = m_A + m_S$

Mass fraction (concentration) is the fraction of the mass of solute divided by the total mass of the system.

$$x = x_S = \frac{m_S}{m_L} = \frac{kg\ solute}{kg\ solution}$$

Mass balance for a single effect evaporator : $\dot{m}_{st} + \dot{m}_{L0} = \dot{m}_{L1} + \dot{m}_V + \dot{m}_{cond}$

The heating chamber is separated from the solvent space so we can write:

$$\dot{m}_{st} = \dot{m}_{cond}$$

$$\dot{m}_{L0} = \dot{m}_{L1} + \dot{m}_V$$

Mass balance of the solute: $\dot{m}_{L0} \cdot x_0 = \dot{m}_{L1} \cdot x_1 + \dot{m}_V \cdot x_V \qquad \text{where} \quad x_V \approx 0$

Concentration of the solution at the end of evaporation:

$$x_1 = \frac{\dot{m}_{L0}}{\dot{m}_{L1}} \cdot x_0$$

Membrane

Semi-permeable layer with two main features:

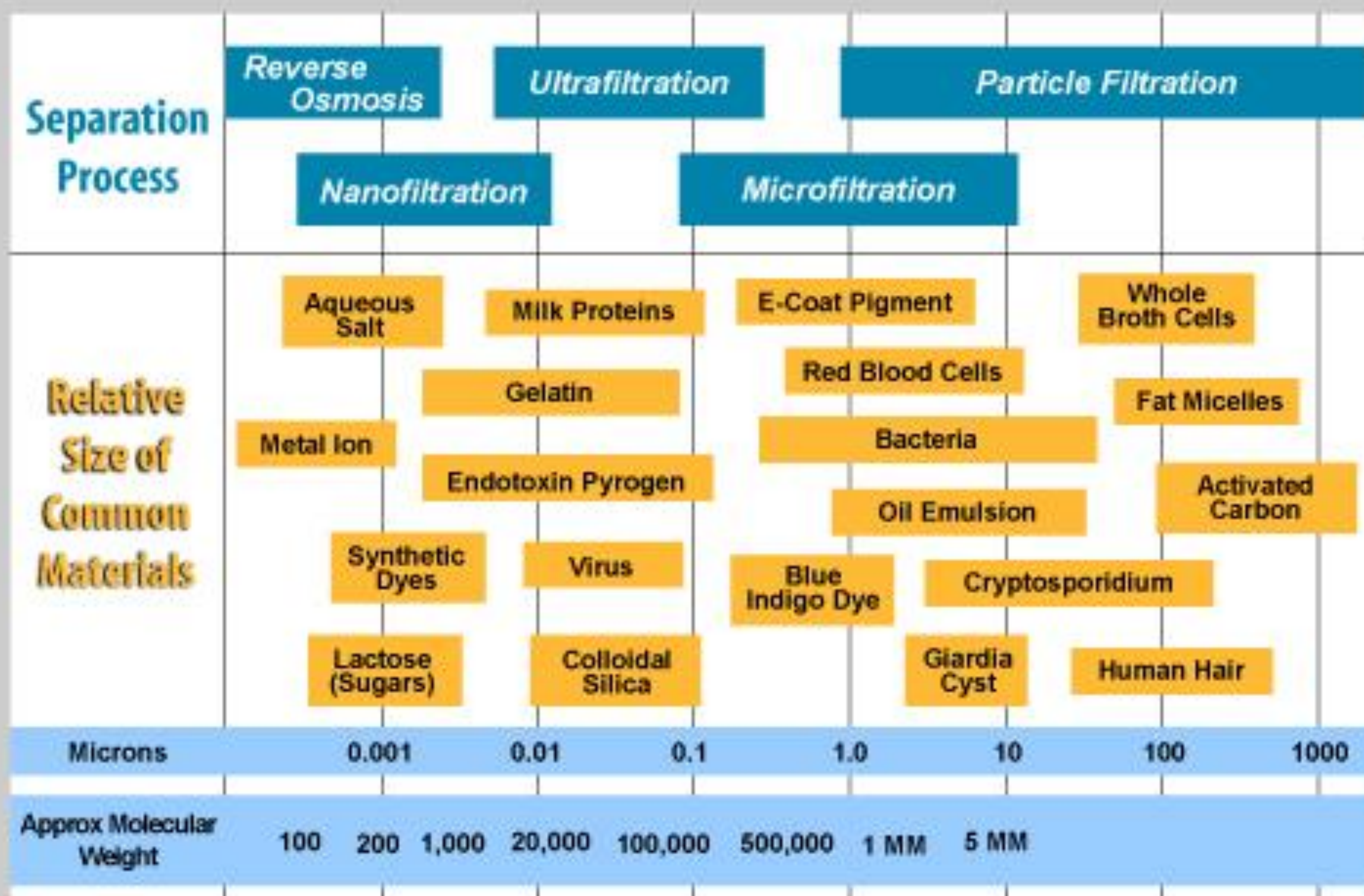
- selectivity
- permeability

Inlet flow is separated:

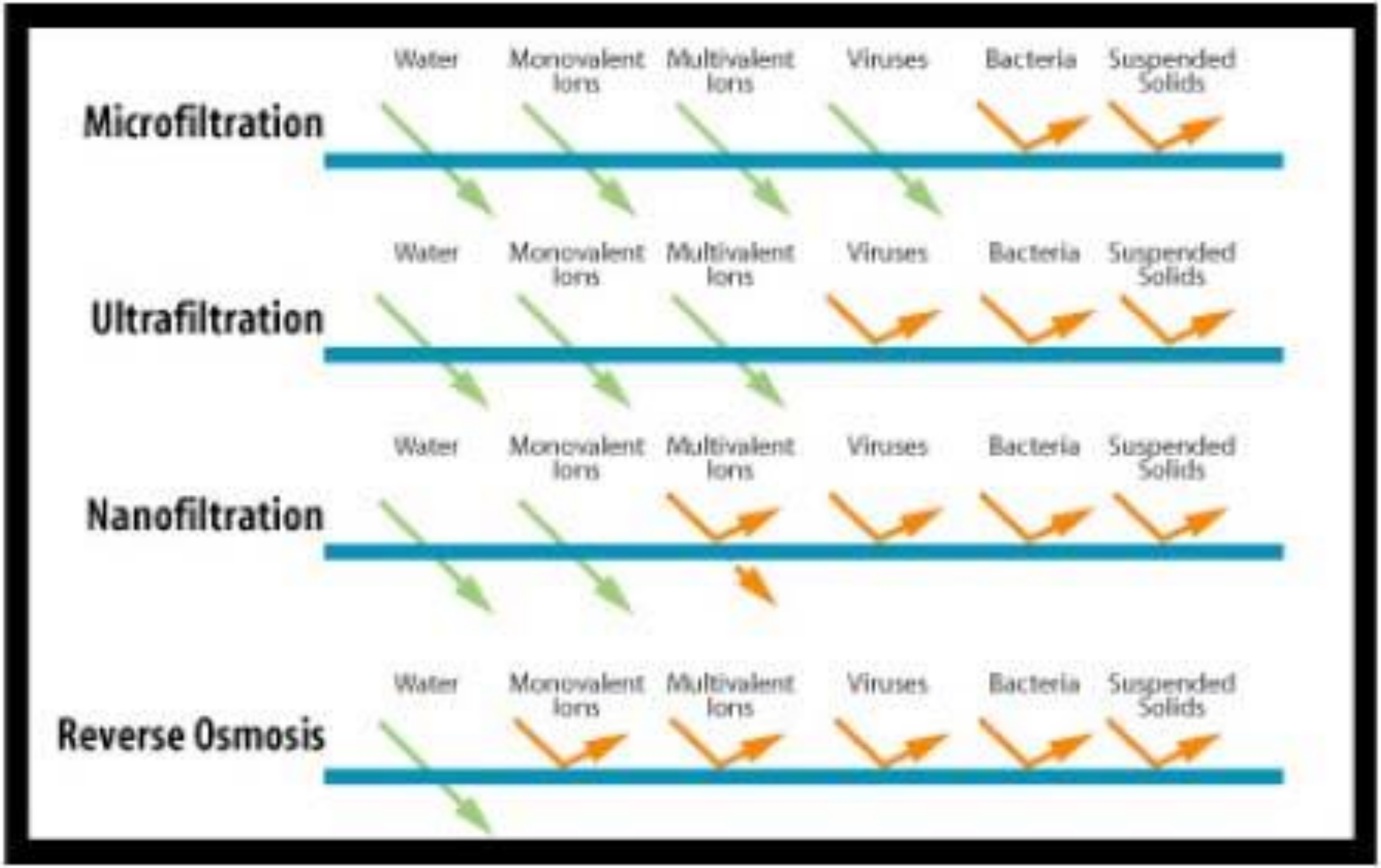
- permeate (cleared water)
- retentate (concentrated contamination)

MEMBRANE TECHNOLOGY

• Ultrafiltration (UF)	5.10^{-9}-3.10^{-7} m
• Nanofiltration (NF)	2.10^{-9}-10^{-7} m
• Mikrofiltration (MF)	10^{-7}-5.10^{-6} m
• Reverse osmosis (RO)	5.10^{-10}-5.10^{-9} m
• Dialyzis	5.10^{-10}-5.10^{-8} m

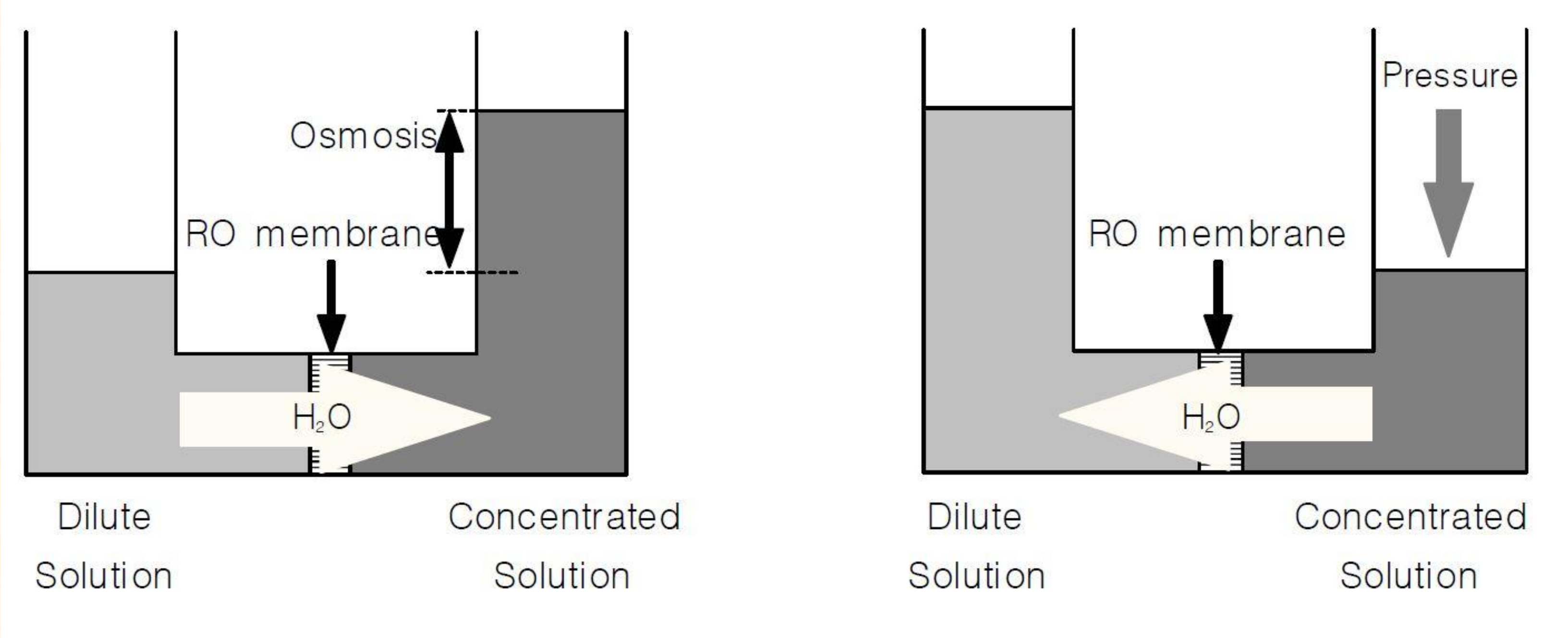


Note: 1 micron (micrometer) = 4 x 10-5 inches = 1 x 104 Angstrom units



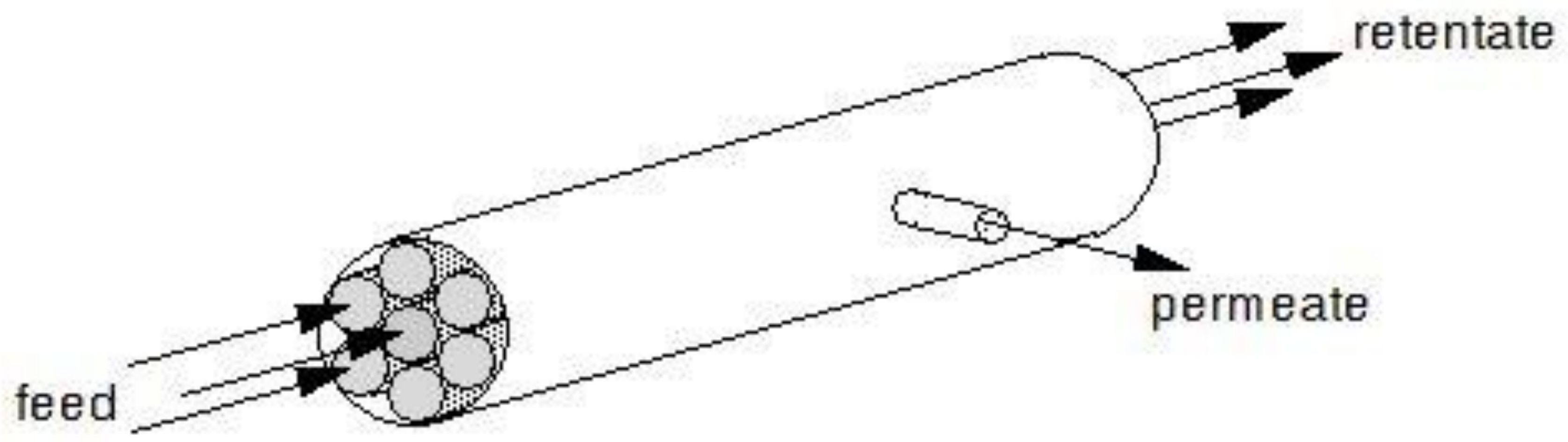
Membrane Process Characteristics

Osmosis Reverse osmosis



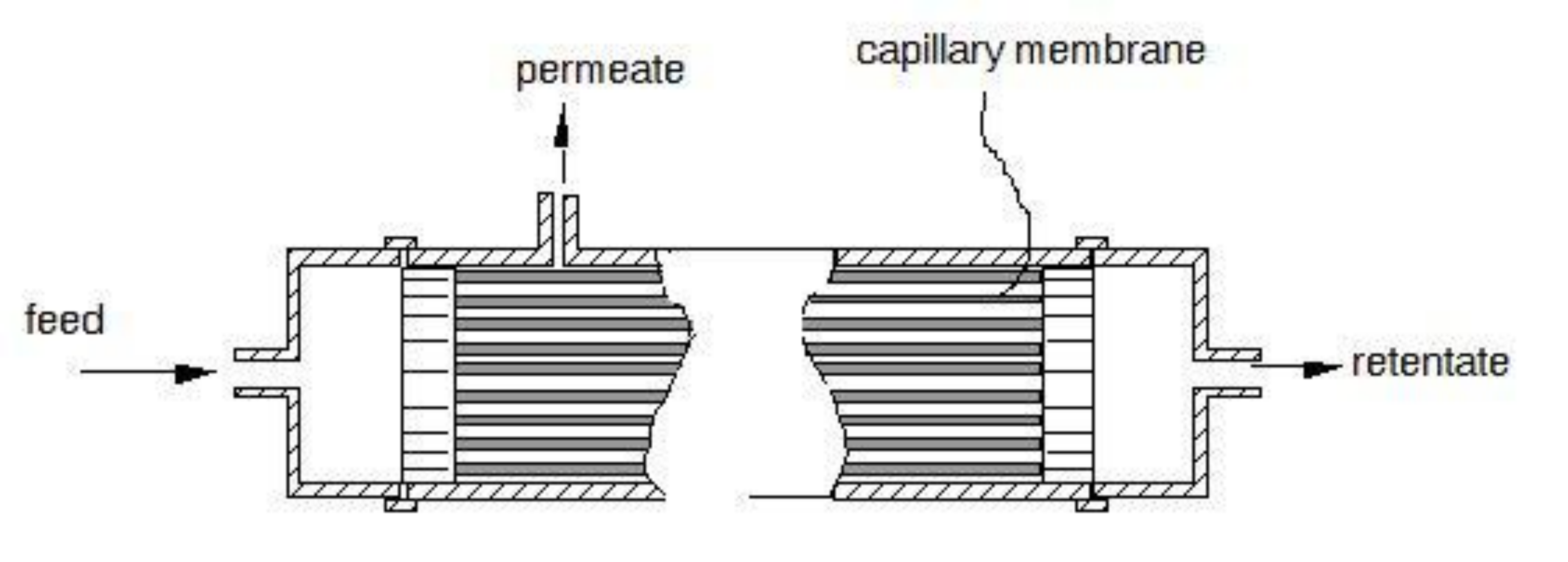
Tubular modules

Tubular module

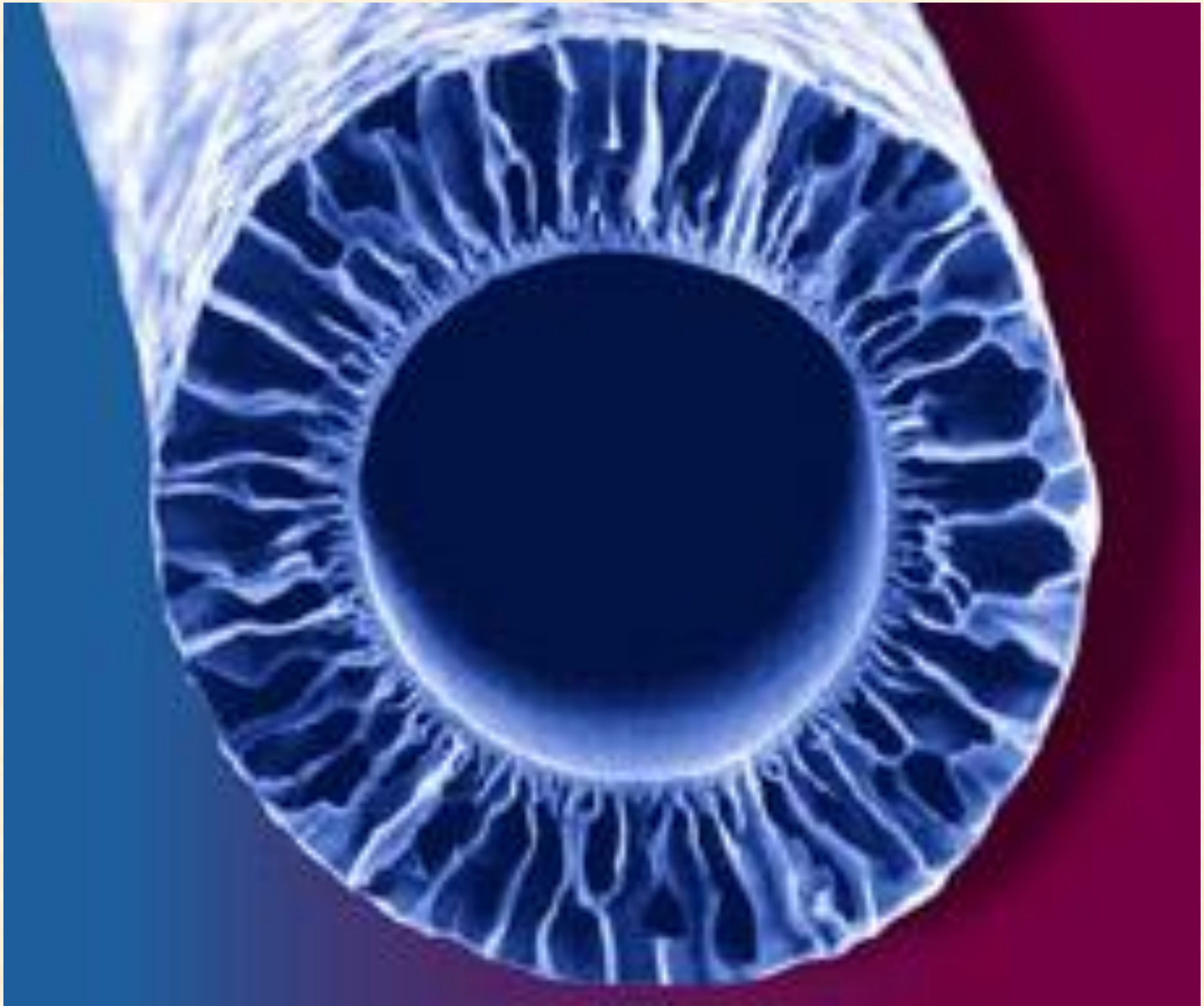


Membrane station

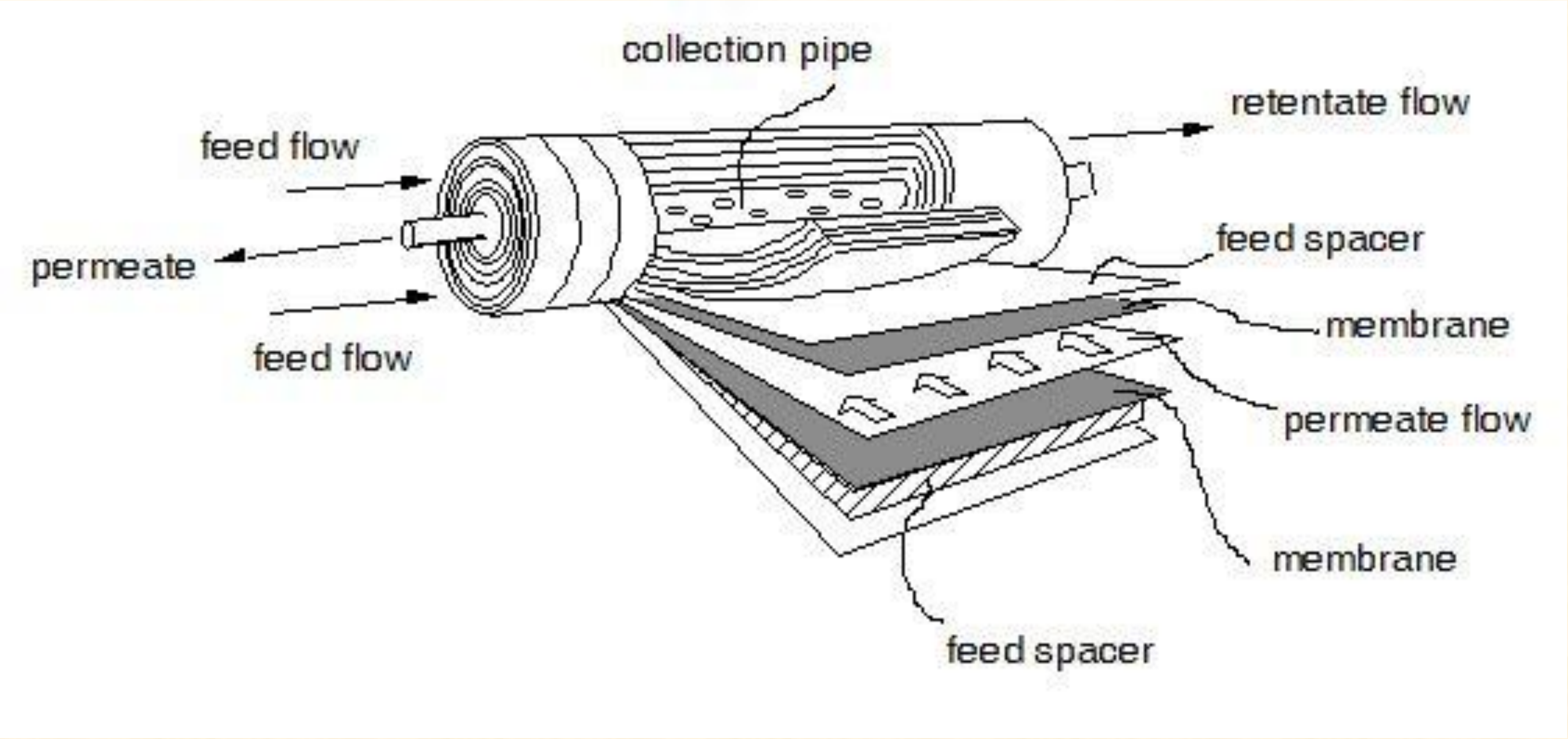
Capillary membrane module



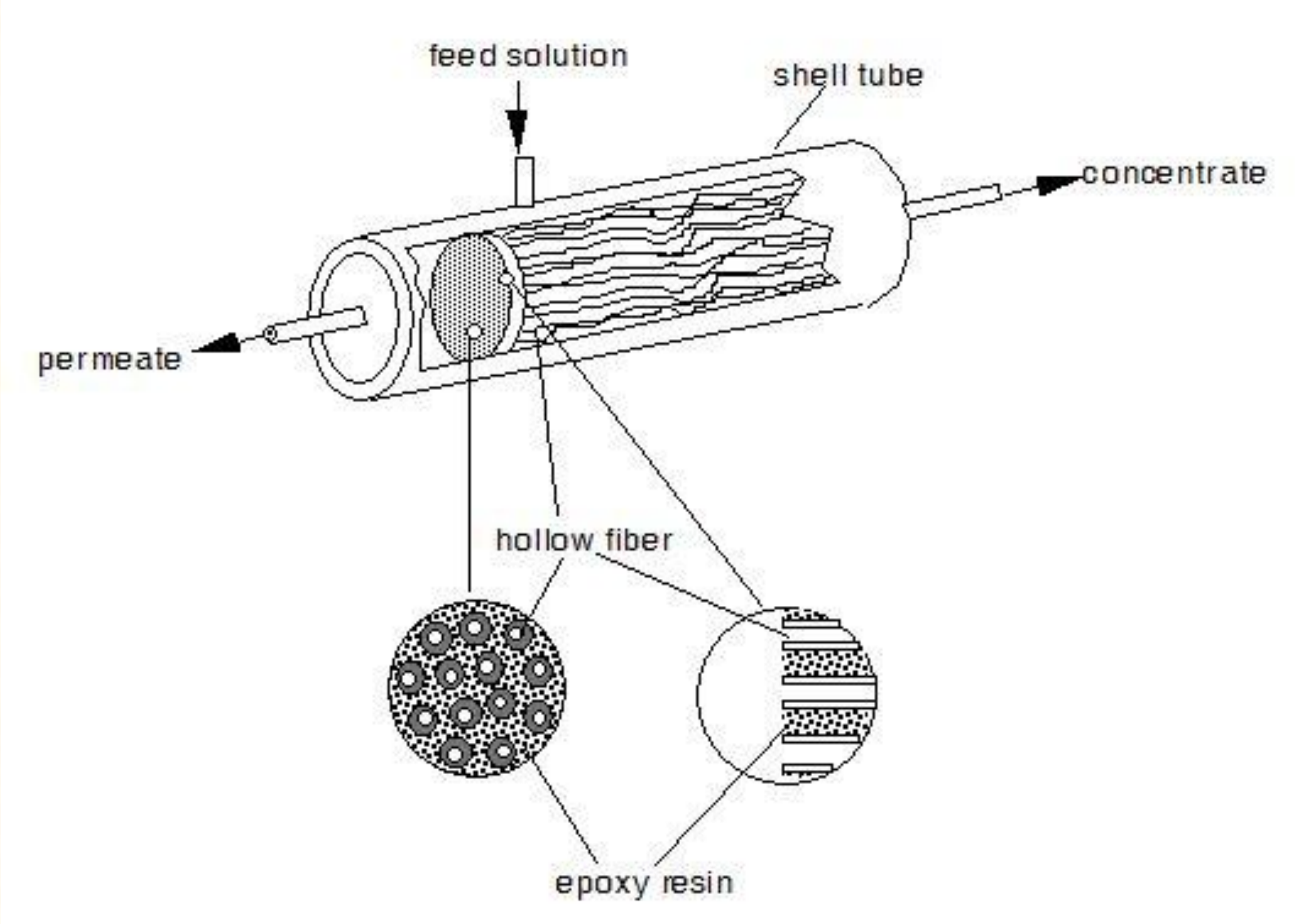
Capillary membrane module



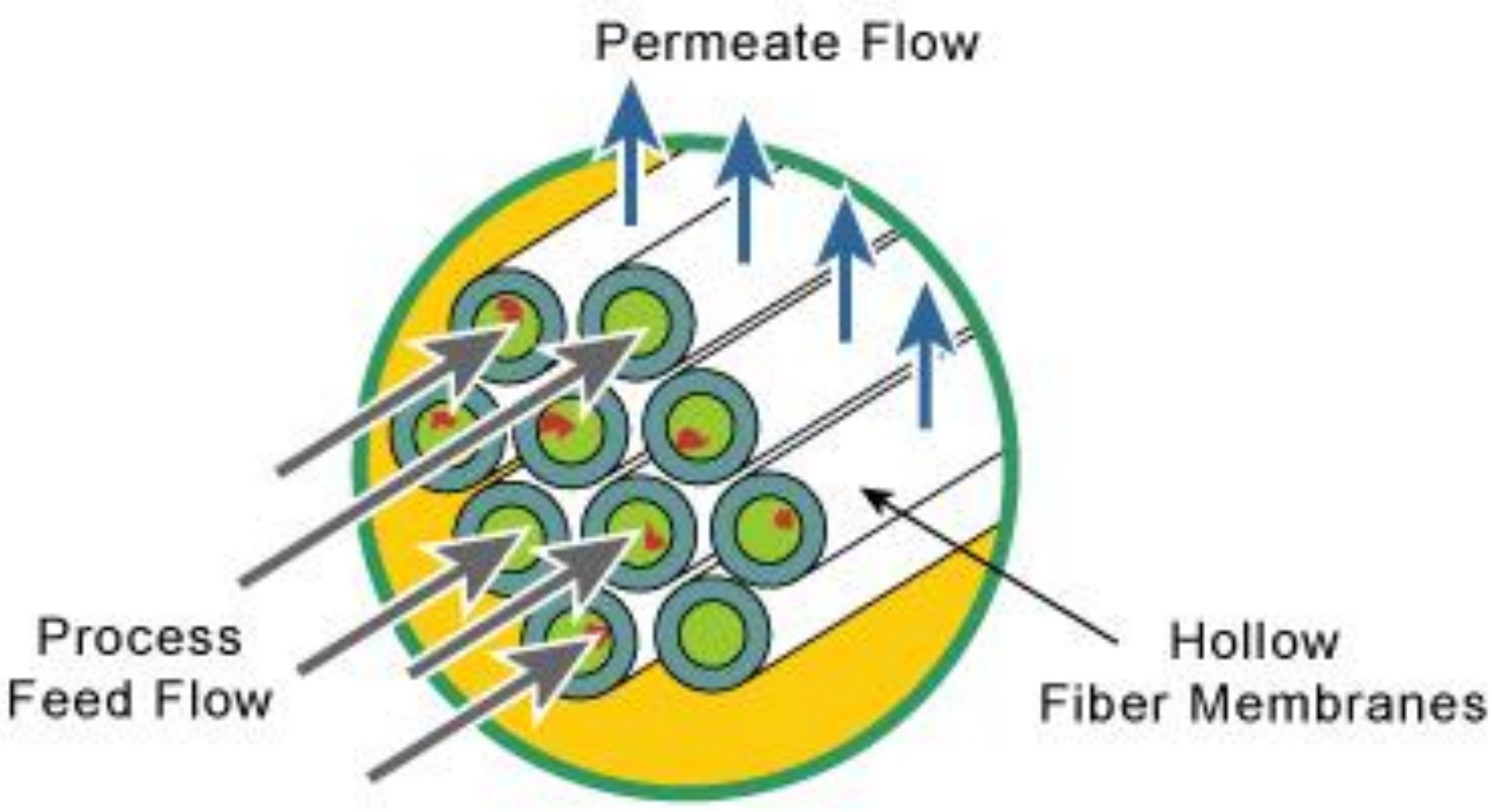
Spiral wounded module



Hollow fiber module



Hollow fiber module



Hollow fiber modules

Spiral wounded module