Membrane Processes:

Membrane Processes are becoming popular because they are considered "Green" technology - no chemicals are used in the process. A membrane is a selective barrier that permits the separation of certain species in a fluid by combination of sieving and diffusion mechanisms. Membranes can separate particles and molecules and over a wide particle size range and molecular weights.

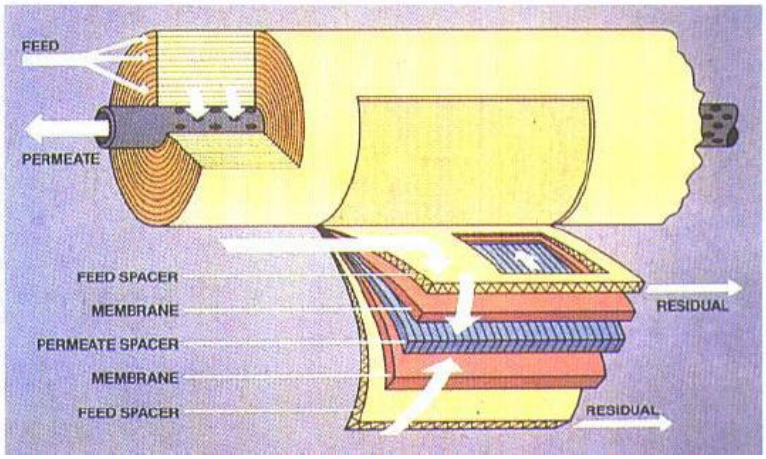
Four common types of membranes:
•Reverse Osmosis
•Nano filtration
•Ultra filtration
•Micro filtration

The R.O. membrane is semi-permeable with thin layer of annealed material supported on a more porous sub-structure.
• The thin skin is about 0.25 micron thick and has pore size in the 5 – 10 Angstrom range.
•The porous sub-structure is primarily to support the thin skin. The pore size of the skin limits transport to certain size molecules.
•Dissolved ions such as Na and Cl are about the same size as water molecules.

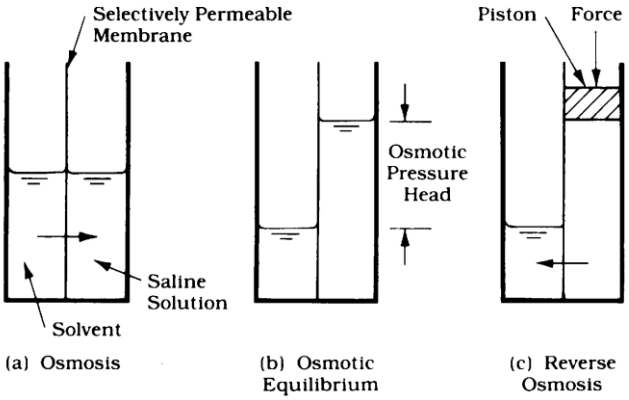
However, the charged ions seem to be repelled by the active portion of the membrane and water is attracted to it.
•So adsorbed water will block the passage and exclude ions.
• Under pressure attached water will be transferred through the pores.

Nanofiltration is a complementary process to reverse osmosis, where divalent cations and anions are preferentially rejected over the monovalent cations and anions.
•Some organics with MW > 100 -500 are removed There is an osmotic pressure developed but it is less than that of the R.O. process.
•Microfiltration and Ultrafiltration are essentially membrane processes that rely on pure straining through porosity in the membranes.
•Pressure required is lower than R.O. and due entirely to frictional headloss

Spiral-Wound Membrane Element



If clean water and water with some concentration of solute are separated by a semi-permeable membrane (permeable to only water) water will be transported across the membrane until increases hydrostatic pressure on the solute side will force the proces to stop.



The osmotic pressure head (at equilibrium) can be calculated from thermodynamics.The chemical potential (Gibbs frees energy per mole) of the solvent and the solute(s) in any phase can be described as:

Applications of Micro- and Ultrafiltration Conventional water treatment (replace all processes except disinfection).
•Pretreat water for R.O and nanofiltration.
•Iron/Manganese removal (after oxidation).
Applications for R.O. and nanofiltration:
•R.O. application mostly desalination.
•Nanofiltration first developed to remove hardness.

Comparison of Membrane process:

Ultrafiltration	Reverse Osmosis	Microfiltration
Operates on difficult colloidal water	Requires extensive pre-treatment of colloids	Rapidly fouled by colloids giving high replacement costs
Low pressure (2-6 bar)	High pressure (10-30 bar)	Low pressure (2-4 bar)
Low energy consumption	High energy	Low energy
High recovery (up to 95%)	Low recovery (50-80%)	100% recovery
Chemical tolerance pH 1-13	pH 2-11	pH 1-13
High temperature up to 80°C	45°C max.	High temperatures possible
High resistance to oxidising agents	Limited resistance to oxidising agents	High resistance to oxidising agents
Stream sterilisable membranes available	Stream sterilisation not possible	Stream sterilisation possible
Hygienic module designs available	Modules not as hygienic	Hygienic designs available