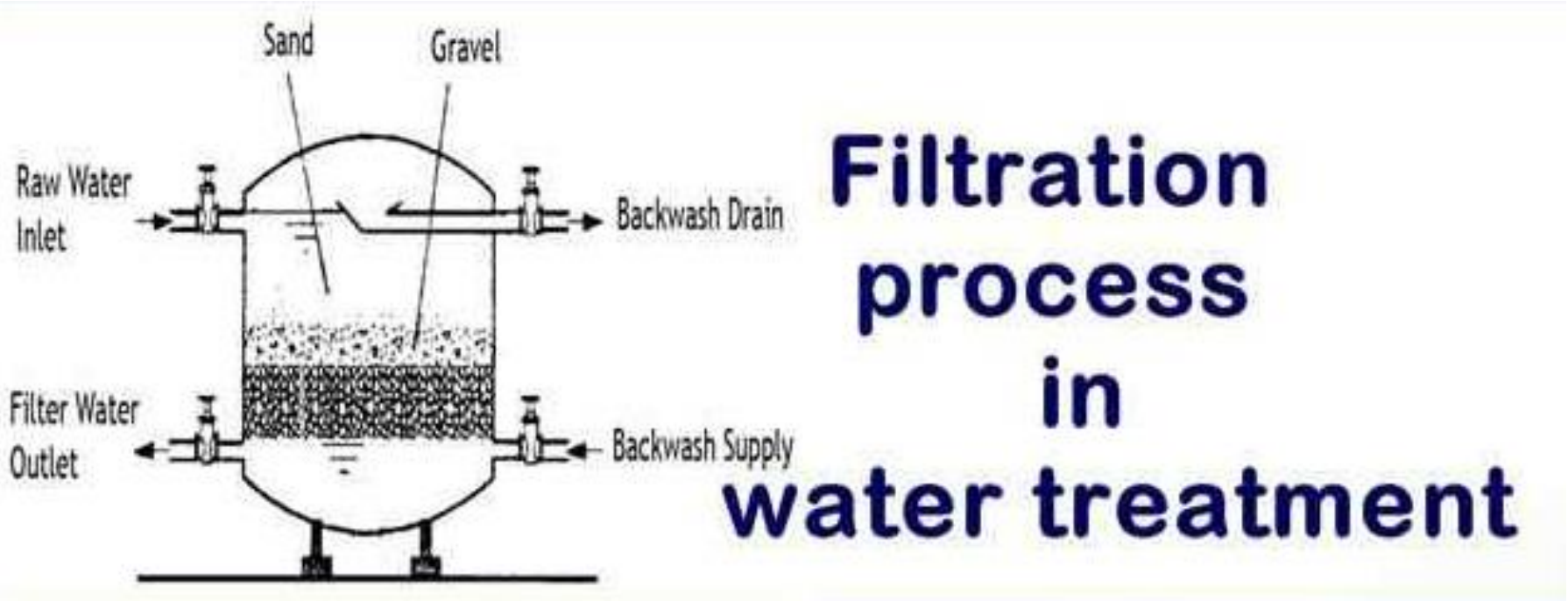
Water Purification by Filtration



What is filtration?

- **Filtration is a process of removing particulate matter from water by forcing the water through a porous media.**
- **This porous media can be natural, like sand, gravel and clay, or it can be a membrane wall made of various materials.**
- **Sometimes, large particles are settled before filtration; this is called sedimentation.**
- **The size of materials that can be removed during filtration depends upon the size of the pores of the filter.**

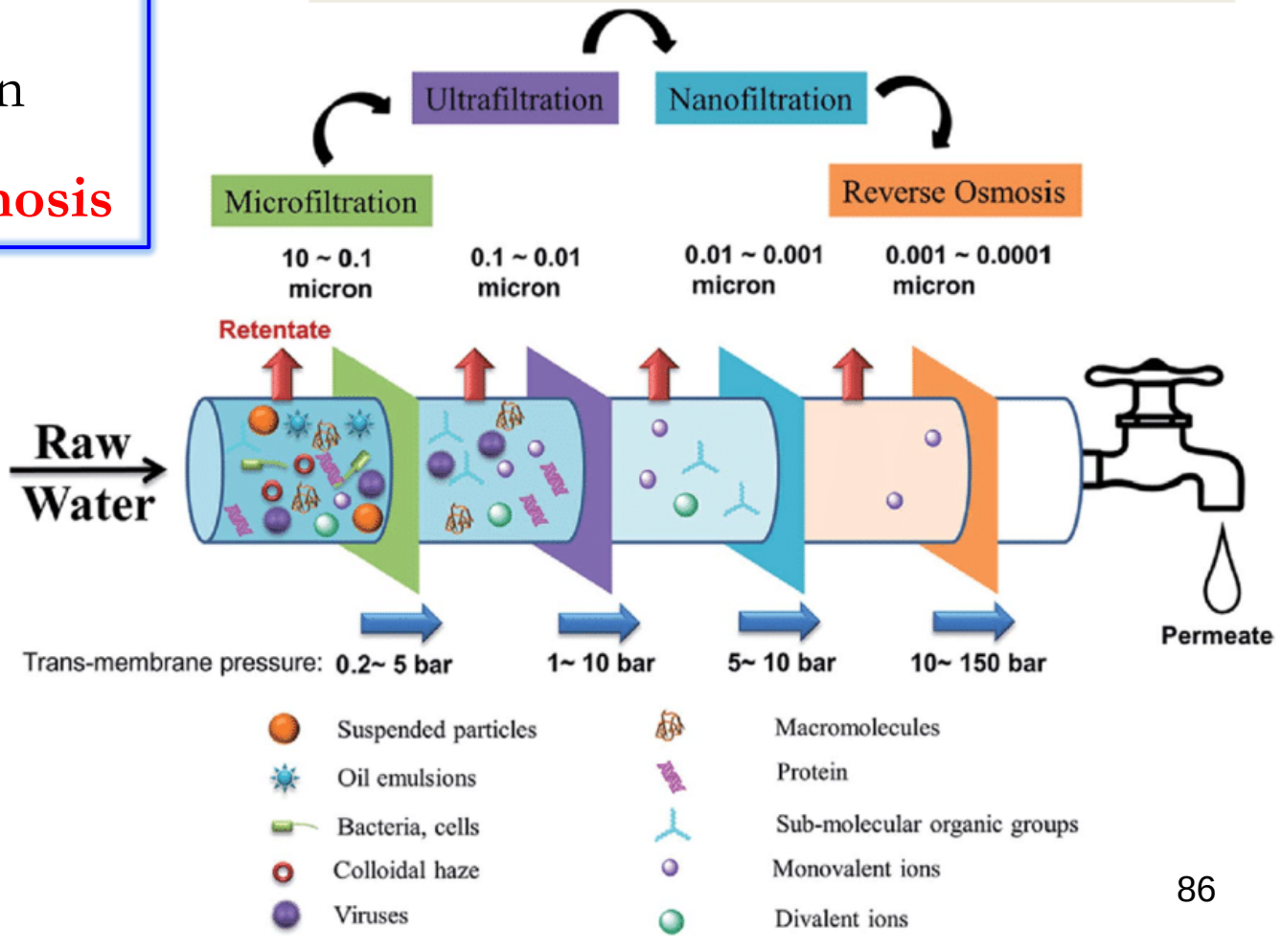
Water Contaminants

Class	Typical Example
Suspended solids	Dirt, clay, colloidal materials
Dissolved organics	Trihalomethanes, synthetic organic chemicals, humic acids, fulvic acids
Dissolved ionics (salts)	Heavy metals, silica, arsenic, nitrate
Microorganisms	Bacteria, viruses, protozoan cysts, fungi, algae
Gases	Hydrogen sulfide, methane, radon

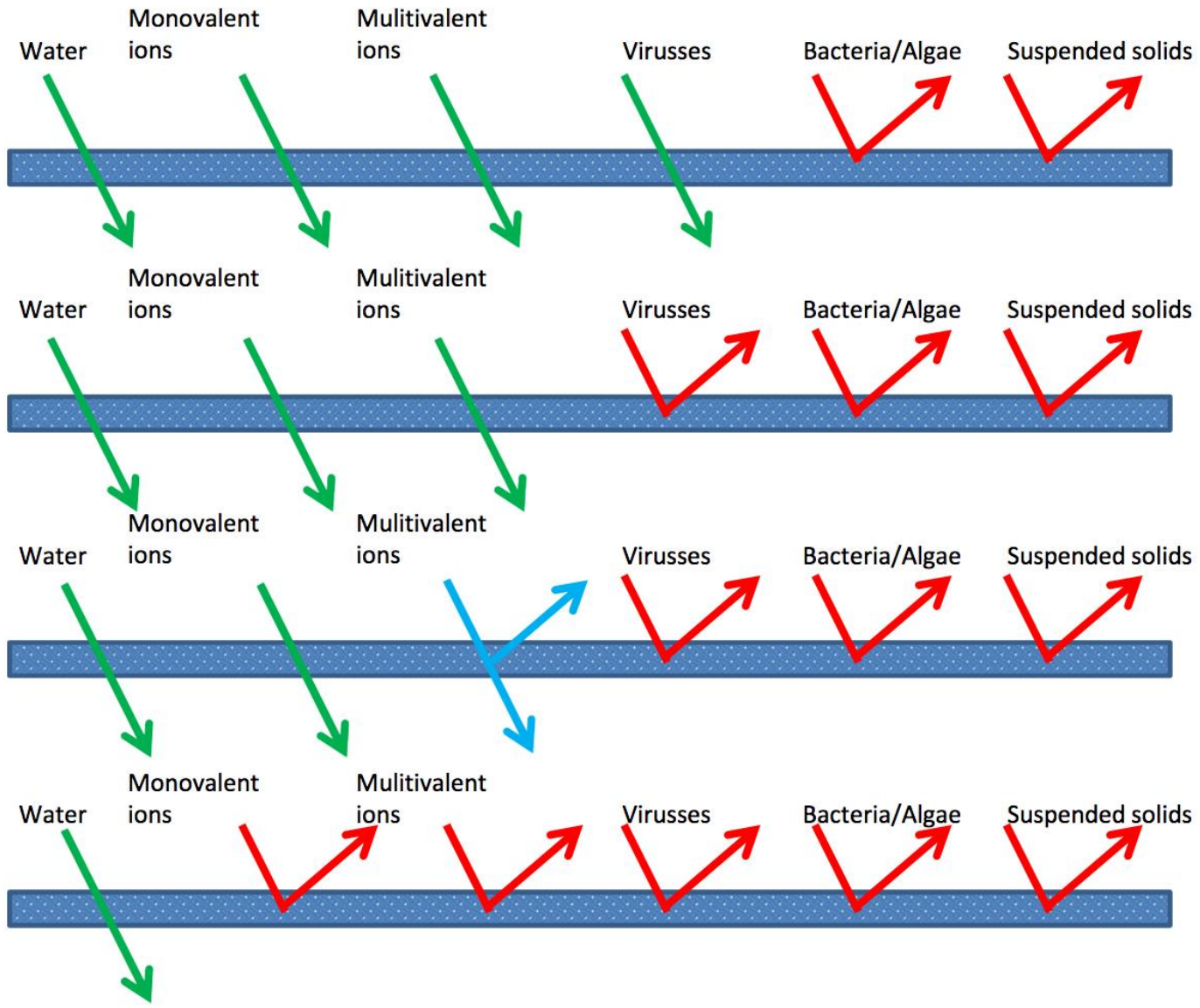
Different Kinds of Filtration

1. Micro filtration
2. **Ultra filtration**
3. Nano filtration
4. **Reverse Osmosis**

Membrane Processes are becoming popular because they are considered "Green" technology - no chemicals are used in the process.



Comparison membrane techniques



Membrane Filtration comparison

Filtration type	Pore size	Impurities removed
Microfiltration	0.1-10 μm	Suspended Particles, Microorganisms
Ultrafiltration	0.1 – 0.01 μm	Suspended solids, solutes of higher molecular weight
Nanofiltration	1-10 nm	Multivalent Cations, Organic Impurities
Reverse Osmosis	0.1 nm (< 1nm)	Removes most of the impurities (bigger than 0.1 nm)

1. Microfiltration

Microfiltration (MF) membranes are available in pore sizes ranging from **0.1 to 10 μm**. **MF porosity is the highest in the membrane filtration family**, with the result that MF membranes allow water, ions, dissolved organic material, small colloids, and viruses to pass through, while retaining larger contaminants such as:

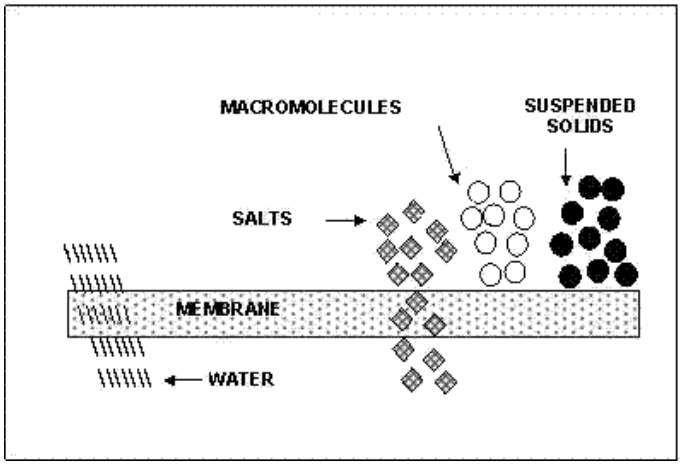
- **Algae**
- **Bacteria**
- **Pathogenic protozoa,** including Giardia lamblia and Crypotosporidium
- **Sediment,** including sand, clay, and complex metals/particles

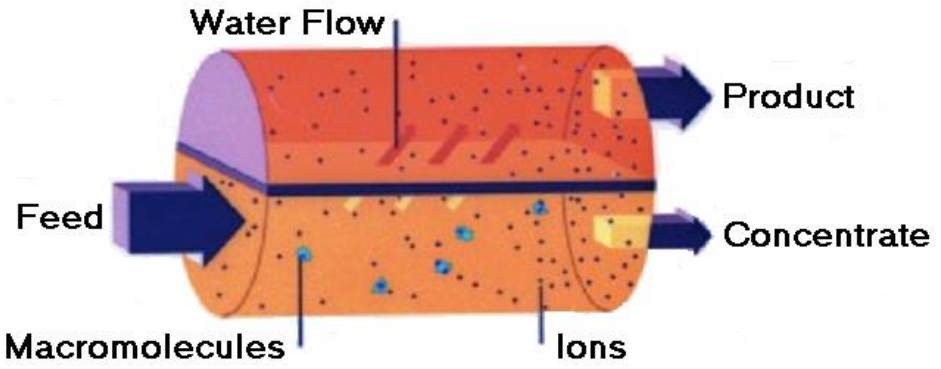
2. Ultrafiltration

- Ultrafiltration is basically a pressure driven separation process, governed by a screening principle and dependent on particle size

- Ultrafiltration membranes have a pore size between **10 nm and 100 nm**, this allowing retention of compounds with a molecular weight of 300-5,00,000 Daltons.

- The Ultrafiltration rejected water consist of sugars, biomolecules, polymers, colloidal particles and viruses.





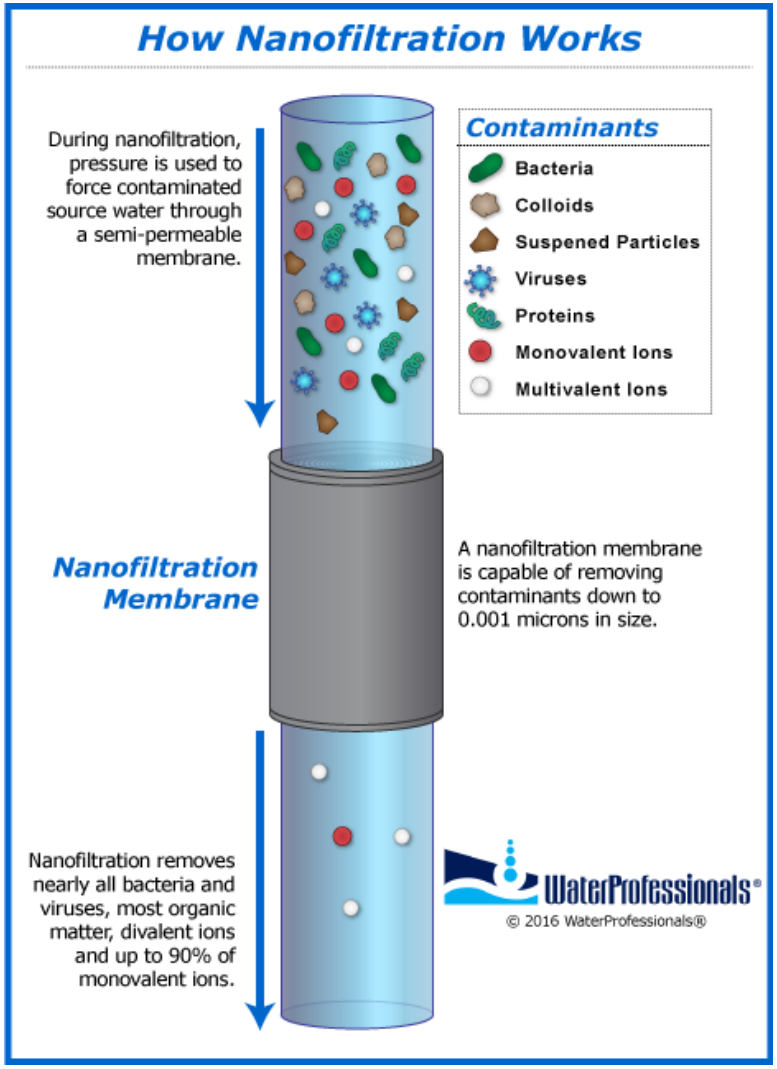
2. Ultrafiltration

Most membranes are synthetic organic polymers (e.g. polysulfone, cellulose acetate).

- Microfiltration and ultrafiltration membranes are often made from the same materials, but they are prepared under different membrane formation conditions so that different pore sizes are produced.
- Membranes can also be prepared from inorganic materials such as ceramics or metals.
- Ceramic membranes are microporous, thermally stable, chemically resistant, and often used for microfiltration.
- However, disadvantages such as high cost and mechanical fragility have hindered their widespread use. Metallic membranes are often made of stainless steel and can be very finely porous.
- Their main application is in gas separations, but they can also be used for water filtration at high temperatures or as a membrane support.

3. Nanofiltration

- Nanofiltration (NF) is a membrane filtration – based method.
- Nanofiltration membranes have pore sizes from **1 to 10 nm**.
- NF membranes used are predominantly created from polymer thin films.
- Materials that are commonly use include polyethylene terephthalate or metals such as aluminium



3. Nanofiltration

Benefits of Nanofiltration

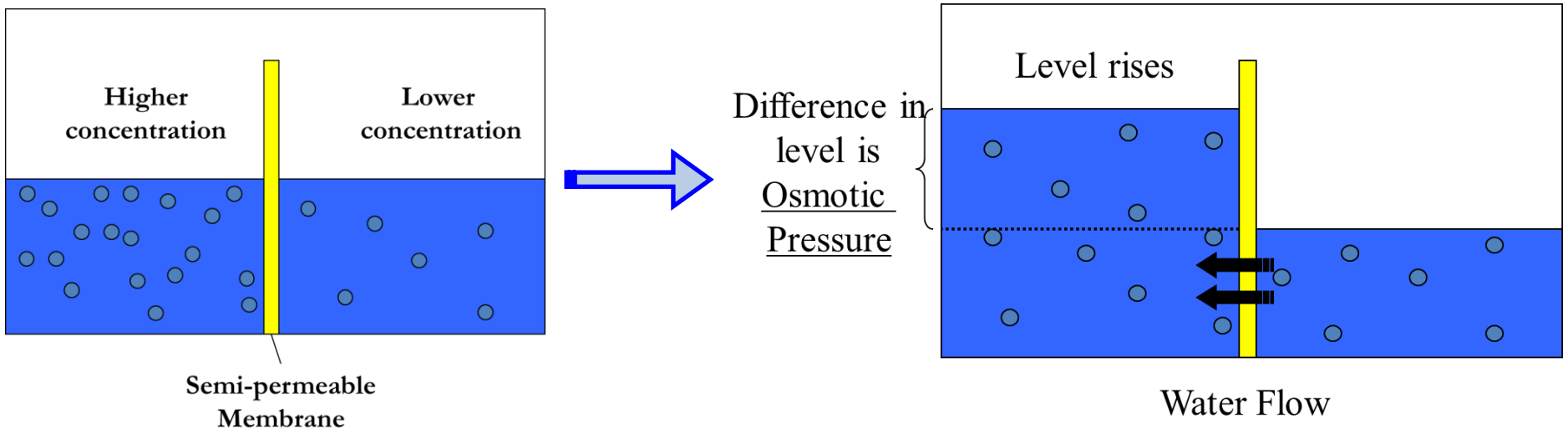
- ✓ Low cost of operation and low energy cost
- ✓ Comparatively lower discharge and less wastewater
- ✓ Reduction in heavy metals and reduction in water hardness
- ✓ Reduction/Removal of viruses, bacteria and pesticides

Drawbacks of the process of Nanofiltration

- ✗ Membrane fouling
- ✗ Treatment of concentrates
- ✗ Membrane lifetime and chemical resistance
- ✗ Insufficient rejection for individual components

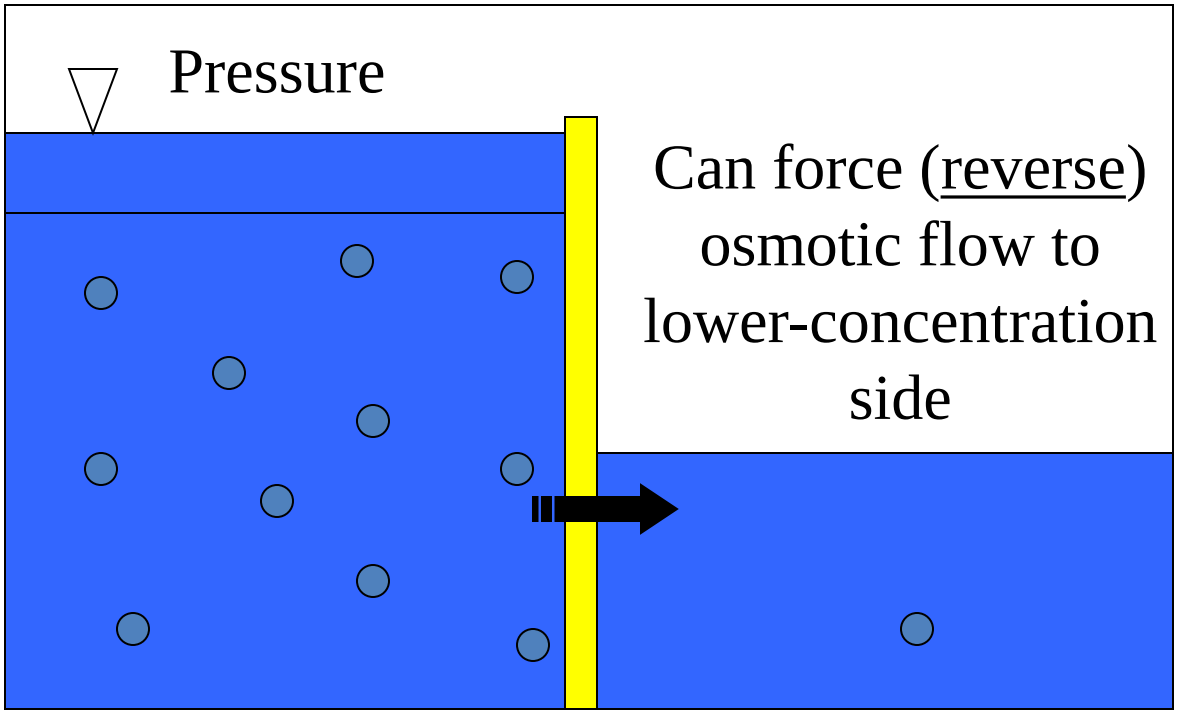
4. Reverse Osmosis

Osmosis

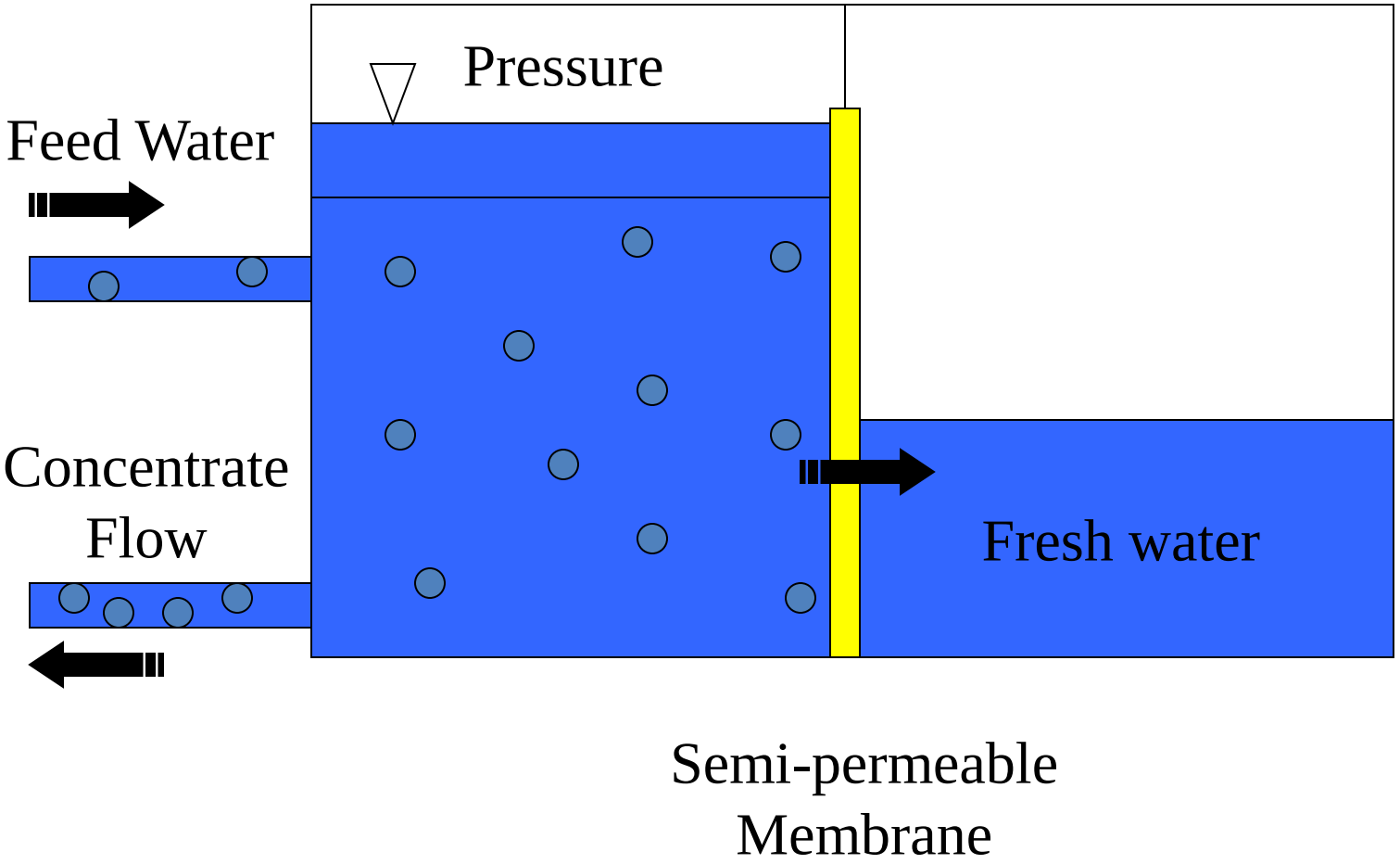


- **Osmosis** is the movement of water or other solvent through a plasma membrane from a region of low solute concentration to a region of high solute concentration.
- **Osmosis** is passive transport, **meaning** it does not require energy to be applied.

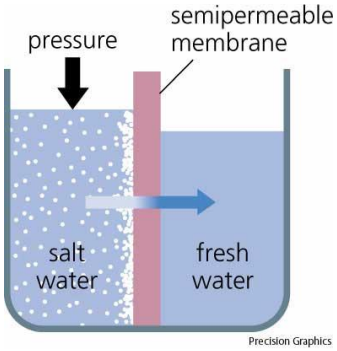
4. Reverse Osmosis

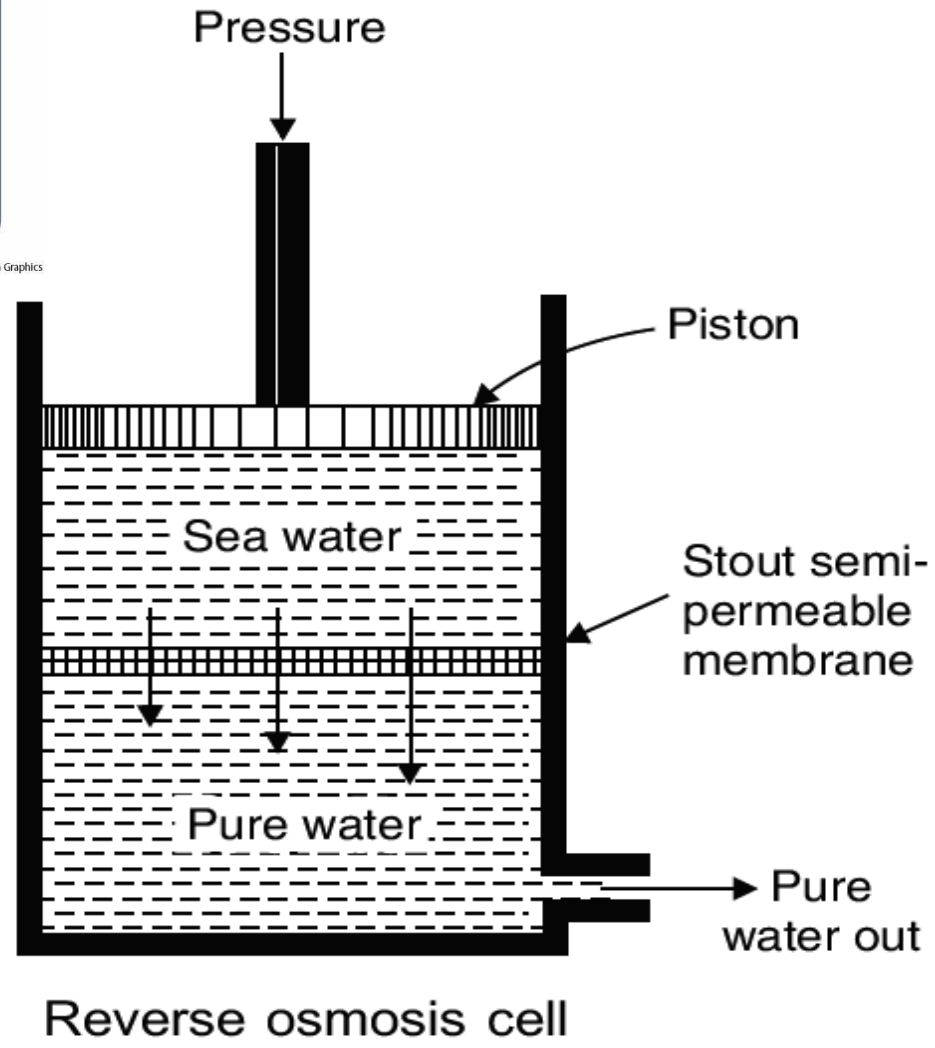


Reverse Osmosis Applied



4. Reverse Osmosis





Reverse osmosis cell

- **Super filtration**
- **15-40 kg cm^2**

- Cellulose acetate
- Polysulfone
- Polysulfone amide
- Polyamide
- Poly-acrylonitrile

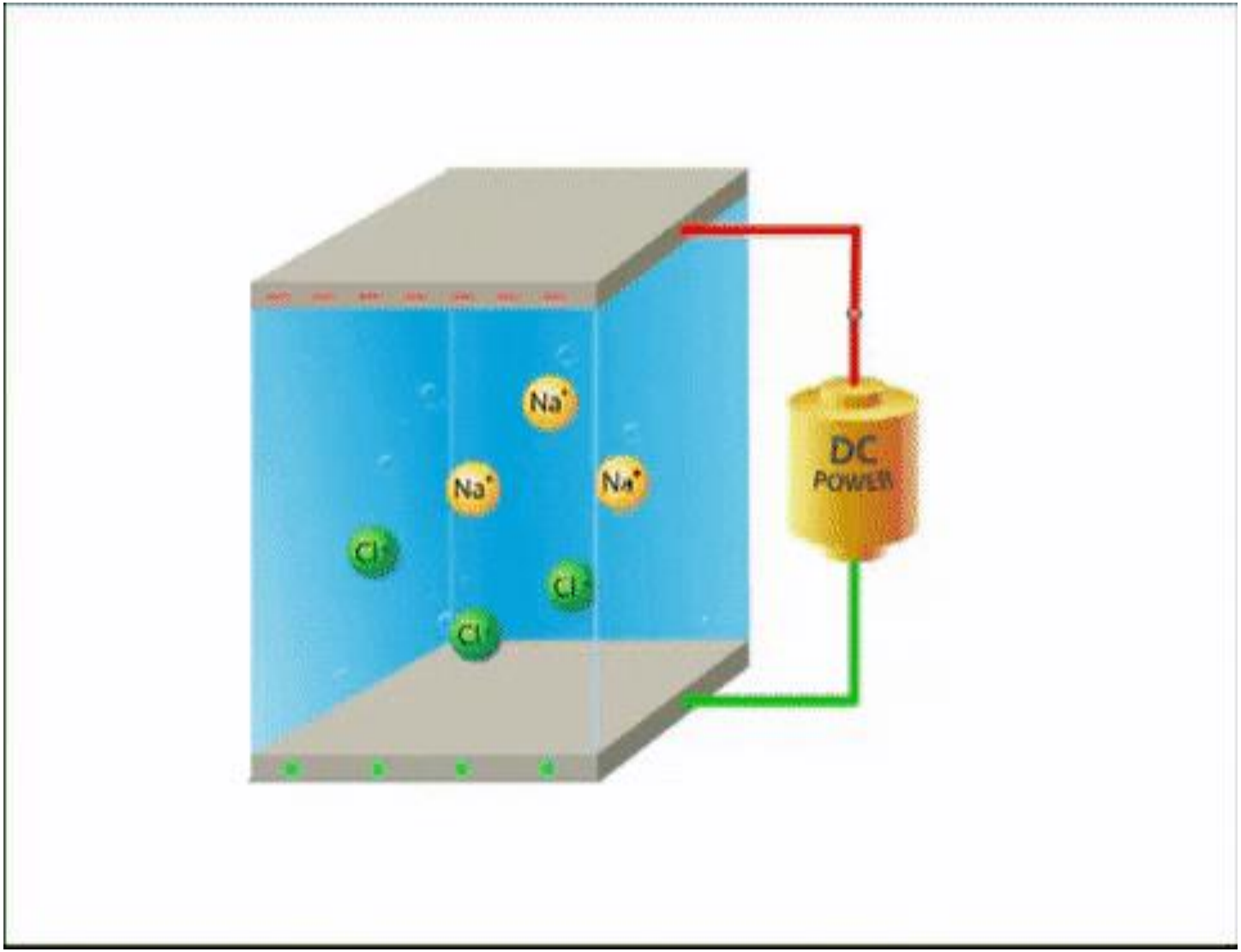
Advantages

- Removes colloidal silica
- Long life
- Can be replaced within few minutes

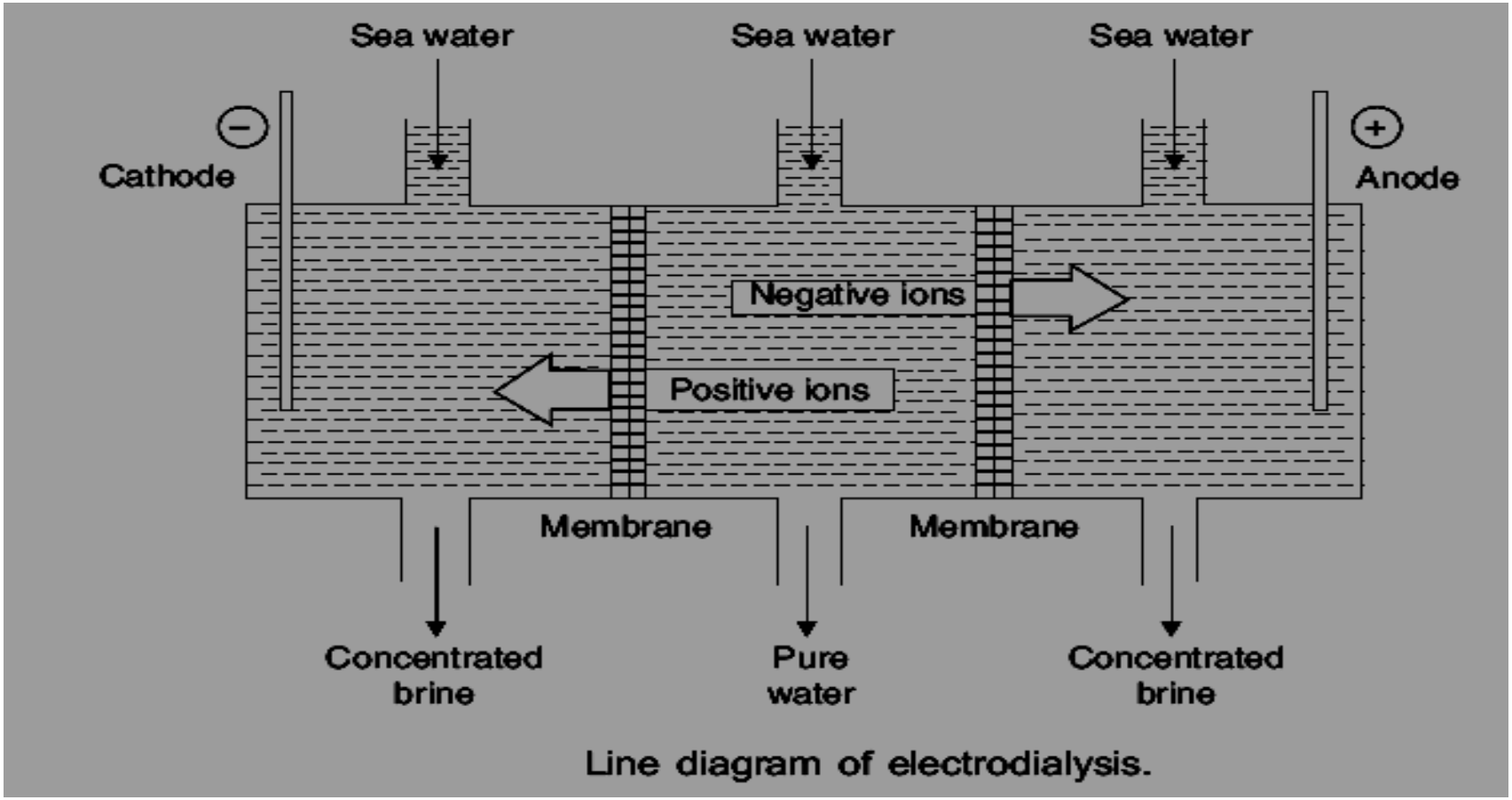
Desalination of brackish water

- Water containing dissolved salts with a peculiar salty (brackish) taste is brackish water
- The process of removing common salt from water is desalination
- Electrodialysis consists of a large container with two membrane separators, one permeable to positive ions and the other permeable to negative ions.
- In the outer compartments anode and cathode are arranged to pass DC Voltage.
- When DC voltage/current is passed through the cell, Na^+ will move towards cathode and Cl^- will move towards anode through the membrane.
- Hence, the concentration of salt decreases in the middle compartment and increases in the side compartments.
- Water from the middle compartment is collected and this water is desalinated water.

Electrodialysis



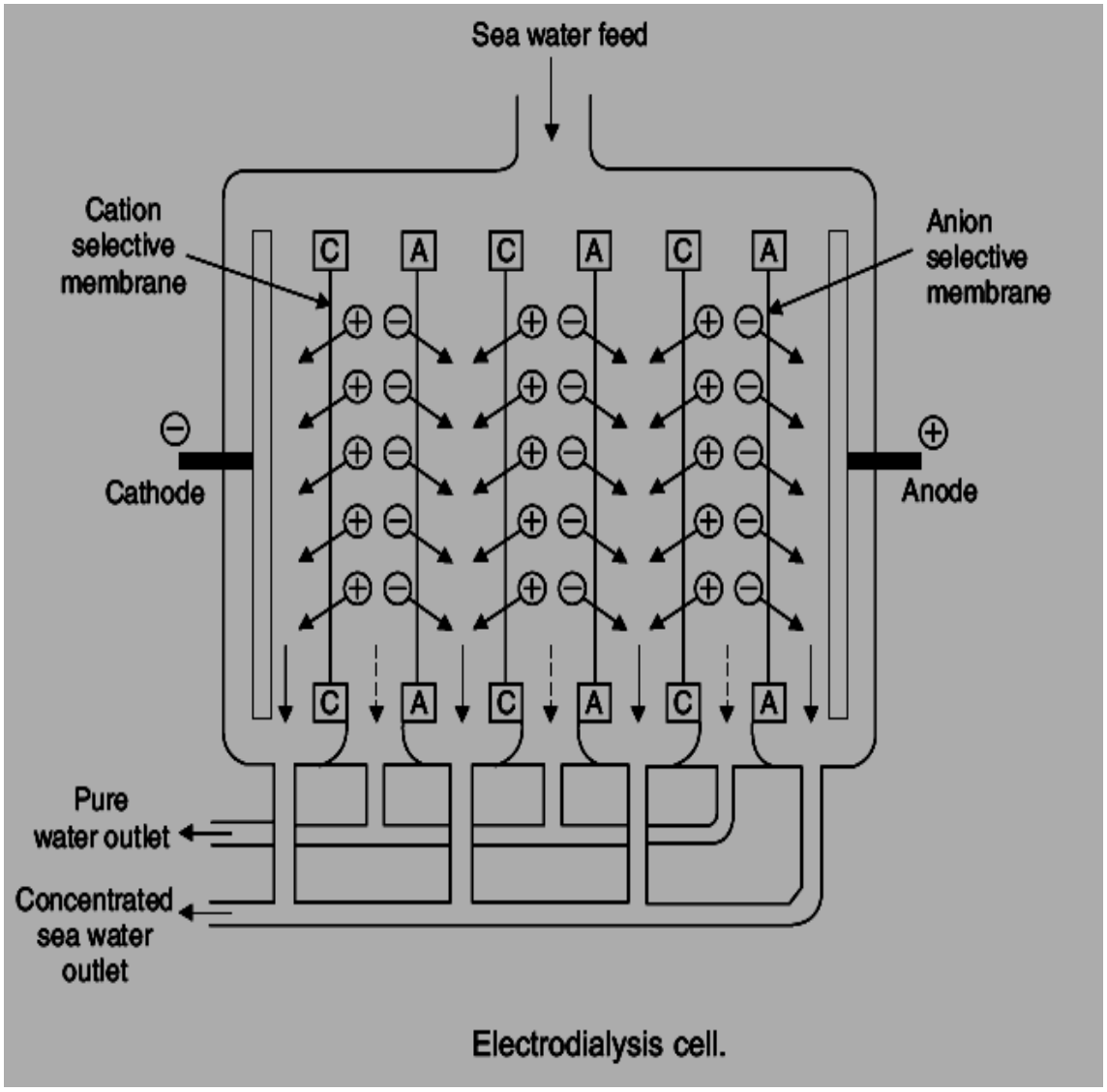
Electrodialysis diagram



Line diagram of electrodialysis.

For efficient separation, ion-selective membranes are used which selectively allow cations or anions to pass through them.

Electrodialysis cell



Electrodialysis cell.

- Electrodialysis cell consists of Large number of pairs of rigid Plastic membranes.
- Saline water at a pressure of 5-6 kg/cm^2 is passed through the membrane pairs.
- DC current is applied perpendicular to the direction of water flow.

Advantages are:

1. Unit is compact and installation is economical
2. Best suited if electricity is available.