TRI-AQUA with ISCT

present

# Introduction for water chemistry and needs to desalination


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*AUC Water & WW Certified*

# Agenda

This Workshop will cover :

- Classification of water types and some terms
- Water Treatment in General
- Desalination Techniques
- Revers Osmosis in detail

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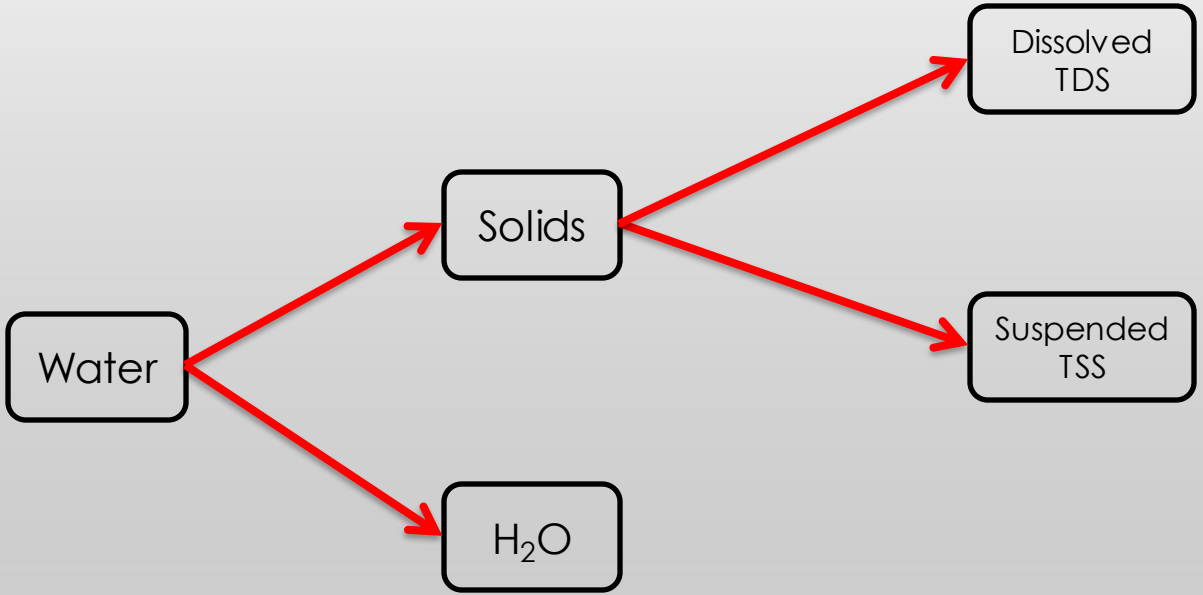
# Water Treatment and Desalination

Water Composition

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Water classification

# Classification

- According Salinity
- According Quality grade and use

# Water Treatment and Desalination

Water classification

## According Salinity

- Fresh water ……. …….. …….. TDS < 500 ppm ( < 0.05% )
- Brackish water .. ……. …….. TDS < 30,000 ppm ( < 3% )
- Sea water ……. ……. …… TDS > 30,000 ppm ( >3% )

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# Water Treatment and Desalination

Water classification

## According Quality grade and use

**Saline water :**

water that contain high value of salt content and it's uses depend on it's salinity ratio and mainly include sea and brackish water

**Potable water :**

water that meet drinking water guidelines such WHO which in most cases it is treated surface water and it's uses mainly for drinking purposes

**Hard water :**

Water that contain hardness salts such carbonate and bicarbonate and sulfate salts which have great tendency to precipitated on surfaces and decrease detergent efficiency

**Soft Water :**

water that free from hardness salt and mainly used for hot systems such as boilers and membrane filtration systems such as R.O

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# Water Treatment and Desalination

Water classification

**Purified water :**

water that produced by treatment or desalting techniques such R.O and mainly used in food grade productions and some pharmaceutical production if compatible with it's guidelines such pharmacopeia.

**Ultra-pure water :**

mainly it is polished purified water which subjected to extra treatment such EDI tech. used mainly for pharmaceutical and medical purposes.

**Demi-Water :**

It is demineralized water produced mainly by water Deionizers ( ion exchange technique ) used mainly for pharmaceutical and medical purposes.

**Distilled water :**

Water that produced by distillation technique such MED & MSF and used for high pharma grade such WFI purposes.

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# Water Treatment and Desalination

Important Terms

## Terminology

- **TS** …. Total solids
- **TDS** …. Total Dissolved Solids
- **TSS** …. Total Suspended Solids
- **Surface water** …. Water we can see it's flow such as rivers –lakes
- **Sub-surface water** …. Water founded on small depth 5-15m
- **Ground water** …. Water under ground on large depth such as well & springs

- **Well water** …. Underground water that need hydraulic mechanical force to bring it to the surface

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# Water Treatment and Desalination

Important Terms

- **Spring water** …. Underground water that flow under natural ground pressure to the surface without any mechanical force
- **Desalination** …. Separation process of salts from salty water to reduce the TDS which also called ( Desalting process )
- **Distillation** …. Desalination technique which use steam & heat in production of purified water
- **Demineralization** …. Separation process to approaching complete removal of the TDS

# Water Treatment and Desalination

Important Terms

- **R.O** …. Reverse Osmosis
- **N.F** …. Nano Filtration
- **U.F** …. Ultra Filtration
- **M.F** …. Micro Filtration
- **M.S.F** …. Multi Stage Flash
- **M.E.D** …. Multi Effect Distillation
- **E.D** …. Electro-Dialysis
- **EDI** …. Electro-Deionization

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Water Treatment in General

# Water Treatment and Desalination

**According to matching between the two columns we select the suitable water treatment technique**

- **Water Resources**

- Surface water (rivers-lakes..)
- Sub-surface water
- Ground water (well-springs)
- Rain water
- Sea water

- **Target water usage**

- Agriculture & irrigation
- Industrial use
- Drinking
- Medical use

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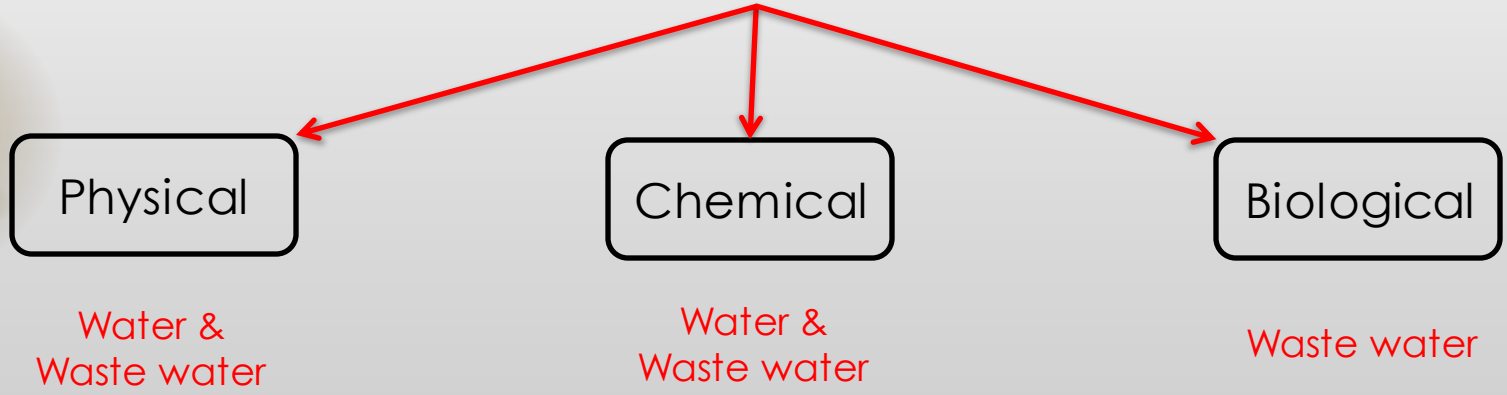
Water Treatment in General

# Water Treatment and Desalination

**In general treatment of water done though only three ways**

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# Water Treatment and Desalination

Water Treatment in General

## Physical Treatment

Methods that depend mainly on physical parameter such :

- Water Intake screening
- Natural Sedimentation
- Filtrations
  - media filtration ( targeted the TSS )
  - membrane filtration ( targeted the TDS )

- Distillation ( one of desalination techniques )
- Disinfection by radiation

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# Water Treatment and Desalination

Water Treatment in General

## Screening

- Removes large solids
  - Plastic bodies
  - branches
  - fish
- Simple process
  - may incorporate a mechanized trash removal system
- Protects pumps and pipes in WTP

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# Water Treatment and Desalination

Water Treatment in General

## Design parameter

- The bar diameter ($\Phi$) = 1.3 – 1.9 cm (or)
  0.5 – 0.75 inches.
- The spacing between two bars (S) = 2 – 5 cm
- The inclined angle of the bar screen ($\theta$) = 30 – 60o

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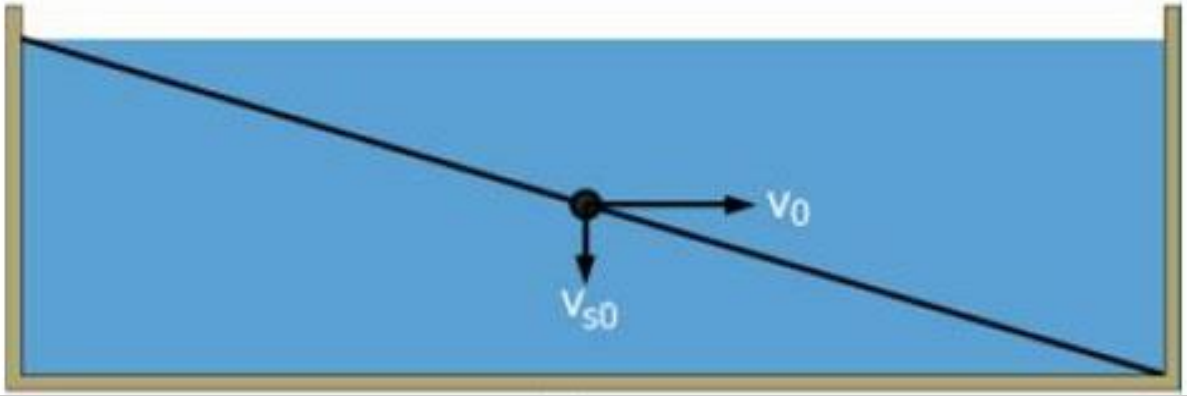
# Water Treatment and Desalination

Water Treatment in General

## Natural Sedimentation

Separate solids from liquid using the force of gravity. In sedimentation, only suspended solids (SS) are removed.

### Horizontal sedimentation

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# Water Treatment and Desalination

Water Treatment in General

| Diameter (m) | Types of particles | Settling time over 30 cm |
|---|---|---|
| $1.10^{-2}$ | gravel | 0.3 sec |
| $1.10^{-3}$ | coarse sand | 3 sec |
| $1.10^{-4}$ | fine sand | 38 sec |
| $1.10^{-5}$ | silt | 33 min |
| $1.10^{-6}$ | bacteria | 35 hours |
| $1.10^{-7}$ | clay | 230 days |
| $1.10^{-8}$ | colloids | 63 years |

# Water Treatment and Desalination

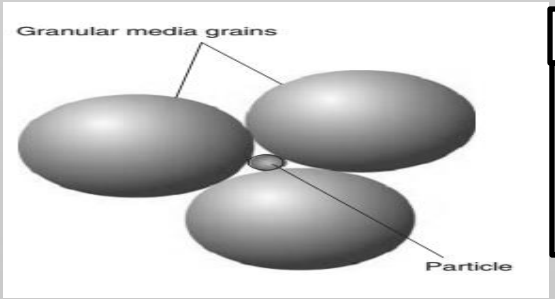
Water Treatment in General

## Filtrations

Mainly it is mean separation of solid phase from liquid phase and can classified to two main categories :

### 1- Media Filtration

is Mechanical straining removes some particles by trapping them between the grains of the filter medium (such as sand) mainly concerned with TSS.




| Filter Media |
| --- |
| ❑ Sand |
| ❑ Gravel |
| ❑ Carbon |

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# Water Treatment and Desalination

Water Treatment in General

## 1- Membrane Filtration

is Mechanical straining removes some constituent by trapping them on pores on membrane filter (UF , MF , NF , RO ) some concerned with TSS and another with TDS.



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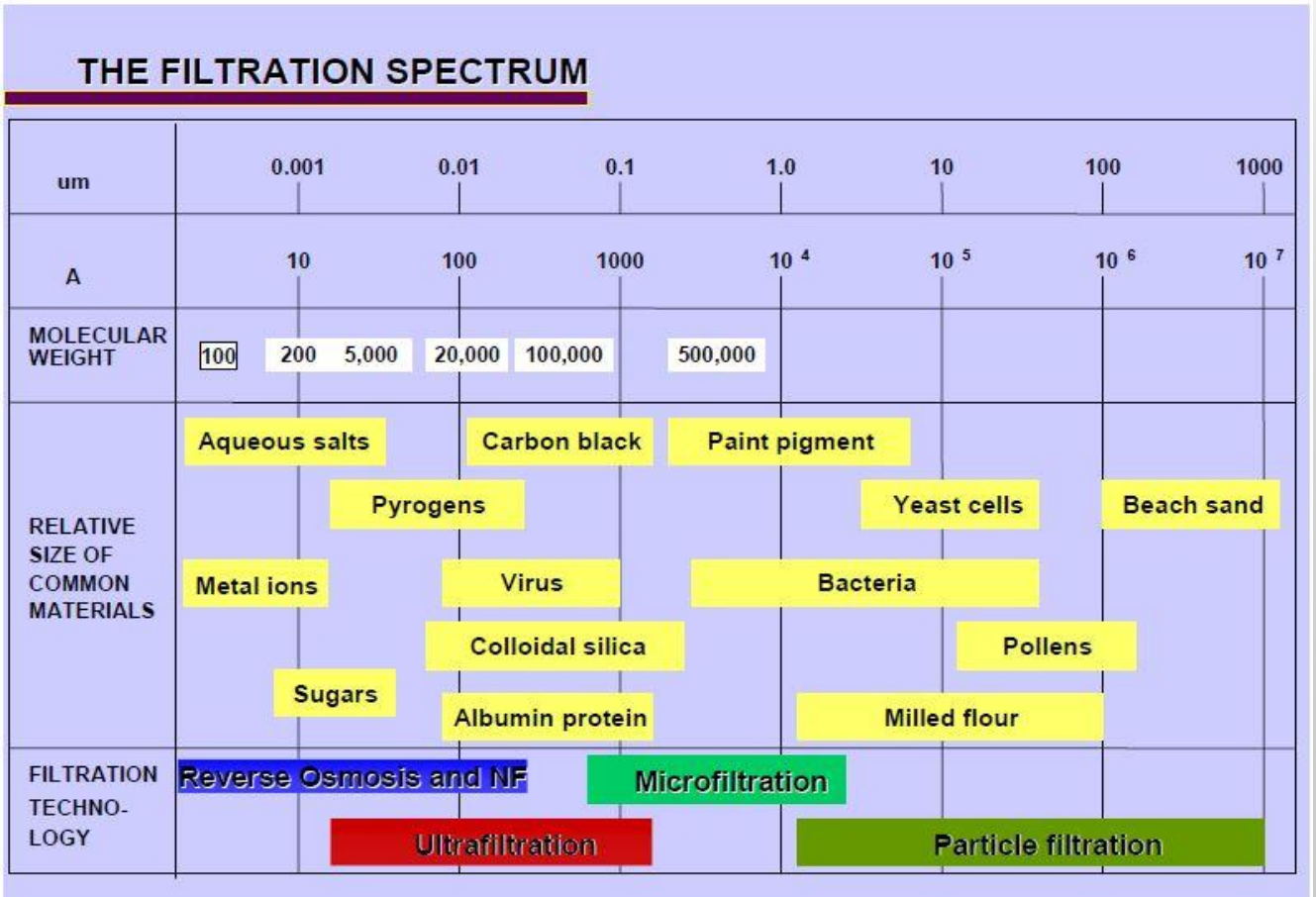
# Water Treatment and Desalination

Water Treatment in General

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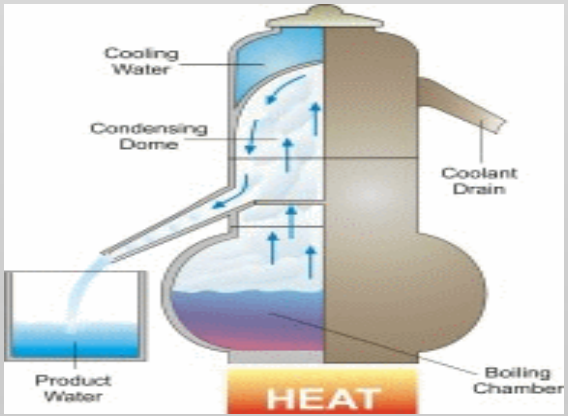
# Water Treatment and Desalination

Water Treatment in General

## Distillation

It is one of desalination techniques in which use thermal energy to evaporate pure water as steam and get it after condensation

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# Water Treatment and Desalination

Water Treatment in General

## Disinfection by radiation

One of the most effective method of killing the micro-organisms which using UV-radiation at wavelength

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# Water Treatment and Desalination

Water Treatment in General

## Chemical Treatment

Methods that depend mainly on Chemicals addition such :

- Oxidation
- Disinfection
- Coagulation & flocculation
- Ion Exchange
- pH Adjustment

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# Water Treatment and Desalination

Water Treatment in General

## Oxidation and Disinfection

### Chlorination

- It's a process of addition of free chlorine to the inlet water using some chemicals such as Calcium & Sodium Hypochlorite

- this process do two functions in the water treatment series ( Oxidation & Disinfection )

- **Oxidation process :**

Inorganic metal species (e.g., iron or manganese) are oxidized to insoluble forms and are removed by precipitation. Other inorganic species such as hydrogen sulfide, an odorous gas, is oxidized to non-odorous sulfate.

**Disinfection is used to refer to two activities:**

(1) primary disinfection—the inactivation of microorganisms in the Water

(2) secondary disinfection—maintaining a disinfectant residual in the treated-water distribution system.

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Water Treatment in General

# Water Treatment and Desalination

## Disinfection Reactions

$$Cl_2 \text{ (chlorine gas)} + H_2O \text{ (water)} \longleftrightarrow HOCl \text{ (hypochlorous acid)} + HCl \text{ (hydrchloric acid)}$$

$$CaOCl \text{ (calcium hypochlorite)} + H_2O \text{ (water)} \longleftrightarrow 2HOCl \text{ (hypochlorous acid)} + Ca(OH) \text{ (calcium hydroxide)}$$

$$NaOCl \text{ (sodium hypochlorite)} + H_2O \text{ (water)} \longleftrightarrow HOCl \text{ (hypochlorous acid)} + Na(OH) \text{ (sodium hydroxide)}$$

$$HOCl \text{ (hypochlorous acid)} \longleftrightarrow H^+ \text{ (hydrogen)} + OCl^- \text{ (hypochlorite ion)}$$

## Oxidation Reactions

$$H^+ + HOCl + e^- \longrightarrow \tfrac{1}{2} Cl_{2(g)} + H_2O$$

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# Water Treatment and Desalination

Water Treatment in General

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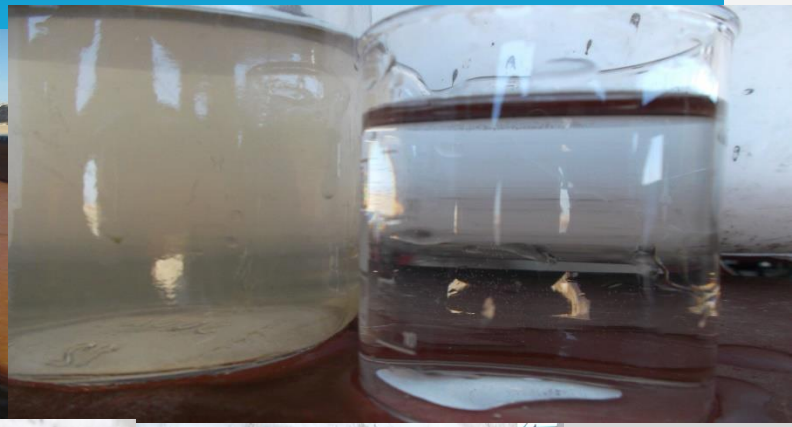
# Water Treatment and Desalination

Water Treatment in General





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# Water Treatment and Desalination

Water Treatment in General

## Coagulation & Flocculation

When natural sed. Fail to settle all suspended particles such colloids so the addition of coagulant target the removal of suspended tiny particles from the water.


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# Water Treatment and Desalination

Water Treatment in General

***ALUM***

$Al_2(SO_4)_3$ + 3 $Ca(HCO_3)_2$ ----------> 2 $Al(OH)_3$ + $3CaSO_4$ + 6 $CO_2$

Aluminum Sulfate + Calcium Bicarbonate (already in the water to treat) gives Aluminum Hydroxide + Calcium Sulfate + Carbon Dioxide

***FERRIC SULFATE***

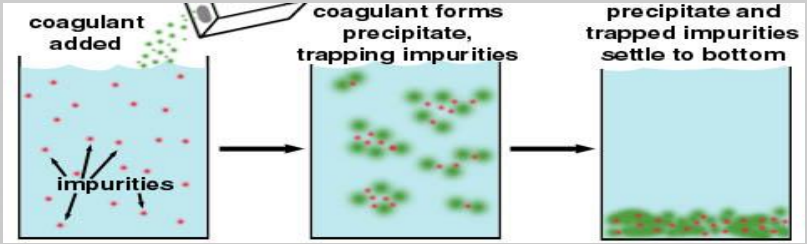
$Fe_2(SO_4)_3$ + 3 $Ca(HCO_3)_2$ ----------> 2 $Fe(OH)_3$ + $3CaSO_4$ + 6 $CO_2$

Ferric Sulfate + Calcium Bicarbonate (present in the water to treat) gives Ferric Hydroxide + Calcium Sulfate + Carbon Dioxide

***FERRIC CHLORIDE***

2 $FeCl_3$ + 3 $Ca(HCO_3)_2$ ----------> 2 $Fe(OH)_3$ + $3CaCl_2$ + $6CO_2$

Ferric Chloride + Calcium Bicarbonate (present in the water to treat) gives Ferric Hydroxide + Calcium Chloride + Carbon Dioxide

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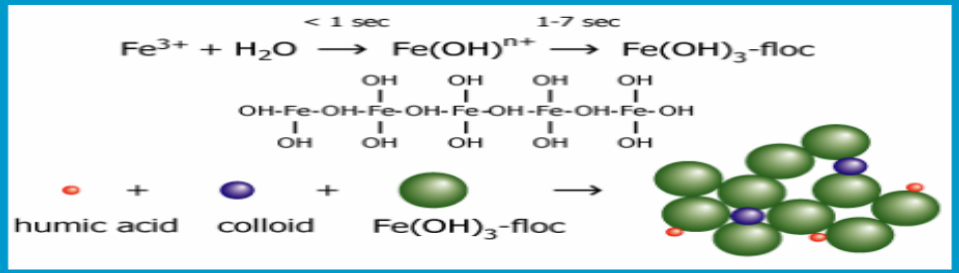
# Water Treatment and Desalination

Water Treatment in General

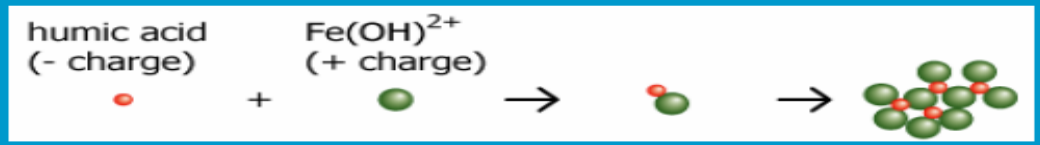
## Precipitation (sweep) coagulation




At low turbidites
$Fe(OH)_3$ floc is neutral, flocs can collide

## Adsorptive coagulation

$Fe^{3+} + H_2O \xrightarrow{< 1 \text{ sec}} Fe(OH)^{2+}$




Adsorptive coagulation occurs at a low pH, because positive hydrolysis products are needed.

restabilisation:
- under-dosage of coagulants
- over-dosage of coagulants

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# Water Treatment and Desalination

Water Treatment in General

## Jar Test

Used to determine the optimum coagulant dose

- 6 vessels each 1 liter put in them different coagulant doses.
- Flash mixing for 30 sec. (100 - 300 rpm)
- Gentle mixing for 10 min. (1 - 3 rpm)
- Sedimentation for 30 min.

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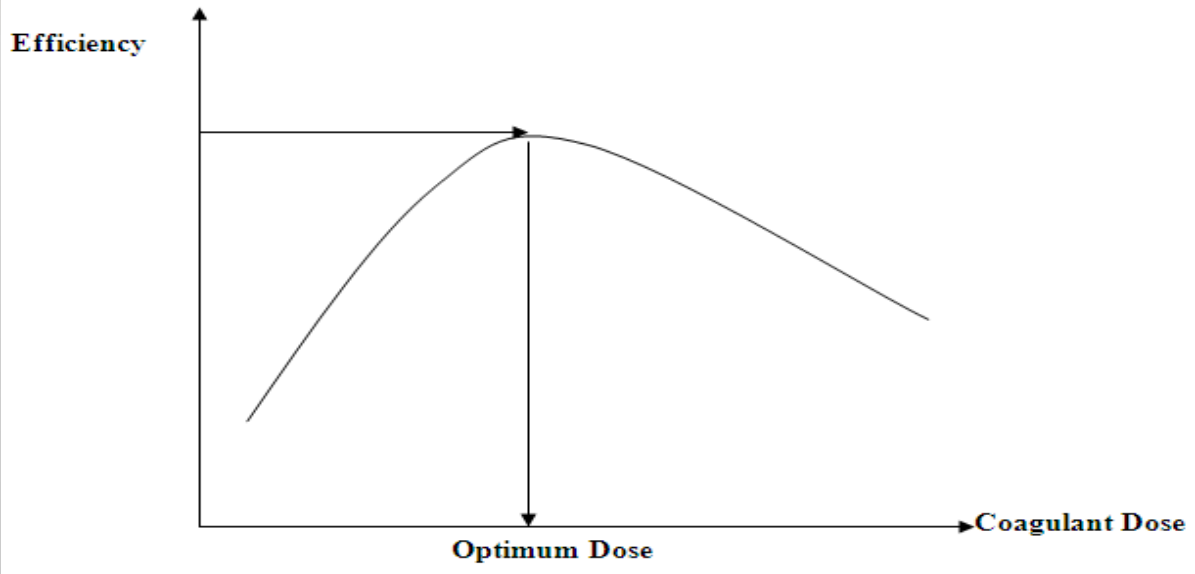
# Water Treatment and Desalination

Water Treatment in General

Get removal efficiency for each vessel, then plot the relationship between coagulant dose and removal efficiency, and then get from the curve the optimum dose at maximum removal efficiency

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Water Treatment in General

# Water Treatment and Desalination

## Ion Exchange

- Exchange between ions done depending mainly on ions chemical priority
- resins are synthetic polymers that are capable of exchanging particular ions within the polymer with ions in the solution that is passed through them.
- This synthetic resins are mainly aim either water softening or demineralization.

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# Water Treatment and Desalination

Water Treatment in General

**This table showing chemical replacement priority which decrease from up to down**

**TABLE 12.1 General Order of Ion Selectivity in Water below 1000 mg/L TDS**

| Cations | Anions |
|---|---|
| $Fe^{3+}$ | $CrO_4^{2-}$* |
| $Al^{3+}$ | $SO_4^{2-}$* |
| $Pb^{2+}$ | $SO_3^{2-}$* |
| $Ba^{2+}$ | $HPO_4^{2-}$* |
| $Sr^{2+}$ | $CNS^-$ |
| $Cd^{2+}$ | $CNO^-$ |
| $Zn^{2+}$ | $NO_3^-$ |
| $Cu^{2+}$ | $NO_2^-$ |
| $Fe^{2+}$ | $Br^-$ |
| $Mn^{2+}$ | $Cl^-$ |
| $Ca^{2+}$ | $CN^-$ |
| $Mg^{2+}$ | $HCO_3^-$ |
| $K^+$ | $HSiO_3^-$ |
| $NH_4^+$ | $OH^-$ |
| $Na^+$ | $F^-$ |
| $H^+$ | |
| $Li^+$ | |

* These ions may be displaced as they are protonated at low pH to: $HCrO_4^-$, $HSO_3^-$, $H_2PO_4^-$

*Notes:* Changes in position may occur between products of different manufacture or having slightly different skeletons or exchange groups. In general, selectivity is affected by:

(*a*) Ionic valence: 3 > 2 > 1.

(*b*) Atomic number: Ba > Sr > Ca > Mg in Group IIA.

(*c*) Hydrated ionic radius: the larger the radius, the lower the selectivity and exchange capacity.

# Water Treatment and Desalination

Water Treatment in General

## pH Adjustment

pH adjustment done increasing pH value by adding alkali or lowering it through adding acid such :

- Before R.O we need slightly acidic water
- After R.O we need slightly alkaline water ( some cases )

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# Water Treatment and Desalination

Water Treatment in General

## Biological Treatment

Mainly this technique applied on waste water which utilize living microorganisms to digest the chemical pollutant in the waste to convert it to its primary composition like $CO_2$ & $H_2O$

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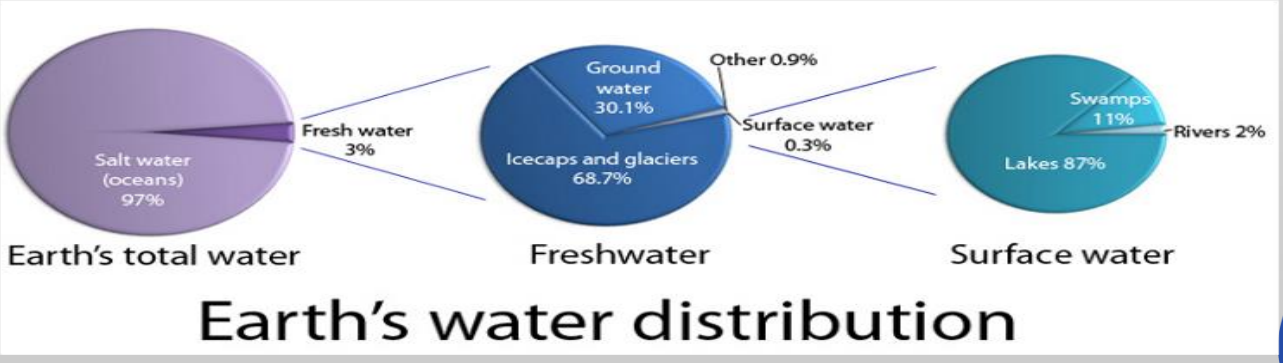
# Water Treatment and Desalination

Desalination Techniques

## Desalination

**it is a separation process used to reduce the dissolved salt content of saline water to acceptable levels**

- Desalination has become major water resource world wide Why ???

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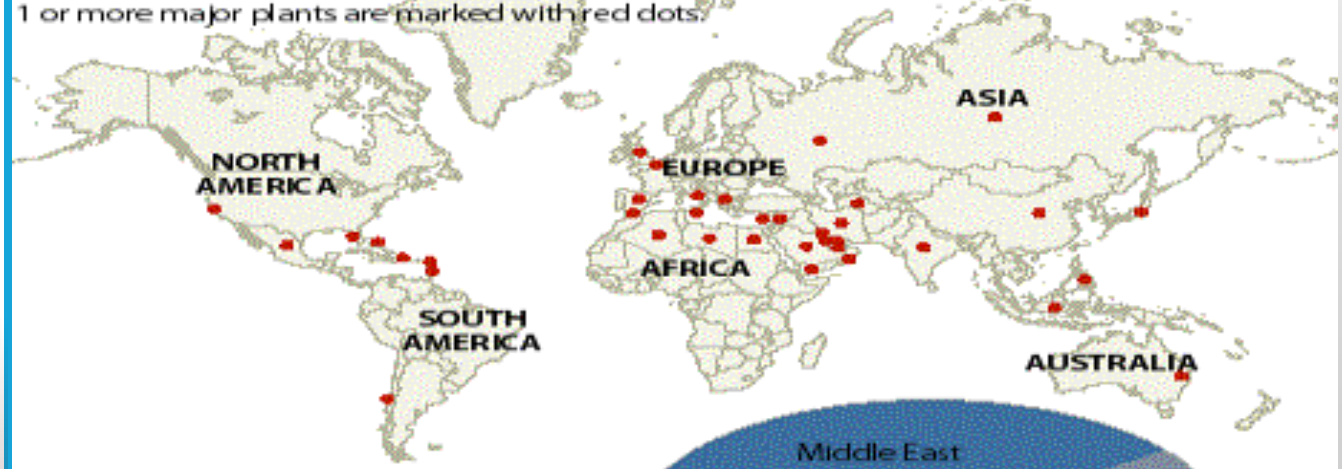
# Water Treatment and Desalination

Desalination Techniques

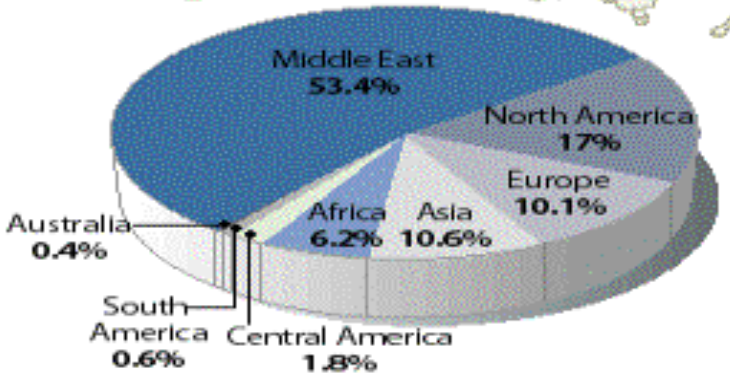
## MAJOR DESALINATION PLANTS WORLDWIDE

The United States has 2 major municipal seawater-desalination plants — 1 under construction in Tampa and another inactive plant in Santa Barbara, Calif. Other countries with 1 or more major plants are marked with red dots.




**Capacity by region**

A breakdown of where desalination technology is used on seawater, salty underground water and in other water treatments around the world.




SOURCES: Engineering News-Record; Aqua Resources International Corp.; International Desalination Association

SCOTT HIESTAND/ORLANDO SENTINEL

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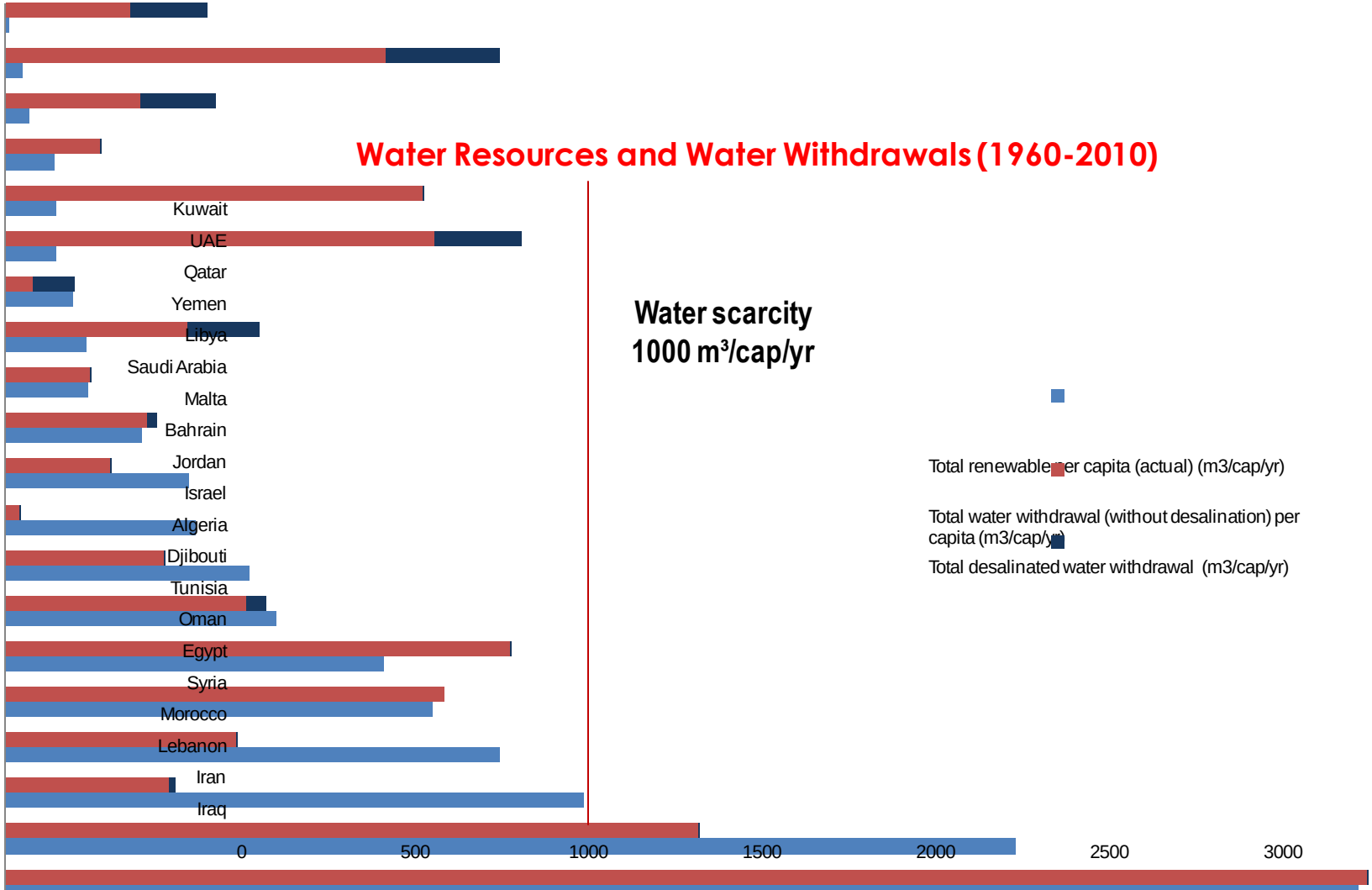
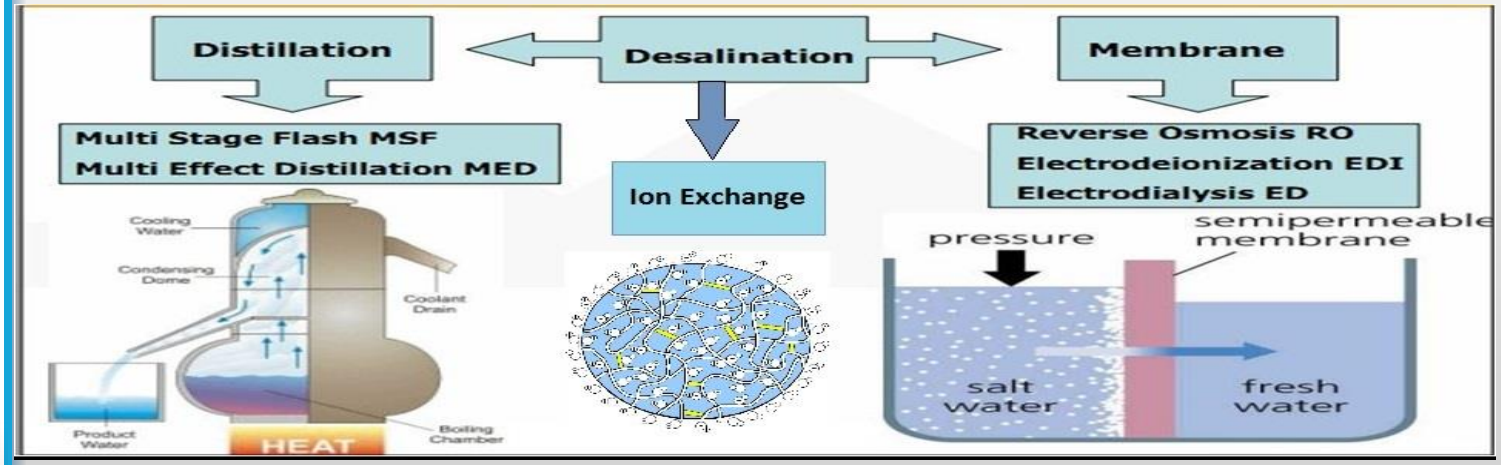
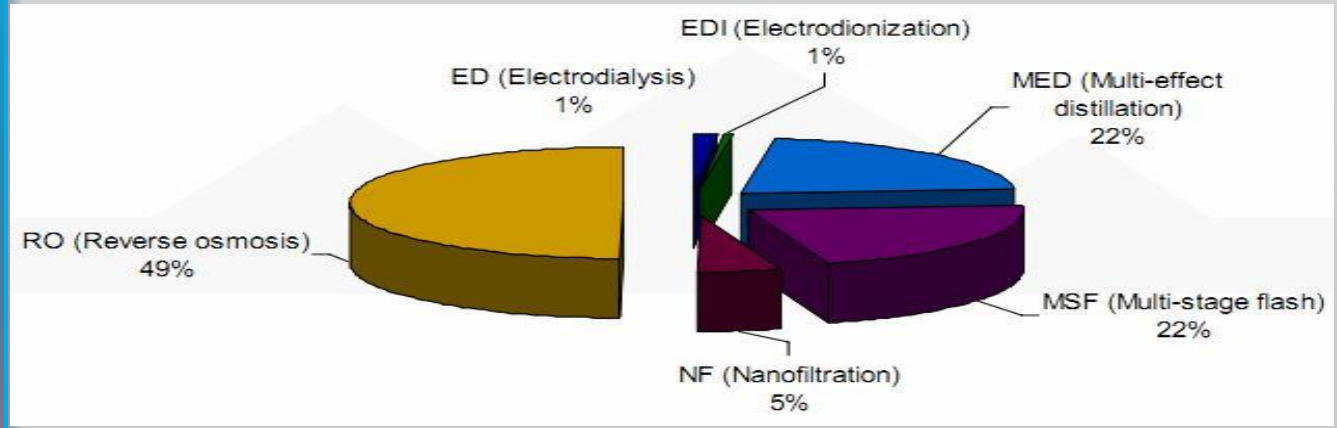

Water Resources and Water Withdrawals (1960-2010)
Water scarcity
1000 m³/cap/yr
Total renewable per capita (actual) (m3/cap/yr)
Total water withdrawal (without desalination) per capita (m3/cap/yr)
Total desalinated water withdrawal (m3/cap/yr)
Kuwait
UAE
Qatar
Yemen
Libya
Saudi Arabia
Malta
Bahrain
Jordan
Israel
Algeria
Djibouti
Tunisia
Oman
Egypt
Syria
Morocco
Lebanon
Iran
Iraq
0
500
1000
1500
2000
2500
3000

# Water Treatment and Desalination

Desalination Techniques

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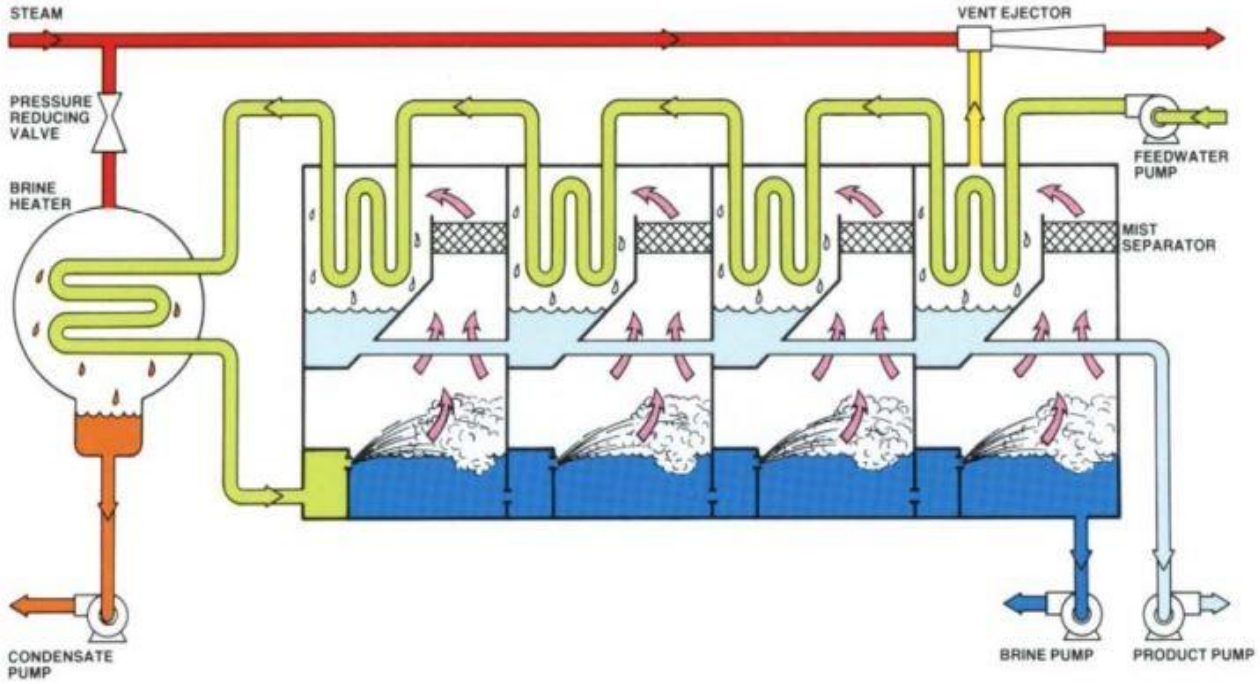
# Water Treatment and Desalination

## Distillation by MSF

Desalination Techniques




The principle of Multi Stage Flash Distillation, MSF

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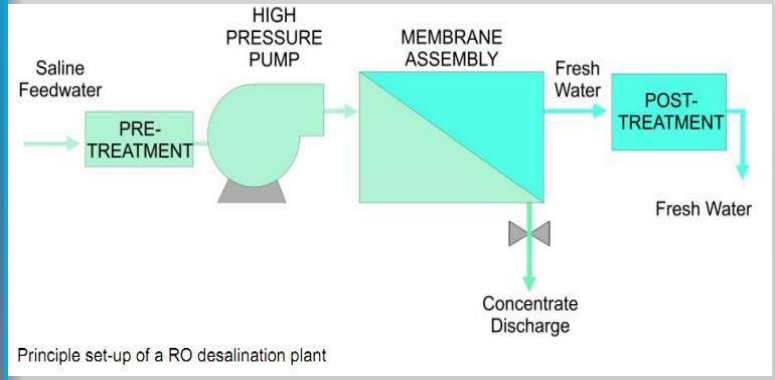
# Water Treatment and Desalination

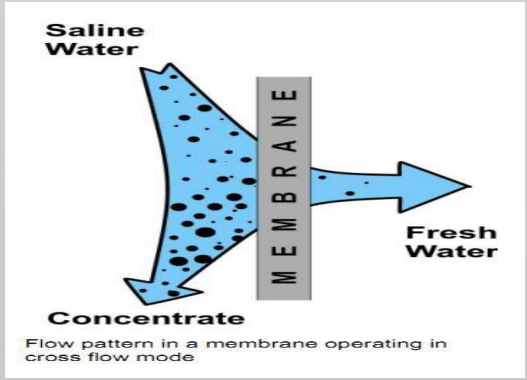
## Membrane Desalination Processes

Desalination Techniques

- Saltwater is forced through membrane sheets at high pressures
- Membrane sheets are designed to catch salt ions
- Process produces clean water and brine one



Principle set-up of a RO desalination plant



Flow pattern in a membrane operating in cross flow mode

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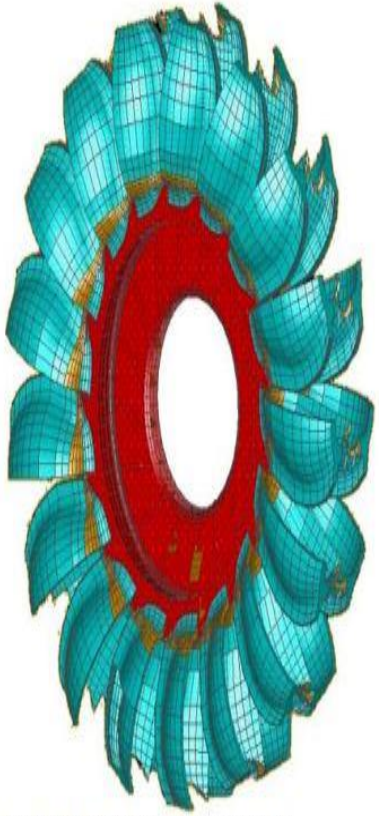
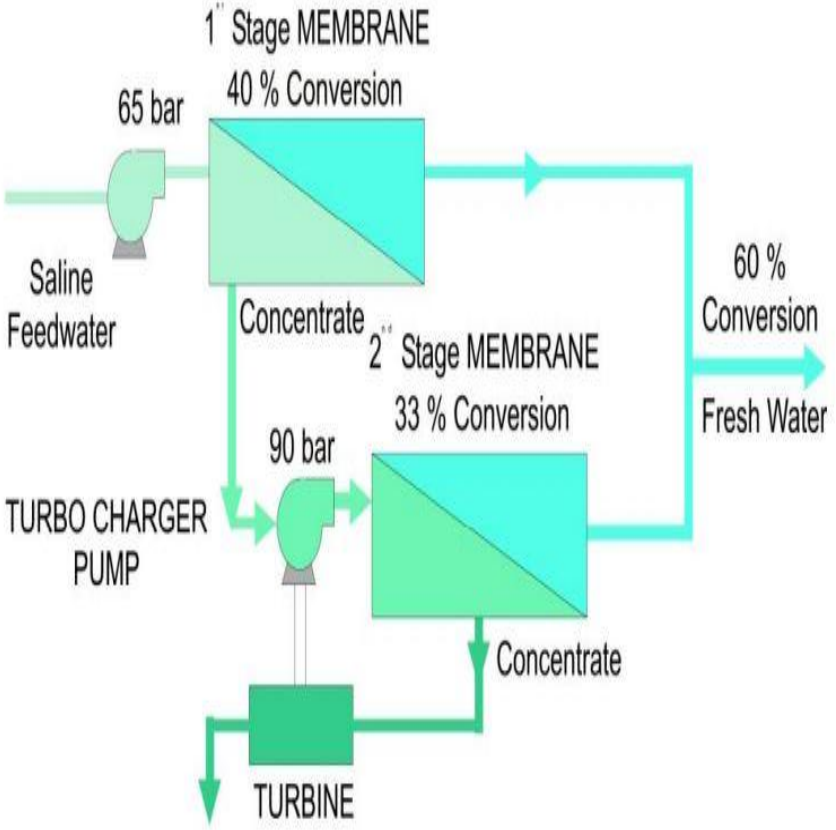
# Water Treatment and Desalination

Desalination Techniques



Pelton Turbine for energy recovery




Two stage RO system with energy recovery

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# Water Treatment and Desalination

## Reverse Osmosis in detail

R.O in detail

1 – What are we meaning by osmosis ?
2 – What are we meaning by reverse osmosis ?
3 – R.O membranes types and configuration.
4 – How does Reverse Osmosis work?
5 – What will Reverse Osmosis remove from water?
6 – Important terms
7 – R.O Plant configuration

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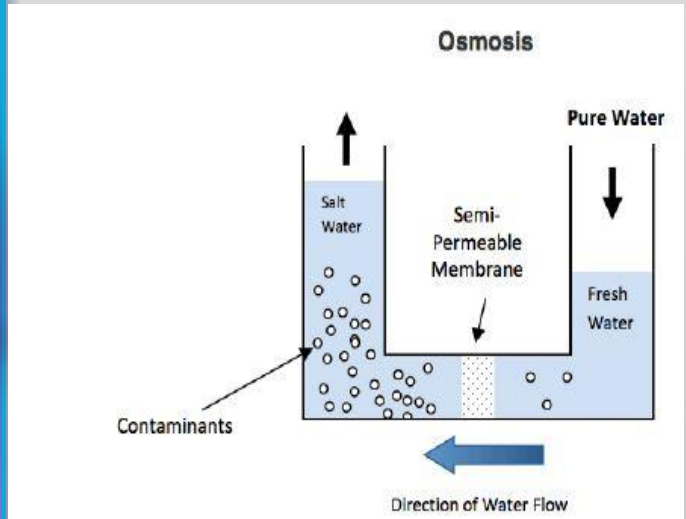
# Water Treatment and Desalination

R.O in detail

## Osmosis

**Osmosis is a naturally occurring phenomenon and one of the most important processes in nature. It is a process where a weaker saline solution will tend to migrate to a strong saline solution. Examples of osmosis are when plant roots absorb water from the soil and our kidneys absorb water from our blood.**




**Water in solution that has less concentration will have a natural tendency to migrate to the solution with a higher concentration.**

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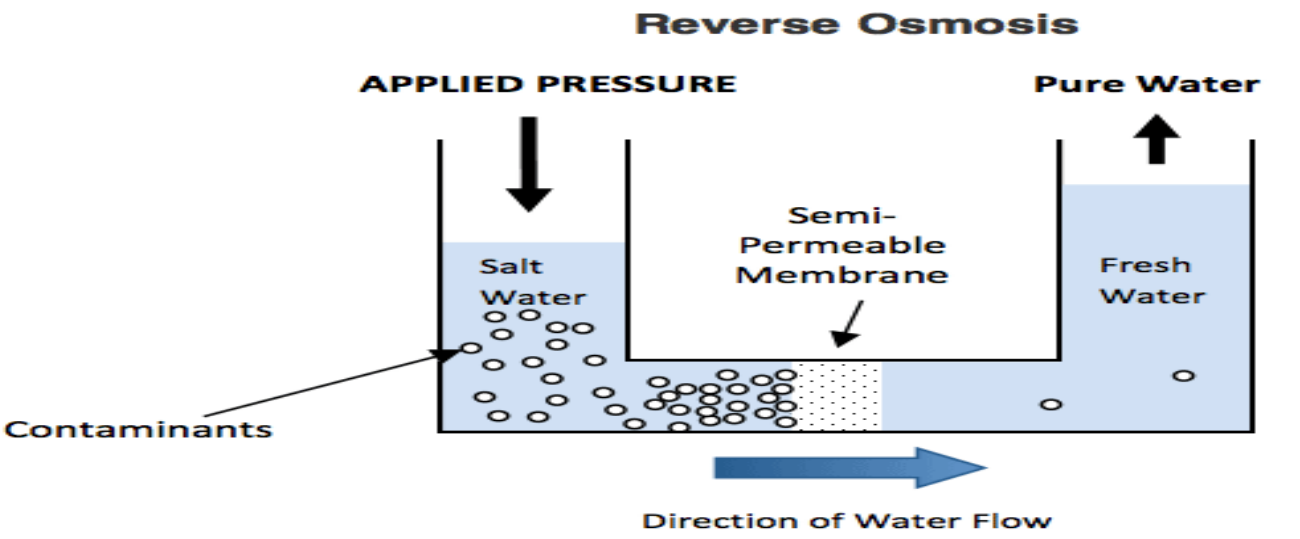
# Water Treatment and Desalination

R.O in detail

## Reverse Osmosis

is the process of Osmosis in reverse However, you need to -'push' - force the water to pass through the membrane by applying pressure that is greater than the naturally occurring osmotic pressure

desalinate water in this process which allowing to pass pure water through while holding back a majority of contaminants.

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# Water Treatment and Desalination

R.O in detail


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# Water Treatment and Desalination

R.O in detail

## R.O membranes types

The most common membranes materials are based on cellulose acetate or poly amide materials

| property | Cellulose acetate | Poly amide |
|---|---|---|
| Surface charge | Neutral | Negative |
| Temperature Tolerance | 35 $^0$C | 45 $^0$C |
| PH | 4-6 | 2-11 |
| Free chlorine | 1 PPM | 0.1 PPM |
| Life time | 2-3 years | 3-5 years |
| Advantages | Less sensitive<br>Chlorine resistance | High Rejection |
| disadvantages | High pressure<br>PH sensitive | Chlorine resistance |

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# Water Treatment and Desalination

R.O in detail

## Membranes configuration

Depending on the configuration the membranes are classified into:

1-Spiral wound module

2-Hollow fiber modules

3-Tubular Modules

4-Capillary modules

5-plate and frame module

The most common module is spiral wound modules

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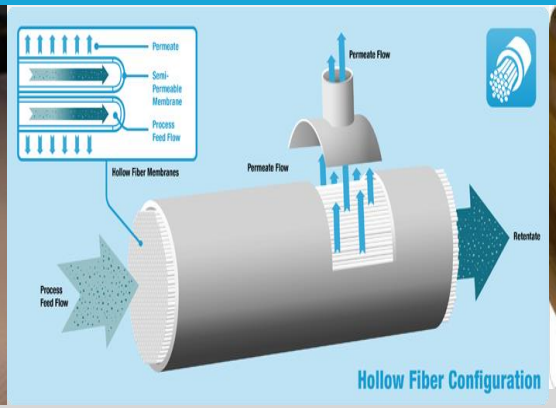
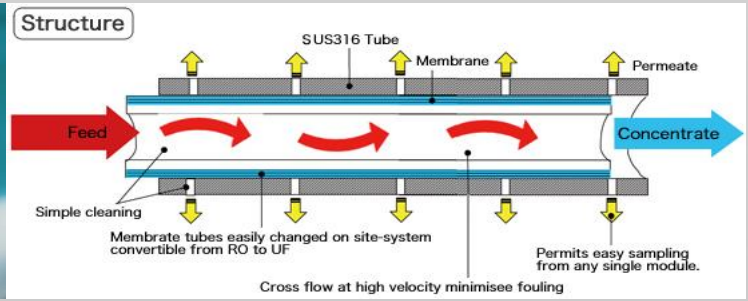
# Water Treatment and Desalination

R.O in detail

Spiral




Hollow Fiber




Tubular module

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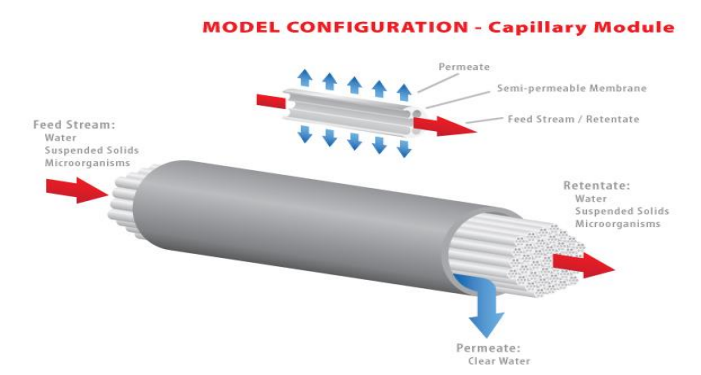
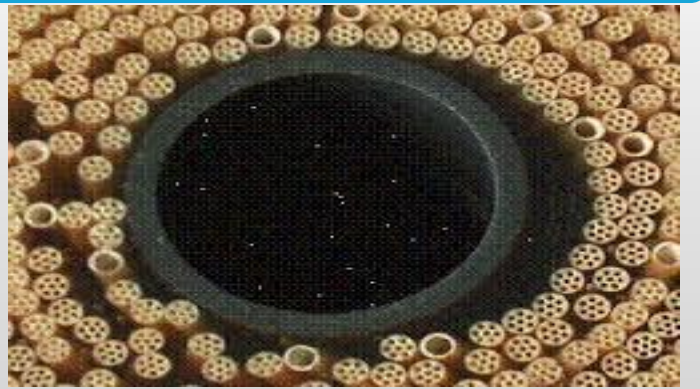
# Water Treatment and Desalination

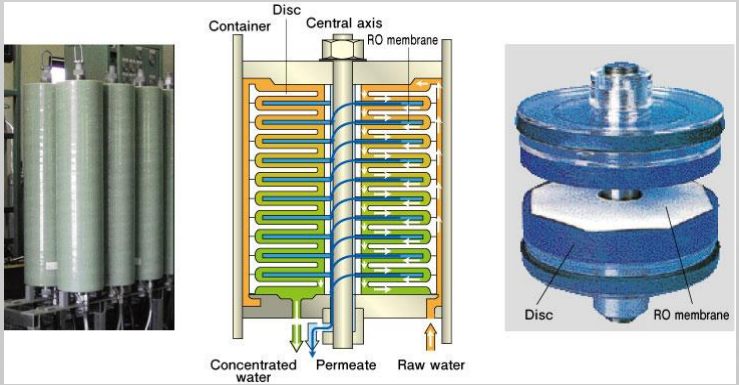


capillary module

R.O in detail

Plate and frame module

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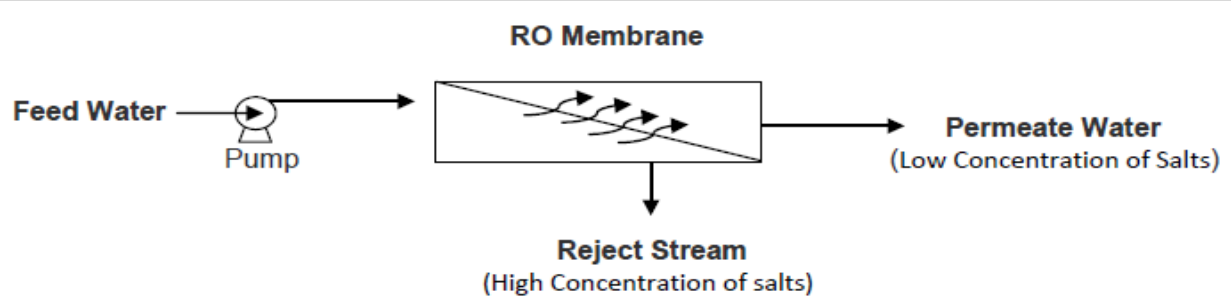
# Water Treatment and Desalination

R.O in detail

## How does Reverse Osmosis work?

Reverse osmosis works by using a high pressure pump to increase the pressure on the salt side of the RO and force the water across the semi-permeable RO membrane. The amount of pressure required depends on the salt concentration of the feed water. The more concentrated the feed water, the more pressure is required to overcome the osmotic pressure.

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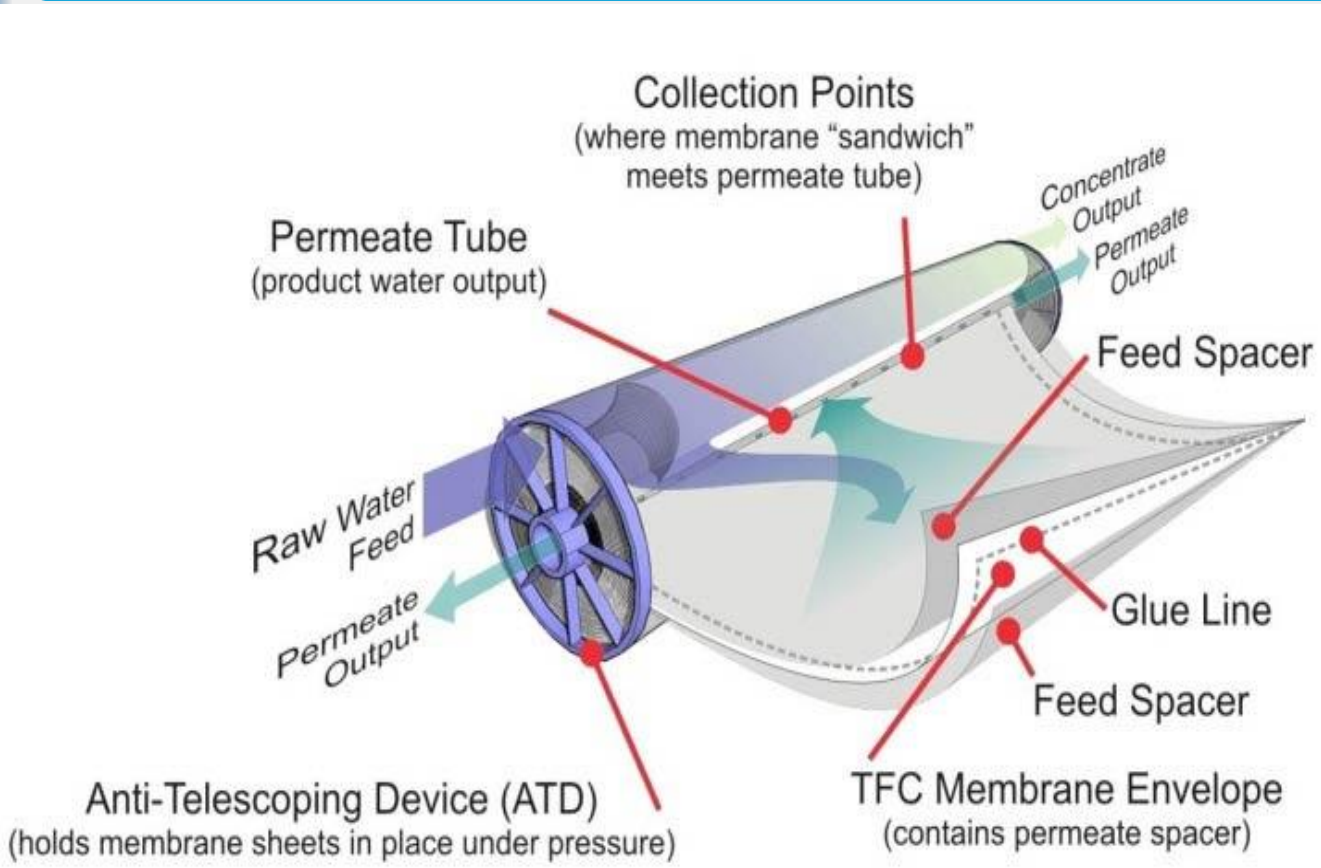
# Water Treatment and Desalination

R.O in detail

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# Water Treatment and Desalination

R.O in detail

## What will Reverse Osmosis remove from water?

Reverse Osmosis is capable of removing up to 99%+ of the dissolved salts (ions), particles, colloids, organics, bacteria and pyrogens from the feed water (although an RO system should not be relied upon to remove 100% of bacteria and viruses). An RO membrane rejects contaminants based on their size and charge. Any contaminant that has a molecular weight greater than 200 atomic weight is likely rejected by a properly running RO system.

Likewise, the greater the ionic charge of the contaminant, the more likely it will be unable to pass through the RO membrane. For example, a sodium ion has only one charge (monovalent) and is not rejected by the RO membrane as well as calcium for example, which has two charges.

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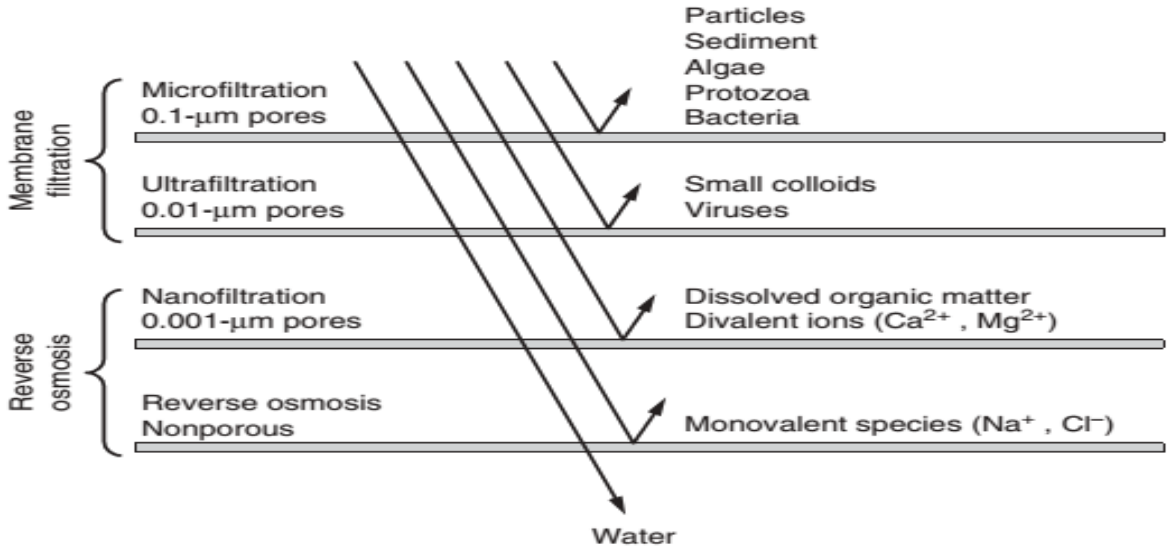
# Water Treatment and Desalination

R.O in detail

**Likewise, this is why an RO system does not remove gases such as CO2 very well because they are not highly ionized (charged) while in solution and have a very low molecular weight. Because an RO system does not remove gases, the permeate water can have a slightly lower than normal pH level depending on CO2 levels in the feed water as the CO2 is converted to carbonic acid.**

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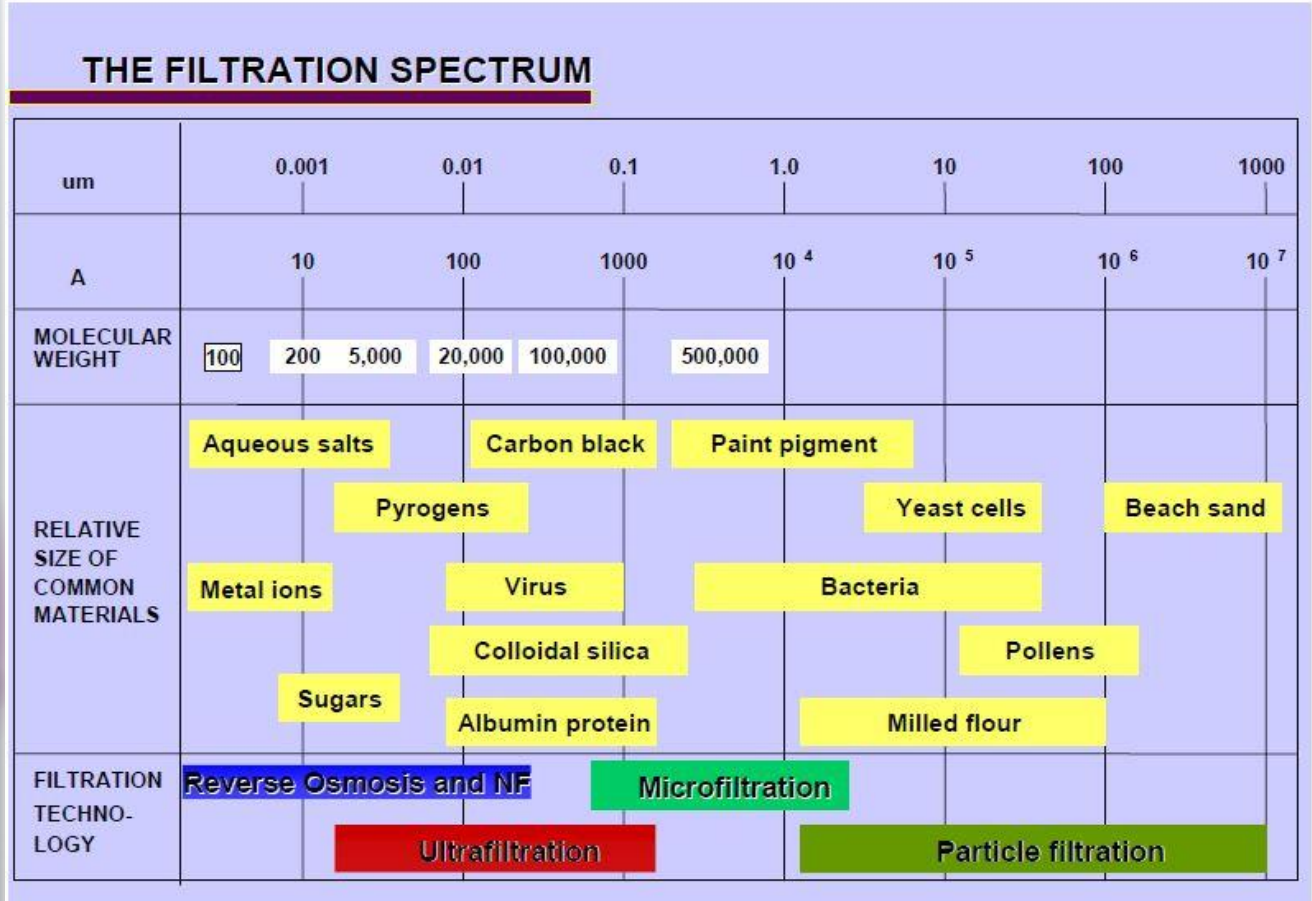
# Water Treatment and Desalination

R.O in detail

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# Water Treatment and Desalination

## TERMINOLOGY

**Permeate water :**

The good produced water that comes out of an RO system has the majority of contaminants removed

**Concentrate , Reject , Brine :**

is the water that contains all of the contaminants that were unable to pass through the RO membrane.

**Recovery % :**

Percent Recovery is the amount of water that is being 'recovered' as good permeate water.

$$\% \text{ Recovery} = \frac{\text{Permeate Flow Rate (gpm)} \times 100}{\text{Feed Flow Rate (gpm)}}$$

R.O in detail

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# Water Treatment and Desalination

R.O in detail

**Salt Rejection % :**

This equation tells you how effective the RO membranes are removing contaminants. A well designed RO system with properly functioning RO membranes will reject 95% to 99% of most feed water contaminants.

$$\text{Salt Rejection \%} = \frac{\text{Conductivity of Feed Water} - \text{Conductivity of Permeate Water} \times 100}{\text{Conductivity of Feed}}$$

**Salt Passage % :**

This is the amount of salts expressed as a percentage that are passing through the RO system. The lower the salt passage, the better the system is performing

$$\text{Salt Passage \%} = (100 - \text{Salt Rejection\%})$$

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# Water Treatment and Desalination

R.O in detail

**Concentration Factor :**

The concentration factor is related to the RO system recovery and is an important equation for RO system design. The more water you recover as permeate (the higher the % recovery), the more concentrated salts and contaminants you collect in the concentrate stream. This can lead to higher potential for scaling on the surface of the RO membrane when the concentration factor is too high for the system design and feed water composition.

$$\text{Concentration Factor} = \frac{1}{1 - \text{Recovery}/100}$$

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# Water Treatment and Desalination

**Flux :**

It's the rate of permeate transferred per unit membranes area (gfd) or (L/m2.h)

$$\text{Flux (Gfd)} = \frac{\text{permeate flow (gpd)}}{\text{total no of membranes X membrane surface area}}$$

Flux value is Known depending on the source of feed water and type of used membranes for example for DOW filmtec memb. LE---440i

| Feed Water Source | Gfd |
|---|---|
| Sewage Effluent | 5---10 |
| Sea Water | 8---12 |
| Brackish Surface Water | 10---14 |
| Brackish Well Water | 14---18 |
| RO Permeate Water | 20---30 |

R.O in detail

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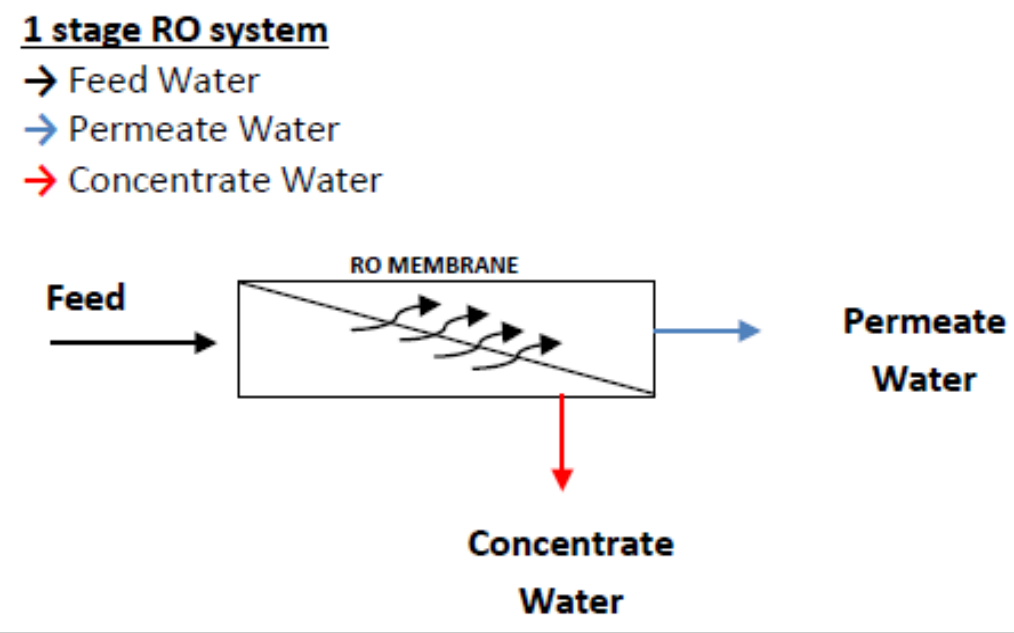
# Water Treatment and Desalination

## passes and stages in a Reverse Osmosis (RO) system




R.O in detail

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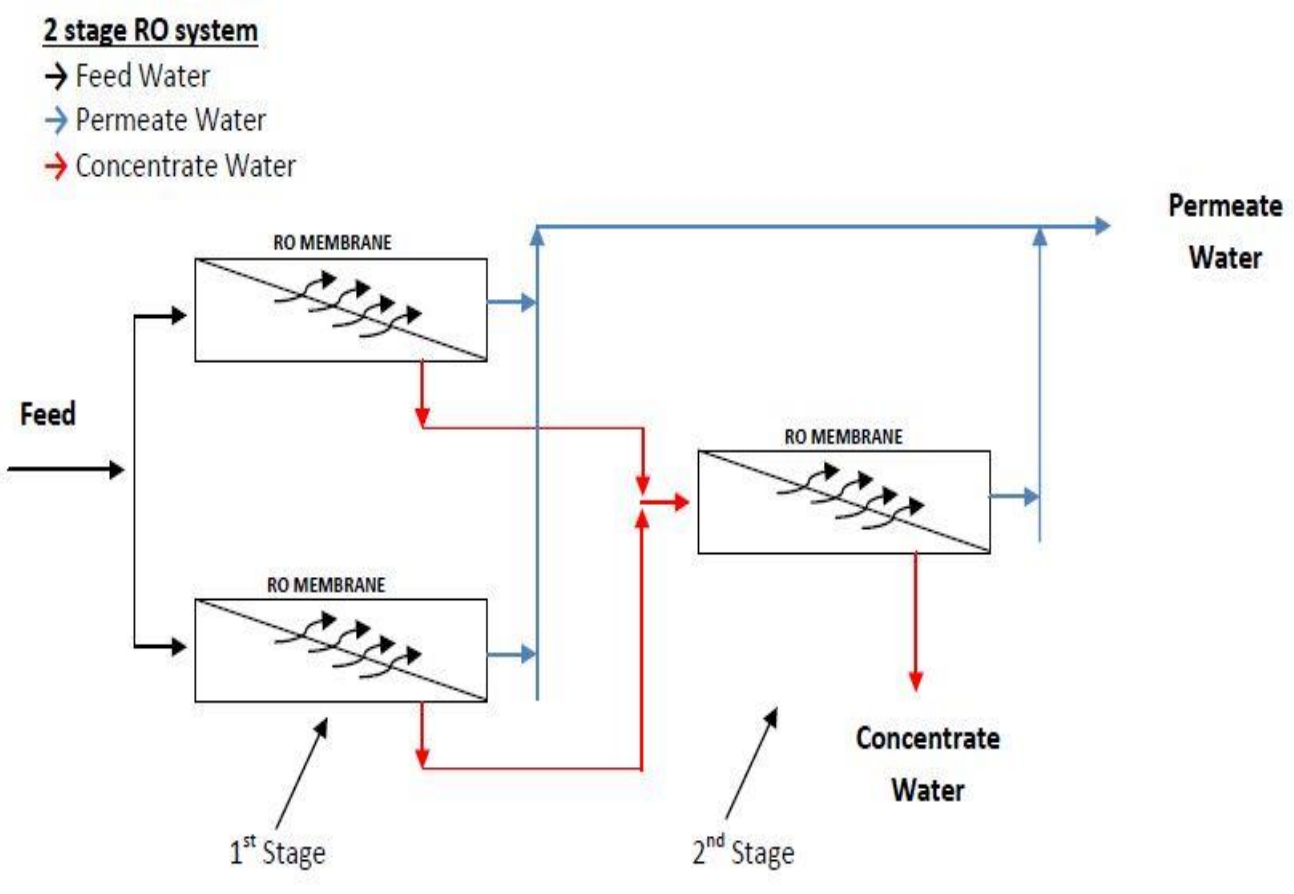
# Water Treatment and Desalination

R.O in detail

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# Water Treatment and Desalination

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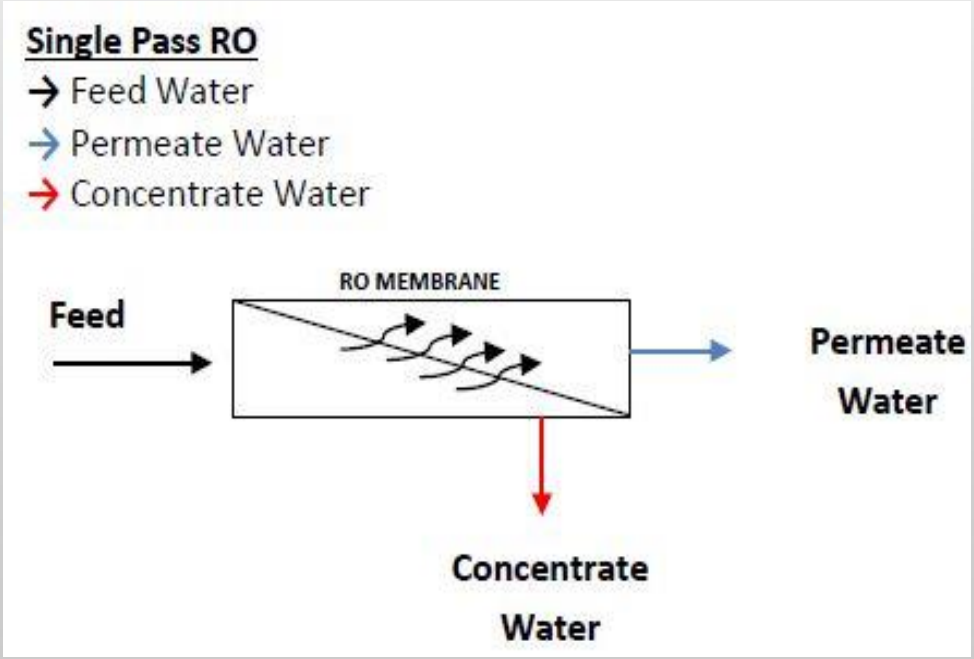
## Passes

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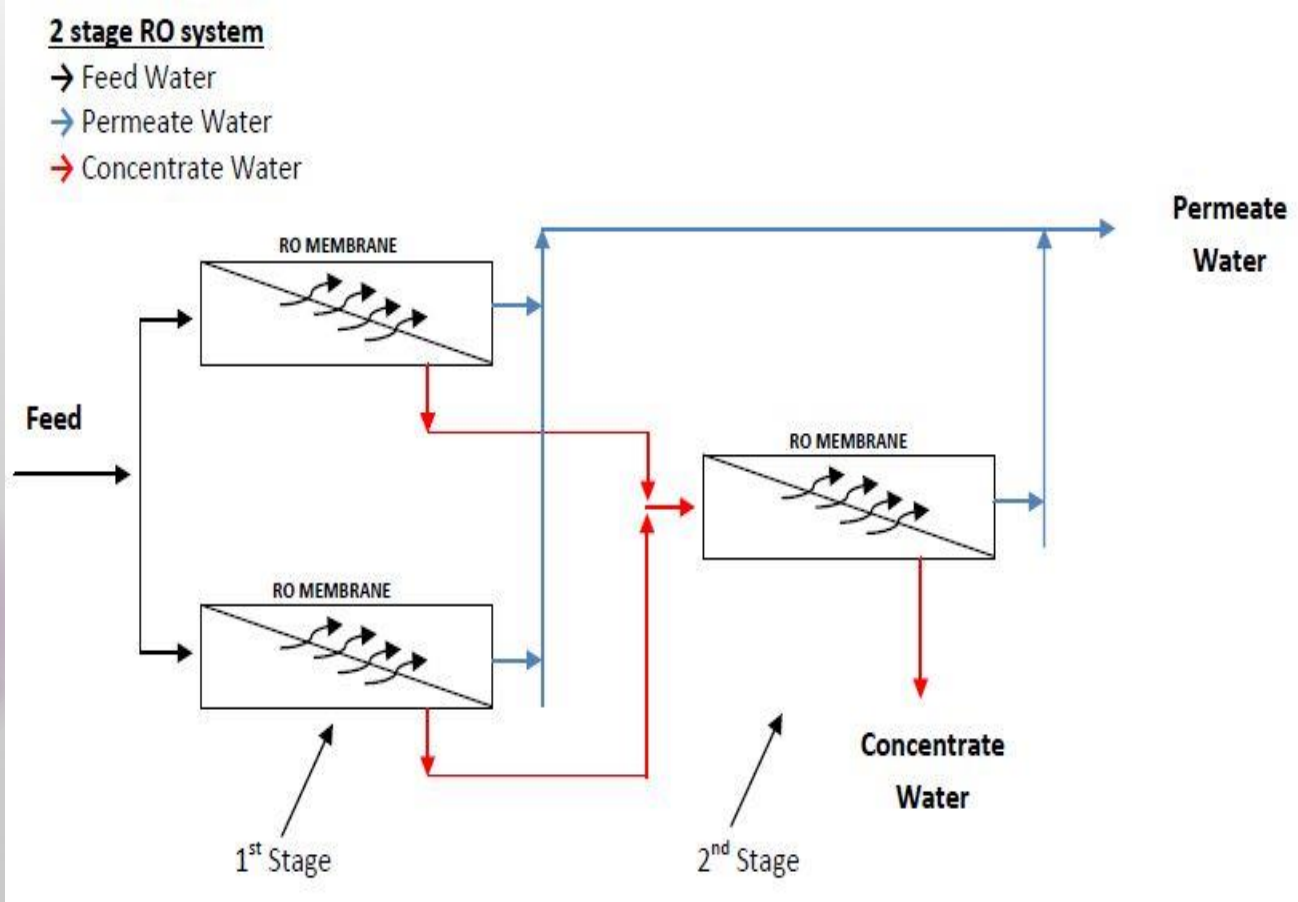
# Water Treatment and Desalination




R.O in detail

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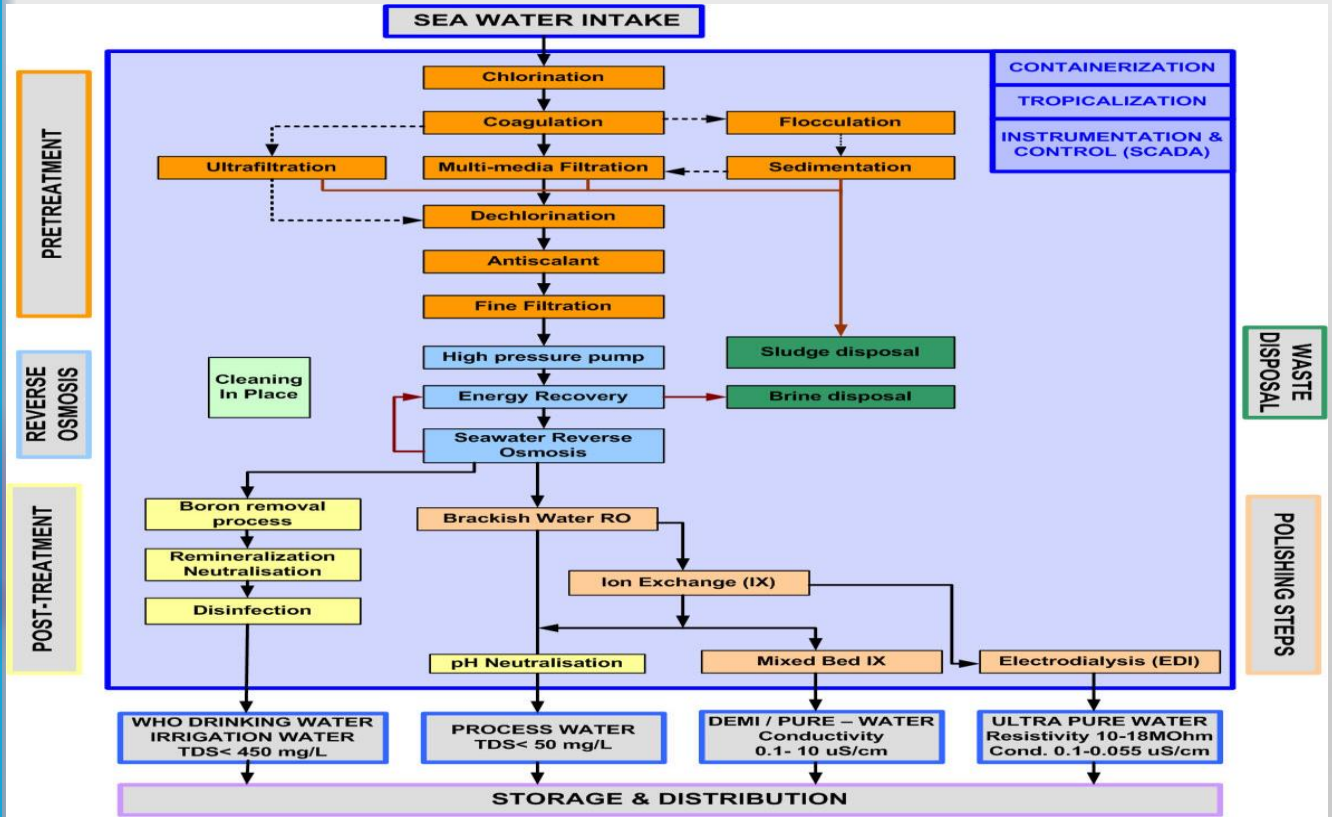
# Water Treatment and Desalination

## R.O Plant configuration




R.O in detail

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# Water Treatment and Desalination

## RO operation

As shown in previous RO plant config. Any plant composed of three stages :

1- Pretreatment stage include

- Primary Chlorination ---------- done
- Coagulation / flocculation ---------- done
- Sedimentation ---------- done
- Media filtration ---------- done
- Dechlorination
- Antiscalant
- Fine filtration ---------- done

2- Revers Osmosis stage include

- High pressure pumps ---------- done
- Membranes array ---------- done

3- Post-treatment stage ( Polishing ) include

- Second RO ---------- done
- DI or mixed bed ---------- done
- EDI
- pH neutralization ---------- done

RO operation troubleshooting

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# Water Treatment and Desalination

## De-Chlorination

- It's a process of removal of free chlorine and its drivatives from water using Physical adsorption technique or Chemical removal technique.

- Physical adsorption done by using GAC (Granulated Active Carbon ) which has great ability to adsorb the free chlorine and it's byproduct ( halo-organics ) from water.

- Residual free chlorine can be reduced to harmless chlorides by activated carbon or chemical reducing agent.

$$C + 2Cl_2 + 2H_2O \longrightarrow 4HCl + CO_2$$

- Chemical removal done by SMBS ( sodium meta bi-sulfite )
- When dissolved in water SMBS will produce SBS

$$Na_2S_2O_5 + H_2O \longrightarrow 2NaHSO_3$$

SBS then reduces hypochlorous acid according to

$$2NaHSO_3 + 2HOCl \longrightarrow H_2SO_4 + 2HCl + Na_2SO_4$$

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RO operation troubleshooting

# Water Treatment and Desalination

## Antiscalent

- An antiscalent is a pretreatment chemical injected into the feed-water before the feed-water enters the RO membranes.

- Its presence affect the precipitation tendency of calcium & magnesium carbonate and sulfates .

- This results is scale not forming as the water is being purified by the RO.

- As the duration of the water in the membrane system is relatively short during the treatment, scale formation is prevented.

- The most widely used antiscalent is sodium hexameta-phosphate ( SHMP )

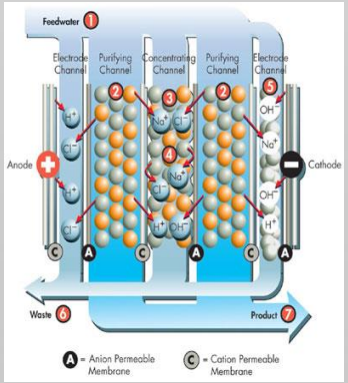
# Water Treatment and Desalination

## Electro-Deionization

## ( EDI – CDI )

-Mainly it is physiochemical process which combines three technologies ( semi-permeable membrane , ion exchange media and electrical separation processes ) to provide high efficiency demineralization process .

- The electrical current is used to continuously regenerate the resin eliminate the periodical need to regeneration and avoid chemical hazardous.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Thank you

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