Master Training Program on Water (Water Supply, In-house Processing, End-of-Pipe) in Textile and Garment factories

Promotion of Sustainability in the Textile and Garment Industry in Asia - FABRIC

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

FABRIC Asia

Day 6 Presentation 3

Effluent recycling options

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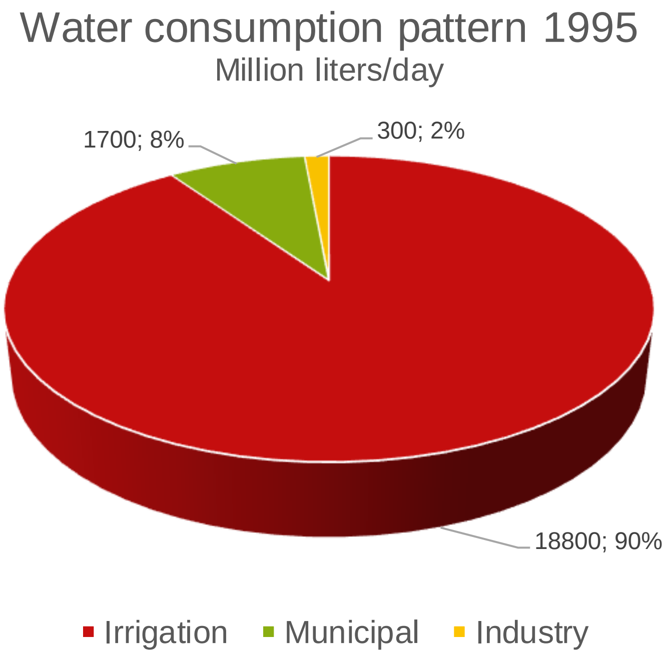
Importance of water in textile industry of Bangladesh

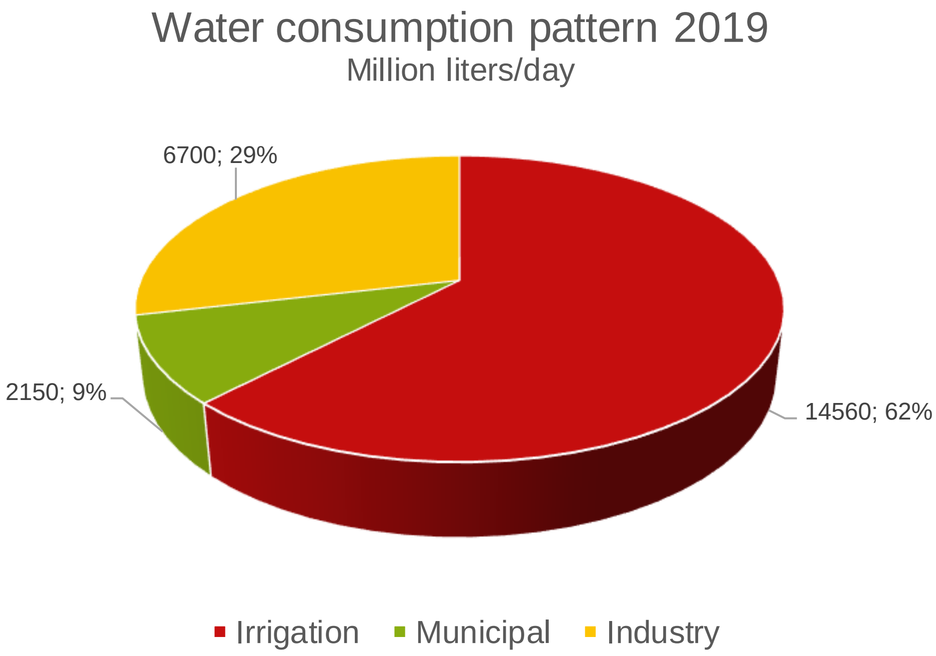
- The textile processing is a water intensive industry.
- Depending on the process and product, 1 kg of raw material processing consume 75-250 litres of water
- Some reports pegs current water consumption at 4500 million litres per day
- This may rise to 7000 million litres per day by 2030.
- Surprisingly, no water audit is done by proponents prior to finalising location and size of the industry

Importance of water in textile industry of Bangladesh

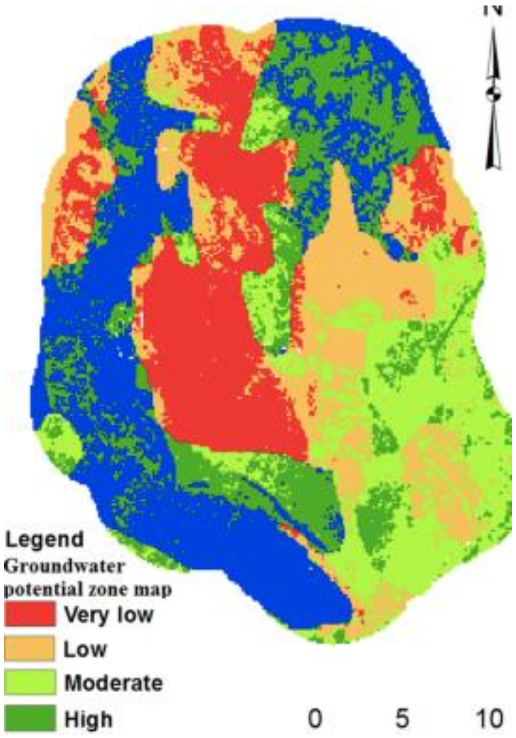
- Most industries in Dhaka uses ground water since they are not happy with river water quality.
- In many places in and around Dhaka, the groundwater table went down alarmingly low.
- This may jeopardise the entire industry and its associated economy, employment and growth of the country.
- Still no concrete plans have been drawn to ensure sufficient water for sustained continuation and growth of this industry.
- To continue growth of this industry, protect the jobs and increase exports, water security of industry need to be ensured.

Change in water consumption pattern of Dhaka





Change in water consumption pattern of Dhaka



- In Dhaka, ground water depletion is in the range of 2 m - 5m annually, some areas groundwater is below 800 ft (250 m).
- The depletion is caused by the low re-charge rate since the rain water does not percolate down fast.
- Situation become graver if annual rainfall rates comes down.
- The magnitude of this depletion indicate present rate of water extraction is more than re-charge potential.
- Imagine…it is like thousands of big pumps continuously pump out ground water and discharge it to the river.
- How long we will sustain???

Options to manage water requirement

- Optimisation of water: reduction of water consumption to less than 50% of the present value. Different technologies, process modifications and optimisation is promoted by many organisations including GIZ. To be pursued further. Not discussed here.

- Zero Liquid Discharge (ZLD). This enable almost all water used by the industry to be recovered and re-used. Possibility to re-use salt too. Full environmental compliance obtained. Discussed in detail in next session.

- Surface water treatment and usage in the factories. Turag & other rivers has sufficient water most of year. This can be further treated and used. But industry cites bad quality of water, especially in summer and has chance of more effluent. Not discussed now.

- Recycling of wastewater without ZLD. This option envisage treatment of effluent, recovery of part of water through RO, but discharge the rest. Complete environmental compliance is still an issue. Recovery of water without RO compromises quality.

Non ZLD effluent recycle operations

- Effluent recycle after only tertiary treatment: many suppliers claimed that after some polishing treatment like oxidation/adsorption, effluent can be re-used. So far a failure.

- Recovery & re-use of caustic soda: concentrating the weak lye through evaporation and then re-use the same. Implemented successfully in some units.

- Recovery & re-use of salt brine from exhaust dye bath using Nano filtration: Using the selective rejection of membranes, get a cleaner saline liquor & re-use it in dyeing. Successfully tested in some units, some stopped using it after challenges.

- Recycling of wastewater without ZLD. This option envisage treatment of effluent, recovery of part of water through RO, but discharge the rest. Technically viable, may be first step to ZLD, Complete environmental compliance is still an issue.

Caustic soda recovery

- A factory uses caustic lye of 20-30% concentration in mercerising and discharge weak lye effluent of 4-5%.
- One ton of raw material may generate 5-6 m^3 of weak caustic lye.
- This effluent can be evaporated, purified by oxidation (say with hydrogen peroxide) and use back in process.
- This may be equal to 450 - 625 litres of caustic lye.
- This is equivalent to 180-250 kg caustic soda flakes/ton of raw material.
- The condensate from Caustic recovery can be used in boiler for steam generation.

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Economics of caustic soda recovery

- Operation cost could be upto **US $ 3 per m^3**, i.e, about **US $ 15-18 per ton**. Including amortisation it is **US $ 60** per ton
- As already noted, the CRP gives 200 kg flakes/ton of production.
- The savings due to say 200 kg flakes @0.4 US $ per kg is **US $ 80** per ton of production
- This means a total saving of **US $ 18-20** per ton of production.
- This is without considering the value of water recovered, reduction in cost of effluent treatment (mainly neutralisation and COD removal) and heat potential in the condensate water
- If spent steam from factory is used for CRP, the cost can be minimised further and some more savings could be realised.

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Membranes in wastewater treatment

Membranes in wastewater treatment

- Membranes are fine filters can filter out all suspended and colloidal solids, some times even dissolved solids.
- Starts with micron filters: remove most bacteria & viruses. MF with fine pore generally used in MBR systems.
- Ultrafilters remove all suspended & colloidal solids. Reduces the turbidity & silt in water. Used in effluent recovery units as pre-treatment to RO.
- Nano-filters can remove organics & tighter NF remove multi valent salts.
- RO membranes can remove salts too and allow only water to pass through. Most wastewater recycling systems & ZLD system uses RO membranes.

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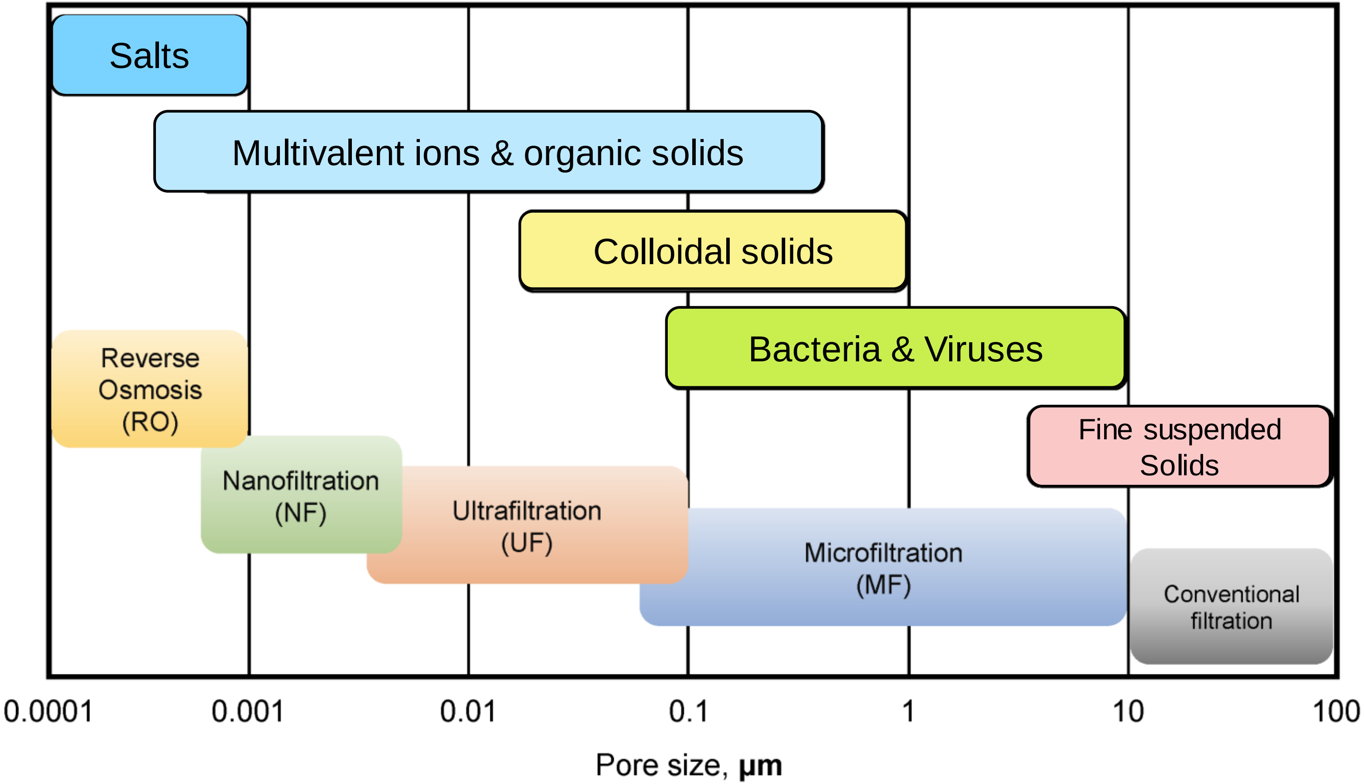
Membranes in wastewater treatment

Relative filtration sizes in micron



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Membrane configuration

- Four main types : plate & frame, tubular, spiral wound & hollow fibre.
- Plate-and-frame module is the simplest configuration, consisting of two end plates, the flat sheet membrane, and spacers.
- In tubular modules, the membrane is often on the inside of a tube, and the feed solution is pumped through the tube.
- Most popular configuration for nanofiltration or reverse osmosis membranes is spiral wound. Here membrane is wrapped around perforated permeate collection tube.
- Hollow fiber modules used for seawater desalination consist of bundles of hollow fibers in a pressure vessel .

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Membranes in wastewater treatment

- Some membranes in microfilters range is used in MBRs.
- Ultrafilter is used in MBRs, as common pre-treatment for RO systems.
- Nano-filtration is used in some factories to segregate the salt solution from dye bath, enabling the salt re-use in dyeing.
- Reverse Osmosis is the main component in water recycling / ZLD in textile industries for removing the salts from the effluent.
- Some cases of ZLD, technologies such as high pressure RO (RO) or membrane distillation is used for concentrating the saline reject from main RO unit. New development: Forward Osmosis.

NANO FILTRATION FOR SALT RECOVERY

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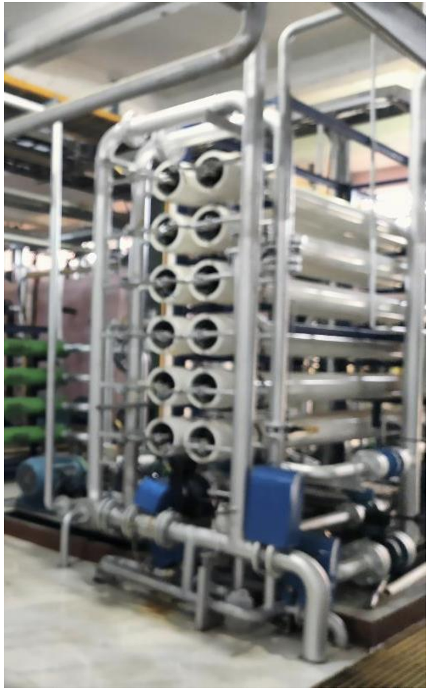
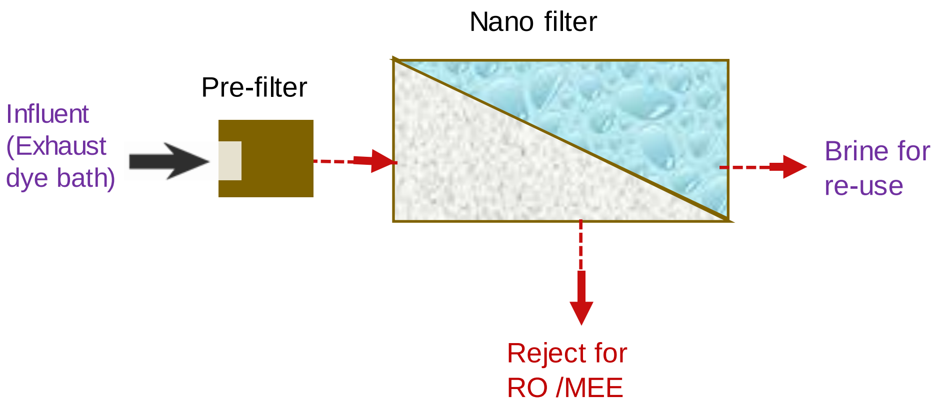
Nanofiltration



- Concept: salt laden exhaust dye bath is pre-treated with filtrations & some times chemical oxidation, passed through a Nano membrane.
- This allows only salt to pass through & remove organics, colour, other impurities.
- Exhaust dye bath with 4 to 7% salt concentration is the feed. The product will be about 6-8% brine.
- Permeate will be clear salt solution and reject have all colour and multivalent ions etc.
- The permeate is re-used in dyeing after adjustments.
- Based on molecular size of organics in exhaust dye bath, a nano-filter with 400-500 Daltons (about 0.0008 microns) pore size can give a decent recovery.

Nanofiltration



First, the exhaust dye bath is filtered through a pre-filter and then through a nano-filter. The permeate will be clear saline liquor which can be re-used in dyeing. The reject carrying all organic impurities, sulphates etc. are taken for reject handling in RO or evaporated to dryness. However, the recovered brine may not be good for all shades.

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Nanofiltration

Nano filtration - myths & facts

- Nano filtration allows only mono/divalent ions and water to pass through, retains hydrolysed dyes and multivalent salts.
- Theoretically it is possible to recover all salts through the membrane, in practice recovery is affected by a variety of factors.
- Pore size of the nano membranes is crucial.
- Too large a pore size (say >1000 daltons) ensure good recovery, above 70% of salt liquor, but allows passage of some smaller organic molecules too.

Nano filtration - myths & facts

- Passage of organics makes recovered salt solution coloured and potentially unsafe for re-use
- On the other hand, too narrow pore sizes (say <300 daltons) ensure recovery of clear salt liquor, safe for re-use
- but then recovery rate could be very low, say less than 35% of input.
- The matter is further complicated by the presence of reacted salts, i.e., salts produced due to inter-reaction of acid and alkali used in the textile processing.

REVERSE OSMOSIS FOR EFFLEUNT DESALINATION

Reverse Osmosis

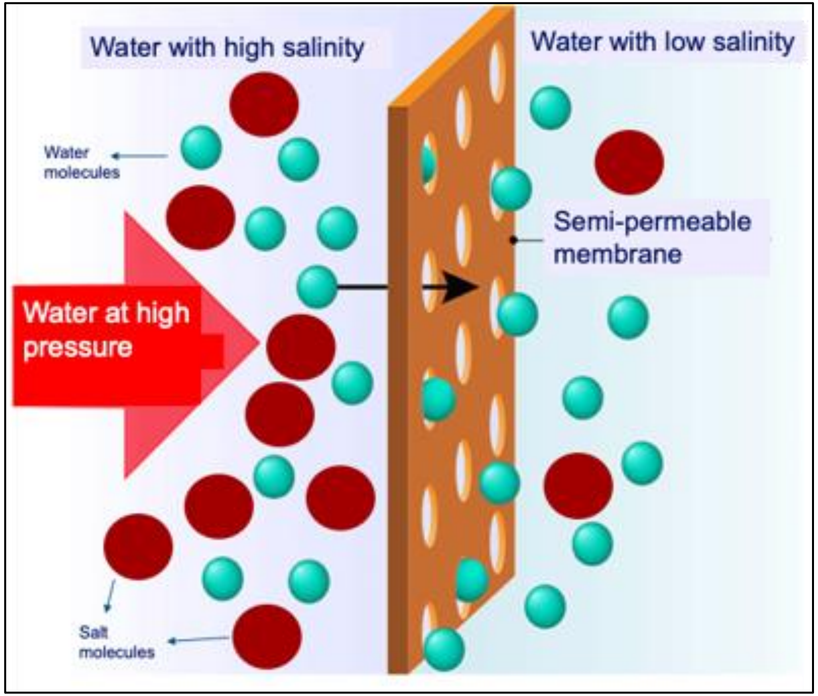
- Reverse Osmosis is the finest of all membranes.
- It is manufactured by polymerization process, modified to create molecular level pores in it.
- It has pore size so small that even the salt molecules are filtered out and only water is allowed to pass through.
- RO operates under very high pressure. Pressure depends on inlet salt concentration
- Unlike MF or UF, RO units are not backwashed and cleaned only using chemicals.

Reverse Osmosis

- Osmosis is a process when saline water is separated from fresh water by a semi-permeable membrane, fresh water moves to the saline water.
- This is due to a pressure exerted by salt water called 'osmotic pressure'.
- If it is reversed, i.e., if we apply pressure on salt side to overcome osmotic pressure, water from saline side passes to fresh water side. This is called Reverse Osmosis.
- Earlier, cellulose acetate was used for making semi-permeable membranes. Now complex polymers used.

Reverse Osmosis

Reverse Osmosis process

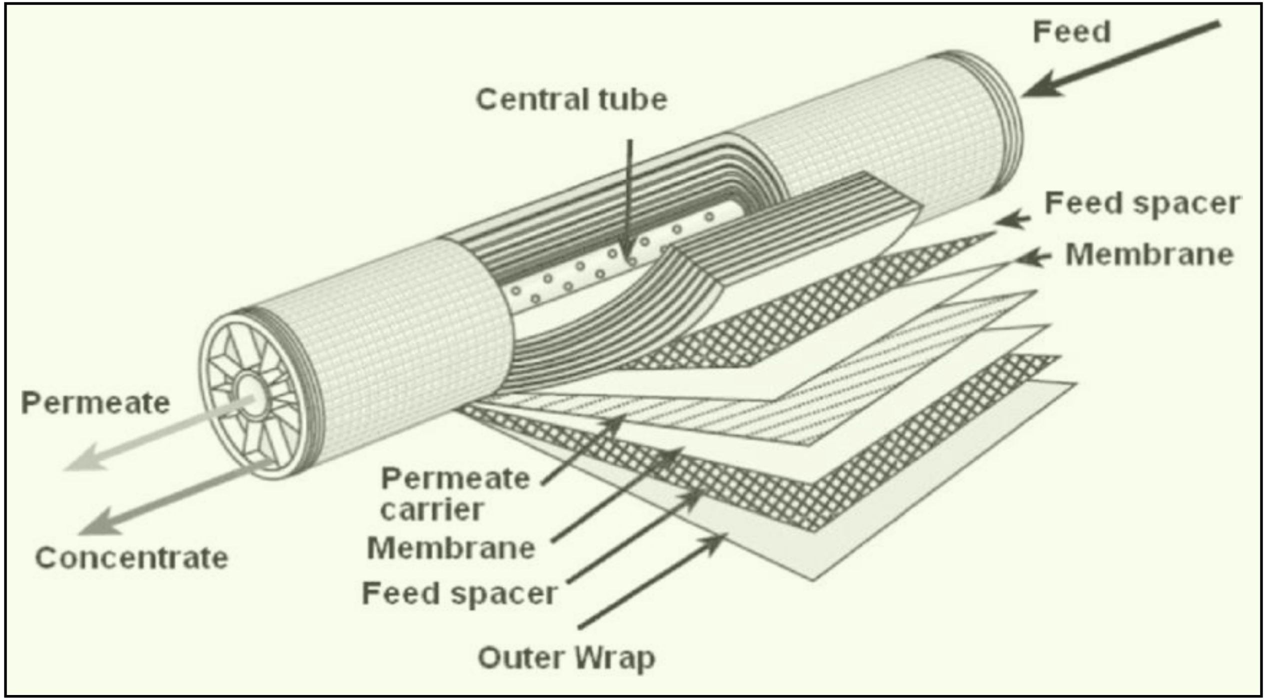


Reverse Osmosis

- RO system generally consist of pre-treatment, high pressure pump, RO membranes.
- In spiral wound configurations RO membranes are stacked in pressure vessels (often FRP).
- Usually 6 membranes in one pressure vessel
- RO membrane made by modified polymerization process, leaves openings of molecular size.
- RO membrane comes in different configuration depends on how the membranes are arranged in a vessel.
- The most common configuration is spiral wound. For wastewater applications, disc & tube is popular.

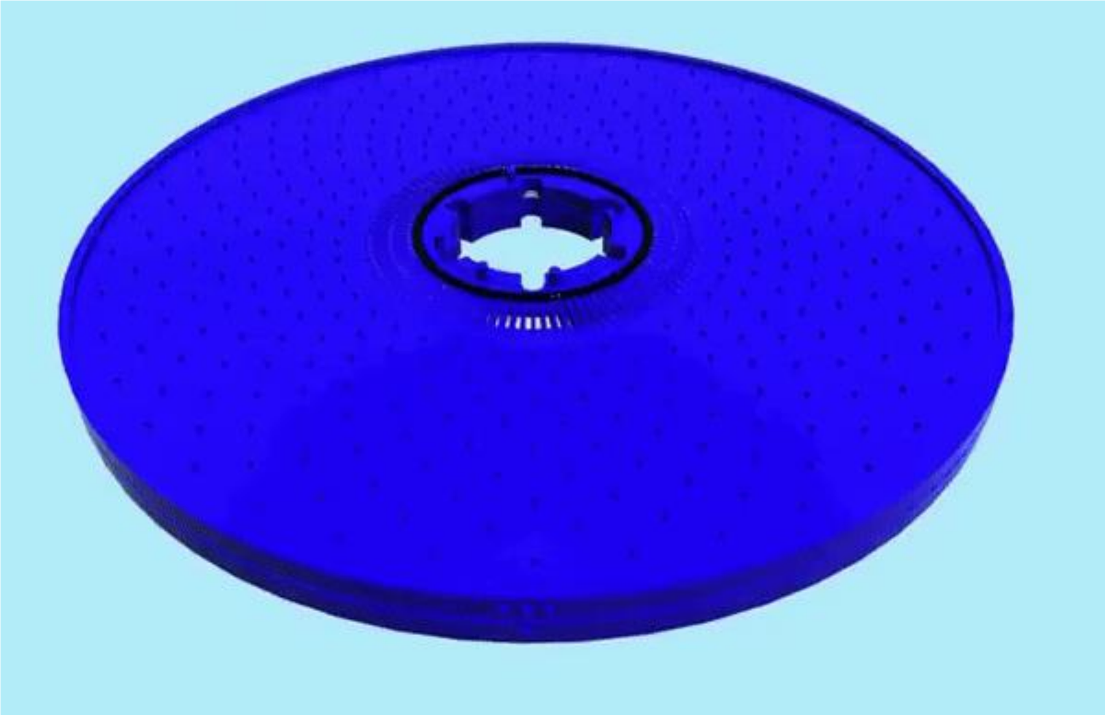
Reverse Osmosis

Spiral wound RO configuration



Reverse Osmosis

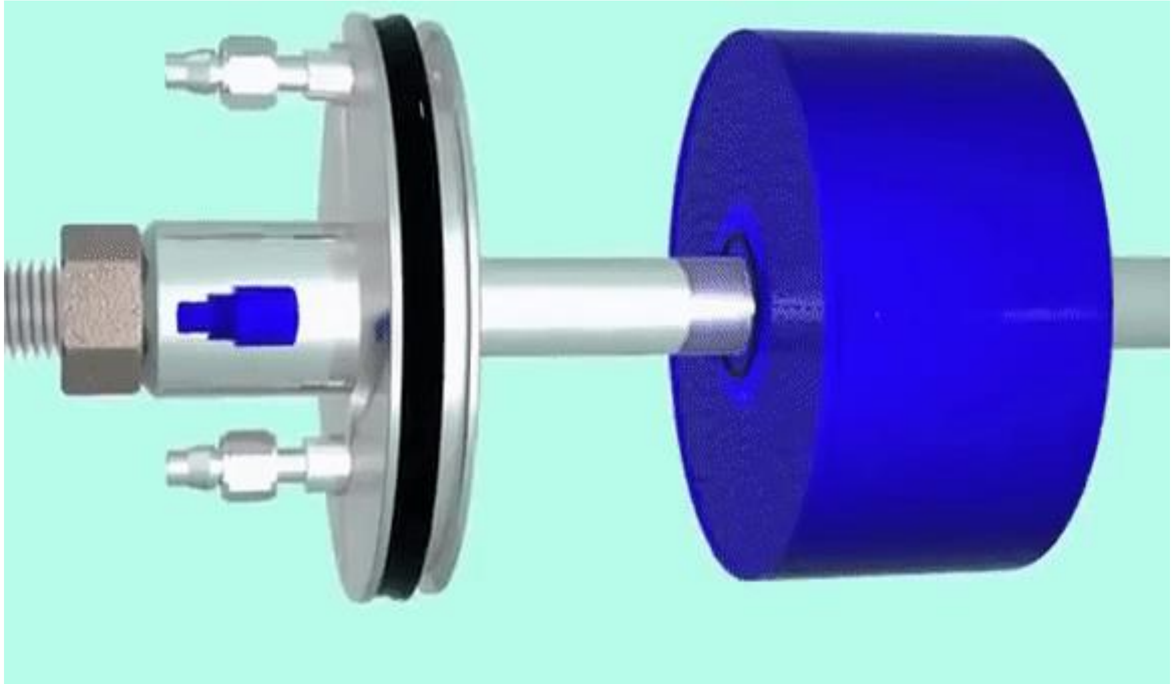
Disc & Tube RO configuration



In order to have a DT membrane stack, first RO membranes are cut in hexagonal shape and then it is placed on a disk. The process is repeated to form a cassette.

Reverse Osmosis

Spiral wound RO configuration



To have a DT membrane module, several cassettes are packed together.

Reverse Osmosis

- RO systems for effluent need extensive pre-treatment.
- Pre-filtration by ultrafiltration (UF) is common.
- If hardness is high, softening is needed (zeolite softener/lime soda softener) to prevent fouling/scaling.
- The term fouling refers to blocking of membrane pore by organic or inorganic solids.
- Effluent with high BOD/COD, or silica/clay/iron etc. fouls membranes.
- Dosing of anti-scalants at RO inlet to control scaling due to calcium carbonate/sulfate.

Reverse Osmosis

- RO inlet is kept at slightly acidic side to reduce scaling potential.
- Periodically, membrane cleaning by cleaning-in-process (CIP) is done.
- Special CIP chemicals with acid/alkali cleaning is used for this process.
- Over a period of time, RO recovery rate (flux rate) comes down due to scaling.
- When cleaning not improve recovery, membranes are replaced (2-4 years).

PARTIAL EFFLUENT RECOVERY THROUGH RO

Partial recovery of effluent through RO

- It is possible to recover part of the effluent, say 75%, through RO systems after proper effluent treatment.
- A single stage RO would ensure good recovery and also lower TDS at the reject.
- In many ETPs it is possible to mix the saline liquor with remaining effluents, still meeting the TDS norms.
- It is much simpler compared to ZLD and need minimal space.
- Since the recovery is not high, feed pressure needed and the membrane fouling will be low.

Partial recovery of effluent through RO

- The main advantage is the reduction of ground water extraction drastically, improving the sustainability of the industry.
- This will also reduce the quantity of effluent discharged.
- This option will much cheaper compared to ZLD (about 15-30 tk/m^3 treated)
- Can be regarded as the first step of ZLD and be appended with additional stages to achieve ZLD in future if needed.
- However, it may not ensure absence of effluent and in case of high TDS effluents, the TDS norms may not be met.
- Special permission from DoE in regards to TDS norms may be needed.

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Factors affecting recovery from RO

- **Degree of water recovery**
  - The feed pressure and fouling potential increases exponentially with increase in recovery.
  - Getting 70% recovery compared to 60% is several times more difficult.
- **Feed water quality.**
  - If the input water is high in silt and organics, the fouling potential increases and reduce recovery.
  - If the total dissolved solids in the feed water is high it reduces the membrane flux rates and reduce recovery.

Factors affecting recovery from RO

Quality of the membranes

- Much research is progressing on the membrane material and configuration.
- Low fouling brackish water membranes give good recovery.
- Higher pressure membranes can higher recovery with higher salinity.

Pre-treatment to RO.

- If the input water is turbidity, silica & silt density index is kept low, recovery will be high.
- Good pre-treatment (commonly involves a UF pre-filtration) would get good & consistent recovery from RO.

Conclusion

- Many new membrane based technologies evolves every day . For instance membrane distillation, EDR, Forward Osmosis etc.
- Non ZLD type of effluent recovery & re-use include caustic soda recovery, salt recovery and partial effluent recovery.
- Caustic soda recovery is a profitable option, more attractive when savings in effluent treatment is considered.
- Salt recovery through nano filters are being implemented by many and some successful case studies are reported.
- Successful operation of membranes pre-supposes good understanding of membrane chemistry, types & configurations.
- Partial recovery of treated effluent using Reverse Osmosis is an interesting option, first step to ZLD.

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