Reuse end-of-life of RO membranes in wastewater treatment for agriculture and industrial fields

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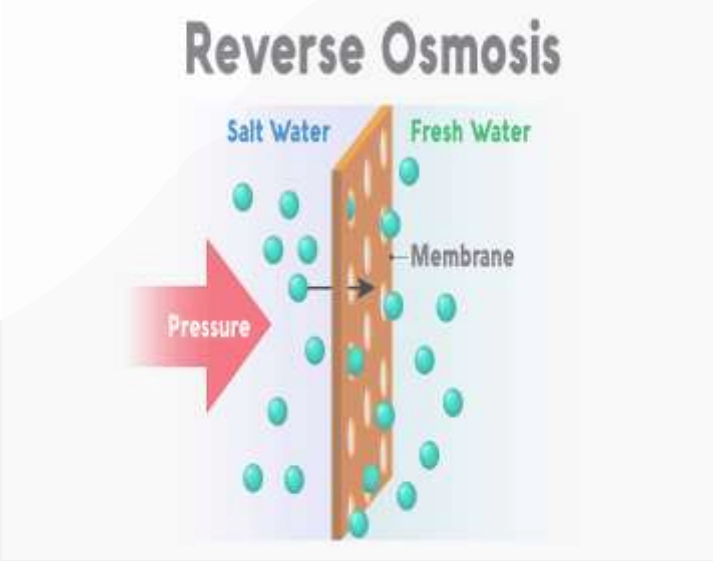
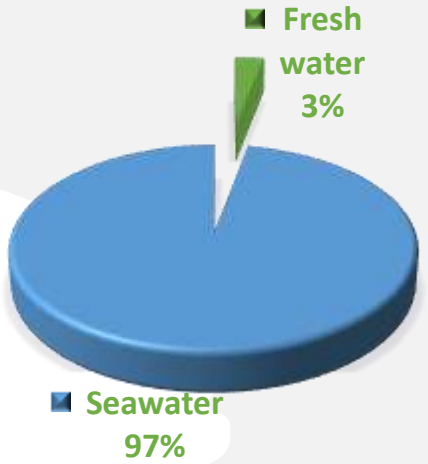
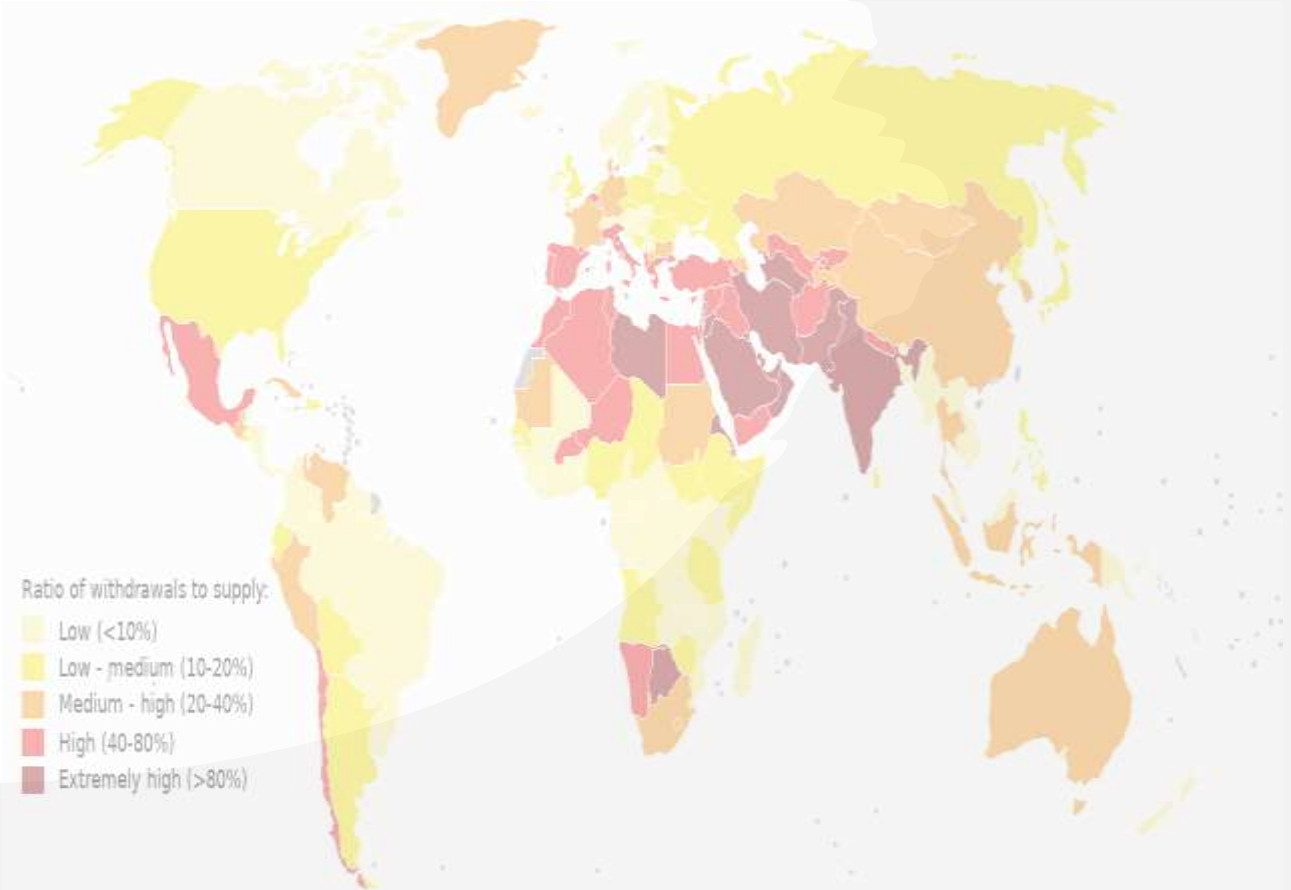


Study background

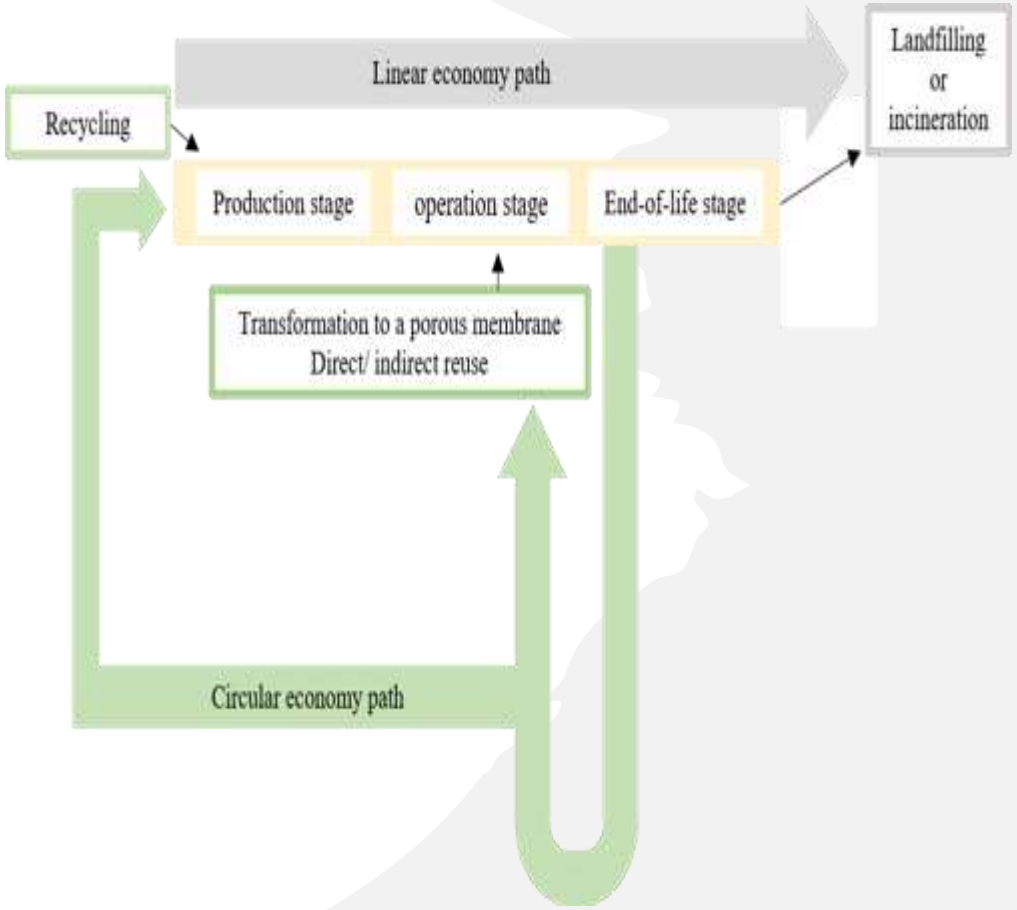


- **Unfair balance of available freshwater**
- **Middle east and north Africa facing a high level of water stress**
- Seawater desalination is the most attractive option for providing potable water
- **Reverse Osmosis (RO) consider as the best separation method according to different majority**
- **By 2025l, expected more than 20 million old RO element**



Study background

- ✓ There are about 65% of desalination plant using RO technology with different plant size
- ✓ The life-time of RO membrane from 5-7 years and might be depending on the raw water
- ✓ Replacing the RO membrane can be for many reason, common factor is mechanical or chemical defect, fouling, and increasing the salt passage
- ✓ Now a day, around 840,000 of old-RO elements discarded at the land field annually



Linear and circular economy paths for the EoL RO module

Goals

- ✓ *To reduce the cost of wastewater reuse by using those end-of-life RO membranes*
- ✓ *To recycle them from the desalination plants and give them a second life chance*
- ✓ *To provide desalination plants operators a solution for their membranes waste disposal*
- ✓ *To treat wastewater using old RO used membranes*
- ✓ *To provide an additional water supply option for irrigation of sensitive crops*
- ✓ *To protect groundwater by treating wastewater before injecting it*

Reducing the environmental impact

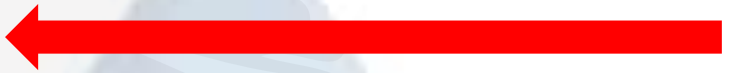
Finding a sustainable solution for discarded RO elements that yearly increased

Reducing cost of wastewater treatment by reusing RO membrane

Finding a second water resource to match the needs of the agricultural and industrial field

Challenges

1. Clean
2. Make it wet
3. Covered by plastic bag
4. A way from sunlight



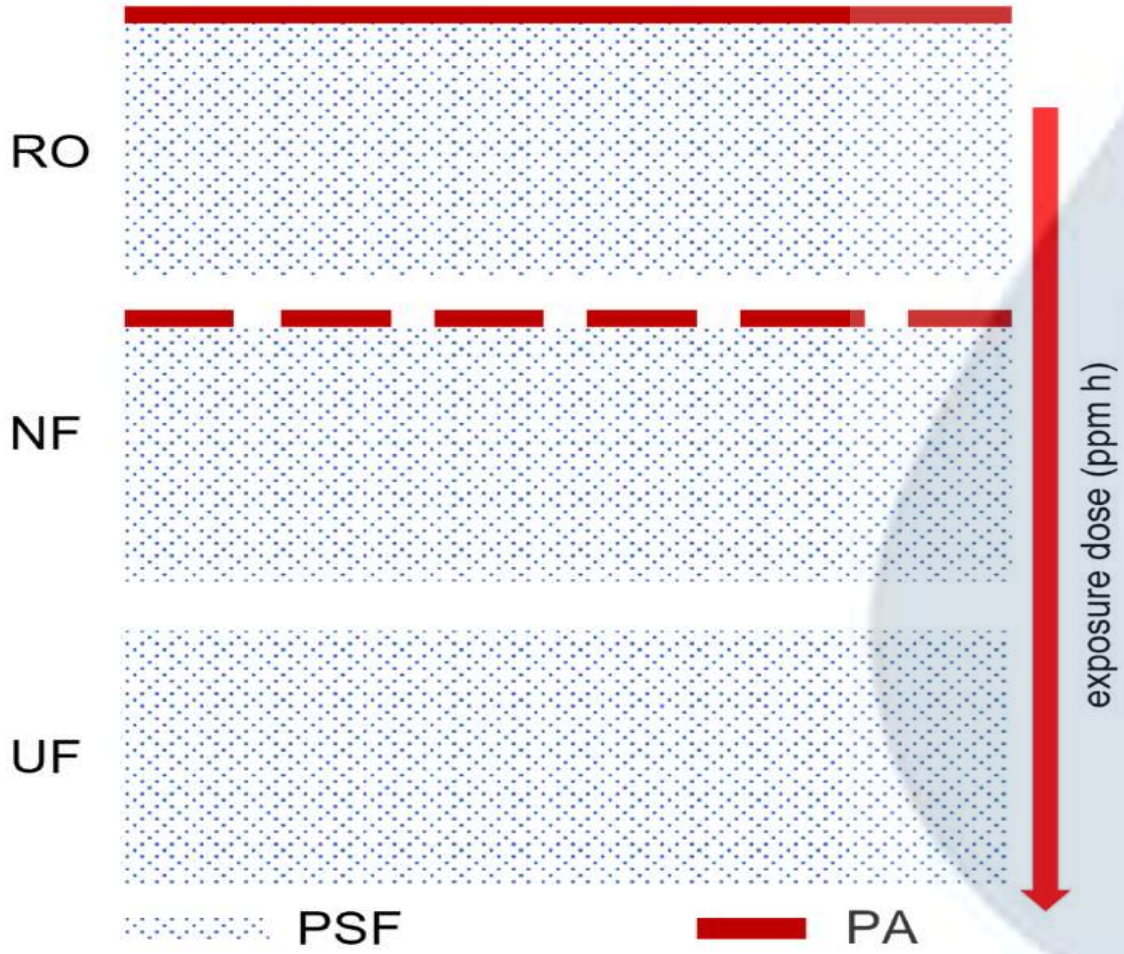
Follow the right protocol to save the element after service

Grantee that no mechanical defect

Avoiding all kind of unwanted substances (fouling and scaling)

Make sure that POLYAMIDE (PA) is totally oxide

Reverse Osmosis membrane



- ✓ The outer design of membrane separation elements is like each other, with differences in the number of layers and the pour size
- ✓ The RO membrane consists of there layers to reject the salt substances, while ultrafiltration consists of two layers to remove some unwanted substances like viruses
- ✓ There are to option for reuse old RO elements:

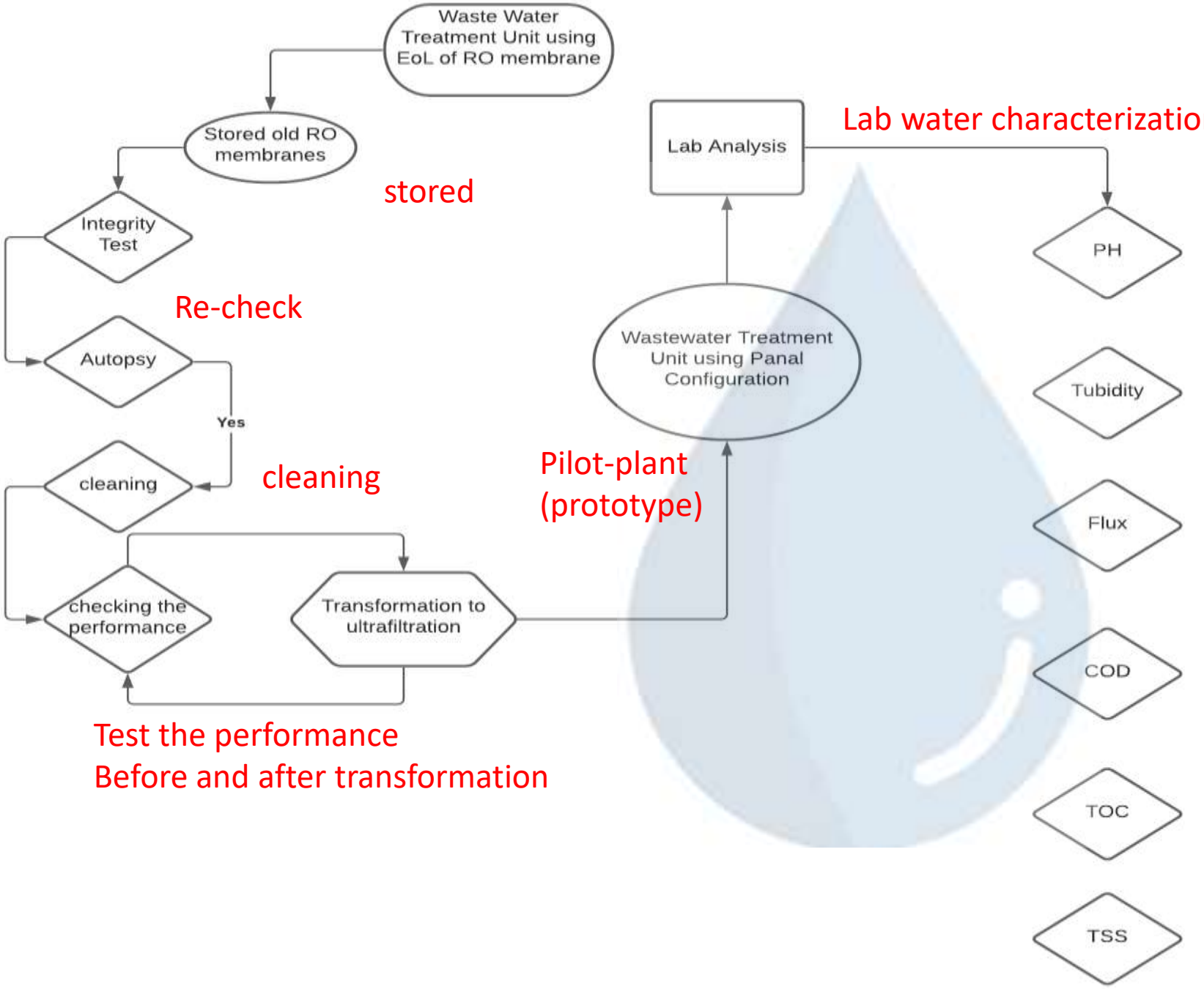
Option-1

Used directly to treated low water salinity

Option-2

Used indirectly by transform it to UF or NF

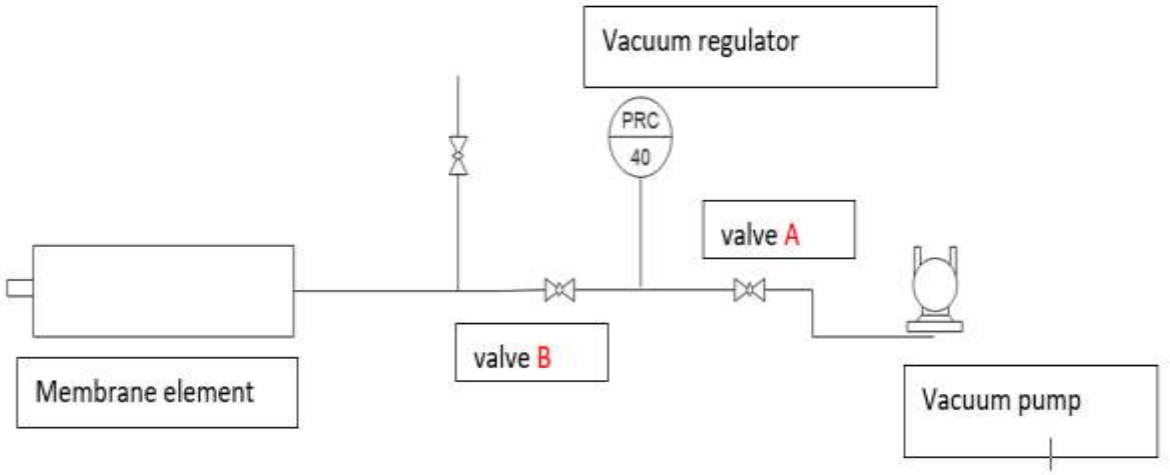
Work methodology (part-1)



Results

Integrity test

- Stored 30 old RO elements from two different site:



Site-1 (15 elements) → Not-follow the storing protocol → 50% can be used directly

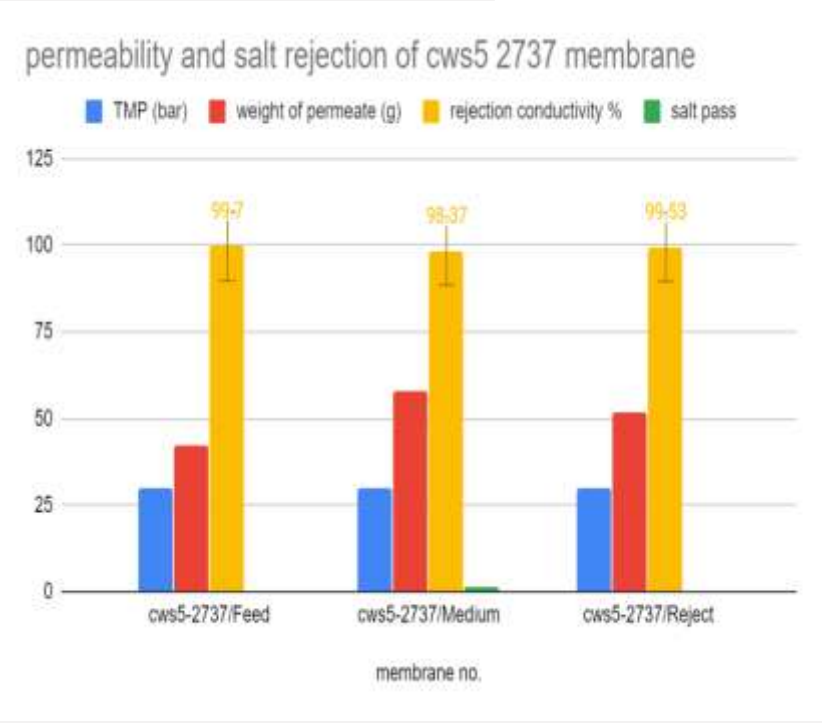
Site-2 (15 elements) → Following the storing protocol → 85% can be used directly

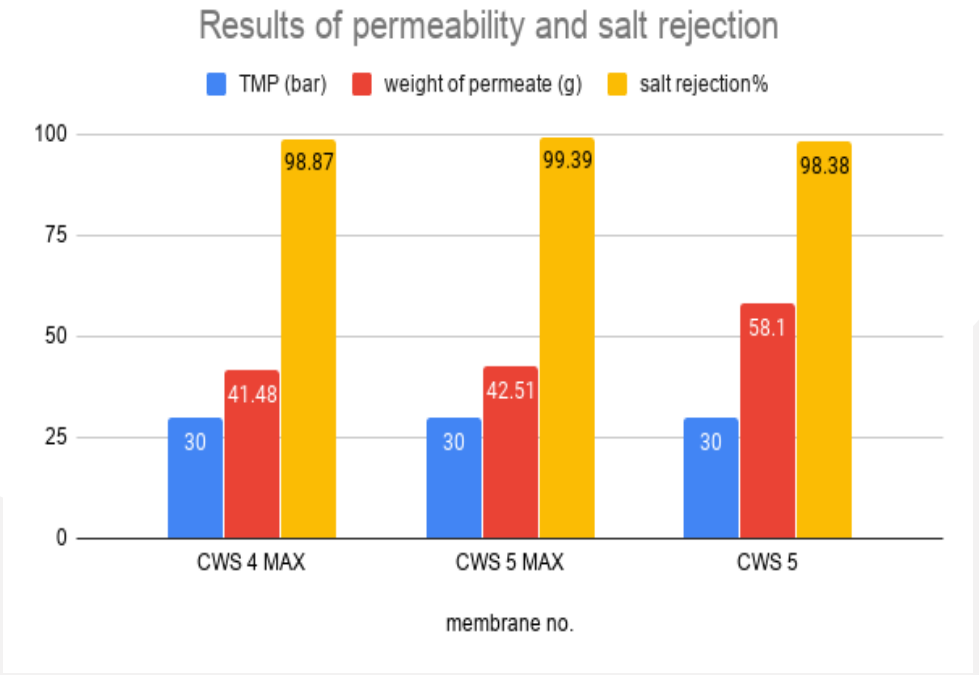
Results

Permeability test

- Taking 20*20 cm sheet samples from different old RO elements
- Examine the rejection of old elements from different positions (feed, medium, and reject sides)

Figure 1 Tangential flow filtration system (cross flow) - IMDEA lab. Spain





Results

Transformation process

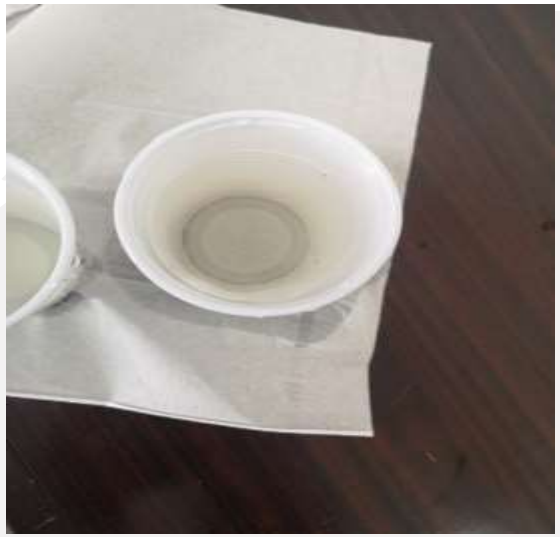
- ✓ Using sodium hypochlorite (NaOCl) with a concentration of 15%
- ✓ The process starts with a concentration of 370 ppm. hr

dose intensity (ppm.hr) = concentration of free chlorine (ppm) * contact time the salt

- ✓ passing membrane almost by 99%
- ✓ Average turbidity rejection achieves 71.5%

Figure : Membrane flat sheet tester (lab-scale)

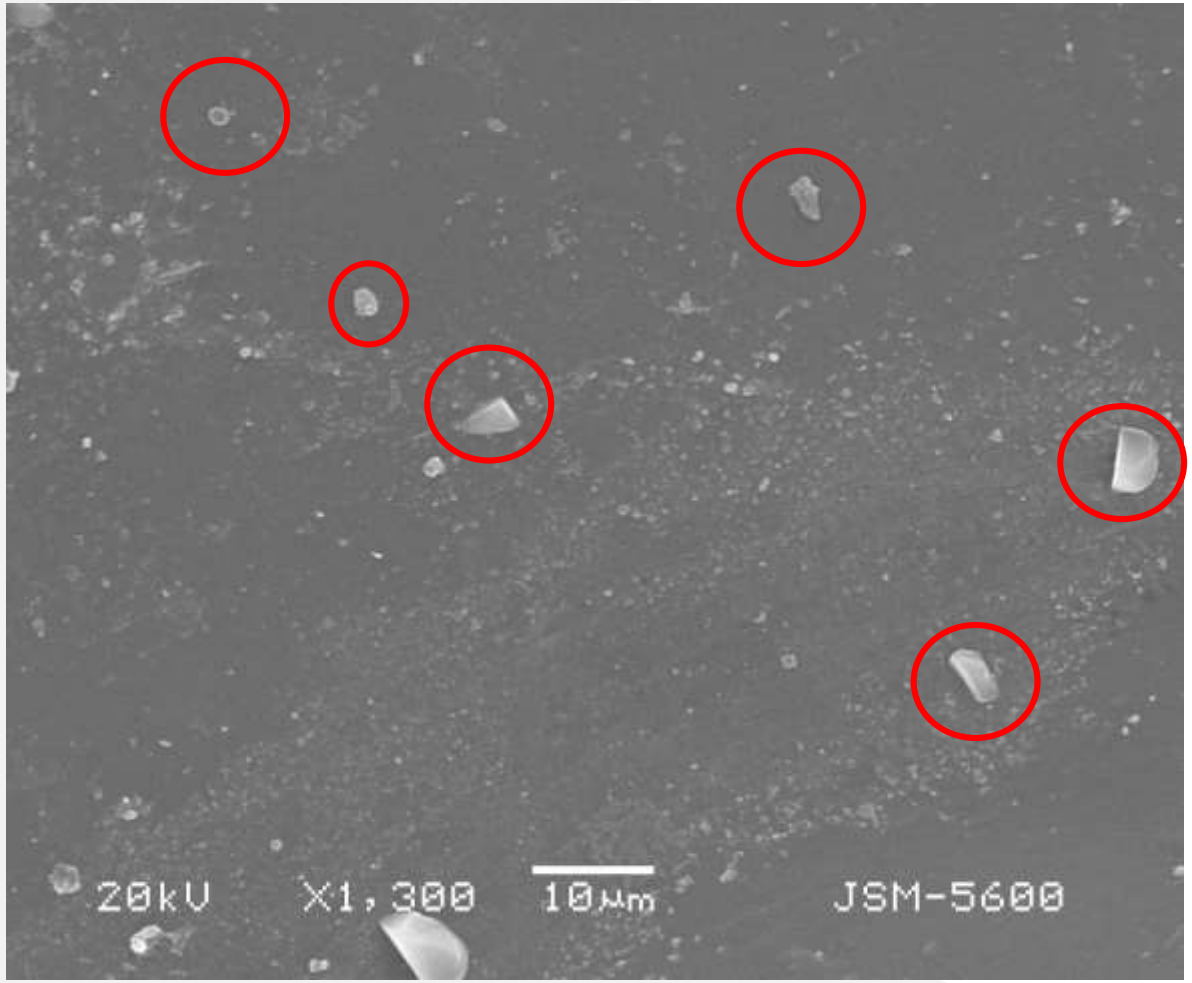
74.2 NTU



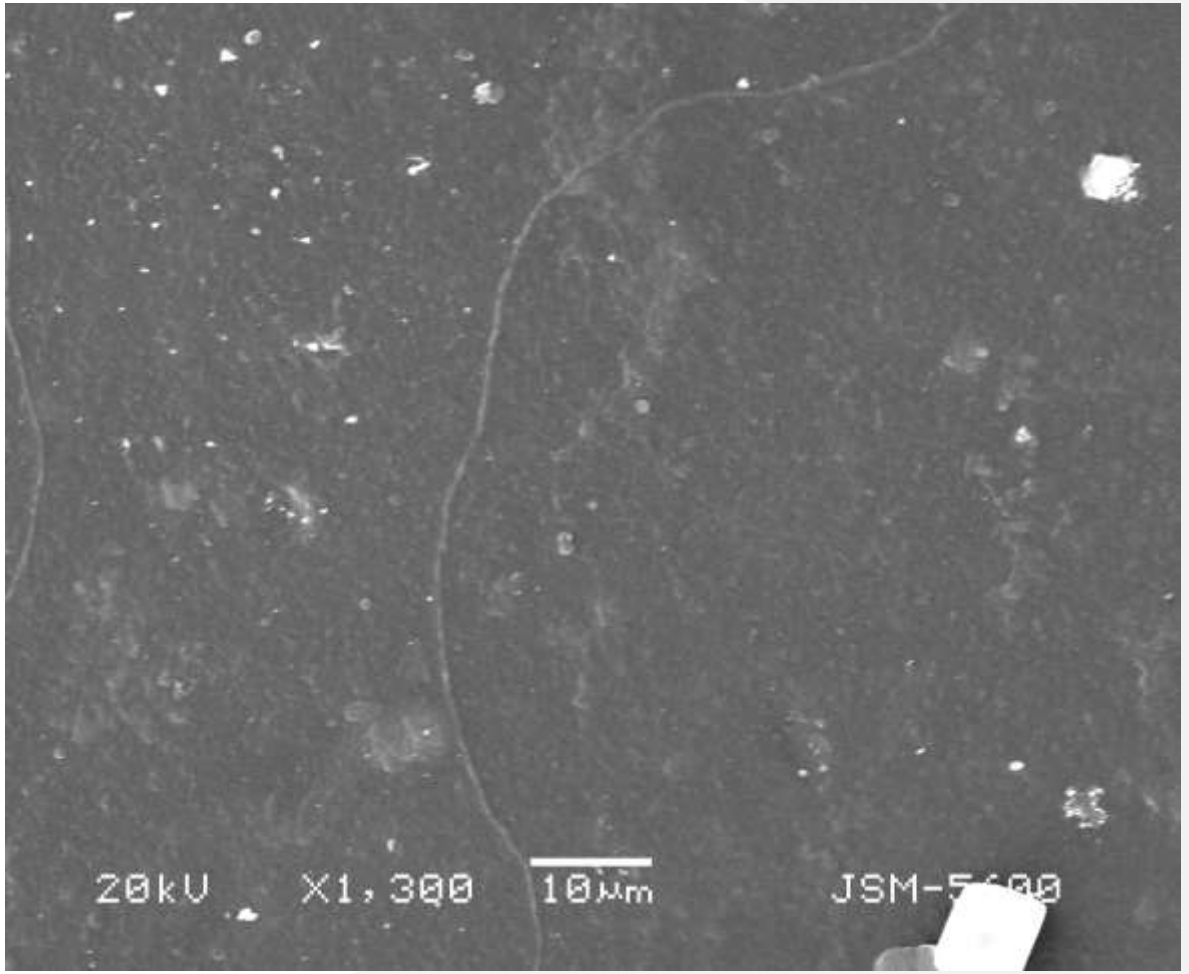
154.3 NTU

Results

Scanning electron microscopy



Top view of the surface of old RO membrane before transformation



Top view of the surface of old RO membrane after transformation

Conclusion and remarks

- ✓ The transformation process of the EoL RO membrane to UF properties was done successfully at both lab and pilot scale at DI of 300,000 ppm.hr
- ✓ The surface characteristics of the EoL RO membrane were changed after the transformation that was indicated by complete removal of the PA layer and the increase in the hydrophilicity (more wetting) of the membrane surface and decrease in salts rejection
- ✓ Lower operating pressure caused lower fouling and corresponded to the longest filtration cycle and highest permeability

Future perspective and recommendation

Desalination industry

- ✓ Measuring the EoL RO module weight and conducting the integrity monitoring test before the transformation
- ✓ Storing those modules when reaching the EoL stage to avoid drying resulted in a damage of the membrane sheets

Future studies and research

- ✓ Conducting economic analysis for the transformation process of the EoL RO module to UF properties
- ✓ Examine three different configuration (as it is, semi-open, and flat-sheet), then record the results for future work

Figure from the project

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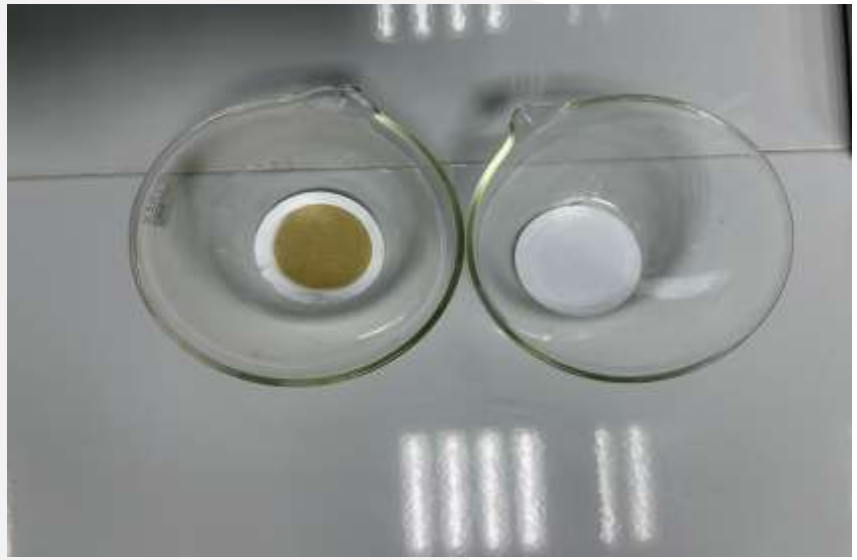

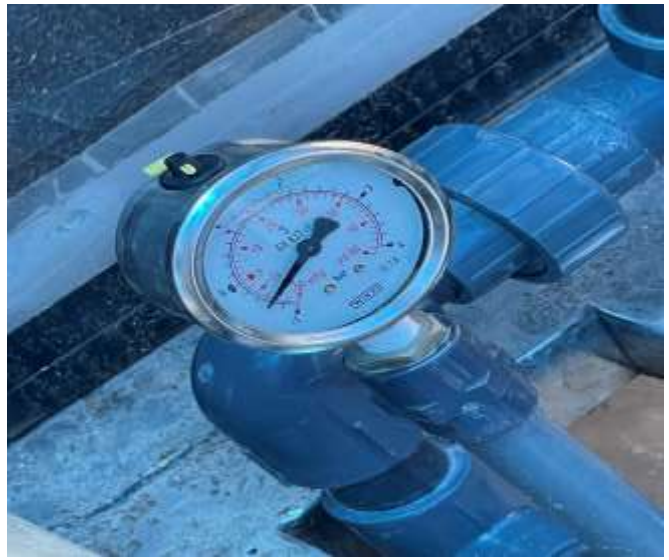

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Thank you