Recent Trends in Membranes Technology:

Emerging Opportunities and Solutions for Desalination and Wastewater Treatment

AHMAD FAUZI ISMAIL, PhD., FASc., CEng., FIChemE.

Advanced Membrane Technology Research Centre (AMTEC)

Universiti Teknologi Malaysia (UTM), Malaysia

Introduction to AMTEC

AMTEC in Brief

June 2018

Asoc. Prof. Dr. Mohd. Hafiz Dzarfan Othman appointed as the second Director of AMTEC

2015

AMTEC has been awarded as national centre of excellence (HICoE)

2008

MRU has been upgraded to Advanced Membrane Technology Research Centre (AMTEC). Prof. Ahmad Fauzi Ismail appointed as the First Director of AMTEC.

2002-2008

Prof. Ahmad Fauzi Ismail had been entrusted to lead MRU-based in Skudai, Johor. Prof Ahmad Fauzi held the position as the Head of MRU until 2008

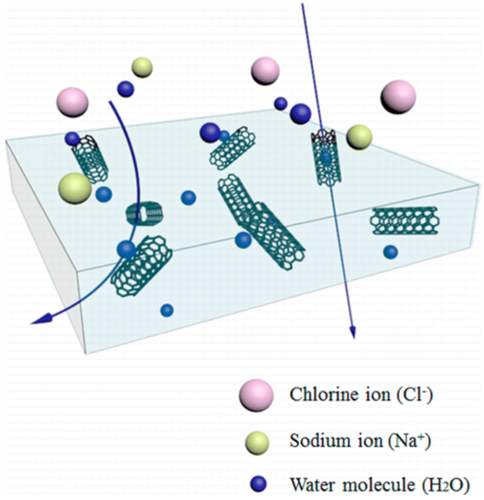
1990-2001

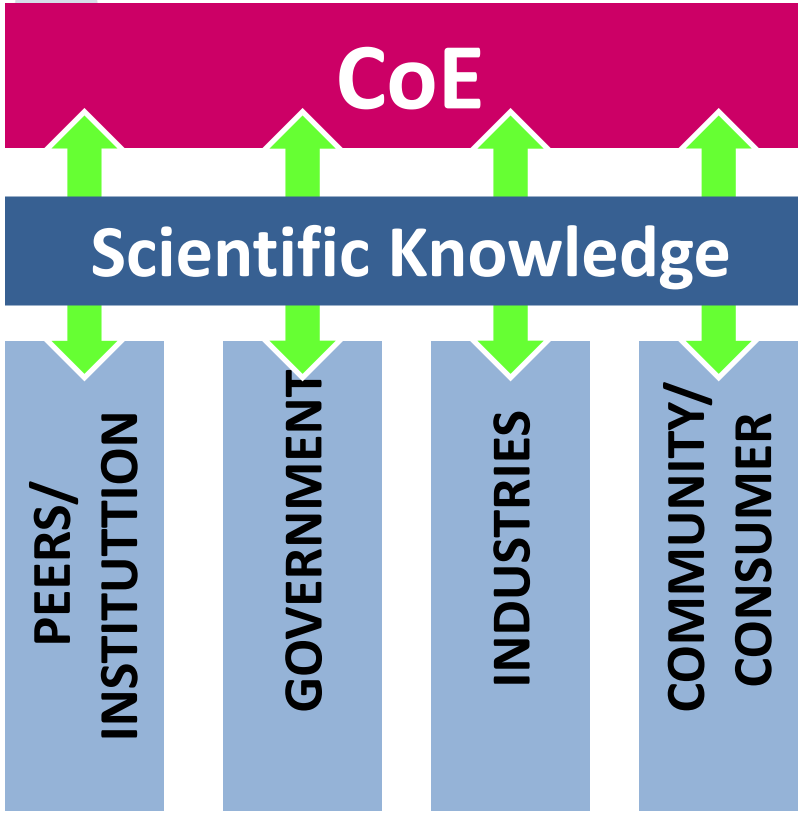
Prof. Hamdani Saidi was the founder of Membrane Research Unit (MRU). He was the first Head of MRU, which was based in UTMKL.

Research Niche and Pillars

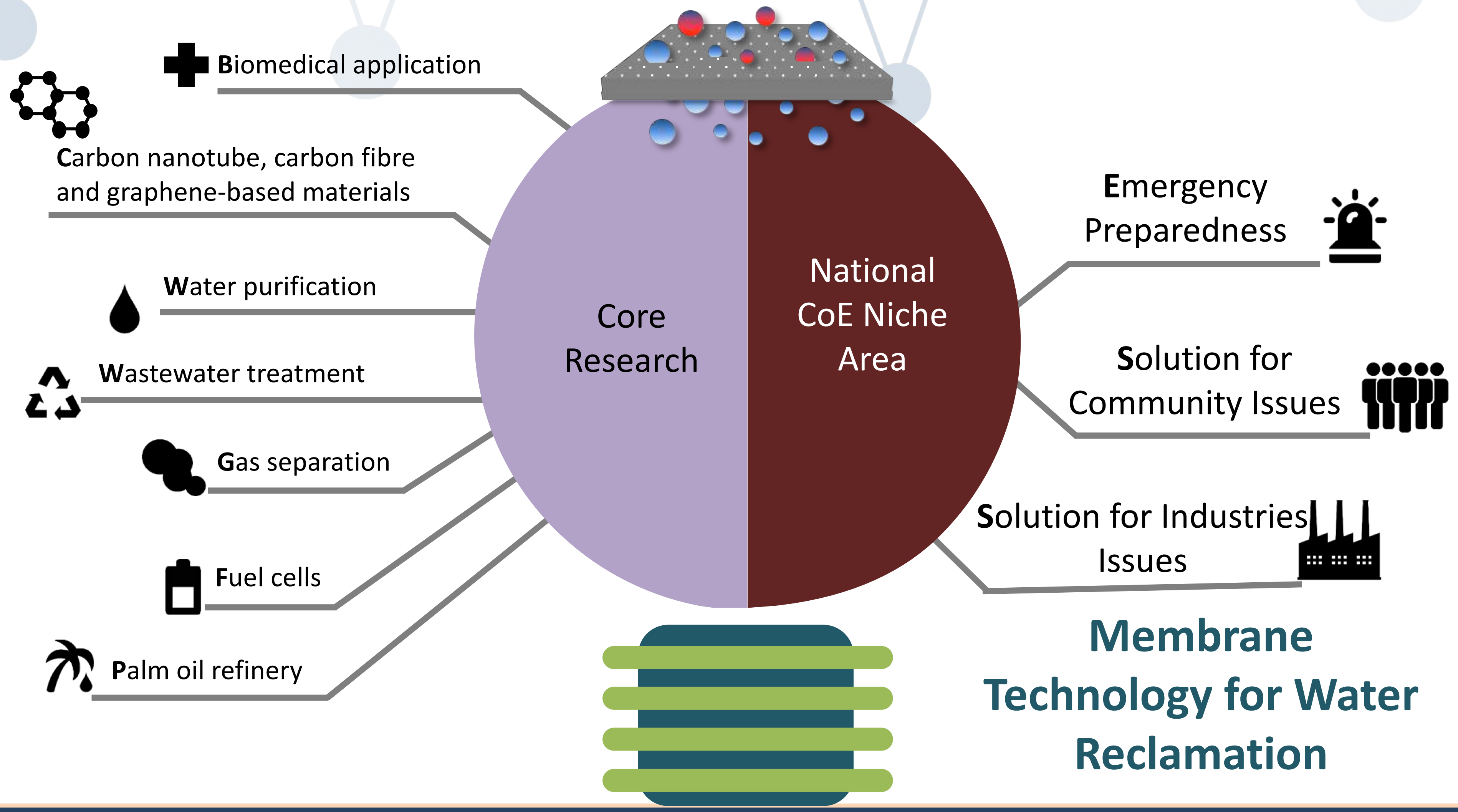
3 Research Niche

Organic Membranes	Inorganic Membranes	Nanocomposite Membranes





Research Area

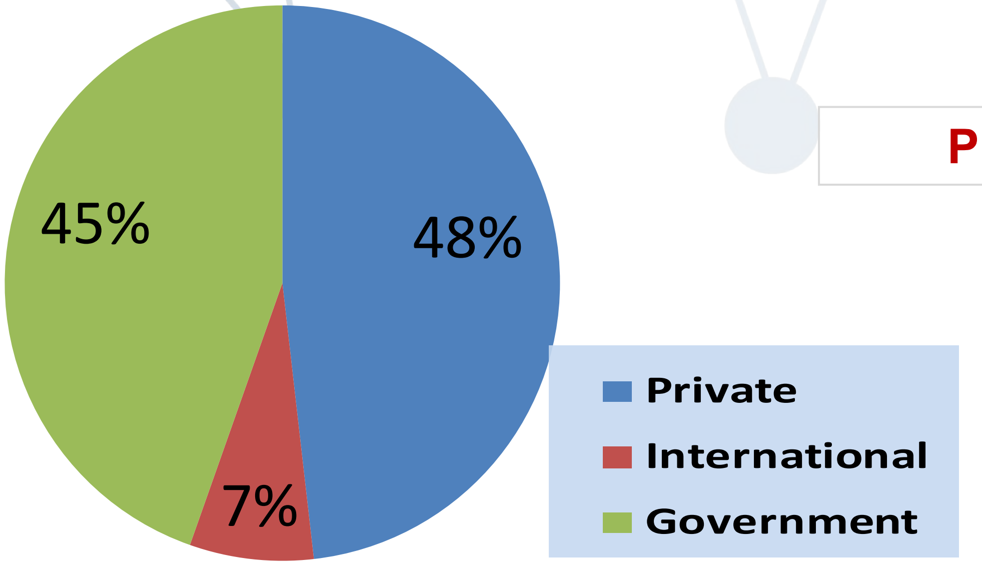


Research Activities

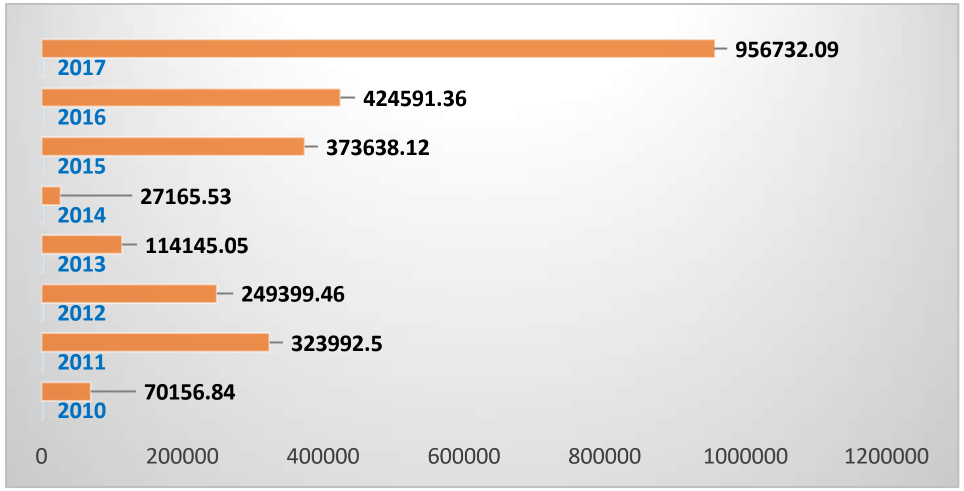
Synthesis → Material Characterization → Membrane Fabrication → Module Preparation → System Design and Testing → Field Test & commercialization

AMTEC in numbers

Research Funding



Income Generation (USD)



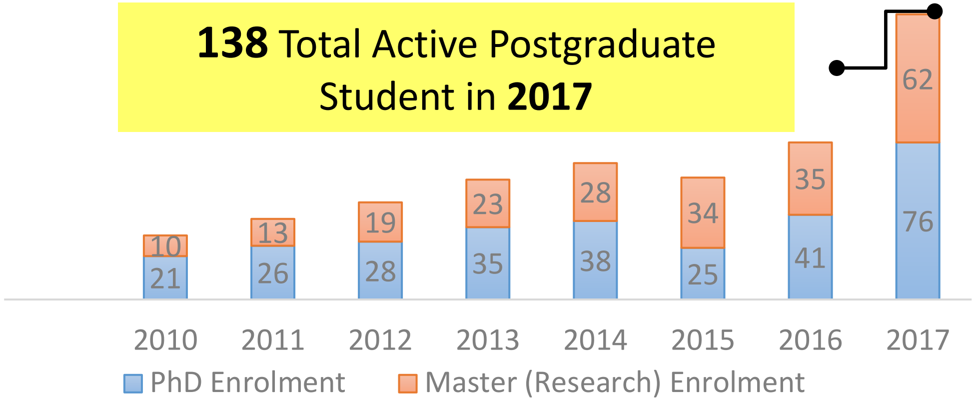
Publications

718 Total number of publications

15,978 Total citations

Talent Generation

138 Total Active Postgraduate Student in **2017**



PhD Graduated	45
Master (by research) Graduated	40

10,000 victims of earthquake in Ranau, Sabah.

6,000 victims of floods & droughts in Kelantan (> 12,000 estimated population in Malaysia) .

3,000 people water shortage problem in Bachok, Kelantan.

2,000 people in Kiulu, Sabah for the supply of treated clean water.

1,000 people water shortage problem in Mersing Johor

COMMUNITY & SOCIAL

INDUSTRY

5 National Collaboration

1 International Collaboration

IMPACT

Income Generated Worth

RM6.04 million

Spin off Company **1**

Malaysia Patent **27**

Academic Staff **16**

Ph.D. Graduated **45**

MSc. Graduated **47**

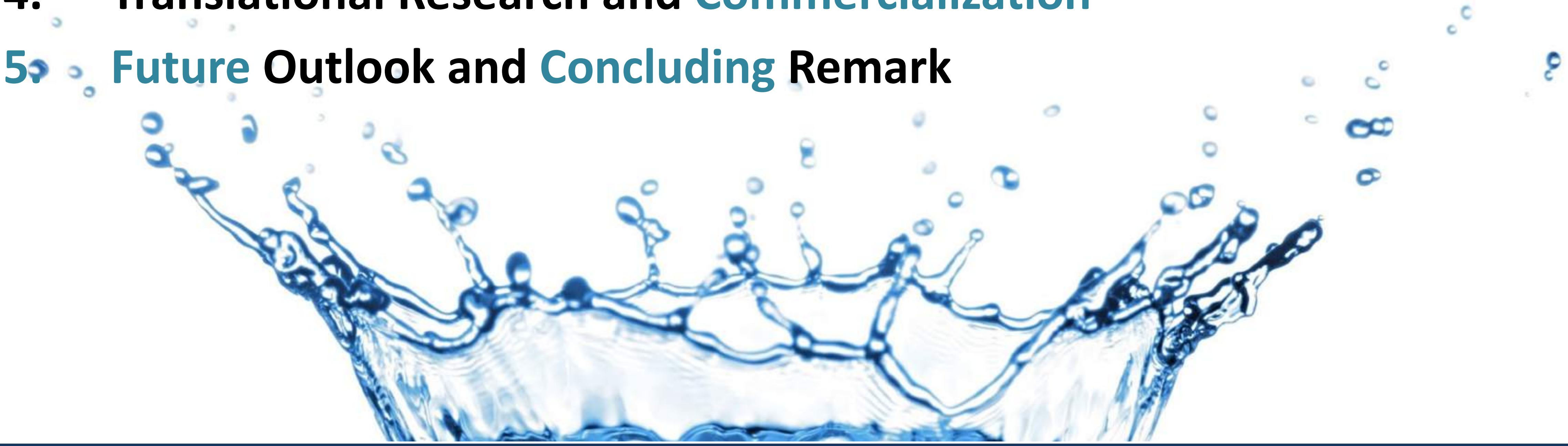
Index Paper **705**

NATION

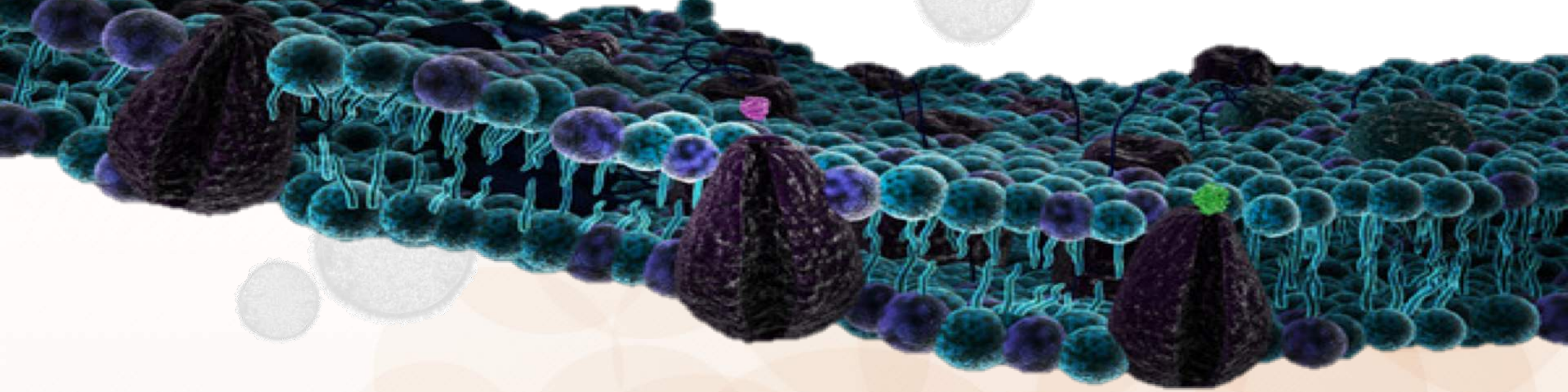
ECONOMY

Presentation Outline

1. Introduction-Desalination and Water Treatment
2. Current Trend of Membrane Technology
3. Performance Evaluation
4. Translational Research and Commercialization
5. Future Outlook and Concluding Remark



1. Membrane *Technology*



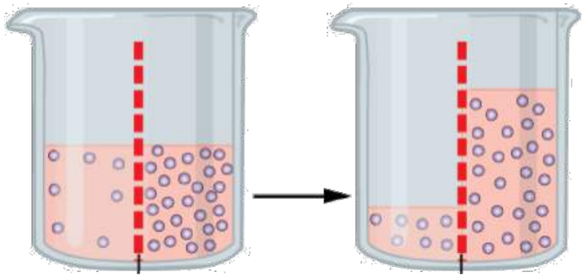
MEMBRANE

- ‘Membrana’, a Latin word defined as skin or thin film.
- Act as boundary or selective barrier between two phases. It is semipermeable.
- Examples: human skin, animals and plants cell

The history of MEMBRANES dates back to the 18th century...

1748

Jean-Antoine Nollet
(1700-1770)
coined the term
"osmosis"



Diffusion of molecules from a place of higher concentration to a place of lower concentration until the concentration on both sides is equal.

1831

J.K. Mitchell
reported semipermeable films allow permeation of gases at different rates.

1855

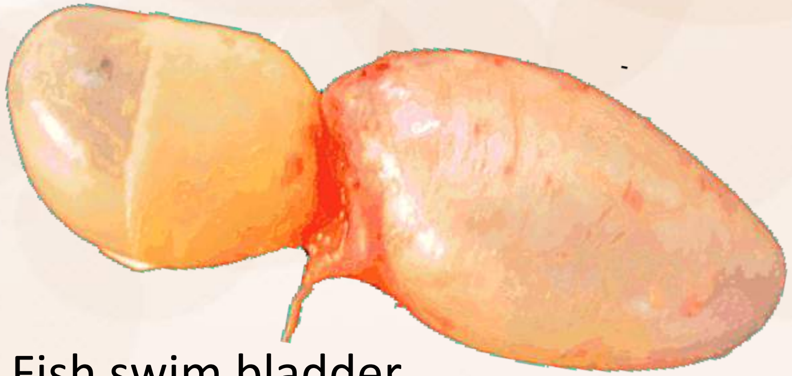
Adolf Fick
postulated the law of diffusion across concentration gradient.

1860

Thomas Graham
described the solution-diffusion mechanism of gases through dense films.

- During the following century, osmosis was of special interest to practitioners in the biological and medical sciences.
- Early membrane investigators experimented with every type of diaphragm available to them, such as bladders of pigs, cattle or fish and sausage casings made of animal gut.

1800-1900



Fish swim bladder

Cow bladder

Elford, Zsigmondy and Bachmann and Ferry
Improved Bechhold technique, which made microporous collodion membranes commercially available.

1907 | **1930** | **1950**

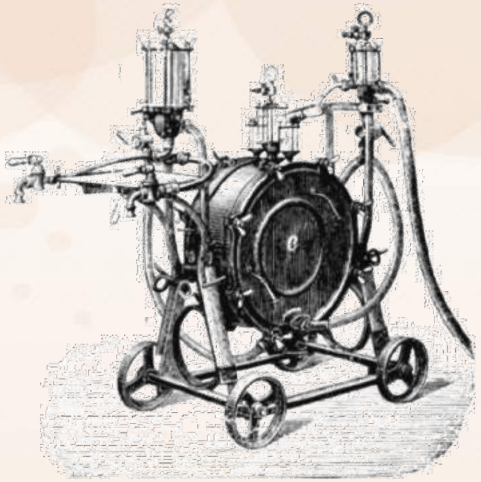
Bechhold (1907)
devised a technique to prepare nitro-cellulose membranes of graded pore size.

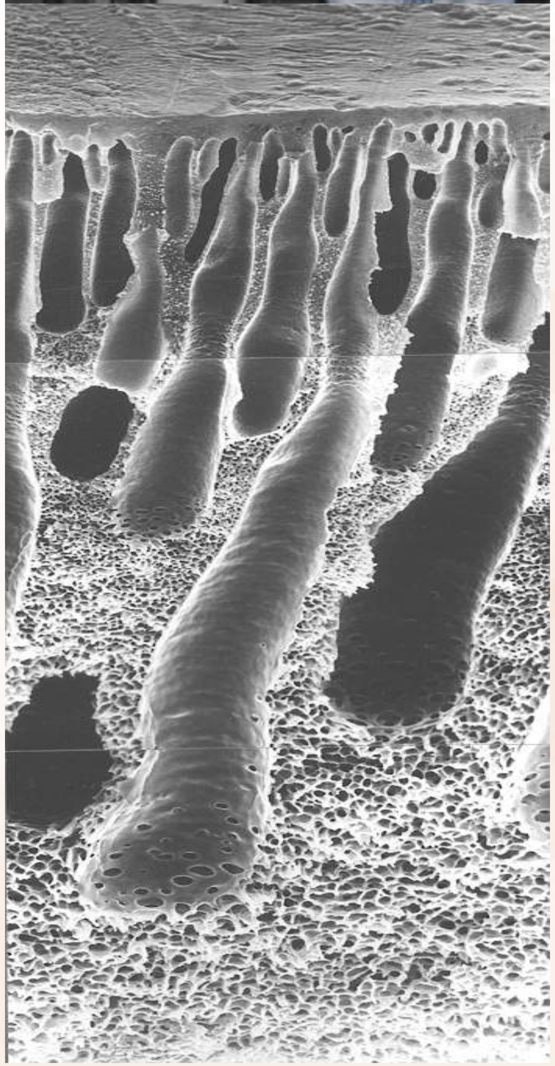
Membranes found their first significant application in the testing of drinking water at the end of World War II. The research effort was sponsored by US Army, which later exploited by Millipore Corp., the first and still the largest US microfiltration membrane producer.

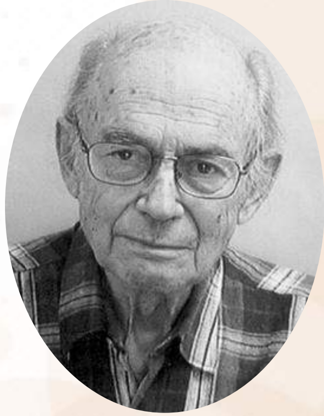
- By 1960, membranes were used in only a few laboratory and small, specialized industrial applications.
- Membranes suffered from four problems that prohibited their widespread use as a separation process: They were too unreliable, too slow, too unselective, and too expensive.

1900-1960

- The seminal discovery that transformed membrane separation technology from a laboratory to an industrial process started from the early 1960s.





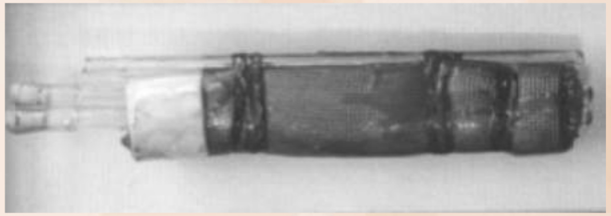


Sidney Loeb &
Srinivasa Sourirajan (1962)

A “skin type” membrane with porous sublayer in a single step which involved quenching in a non-solvent coagulant known as the “phase inversion” technique.

General Atomics (1963)

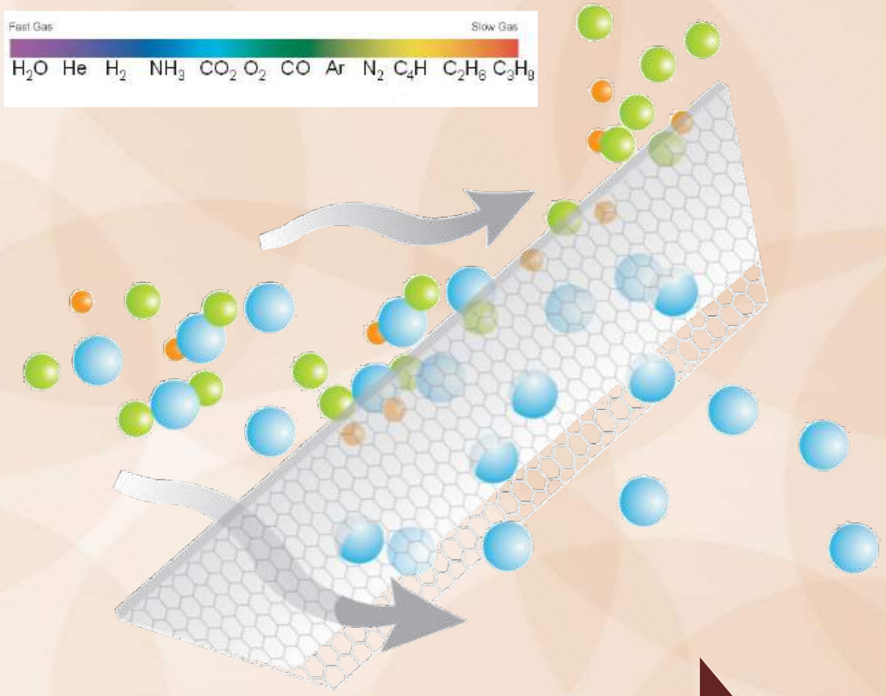
Produced the first spiral-wound Module for reverse osmosis.



1960-1980

Du Pont (1967)

Produced the first hollow fiber module for reverse osmosis.



Henis and Tripodi (1980)
Invented a coating technique which made separating gas by membranes practical on larger scale.

Monsanto (1980)
Launched the first hydrogen separating-membrane (Prism®).

1980-1990

Cynara and Separex
Produced systems to separate carbon dioxide from natural gas.

Dow
Produced systems to separate nitrogen from air.

MEMBRANE TECHNOLOGY

- Progresses in membrane technology is growing rapidly.
- State-of-the-art researches are conducted globally to expand the application of membrane technology into every aspect of our lives.

PRESENT

- Can be applied in heavy duty industrial sectors, energy storage and production, food processing industry, waste treatment for environmental control, providing clean and save daily needs of water supplies, pharmaceuticals, life-saving devices, etc.

APPLICATIONS OF MEMBRANE TECHNOLOGY


By 2020, the global membranes market is projected to grow at a *CAGR of 9.47% from 2015 to reach a value of -
*Compound Annual Growth Rate (CAGR)
USD 32.14 Billion
Membranes Market by Type (Polymeric membranes, Ceramic membranes, and others), by Technology (MF, RO, UF, Pervaporation, Gas Separation, Dialysis, NF, and Others), by Region and by Application - Global Forecast to 2020 , October 2015


Asia-Pacific and North America are the key markets for membranes, whereas the developing economies such as the Middle East & Africa and Latin America are projected to witness high growth rates between 2015 and 2020.
Membranes Market by Type (Polymeric membranes, Ceramic membranes, and others), by Technology (MF, RO, UF, Pervaporation, Gas Separation, Dialysis, NF, and Others), by Region and by Application - Global Forecast to 2020 , October 2015


Water & wastewater treatment, pharmaceuticals & medical uses, and food & beverages are the topmost segments in terms of market share, whereas the *industrial oil & gas processing* segment is projected to witness the highest growth rate.
Membranes Market by Type (Polymeric membranes, Ceramic membranes, and others), by Technology (MF, RO, UF, Pervaporation, Gas Separation, Dialysis, NF, and Others), by Region and by Application - Global Forecast to 2020 , October 2015

Water Scarcity: The FACTS

By 2025, an estimated 1.8 billion people will live in areas plagued by water scarcity, with two-thirds of the world's population living in water-stressed regions.

Water demand is projected to grow by 55 percent by 2050 (including a 400-percent rise in manufacturing water demand)

By 2050, 1 in 5 developing countries will face water shortages.

By 2030 humanity's "annual global water requirements" will exceed "current sustainable water supplies" by 40%.

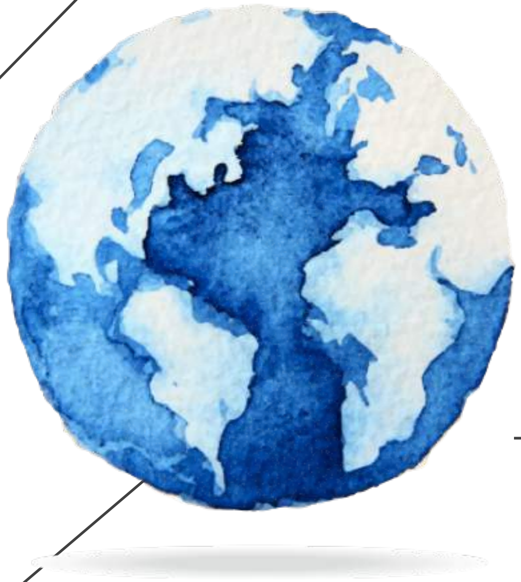
Source: http://www.seametrics.com/blog/global-water-crisis-facts/

Water Scarcity: The Factors

Population growth increases potable water demand

Sustainability of current water resources

Constant exploitation of natural resources by agricultural users

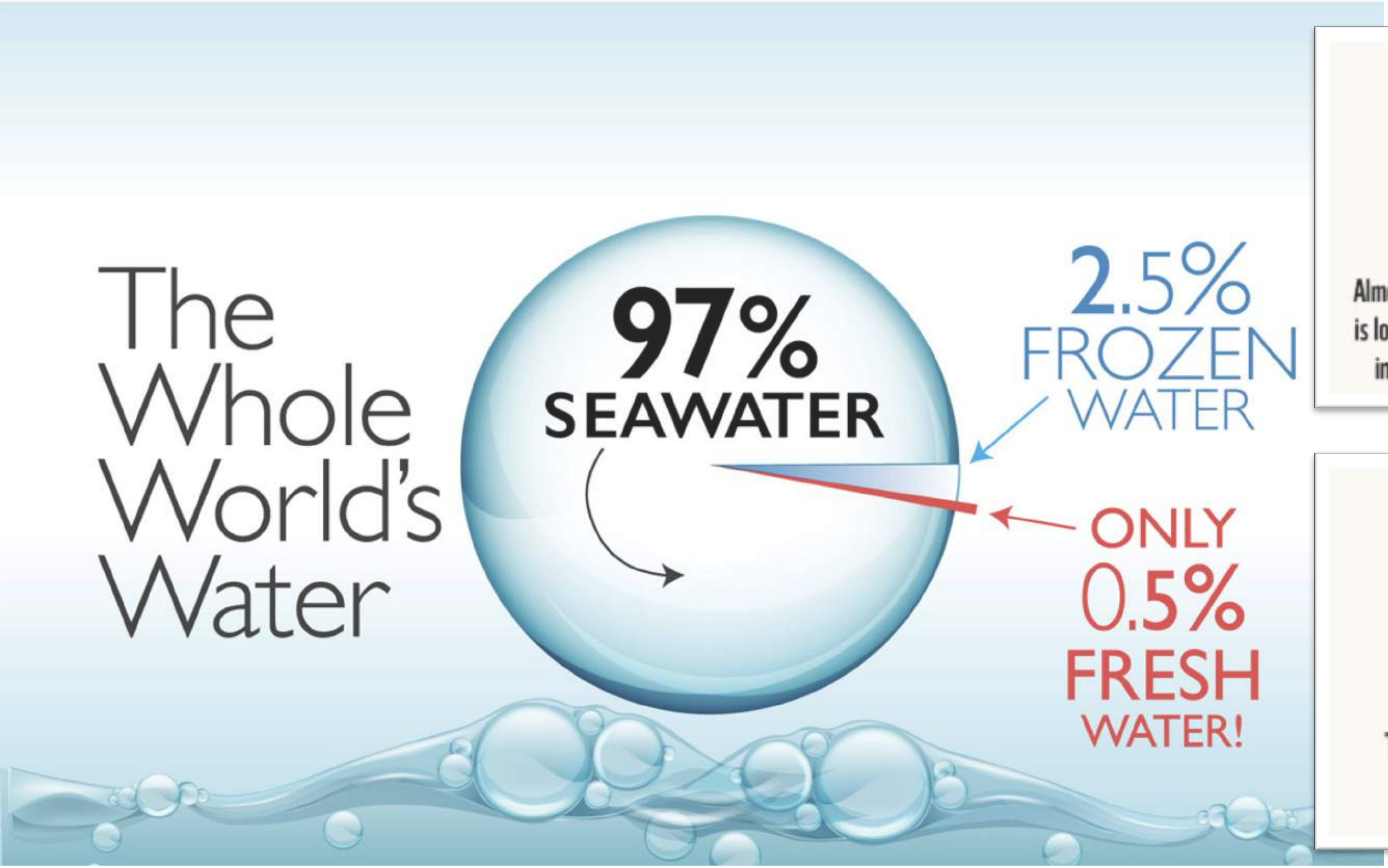


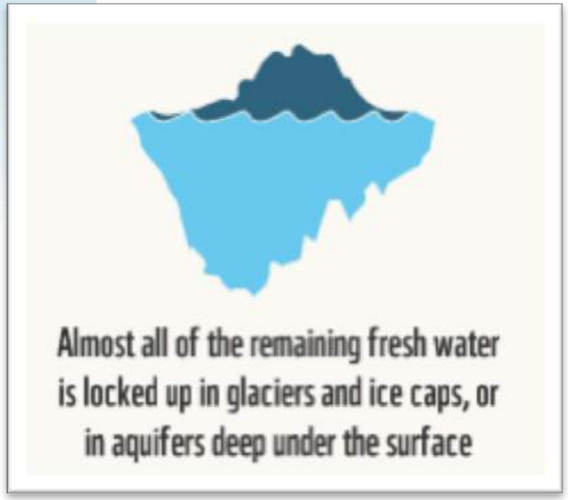
Portable water shortage due to natural disasters (earthquake, flood, etc.)

Water pollution due to industrial discharge/run off

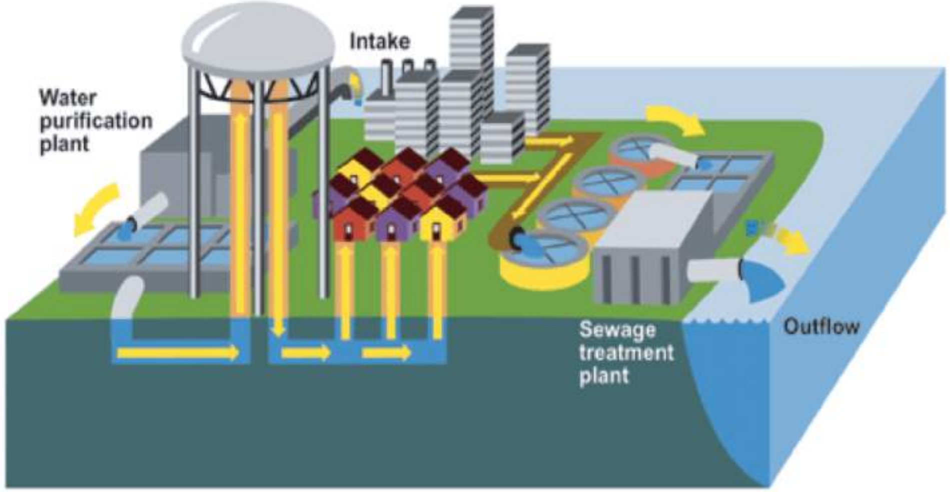
Climate change-Longer droughts are likely as weather patterns change

Availability of Freshwater

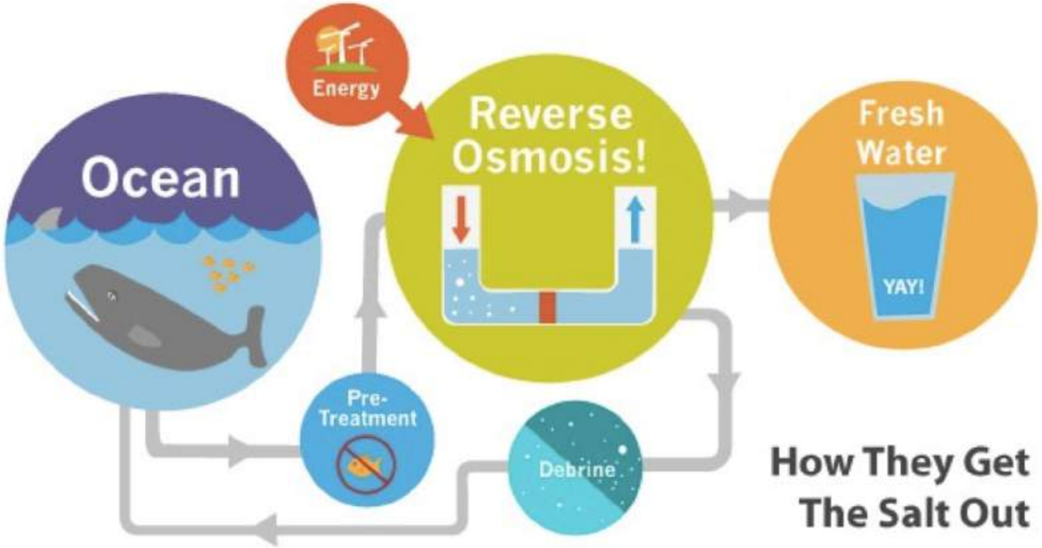




Engineering Solutions



Wastewater Treatment



Desalination

Desalination FACTS

The total number of desalination plants worldwide **~18,500**

The global capacity of commissioned desalination plants **>86.8 million cubic meters per day**

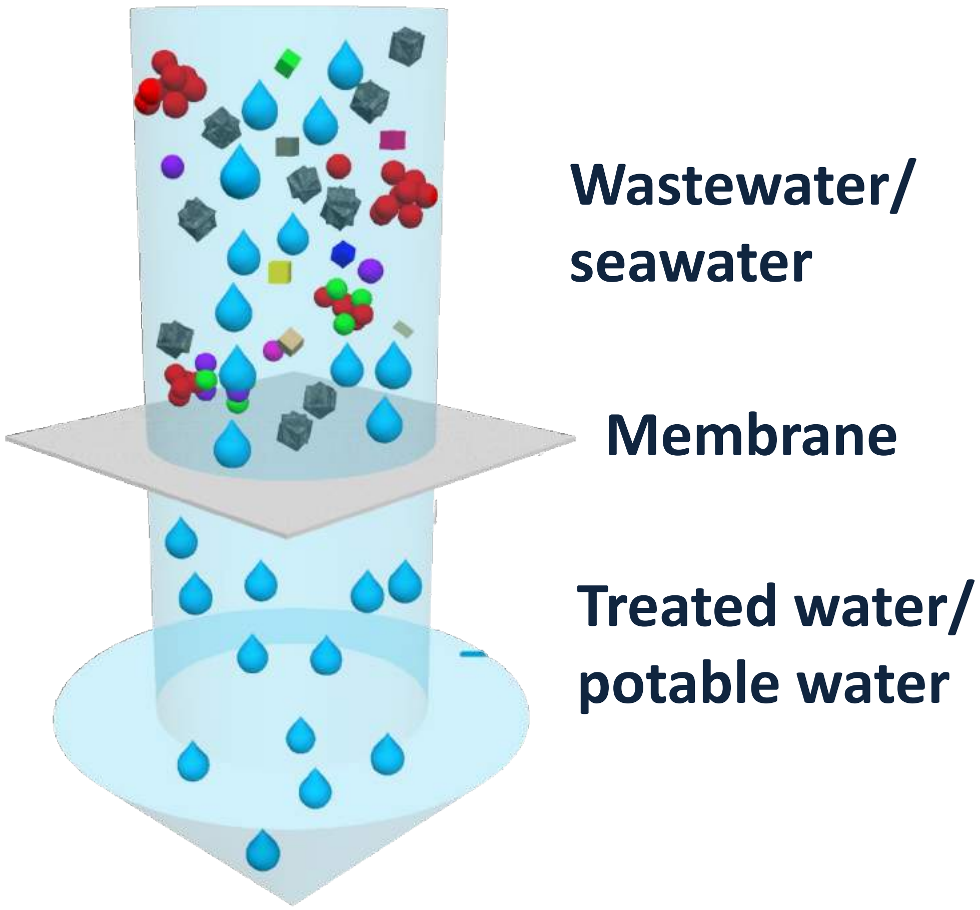
The number of countries where desalination is practiced **>150**

The number of people around the world who rely on desalinated water for some or all their daily needs **>300 million**

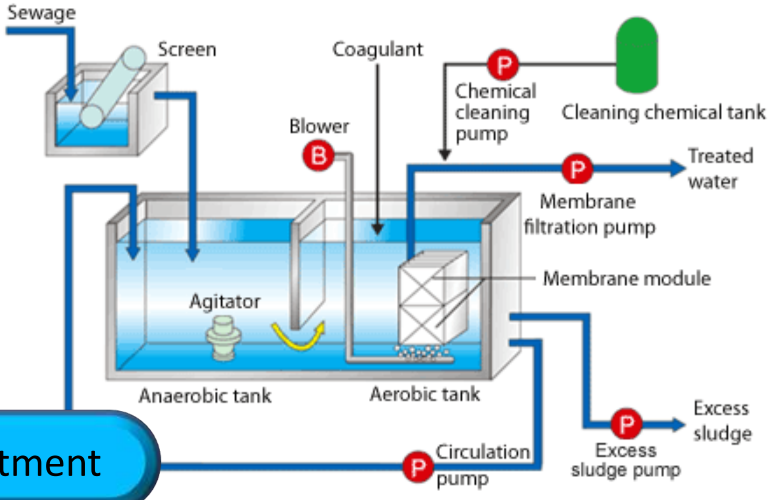
Source: http://idadesal.org/desalination-101/desalination-by-the-numbers/

How Membrane Technology HELPS?

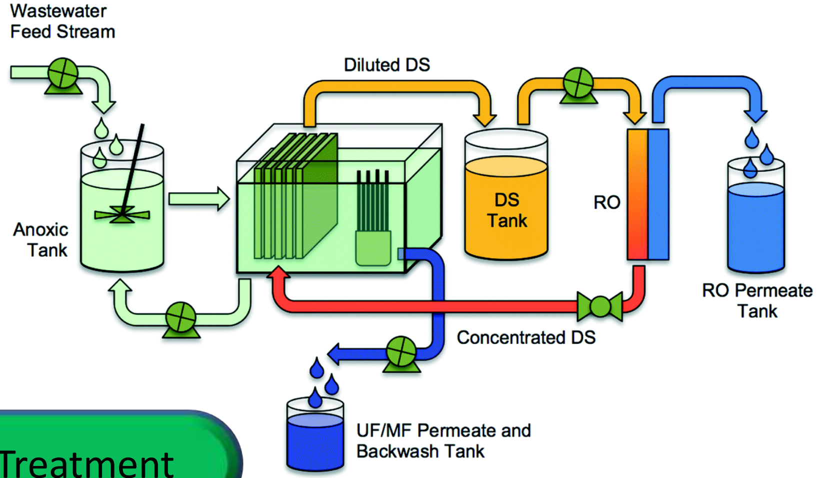
- Low energy cost and capital
- High Stability
- Sustainable
- Mechanically robust
- Ease of operation



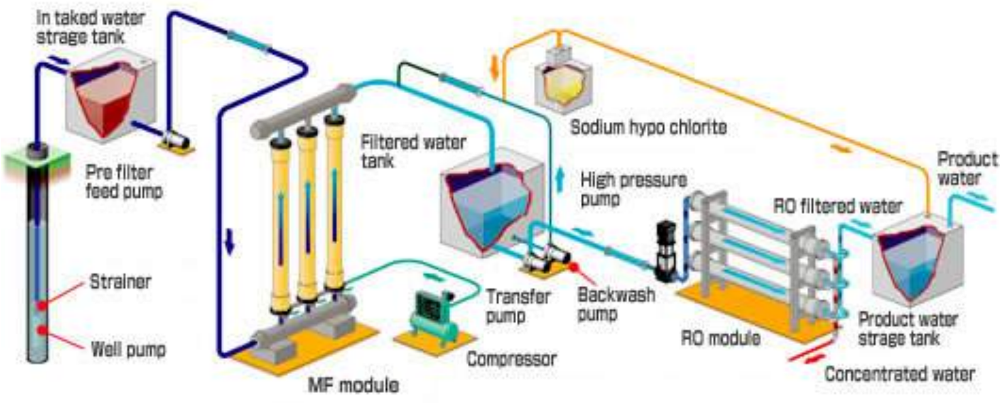
Membrane in Water Treatment



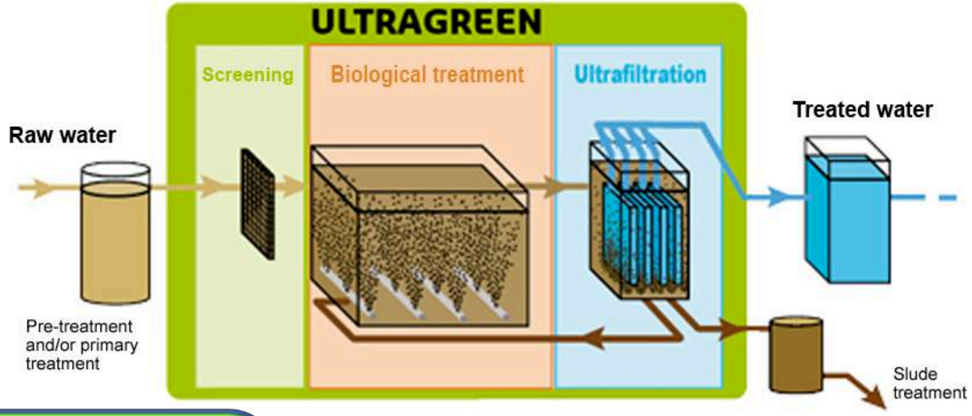
Sewage Water Treatment



Wastewater Treatment



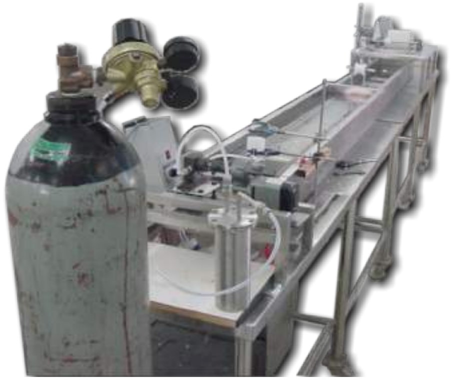
Seawater Desalination



Water Purification

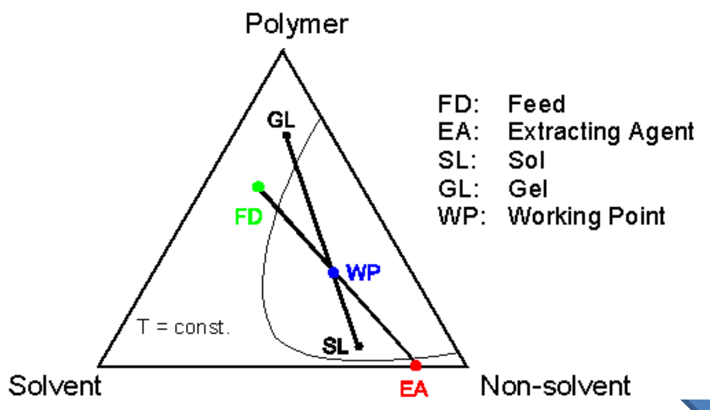
R&D&C of Membrane Technology

Synthesis → Material Characterization → Membrane Fabrication → Module Preparation → System Design and Testing → Field Test & commercialization



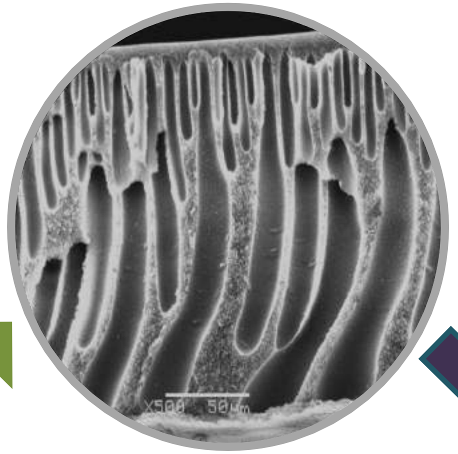
Multidisciplinary in Membrane Technology

ternary systems: solvent/non-solvent/polymer

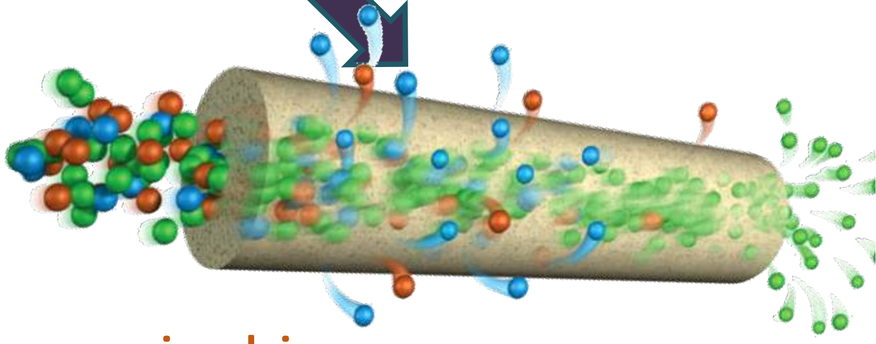


Fundamental sciences studies involving:
Material selection
Dope formulation

Manufacturing Processes involving:
Membrane fabrication
System/Equipment design



Material Science studies:
Membrane characterization
Membrane properties
fine-tuning



Separation Processes involving:
Molecular transport mechanism
Mass transport control

2. Current Trends in Membrane Technology for Wastewater treatment and Desalination

- Nanocomposite Membranes
- Energy-Efficient Membrane Processes
- Energy Harvesting based on Salinity Gradient

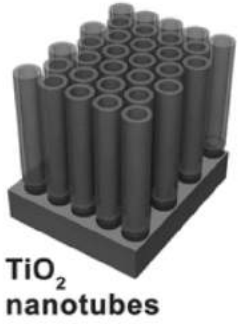
Nanocomposite Membranes

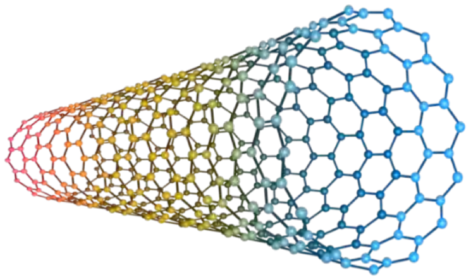
Membrane Design

Nanotube

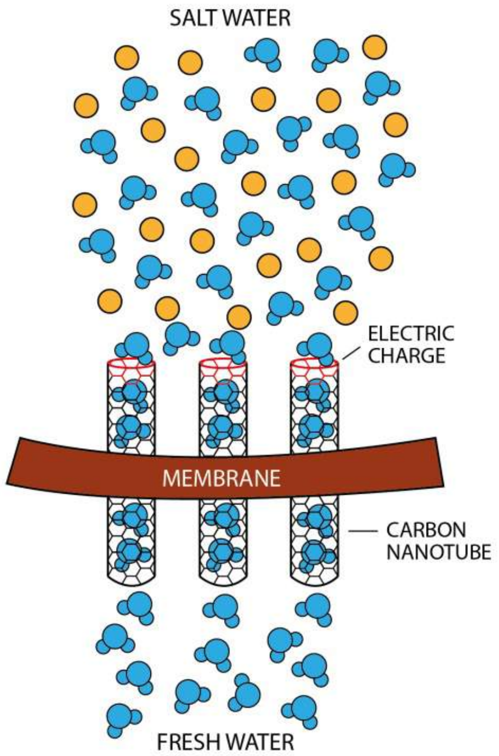
- Halloysite Nanotube
- Carbon Nanotube
- Titanium Nanotube

Changing the chemical composition at the opening of nanotube so that It can have charged or possess some functional groups





The charge at the opening of nanotube act as gate to repel salt ion and only allow water molecule to pass through.

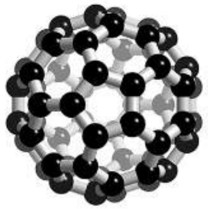


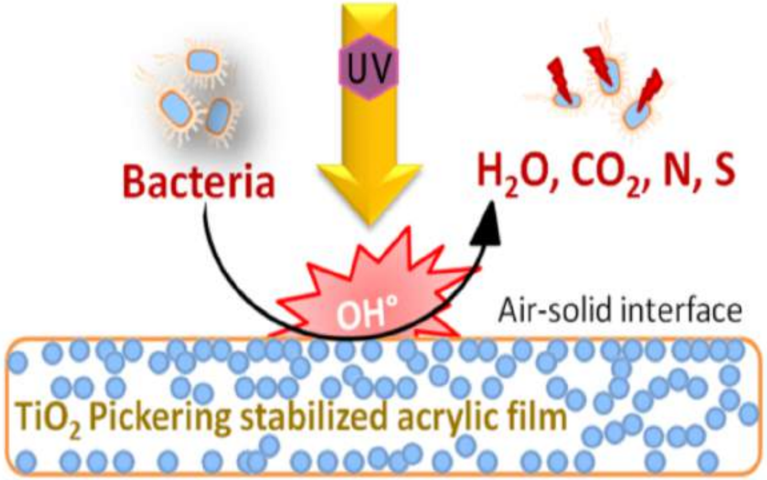
Nanocomposite Membranes

Membrane Design

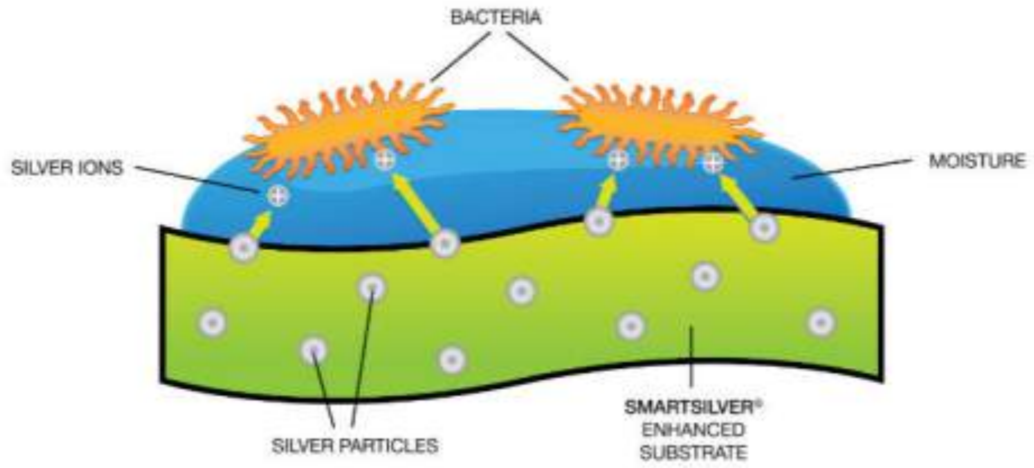
Nanoparticles

- Titanium Dioxide, TiO_2
- Silver, Ag
- Calcium carbonate
- Silver Phosphate, Ag_3PO_4





Most of the nanoparticle are metal oxide which could be easily hydrolyzed to form hydroxides.

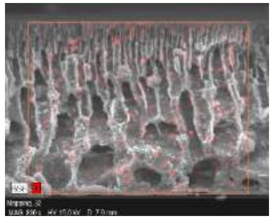


Eg: When TiO_2 or Ag nanoparticle are incorporated in a membrane, photocatalytic antibacteria and antivirus activities of TiO_2 occur simultaneously.

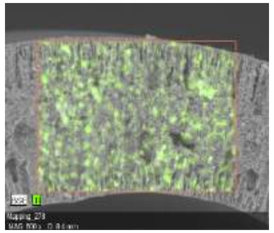
Photocatalytic Nanocomposite Membranes

Photocatalytic nanocomposite membrane development

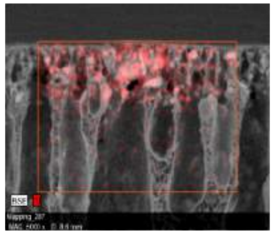
Flat sheet membrane

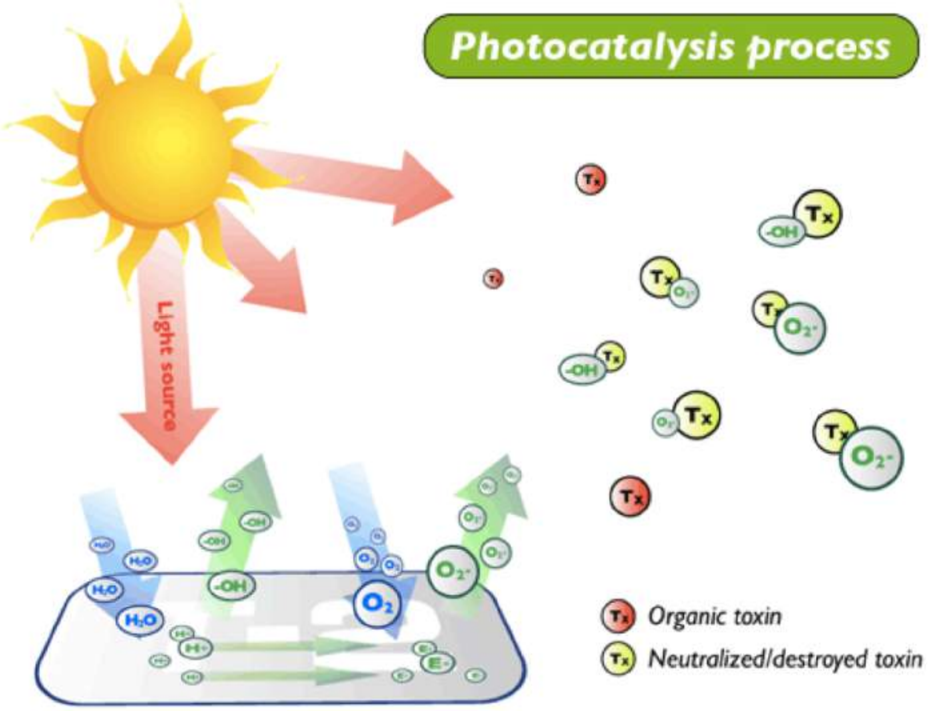


Single layer hollow fiber



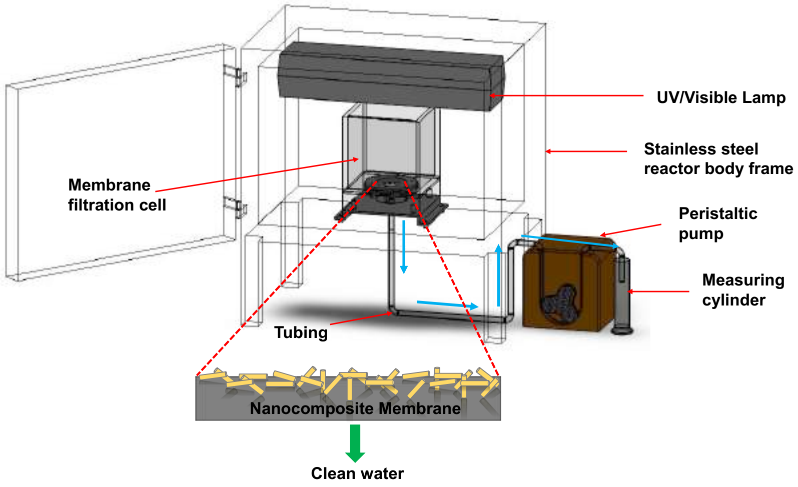
Dual layer hollow fiber

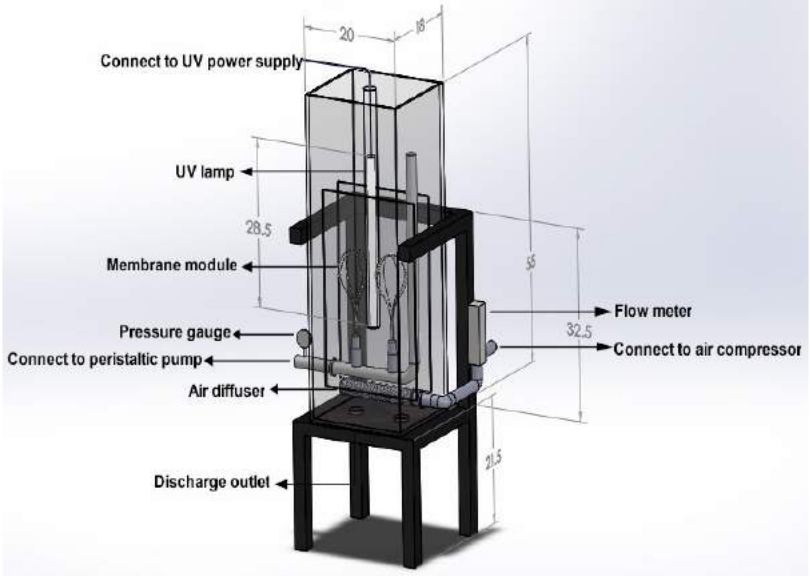




Photocatalytic Membrane Reactors

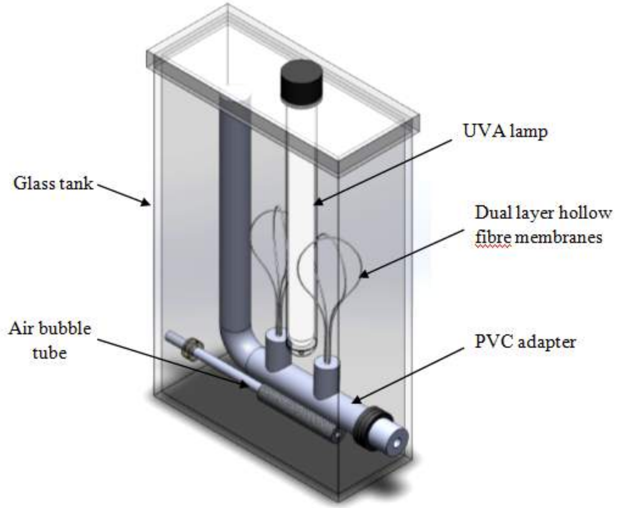
Membrane: Flat sheet membrane
Pollutant: Biphenol A (BPA)



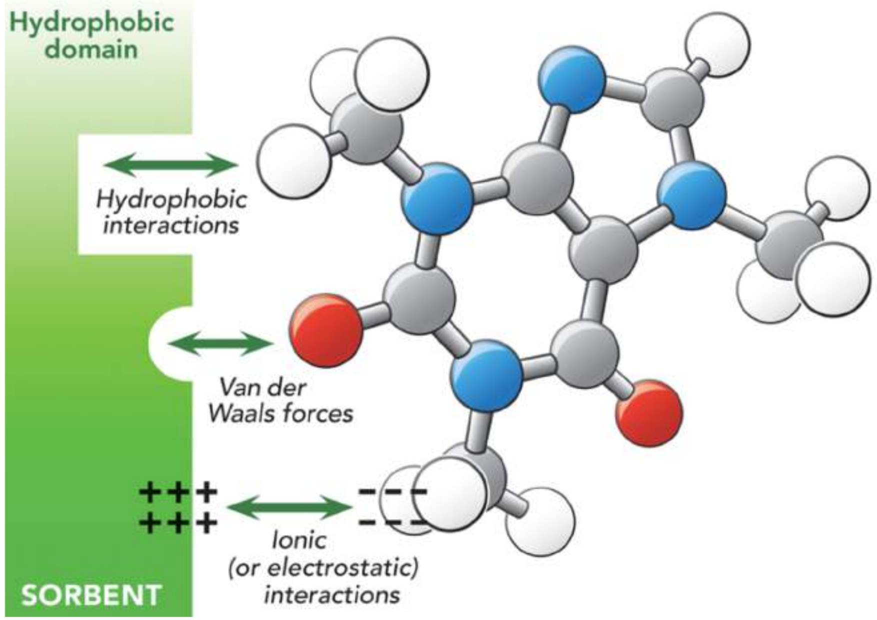


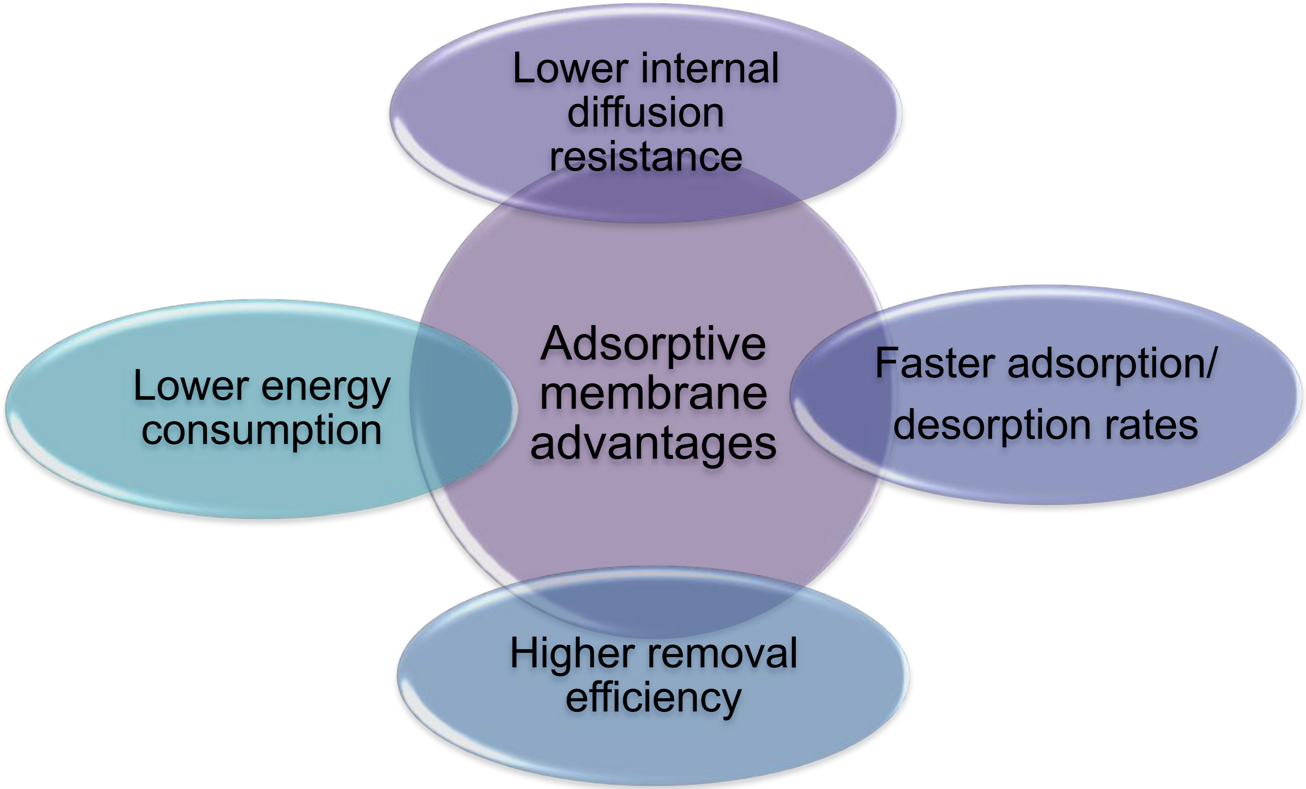
Membrane: Single layer hollow fiber membrane
Pollutant: Oily wastewater

Membrane: Dual layer hollow fiber membrane
Pollutant: Nonylphenol (NP)



Adsorptive Nanocomposite Membranes

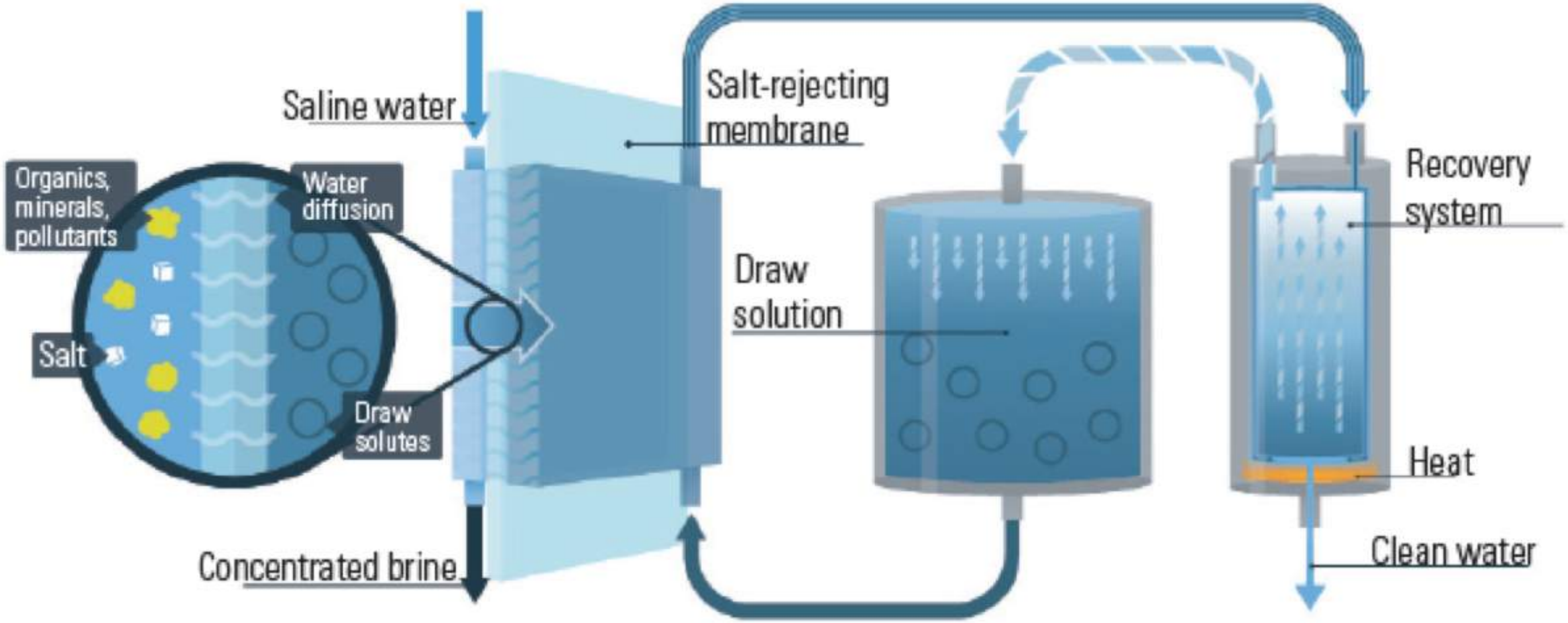




Porous adsorptive membranes are usually prepared by incorporating nano- or microsized adsorbents in the polymer matrix, creating mixed matrix membranes (MMMs)

In the adsorption operation, the solution flows through the membrane pores, performing adsorption and filtration in one step

Energy-Efficient Membrane Processes



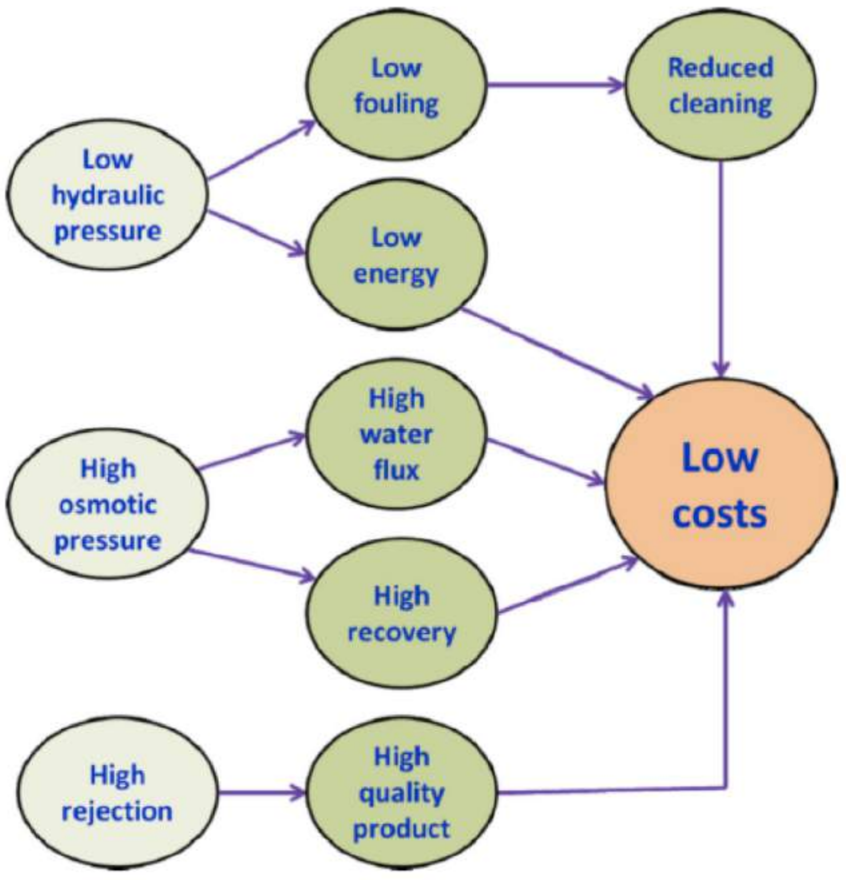
Forward osmosis (FO) is an **osmotically driven membrane process** that takes advantage of the osmotic pressure gradient to drive water across the semipermeable membrane from the **feed solution** (low osmotic pressure) side to the draw solution (high osmotic pressure) side.

Image: Oasys Water

Energy-Efficient Forward Osmosis

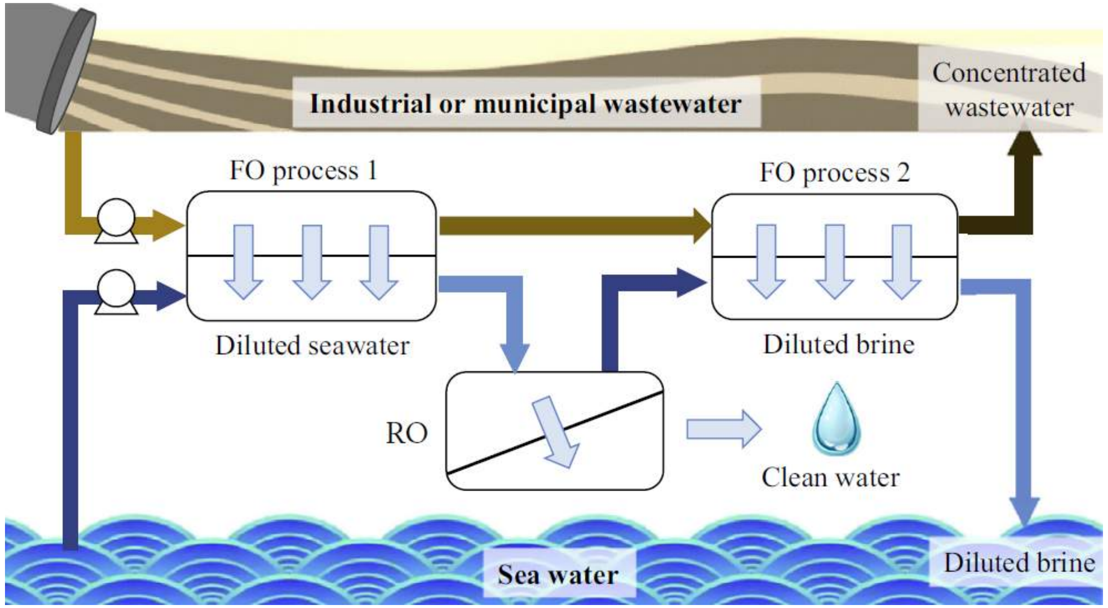
The potential benefits of FO used in water treatment

- Due to the very low hydraulic pressure required, FO delivers many potential advantages over conventional pressure driven membrane processes, such as:
  - less energy input
  - lower fouling tendency
  - easier fouling removal
  - higher water recovery



Zhao et al. Journal of Membrane Science 396 (2012) 1– 21

Energy-Efficient Hybrid System: FO-RO



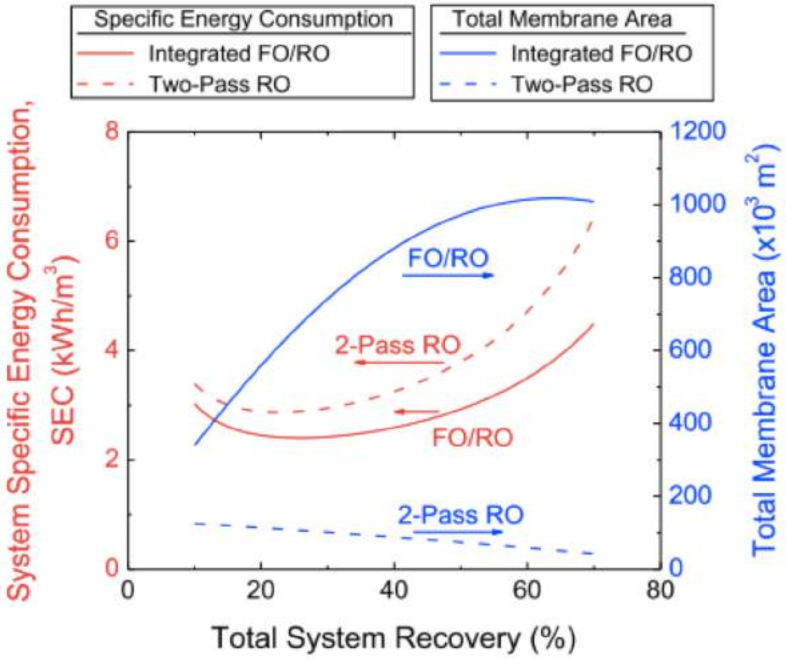
The key benefits include

(i) Energy saving

(ii) Chemical storage and feed systems may be reduced for capital and operations and maintenance cost savings,

(iii) Water quality is improved for increased consumer confidence and reduced process piping costs

(iv) The overall sustainability of the desalination process is improved.



Specific energy consumption (SEC) and total membrane area of an integrated FO-RO seawater desalination process compared to a two-pass RO process.

Chung et al. Separation and Purification Technology 156 (2015) 856-860, Shaffer et al. Journal of Membrane Science 415–416 (2012) 1–8

Energy-Harvesting through Salinity Gradient

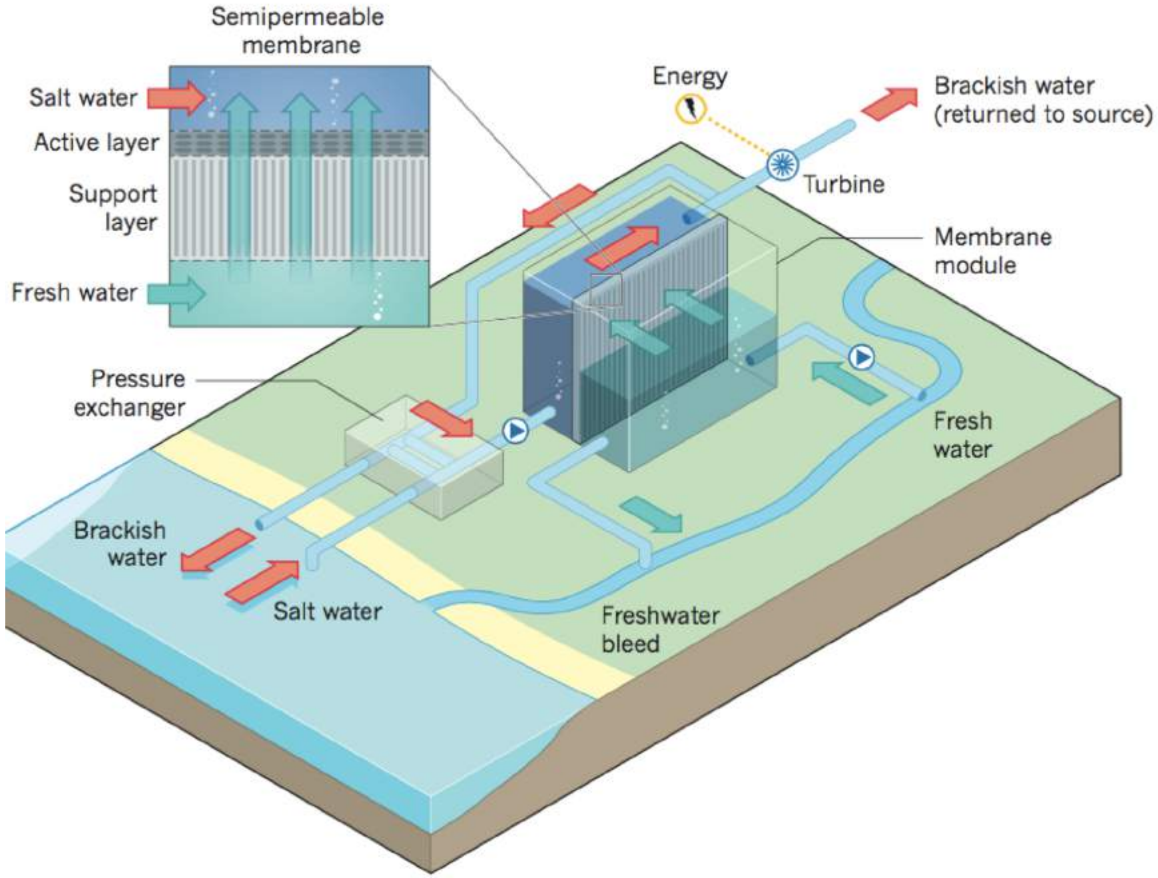
- Salinity gradient energy SGE is a zero-emission and sustainable technology that can be practically applied worldwide to harvest **Blue Energy**.

- When the two mediums are mixed, the SGE can be generated based on the Gibbs free energy.

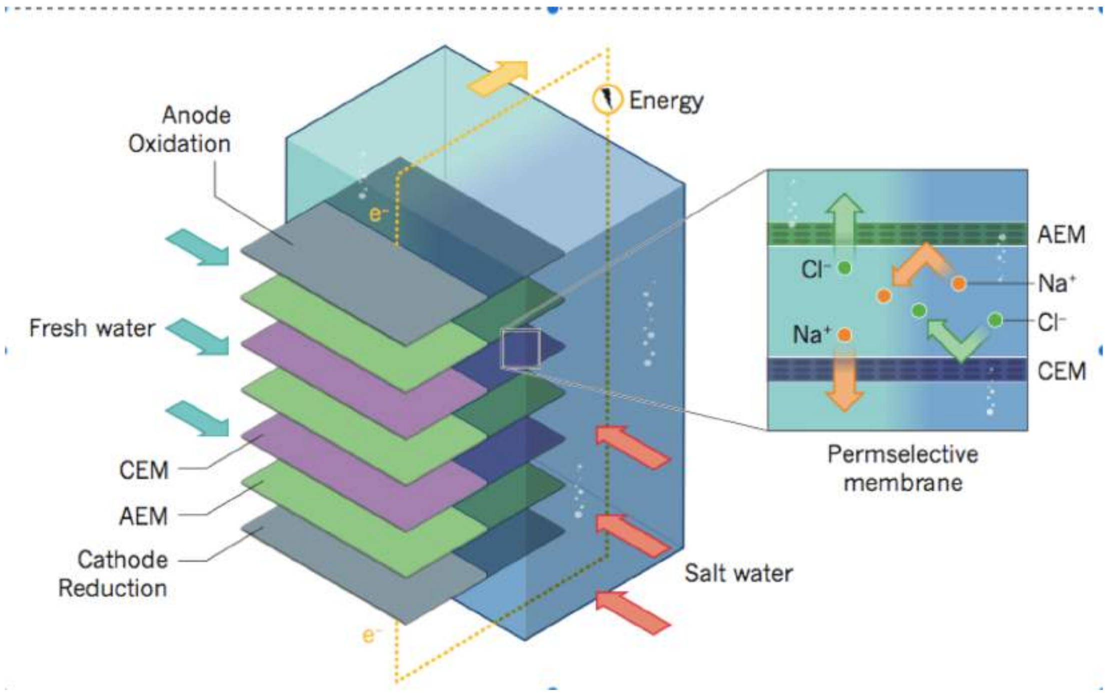
- Pressure retarded osmosis (PRO) and reverse electrodialysis (RED) are the two most commonly known SGE methods that based on membrane technology.

PRO & RED

PRO

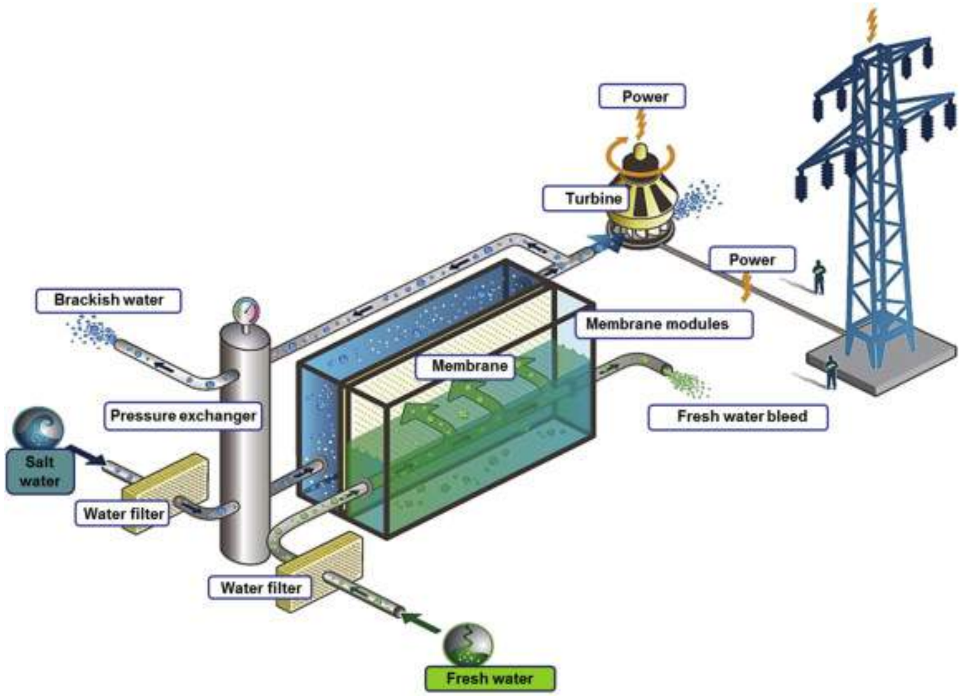


RED



Logan and Elimelech Nature 488 (2012) 313

PRO – Current Development and Challenges



PRO technology generates power by using an **osmotic pressure difference** across a semipermeable membrane to produce a flux of water from a low concentration feed solution to a high concentration draw solution.

Image: Pressure retarded osmosis (PRO) system for salt water adopted by Statkraft (2014) (Water Research, 2014, 66, 122-139)

Theoretically, the maximum extractable energy during the reversible mixing of a dilute stream with saline draw solutions ranging from 0.75 -14.1 kWh/ cubic metre of the low-concentration stream. The actual energy extracted will always be lower because of inherent, irreversible energy losses.

Challenges

- low-cost and robust membranes that have minimal ICP and fouling
- Reverse salt flux in the PRO subsystem

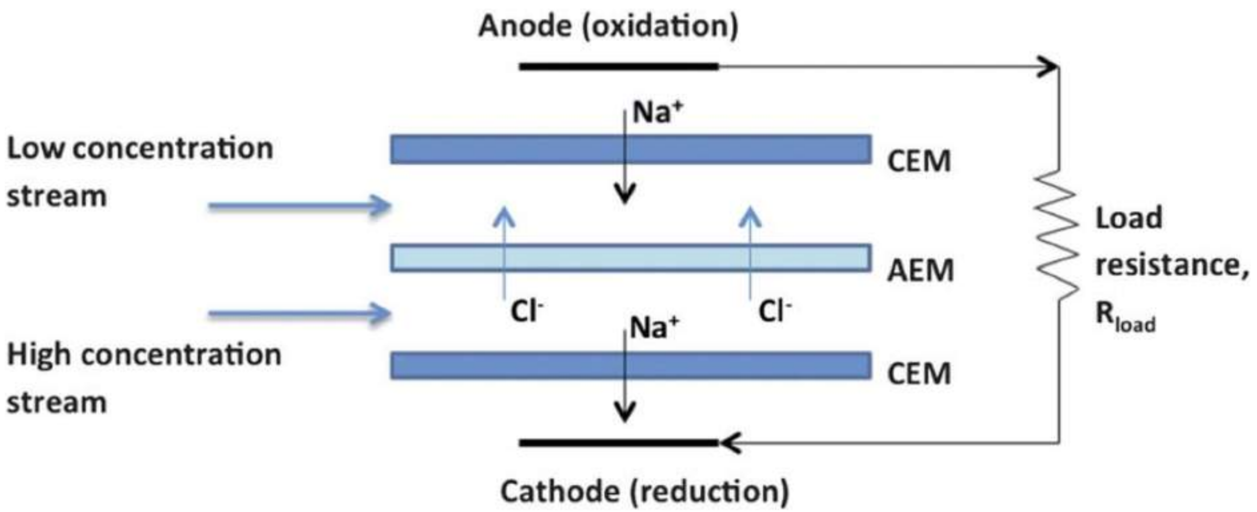
Way forward

- Designing highly selective PRO membranes with a minimal salt permeability
- Employing a novel draw solute that possesses a large molecule size and negligible leakage

(Environ. Sci. Technol., 2015, 49, 13050-13058)

RED – Current Development and Challenges

In RED, the energy generated by the mixing of fresh and salt water based on alternating **cation-exchange membranes (CEMs) and anion-exchange membranes (AEMs)**, with low- and high-concentration solution flowing through each alternate channel. **The difference in electrochemical potential** as a result of the positive ions moving one way and the negative ions moving the other is turned into an electrical current at the electrodes.



Challenges

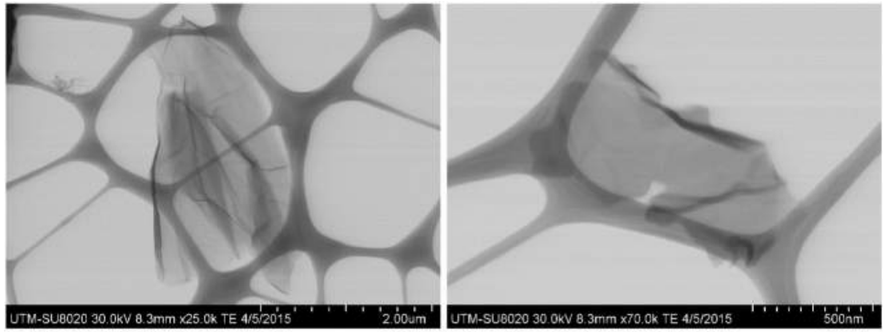
- The cost of ion-exchange membranes
- At least 20 pairs of membranes are needed to overcome energy losses at the electrodes
- Safety concern: Water splitting releases oxygen and, from seawater, toxic chlorine gas from the anode, and potentially explosive hydrogen gas at the cathode

Way forward

- Improvement of membrane materials, membrane spacing and architecture.
- Introducing ridges and flow patterns into the membrane material to avoid using to reduce the size of RED systems 50 and increasing power generation.

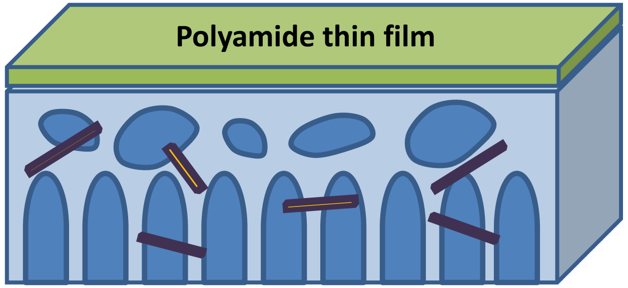
PERFORMANCE EVALUATIONS

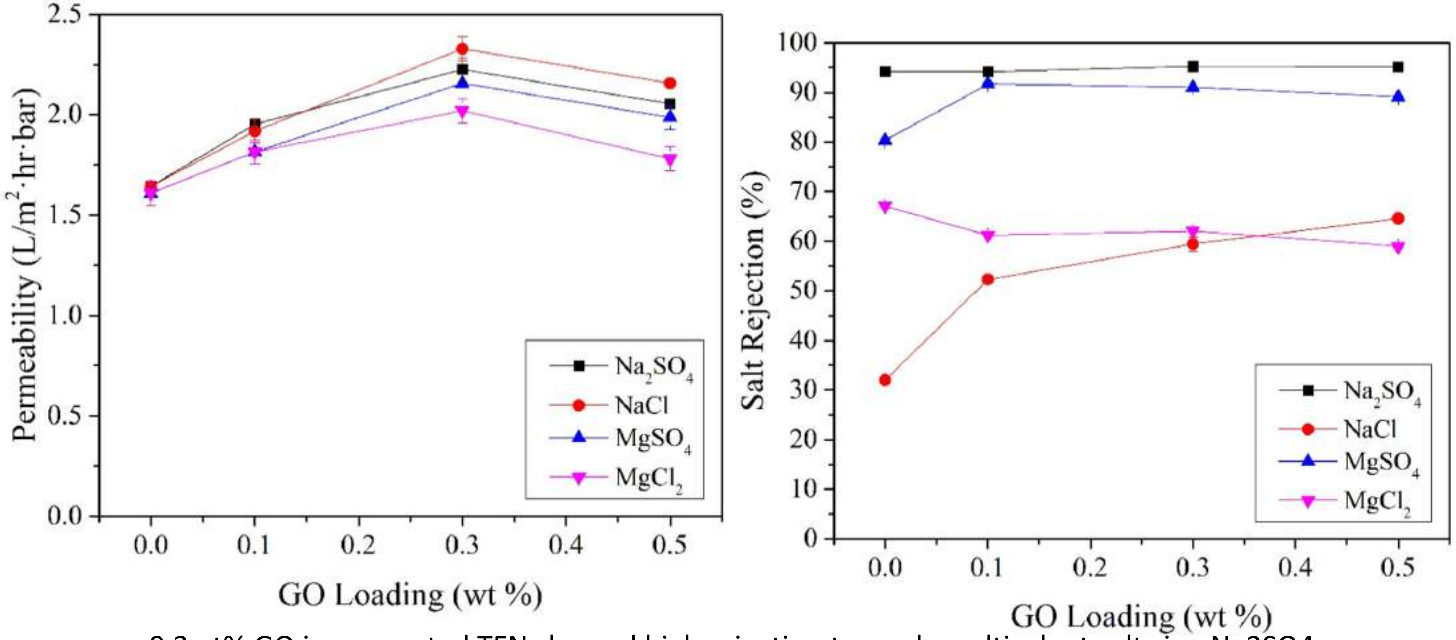
GO/TFN for Nanofiltration



Synthesized GO is single flake form in nature. The sp2 hybridization state of carbon in graphene changed into sp3 hybridization state in GO, resulting in the disruption of the original planar structure of graphene into a wrinkled structured in GO

TFN Formation





- 0.3wt% GO incorporated TFN showed high rejection towards multivalent salts i.e. Na2SO4 rejection: 95.2% and MgSO4 rejection 91.1%.
- GO nanosheets has potential to overcome trade-off effect encountered by typical TFC membrane i.e. increasing both membrane water permeability and salt rejection.
- The improvements were due to unique characteristics of GO nanosheets, i.e. highly charged and hydrophilic surfaces.

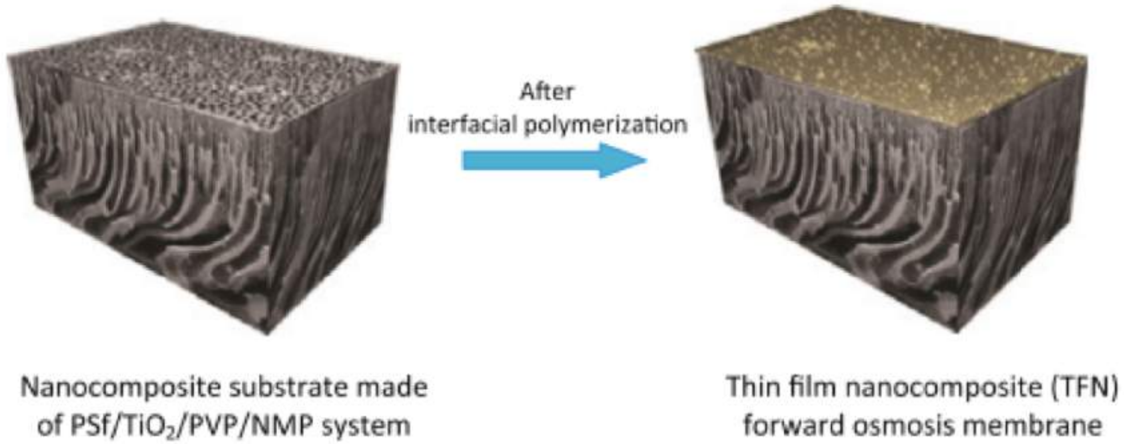
Ismail et al. Desalination 387 (2016) 14–24

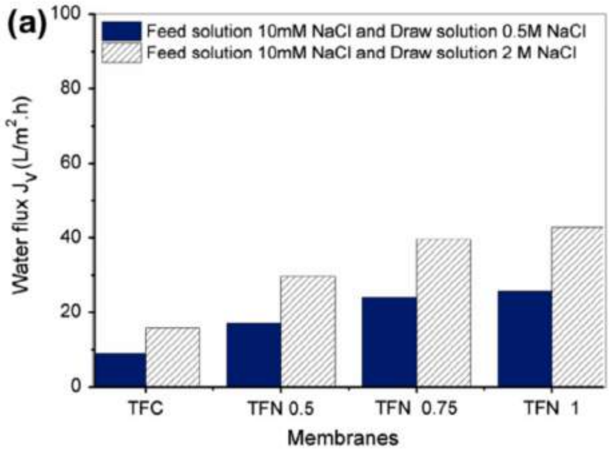
TiO2/TFN for Forward Osmosis

Nanocomposite Membrane:

TiO2 TFN for FO

Polyamide TFN with PSf–TiO2 nanocomposite substrate

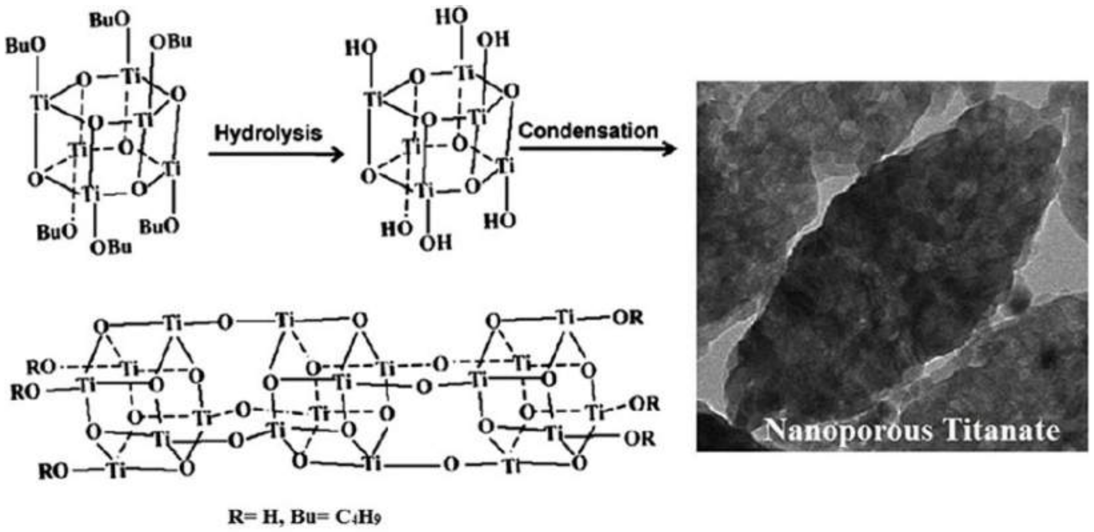




- The hydrophilicity and porosity of the PSf– TiO2 nanocomposite substrate was improved upon addition of TiO2.
- TFN prepared from PSf substrate embedded with 0.5 wt% TiO2 was found to be the best performing FO membrane for water desalination process owing to its high water permeability and low reverse solute flux, without compromising rejection
- The increase in water permeability can be attributed to decrease in structural parameter which resulted in decreased internal concentration polarization (ICP).

A.F. Ismail et al. / Chemical Engineering Journal 237 (2014) 70–80

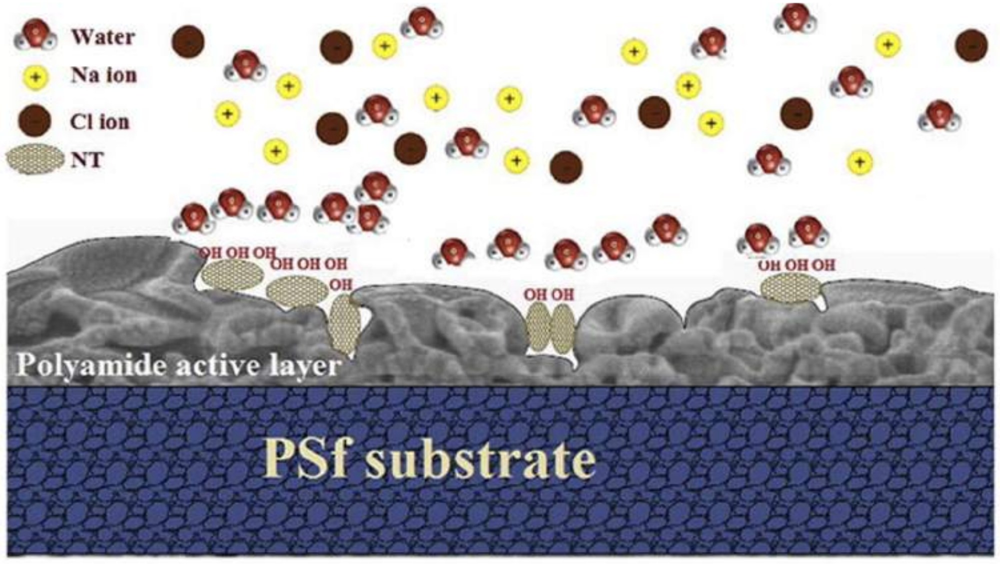
Nanoporous Titanate/TFN Antifouling Membranes



Hydrophilic nanoporous titanate senhanced miscibility of the organic and aqueous phases during interfacial polymerization- Enhanced the interfacial polymerization rate.
The existence of large number of hydroxylgroups (-OH) on the surface of nanoporous titanate improved membrane hydrophilicity

Ismail et al. Materials Science and Engineering C 75 (2017) 463

The presence of strongly hydrated layer at the hydrophilic polyamide surface tends to reduce the adsorption of combined BSA and SiO_2 to the membrane surface

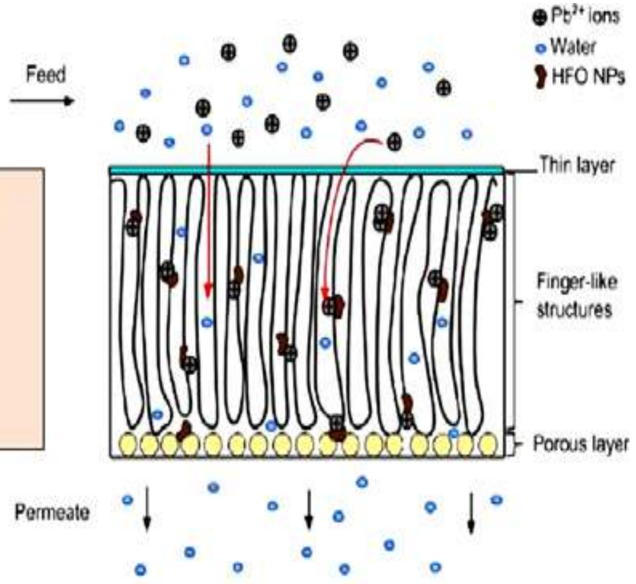


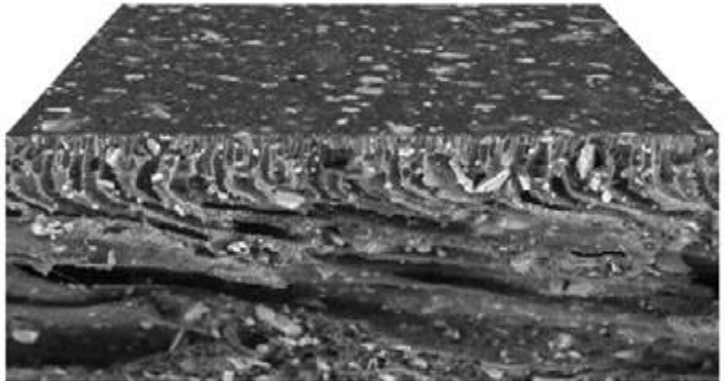
Thin film nanocomposite membrane

Hydrous Ferric oxide MMM adsorptive Membrane

Polysulfone/hydrous ferric oxide ultrafiltration mixed matrix membrane for adsorptive removal of Pb(II)

Properties of PSf/HFO NPs MMMs (M-1.5):
Porosity: 88.8 %
Contact angle: 8.0°
Surface roughness: 74.8 nm
Pure water flux: 942.1 $L/m^2.h$
Pb(II) adsorption capacity: 13.2 mg/g
Pb(II) filtration study: 4000cm^3 <15 µg/L

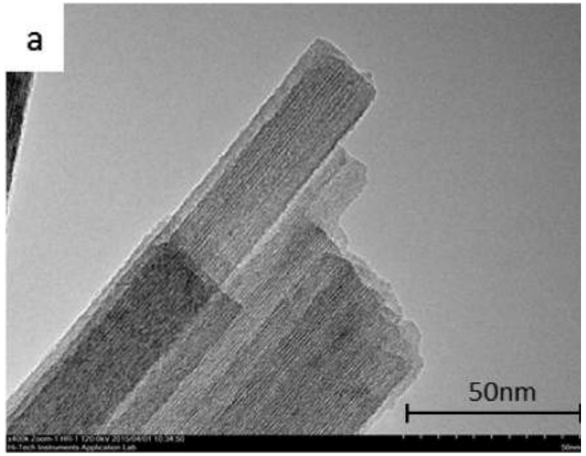


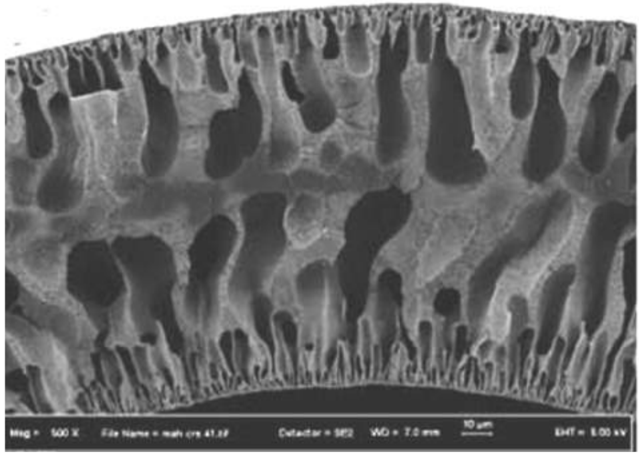


- ✓ Hydrous ferric oxide (HFO) is known to have excellent properties against Pb ions
- ✓ This is due to its high specific surface area to volume ratio, fast kinetic rate, environmental friendly and widely available

A.F. Ismail et al. *Chemical Engineering Journal 289 (2016) 28-37*

Titania Nanotube/PVDF Membrane





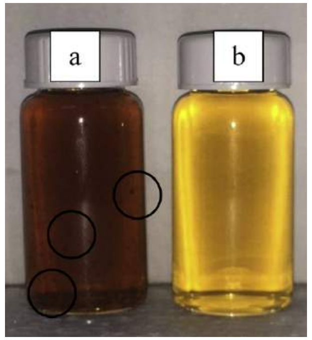
Unique properties of TNT:

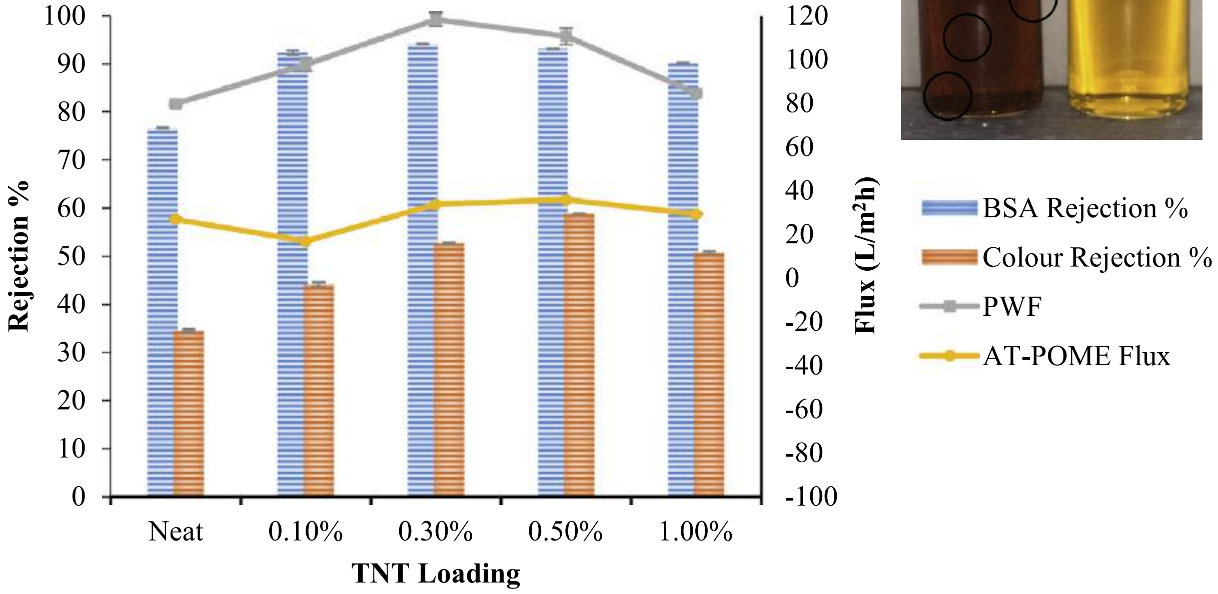
- High surface area due to tubular structure
- Highly hydrophilic for anti-fouling properties

PVDF-TNT 0.5% TNT exhibited the most promising result in terms of AT-POME flux, AT-POME colour removal and fouling stability and recovery (90% flux recovery and >95% rejection recovery rate) after 5 cycles of filtration.

A.F. Ismail et al. Chemical Engineering Journal 316 (2017) 101-110

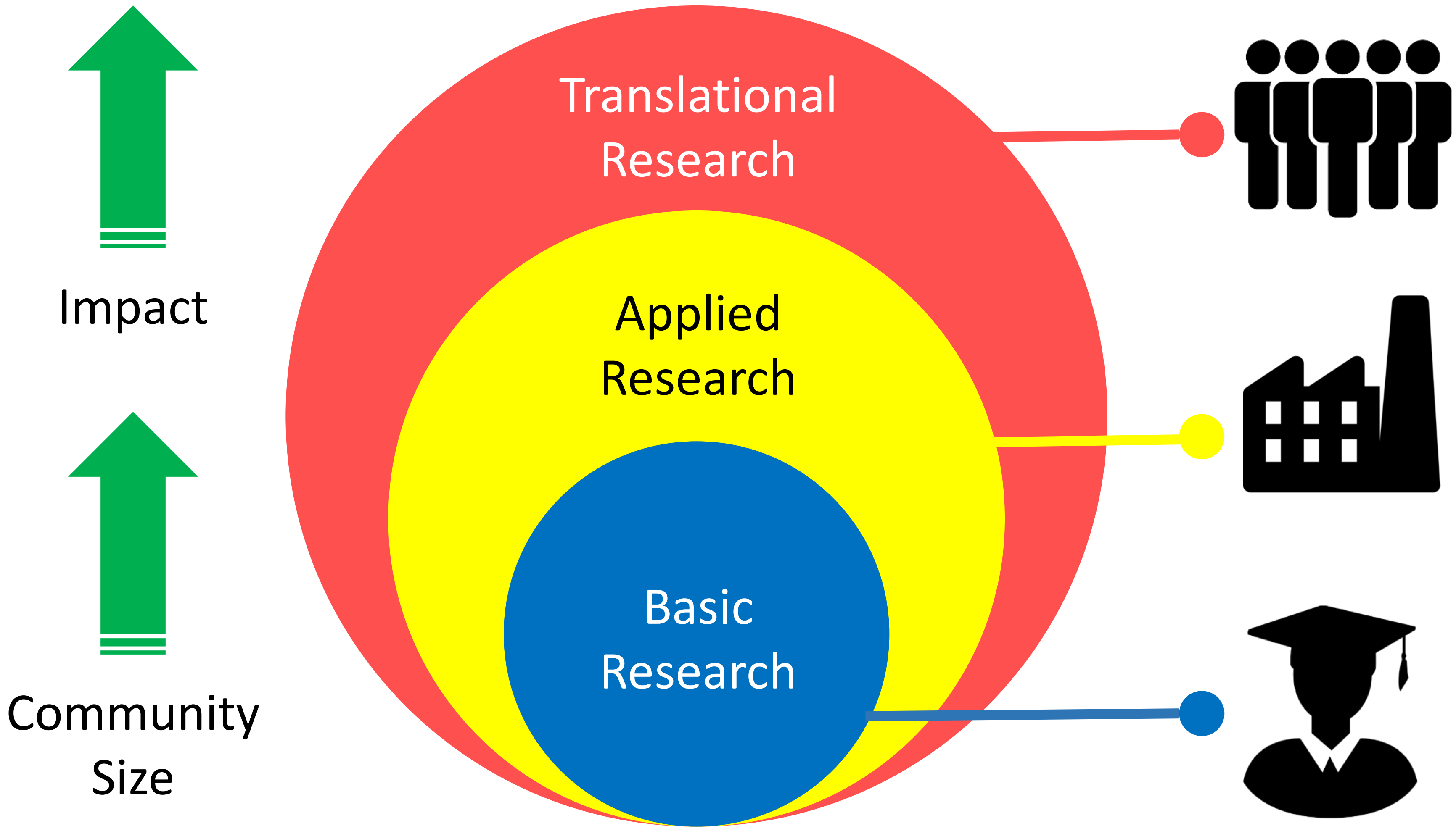
PVDF/TNT Hollow fiber mixed matrix membrane for **decolourization of AT-POME**





Translational Research & Commercialization

Route to Translational Research



Desalination Plant@Pantai Senok, Kelantan, MALAYSIA

Water Quality Analysis Before and After Treatment

Results of Analysis

Parameter	Unit	Method	Seawater	SWRO	* Permitted Level
Physical standard					
pH	-	APHA 4500 H^+ B	7.6	6.5	6.5 - 8.5
Colour	TCU	APHA 2120 B	10 *	< 5	15
Turbidity	NTU	APHA 2130 B	2.7 *	0.30	2
Chemical standard					
Aluminium as Al	mg/L	APHA 3030 F / USEPA 6010 B	0.05	ND (< 0.02)	0.2
Barium as Ba	mg/L	APHA 3030 F / USEPA 6010 B	0.08	ND (< 0.02)	0.7
Biocides (Total)	mg/L	USEPA 8270 B	ND	ND	0.1
Boron as B	mg/L	APHA 3030 F / USEPA 6010 B	2.7 *	0.5	0.5
Cadmium as Cd	mg/L	APHA 3030 F / USEPA 6010 B	ND (< 0.002)	ND (< 0.002)	0.003
Carbon Chloroform Extract	mg/L	GC - In House	ND	ND	0.5
Chloride as Cl^-	mg/L	APHA 4500-Cl^- B	14,120 *	110	250
Fluoride as F^-	mg/L	APHA 4500-F^- D	< 0.1	< 0.1	0.6
Hardness as $CaCO_3$	mg/L	APHA 2340 C	4,300 *	4	500
Iron as Fe	mg/L	APHA 3030 F / USEPA 6010 B	0.19	ND (< 0.02)	0.3
Lead as Pb	mg/L	APHA 3030 F / USEPA 6010 B	ND (< 0.01)	ND (< 0.01)	0.01
Magnesium as Mg	mg/L	APHA 3030 F / USEPA 6010 B	871 *	0.8	150
Manganese as Mn	mg/L	APHA 3030 F / USEPA 6010 B	0.05	ND (< 0.02)	0.1
Mercury as Hg	mg/L	APHA 4500 Hg / APHA 3112 B	ND (< 0.001)	ND (< 0.001)	0.001
Mineral Oil	mg/L	AOAC 945.102 (Mod.)	ND	ND	0.3
Nickel as Ni	mg/L	APHA 3030 F / USEPA 6010 B	ND (< 0.02)	ND (< 0.02)	0.02
Nitrite as NO_2^-	mg/L	APHA 4140 B	< 0.1	< 0.1	0.2
Nitrate as NO_3^-	mg/L	HACH Nitrate Test Kit	< 0.1	0.1	50
Nitrate as N	mg/L	HACH Nitrate Test Kit	< 0.1	< 0.1	10
Phenol as C_6H_5OH	mg/L	HACH Method 8047	ND (< 0.002)	ND (< 0.002)	0.002
Residual Chlorine (Free) as Cl_2	mg/L	APHA 4500-Cl G	0.13	0.05	≥ 0.2
Sodium as Na	mg/L	APHA 3030 F / USEPA 6010 B	3,793 *	54	200
Styrene	mg/L	USEPA 8260 B	ND	ND	0.2
Sulphate as SO_4^{2-}	mg/L	APHA 4500-SO_4^{2-} E	180 *	4	250
Zinc as Zn	mg/L	APHA 3030 F / USEPA 6010 B	0.06	0.15	3
Total Dissolved Solids	mg/L	APHA 2540 C	17,100 *	150	-

Remarks :

*Standard for Water, 25th A Schedule of Malaysian Food 1983 (Act 281) & Regulation (Subregulation 394 (1)) as at ubregulation 394 (1)) as at 1st March 2013.

Issues in Pantai Senok

- No natural supply of potable water- over dependent on tube well supply
- Yellowish and poor water quality supply

The Necessity & Societal Benefits

- SWRO DESAL with max. capacity of 0.5 MLD can benefit 3,300 residents (150 Litre/person) for sustainable daily freshwater supply.
- The clean and sustainable water supply is the catalyst to revive the tourisms industry


SWRO Plant Location

Site Location of Desalination System Installation

DESALINATION SYSTEM:

- *Capacity:* 500 m^2 water storage
- Can provide water supply for 3,300 people

Water Quality :

Salinity	: 17- 38 ppt
Ammonia	: 0.01-0.45 ppm
pH	: 7-8.5

COMMUNITY IN KG. SENOK:

- Total community : ~3000 person
- No. of people who are desperately suffered with water shortage: more than1000 person

LAND ACQUISITION:

- Rental/ purchase
- Ownership of the land
- Area: ¼ acres for the plant and storage system

CONCLUSION:

We are introducing the technology from university to the public and benefits the community in Kg. Senok up to 3,300 peoples.


DILARANG MASUK
UTM
UNIT
PROJEK PENYELIDIKAN TRANSLASIONAL
LOJI NYAHGARAM AIR LAUT
PANTAI SENOK
BACHOK, KELANTAN

FLOOD RELIEF

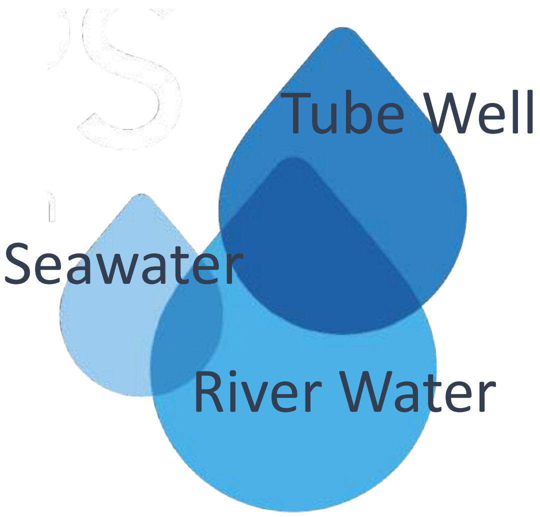
9

Home-grown portable membrane water filtration system

Benefits to

>12,000

Estimated population in Malaysia



Water Sources

Integrated mobile reverse osmosis (RO) water purification system (UTM Membrane)

Clean water support without committing large water production assets from the logistics support structure.

Our Experiences

Membrane system for surface water/ river water treatment

Features:

- Portable system
- Beneficial to 2,000 users (20,000 litre/day)
- High water quality <0.1 NTU
- 99.9 % bacteria and viruses removal
- 100% colloidal removal
- Low cost and maintenance
- No chemicals are required
- Includes back flushing system for cleaning purpose

Our Experiences

Membrane system for brackish/sea water treatment

Features:

- Portable system
- Beneficial to 300-500 users (6000 litre/day)
- High water quality < 0.1 NTU
- 99.9 % bacteria and viruses removal
- 100% colloidal removal
- Low cost and maintenance
- No chemicals are required
- Includes back flushing system for cleaning purpose

AMTEC-AIRB JOINT VENTURE

Main Design Parameters		
Feed Water Capacity (treated WW)	:	1,600 m³/ day
Recycled Water Capacity	:	1,000 m³/ day
Operating Hours	:	21 Hours
System Design Configuration	:	2 x 50%
Treated Water Quality		
Temperature	:	30-36 Celsius
pH	:	6.0 - 8.5
Conductivity	:	< 200 ppm

30%

Cost Saving on water treatment

50%

Reduction in raw water procurement

Extra **50%** of raw water supply can be rechannelled to approx. **3300 people**!

Major TRANSLATIONAL RESEARCH Output

OUTPUT

0.5 MLD of Safe and Clean RO water

Social-economic upgrading in Senok District

Health improvement

Future Outlook

Exploration of more functional and advanced materials/ nanomaterials

Membrane improvement based on emerging materials and membrane design

Integrated system of pressure driven + osmotically driven processes for desalination and wastewater treatment

Membranes and membrane systems for wider emerging treatment applications and commercialization

Concluding Remarks

- Membrane technology is a promising technology to address water shortage issues through **wastewater treatment and desalination**
- Innovation focused on improved **membrane materials** and **system configurations** to reduce equipment and operating costs.
- The current trend of membrane science and technology involves the **development of high performance nanocomposite membrane, energy-efficient membrane processes and blue energy harvesting**
- Membrane technology holds tremendous potential for **translational research** and **global market opportunity**.

Acknowledgements

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THANK YOU!

A. F. Ismail (Fauzi)
fauzi@utm.my or fauzi.ismail@gmail.com
www.utm.my/amtec