Membrane Technology as a Promising Solution for Water Security and Challenge

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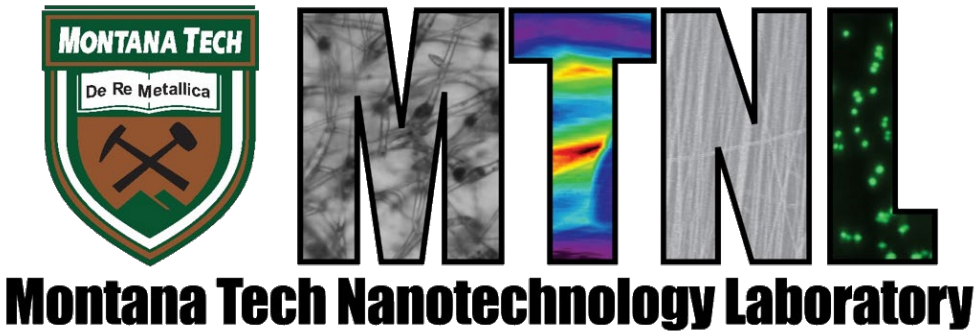

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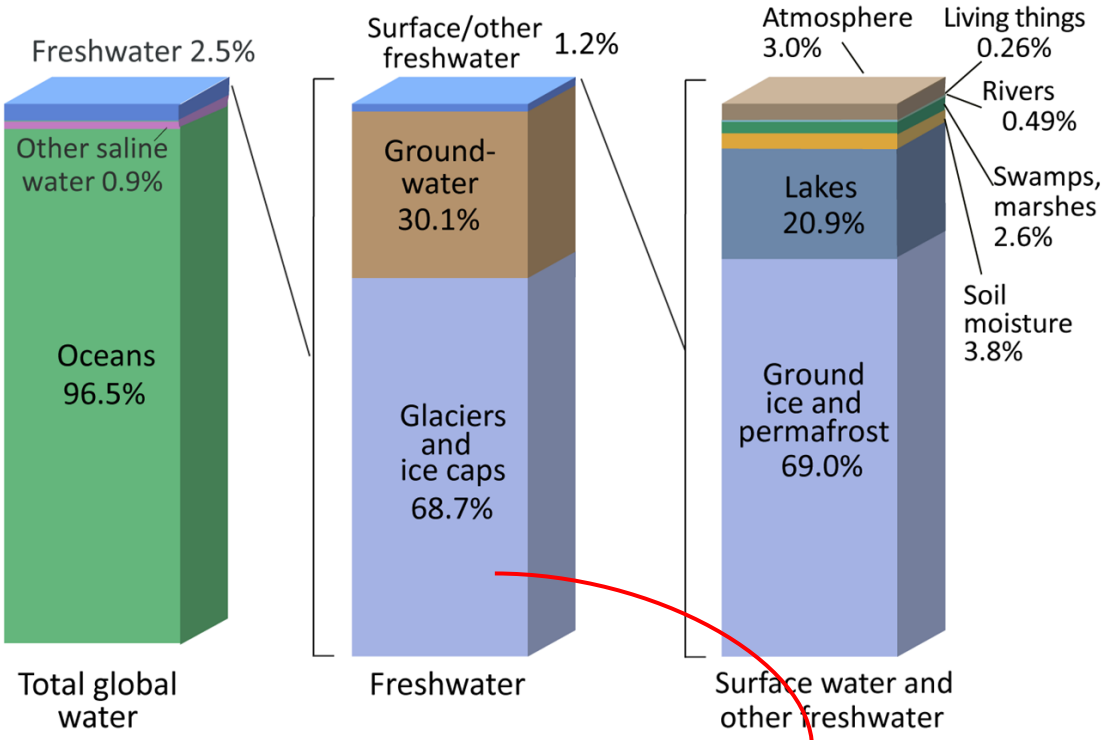
Where is Earth's Water?



Credit: U.S. Geological Survey, Water Science School. https://www.usgs.gov/special-topic/water-science-school
Data source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources. (Numbers are rounded).

Repeat photography documents glacier loss at Grinnell Glacier (Credit: 1911-TW Stanton (USGS), 2016 – L McKeon (USGS), USGS. Public domain.)

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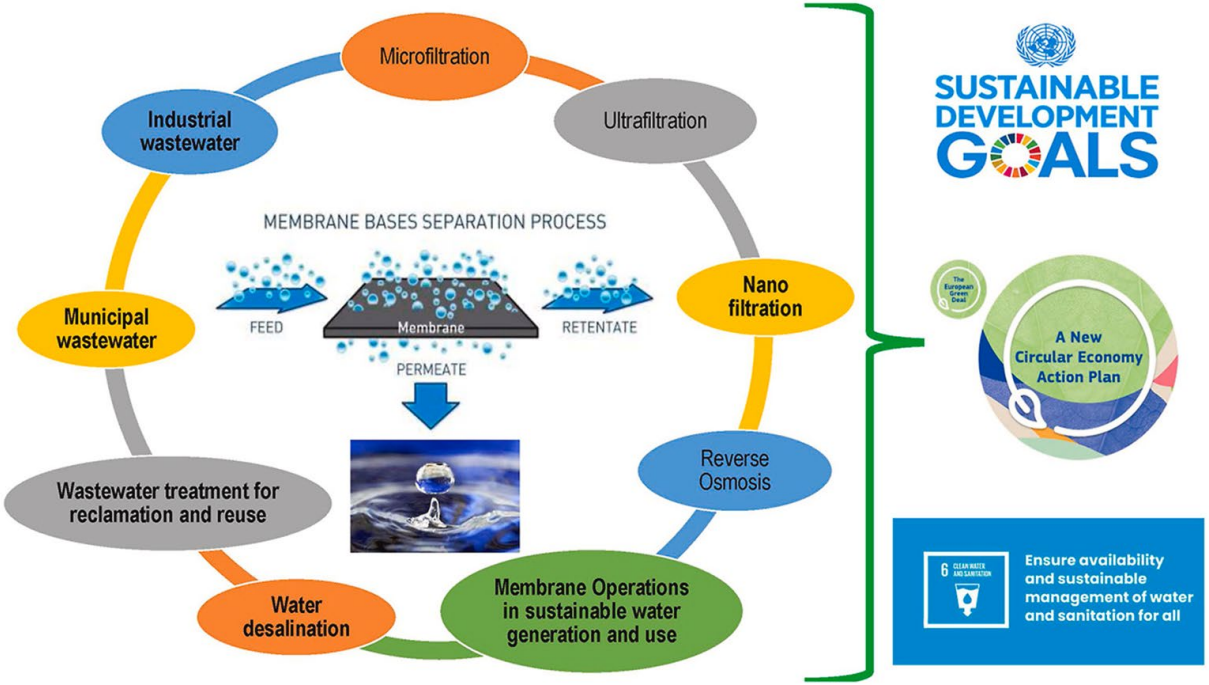
Water: the most indispensable needs for life



- In addition, to seawater and brackish water, **industrial and municipal wastewater** are also considered to be important available resources that need to be taken into consideration to increase sustainability and at the same time to meet SDGs.

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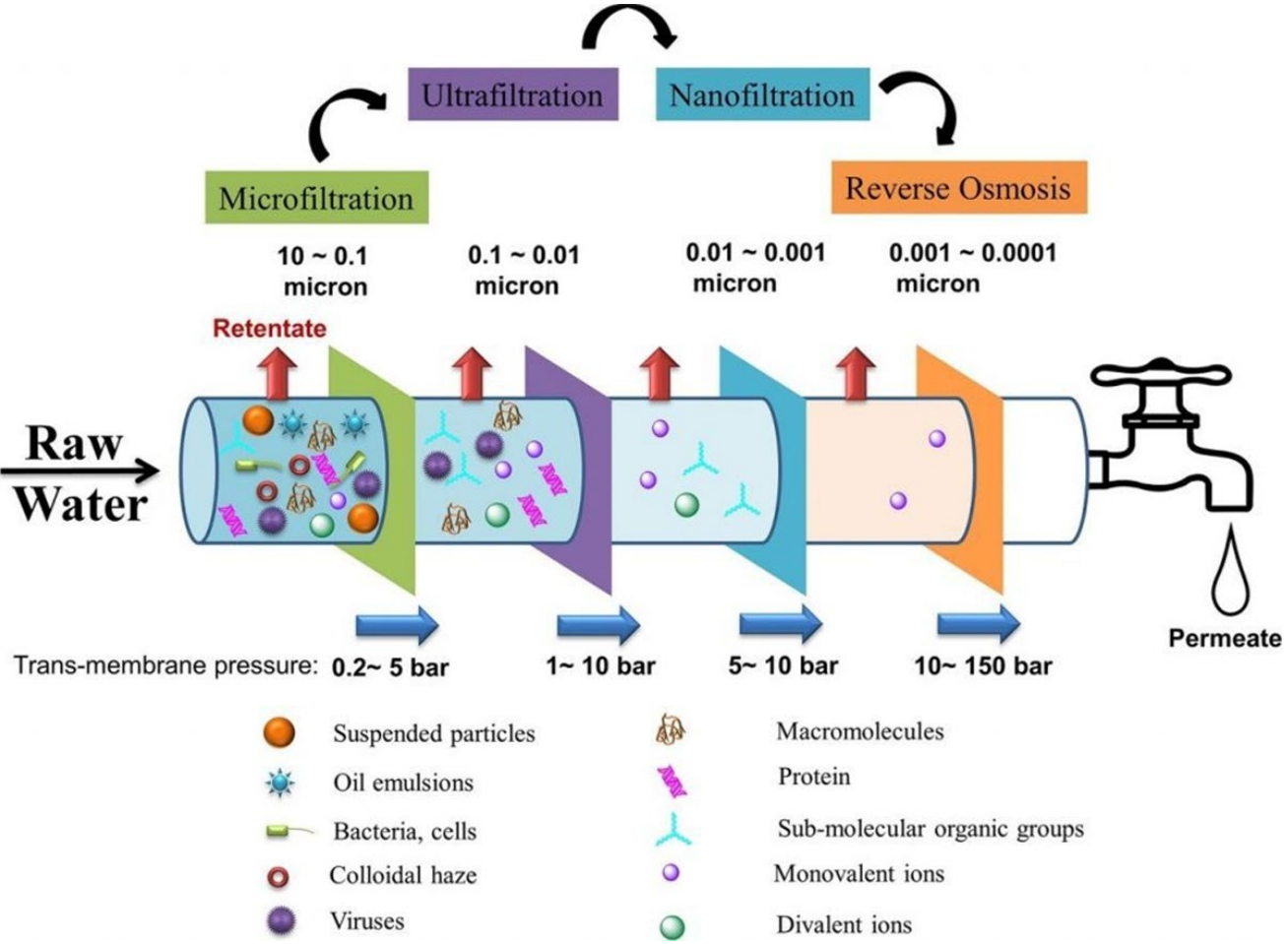
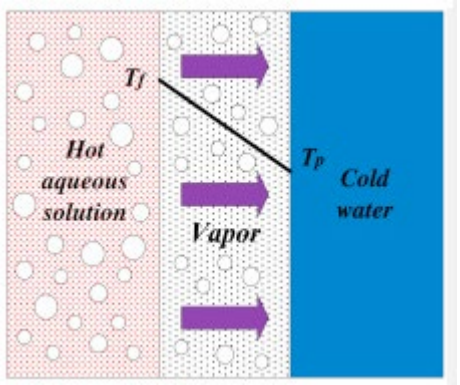
Mansour Issaoui, Salah Jellali, Antonis A. Zorpas, Patrick Dutournie, "Membrane technology for sustainable water resources management: Challenges and future projections" Sust. Chem. and Pharm., 25, page 100590

Membrane Technologies for Safe Drinking Water



Membrane Distillation



- **Membrane Technology** has emerged as a favorite choice for safe drinking water production from surface water, well water, brackish water and seawater (Obotey, Ezugbe, et al., Membranes, 2020).

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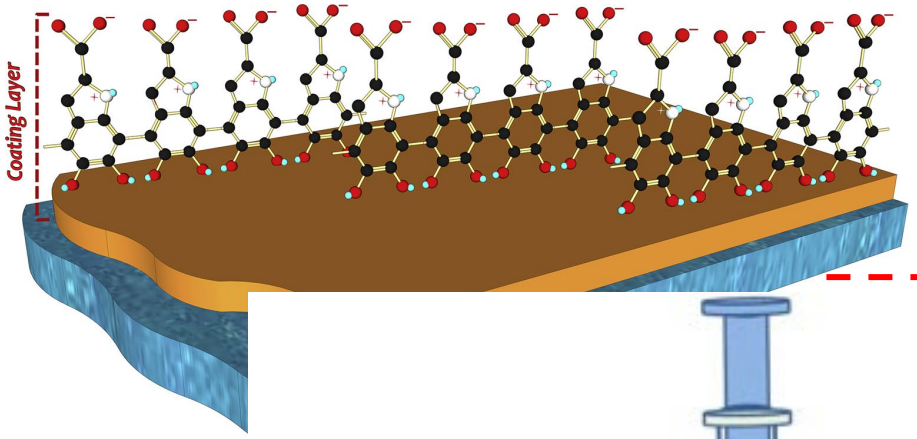
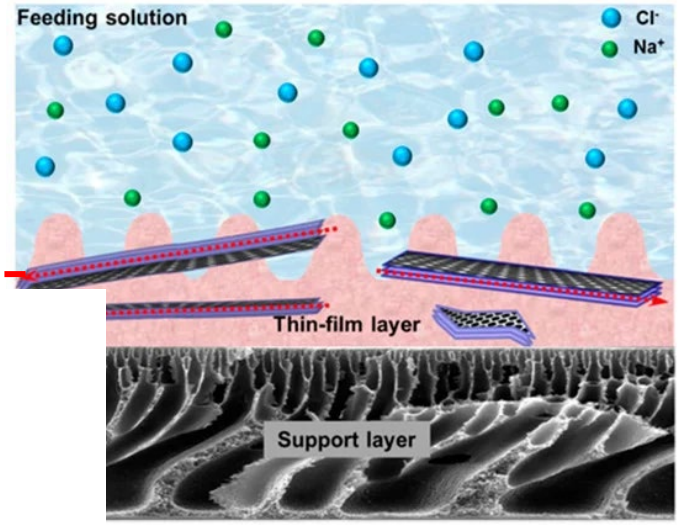
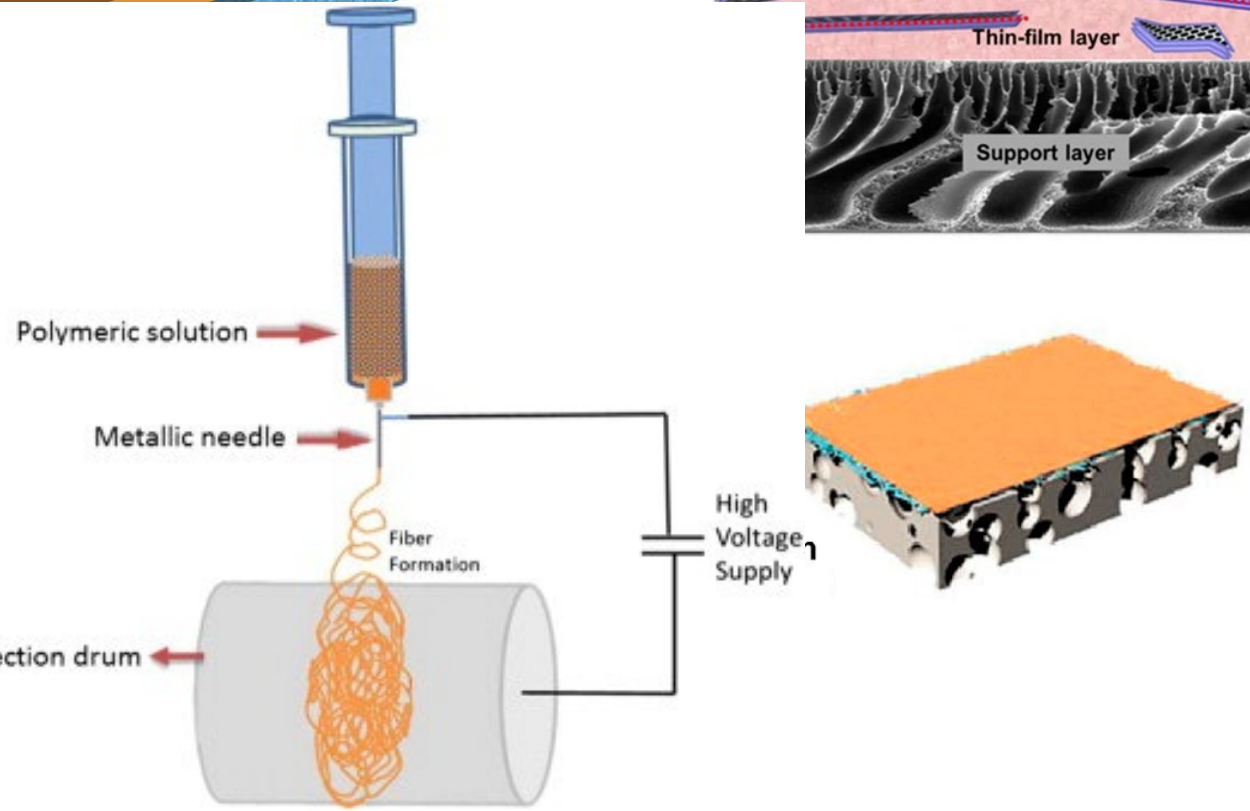
Mantsopa Koena Selatile, Suprakas Sinha RayVincent Ojijo, Rotimi Sadiku "Recent developments in polymeric electrospun nanofibrous membranes for seawater desalination," *Royal Society of Chemistry*, Volume 8, 2018, Pages 37915-37938.

Membrane Technologies





Oxygen



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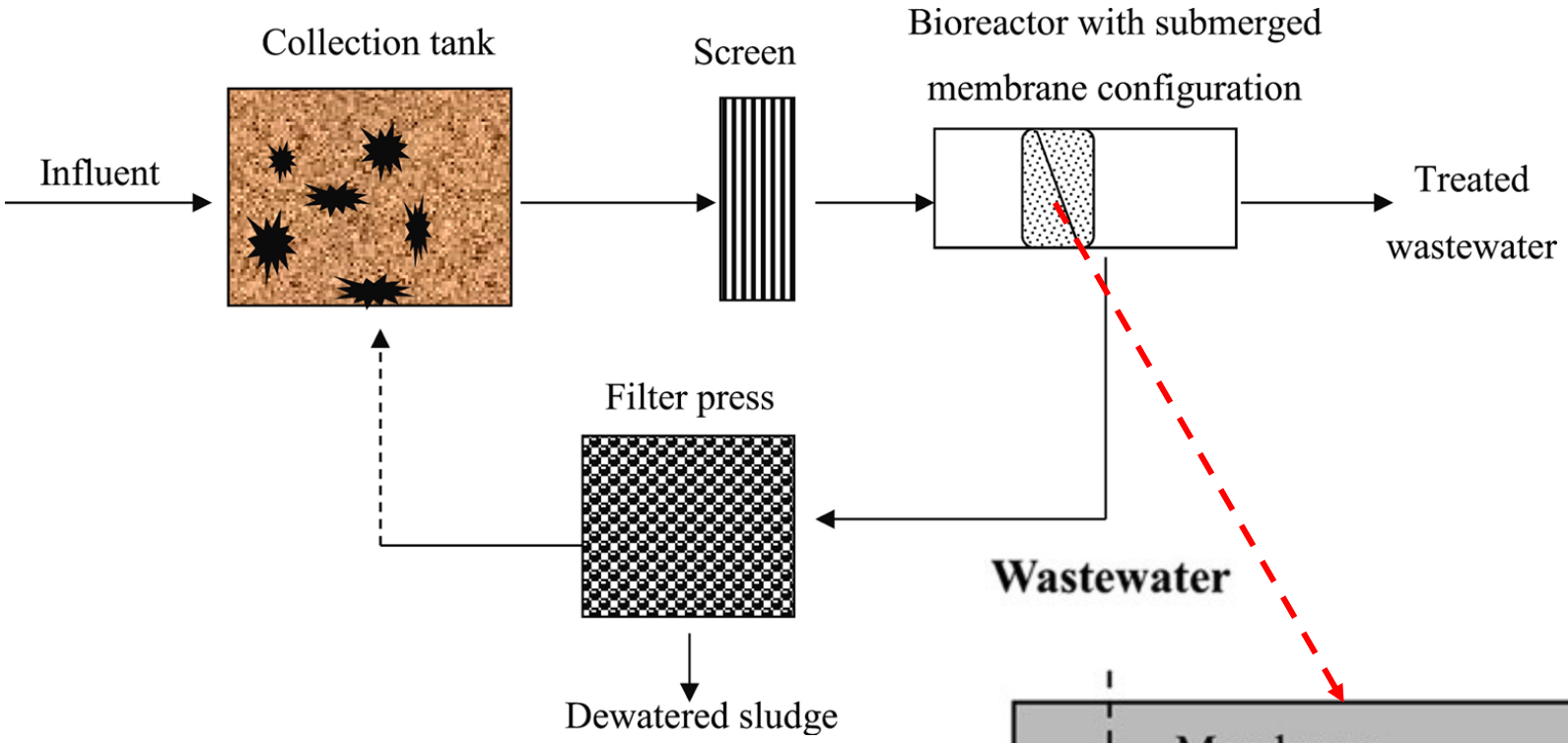
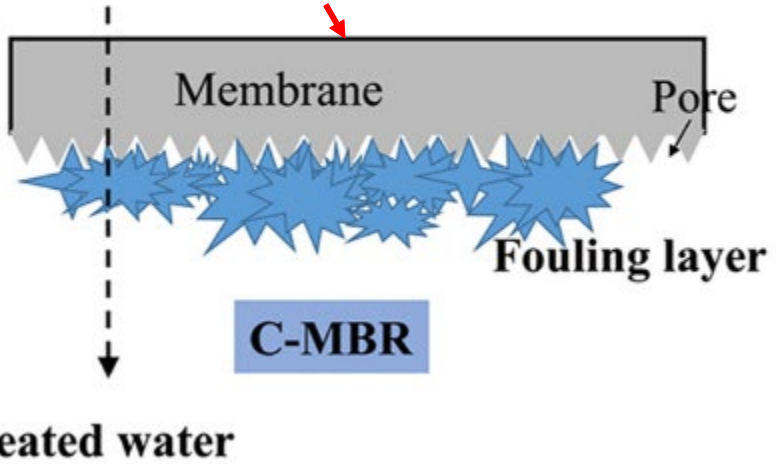
Farah Ejaz Ahmed, Boor Singh Lalia, Raed Hashaikeh, "A review on electrospinning for membrane fabrication: Challenges and applications." *Desalination*, https://doi.org/10.1016/j.desal.2014.09.033

Zhuqing Wang,Aiguo Wu,Lucio Colombi Ciacchi, and Gang Wei, "Recent Advances in Nanoporous Membranes for Water Purification." *mdpi nanomaterials* doi: 10.3390/nano8020065

Wastewater to Reusable Water





Challenges

- Membrane Fouling rates
- High EPS concentrations
- Deteriorative fouling layer
- Mediocre nutrient removal

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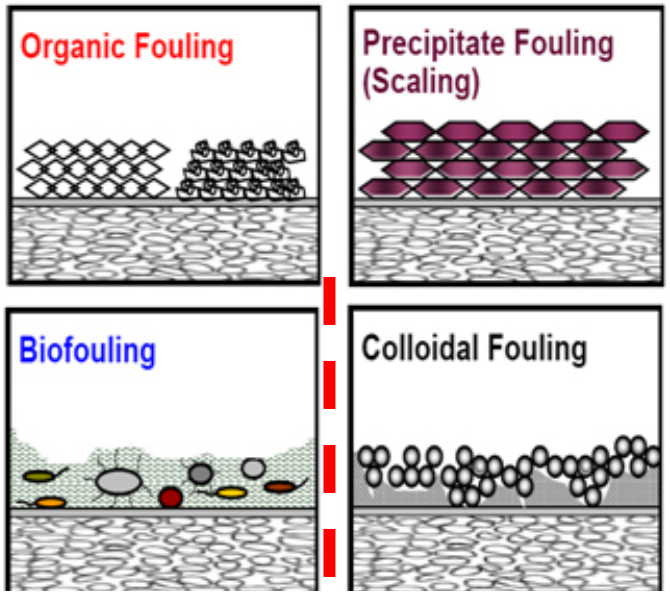
Li Sun, Jinxing Ma, Lipin Li, Yu Tian, Zhong Zhang, Huaiyu Liao, Jibin Li, Wangwang Tang, Di He. "Exploring the essential factors of performance improvement in sludge membrane bioreactor technology coupled with symbiotic algae" *Wat. Research*. Volume 181. Page 115843

Challenge: Membrane Fouling

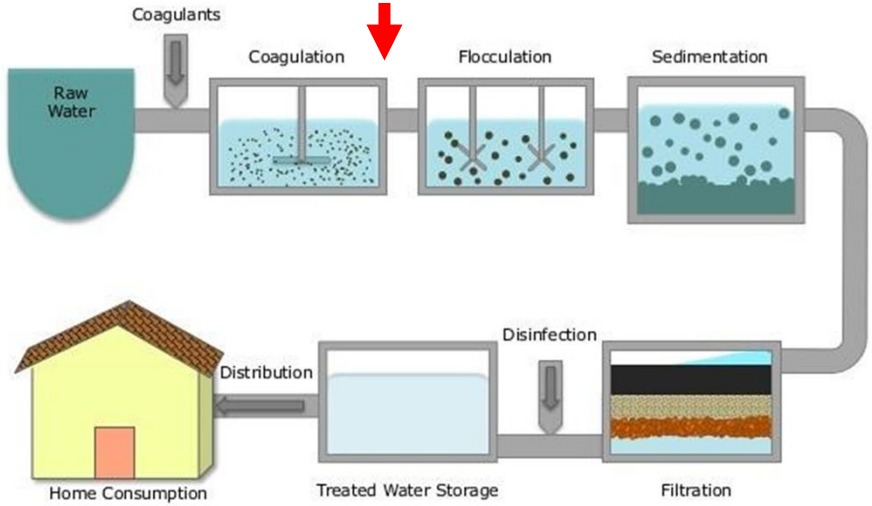


Causes of Membrane Failure (60%) from autopsies

- 31.3 % Biofilm
- 29.0 % Colloidal matter
- 22.1 % Scale
- 10.0 % Metals
- 7.7. % Other organics

Foulants Impact on membrane operations

- ΔP increases
- Flow decreases
- Salt passage increases



Particles at feed end.

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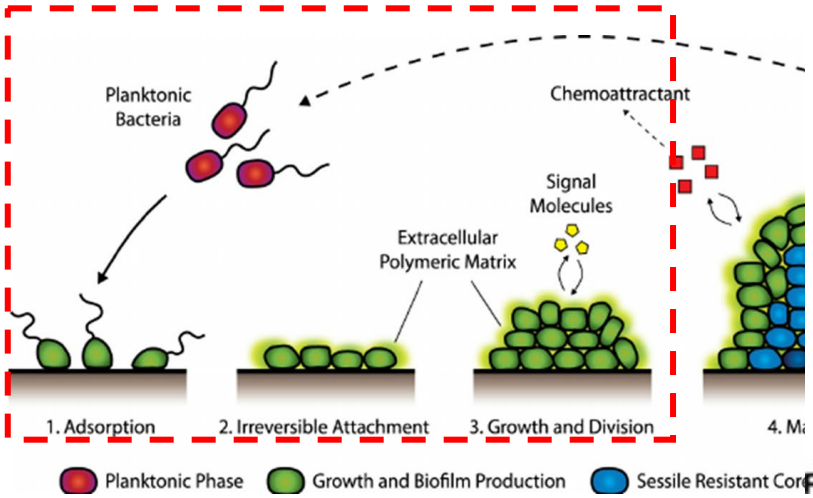
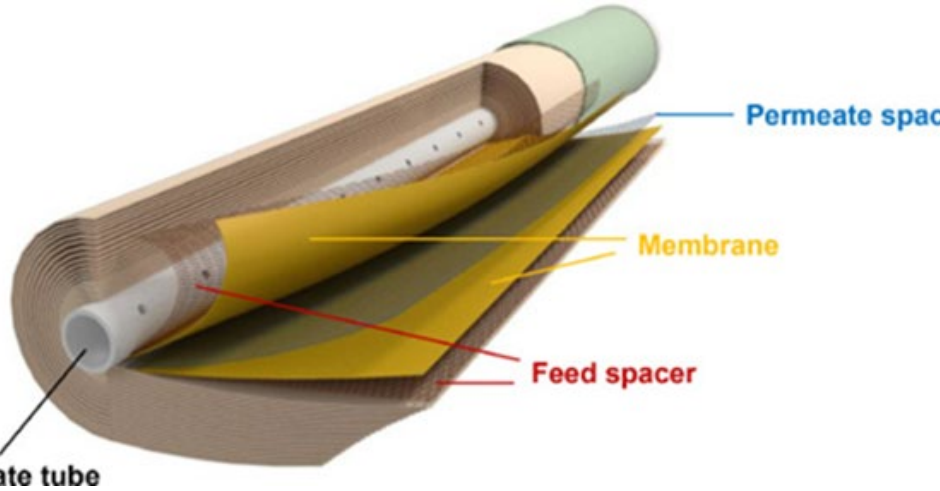
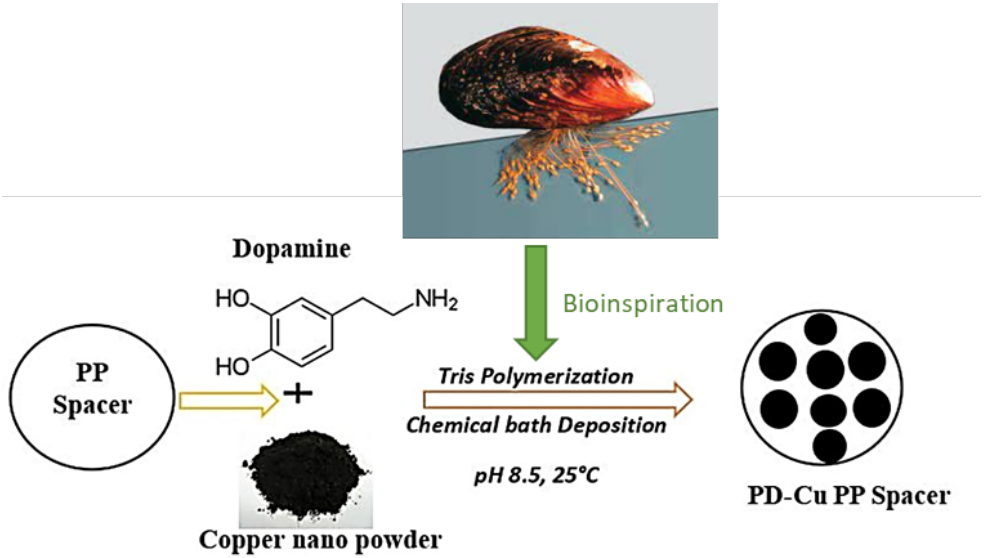
Challenge: Biofouling







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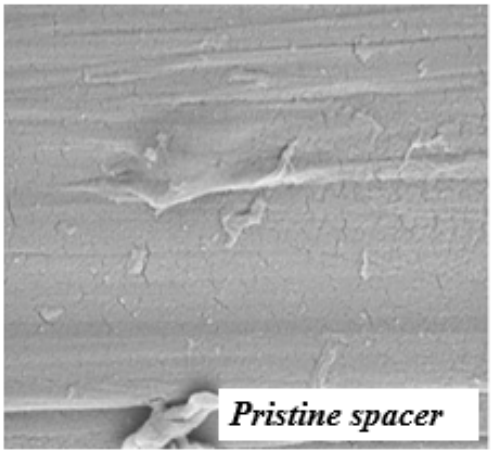
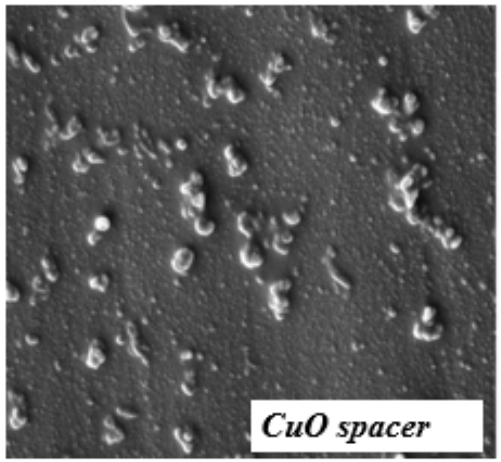
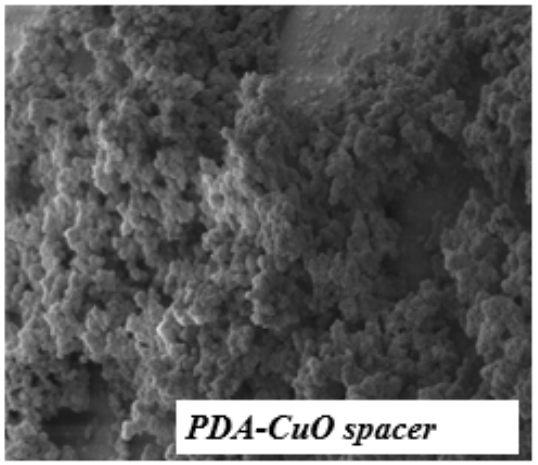
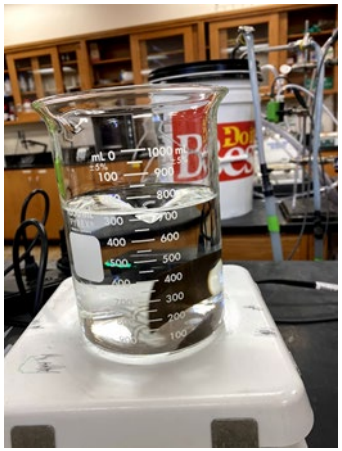
B.F. Gilmore, "Antimicrobial ionic liquids," Ionic Liquids: Applications And Perspectives (2011). DOI: 10.5772/13861

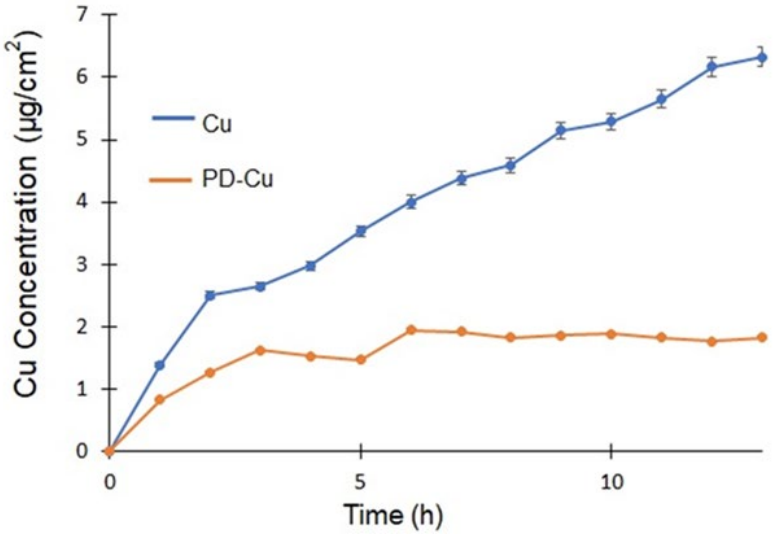
Polydopamine CuO Feed Spacers











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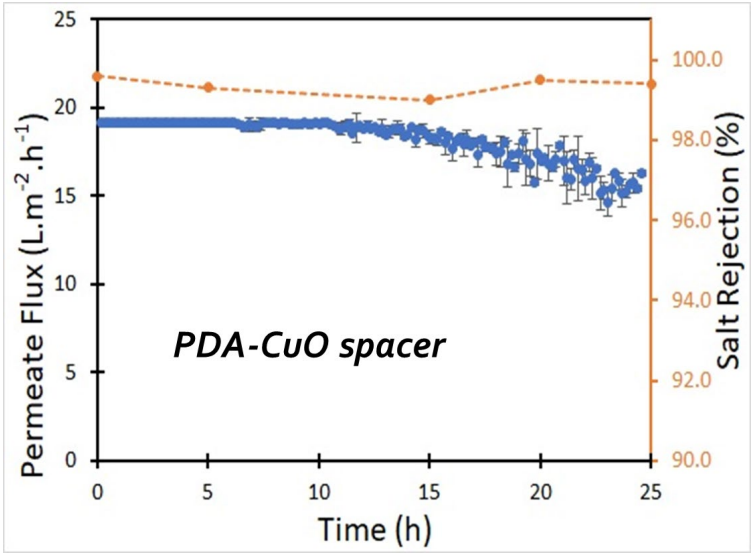
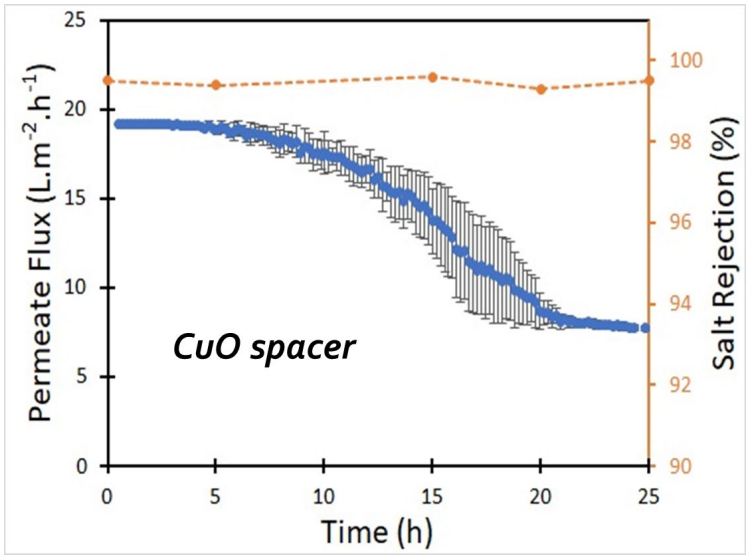
Polydopamine CuO Feed Spacers





- PDA-CuO spacers recorded a ***~52% higher permeate flux*** compared to CuO spacers and >58% less biovolume from the control in 24 h .
- However, both spacers recorded similar membrane biovolumes due to the presence of Cu-ions in both.
- PDA-Cu spacers showed a 17.5% higher permeate flux compared to the control.

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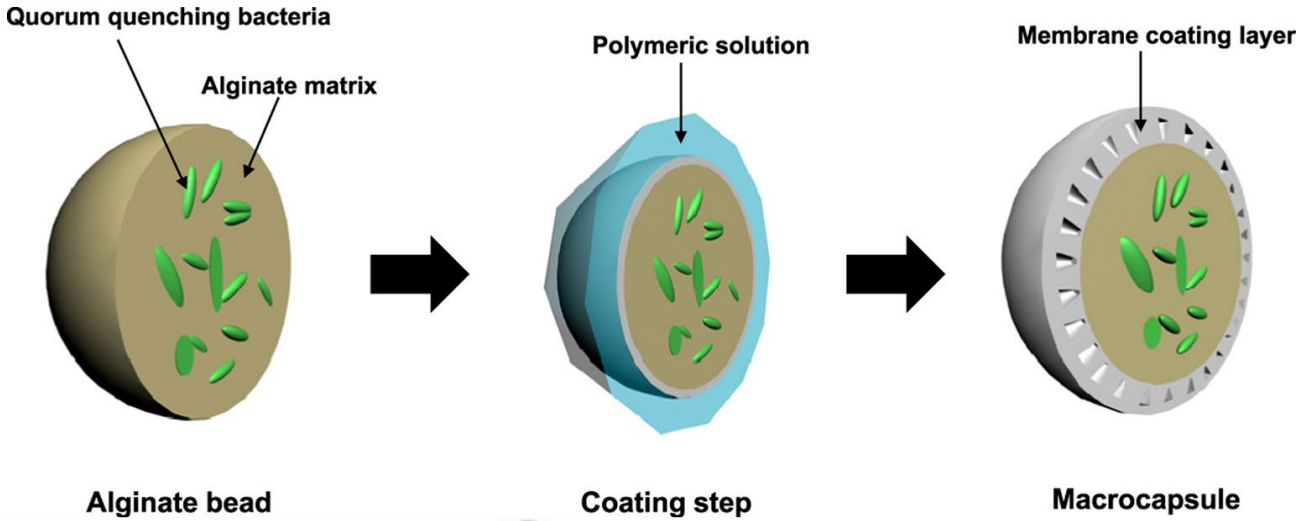
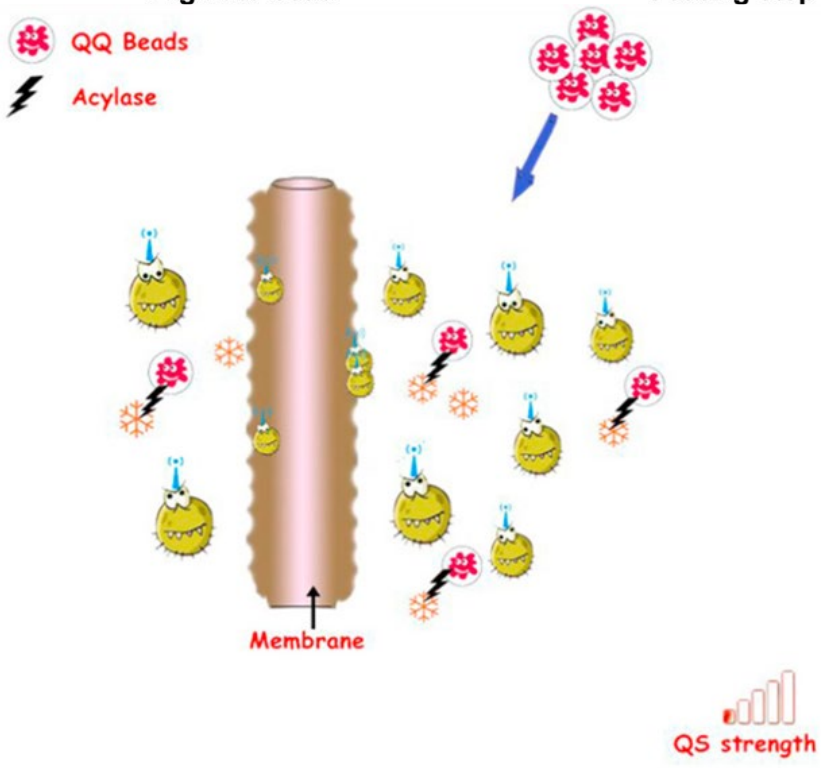
Biofouling Control : Quorum Quenching

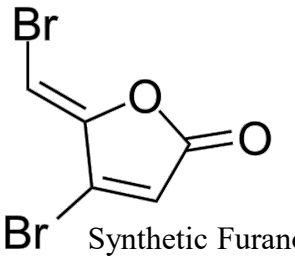




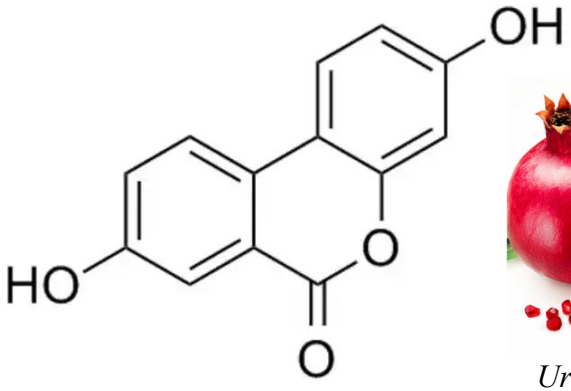
Sang-Ryoung Kim, Ki-Baek Lee, Jeong-Eun Kim, Young-June Won, Kyung-Min Yeon, Chung-Hak Lee, Dong-Joon Lim, Macroencapsulation of quorum quenching bacteria by polymeric membrane layer and its application to MBR for biofouling control." https://doi.org/10.1016/j.memsci.2014.09.009

Hyun-Suk Oh, Kyung-Min Yeon, Cheon-Seok Yang, Sang-Ryoung Kim, Chung-Hak Lee, Son Young Park, Jong Yun Han, and Jung-Kee Lee, "Control of Membrane Biofouling in MBR for Wastewater Treatment by Quorum Quenching Bacteria Encapsulated in Microporous Membrane." https://doi.org/10.1021/es204312u

Selection of Quorum Quenching Molecules



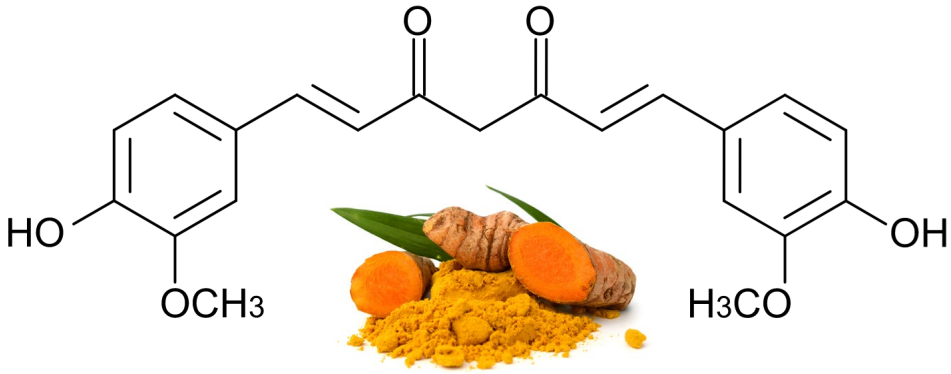
Synthetic Furanone C-30



Urolithin A

Consideration Parameters

- **Biocompatibility**
- **None to low toxicity**
- **Efficiency at low concentration**
- **Pre-existing studies in medical app.**



Curcumin *(Curcuma longa L.)*

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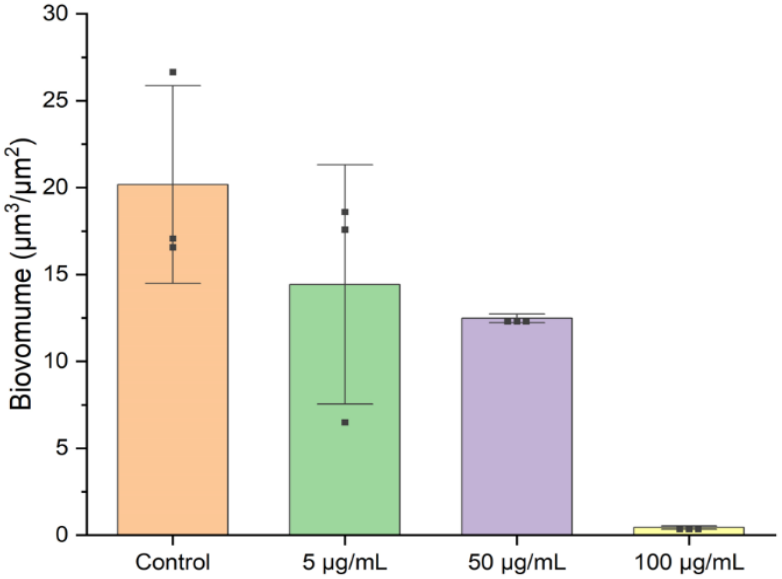
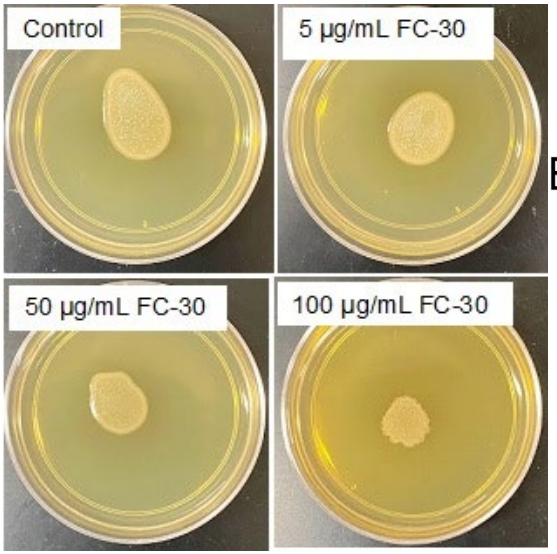
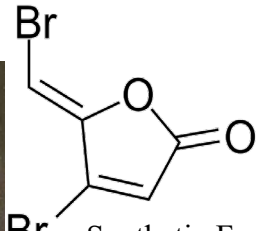
Selection of Quorum Quenching Molecules

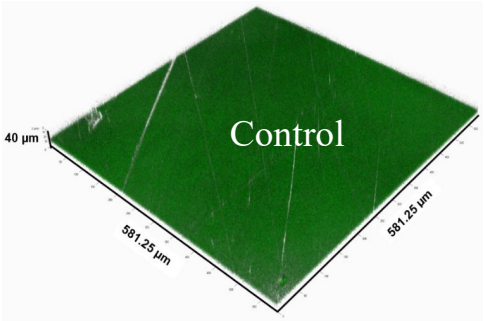


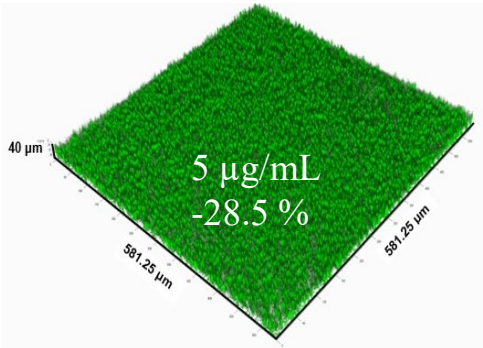


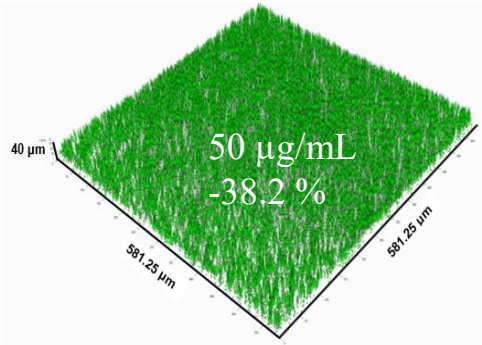


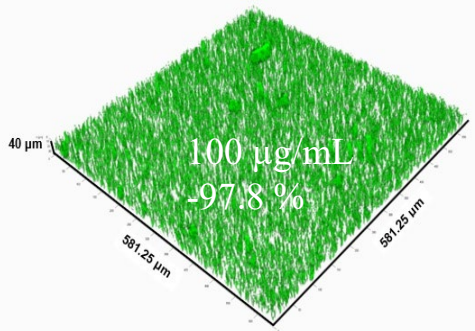
Synthetic Furanone C-30

- Biofilm thicknesses and biovolume **decreased by 98 %** in the presence of 100 μg/mL Furanone C-30 molecules.









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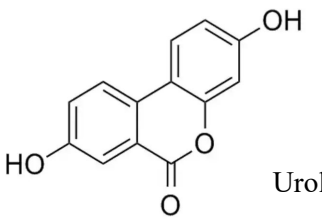
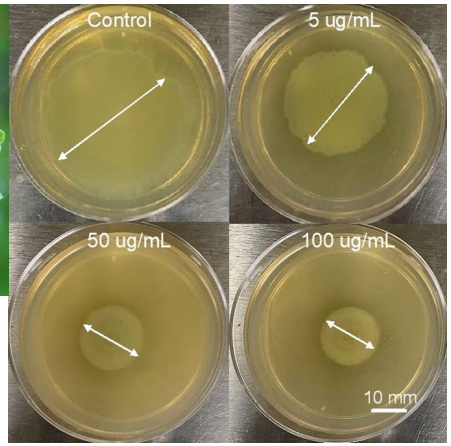
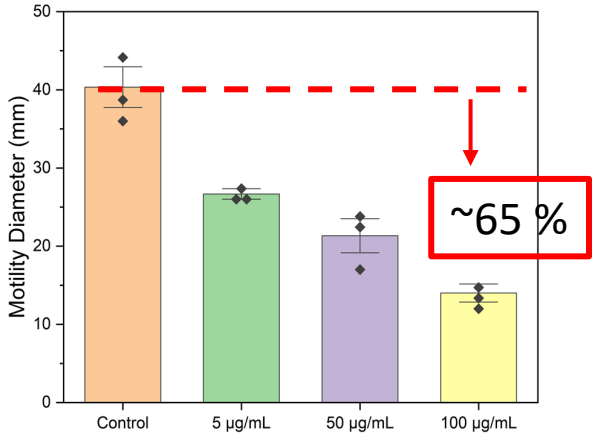
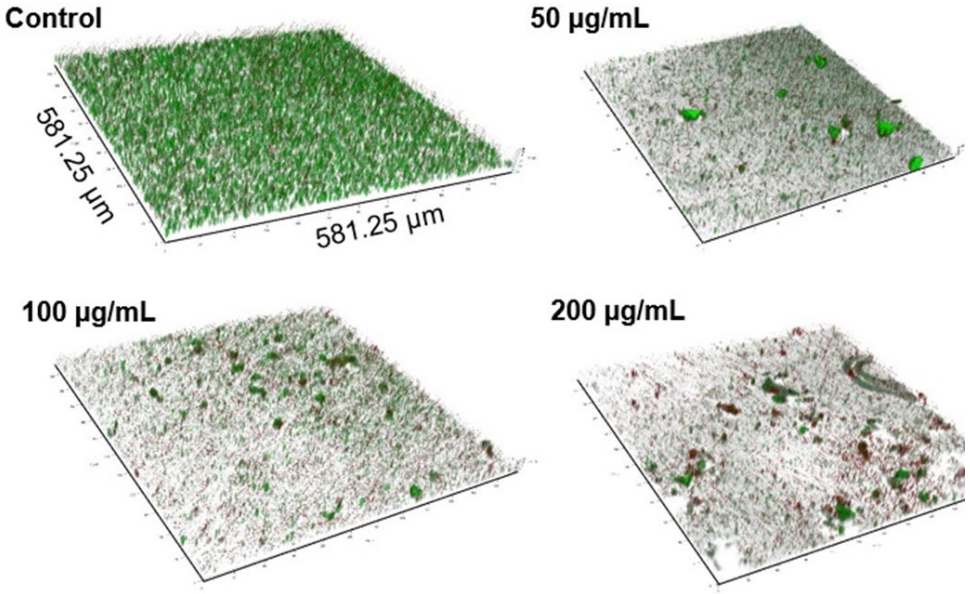
Selection of Quorum Quenching Molecules

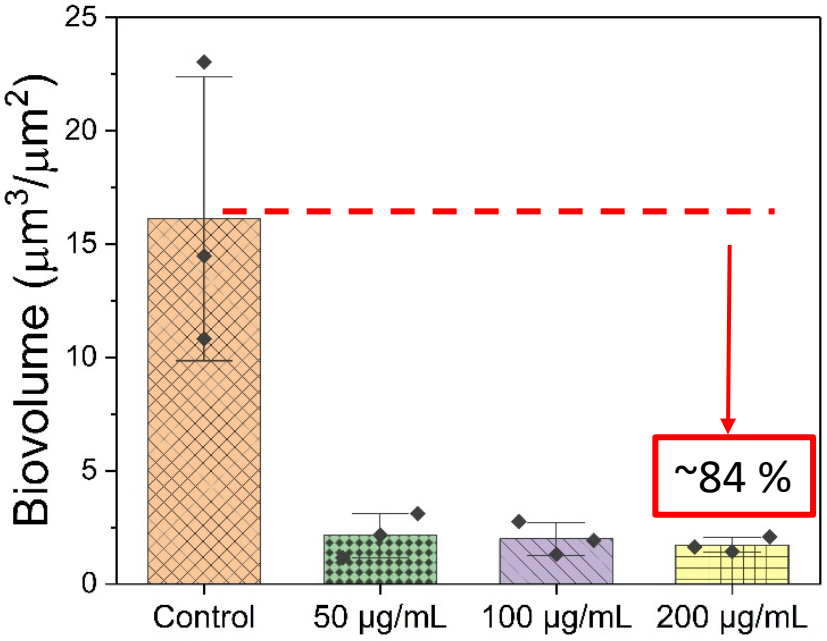


Urolithin A









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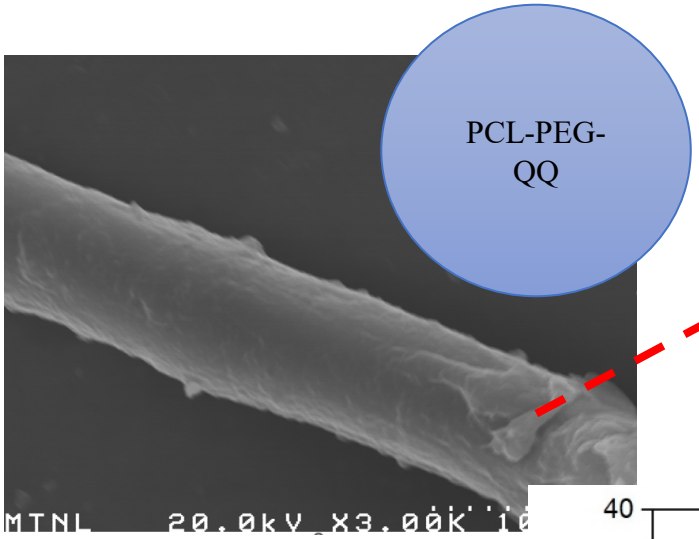
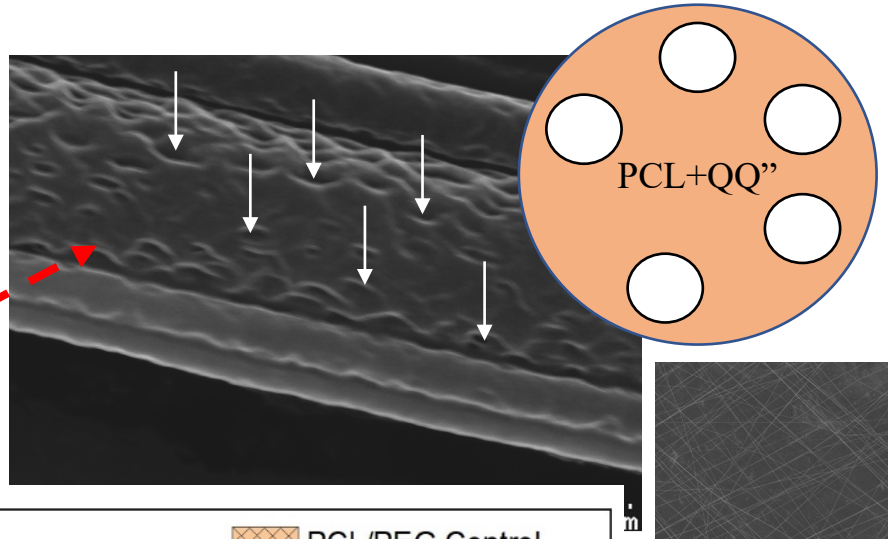
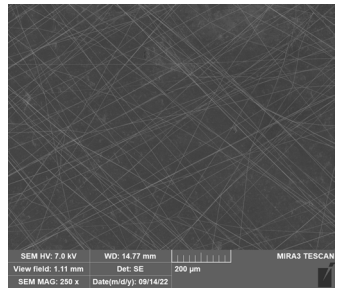
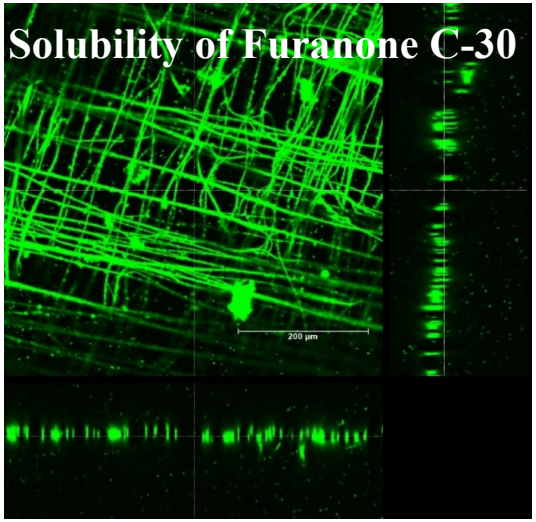
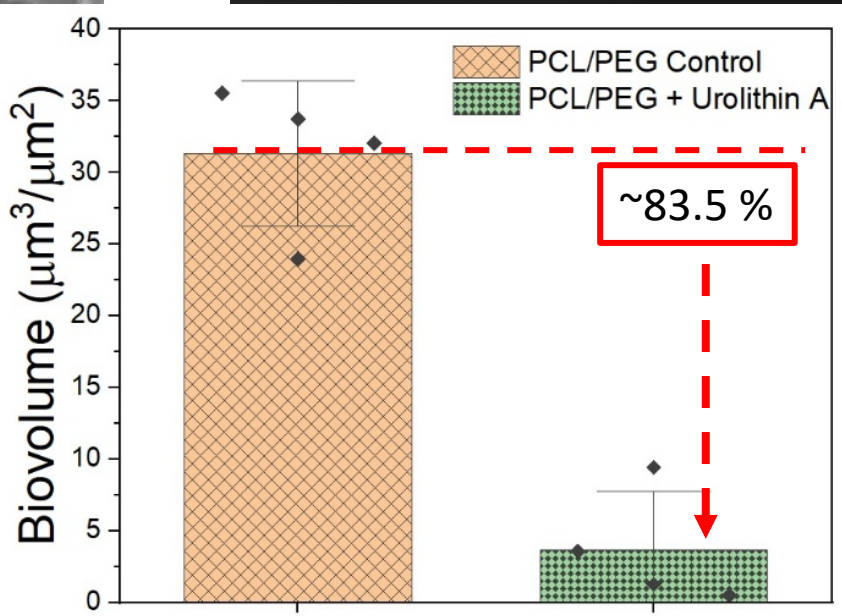
Controlled Release of Quorum Quenching Molecules











~69 % reduction for Furanone C-30

❖ **Though effective in QQ of PAO1 is solution, solubility hindered Furanone C-30's efficiency on membrane surfaces**

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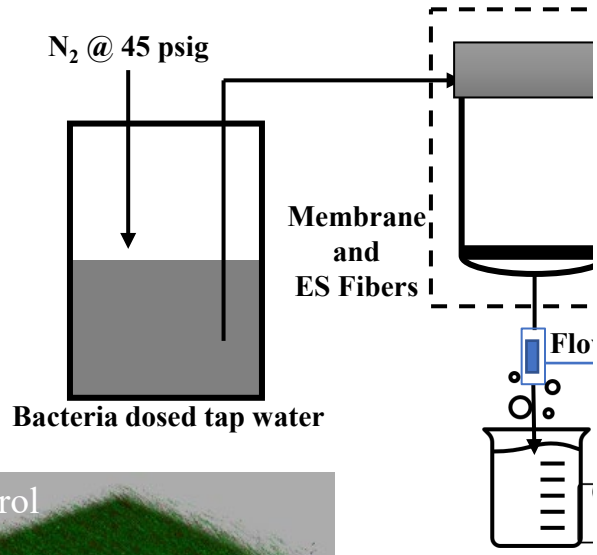
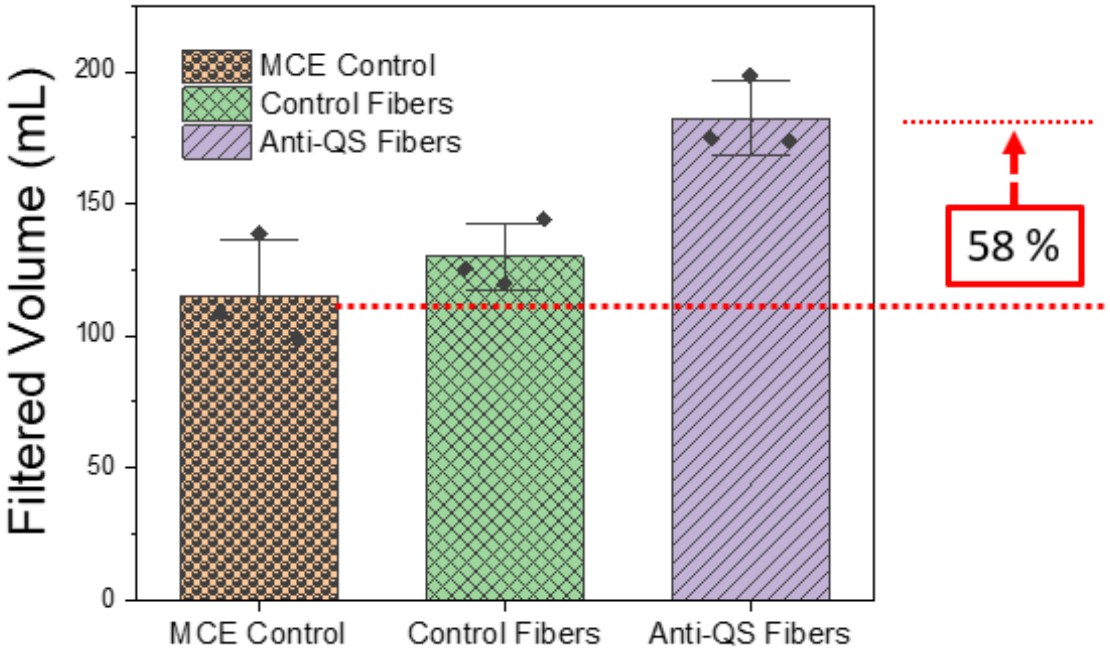
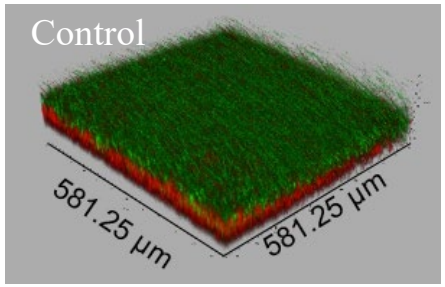
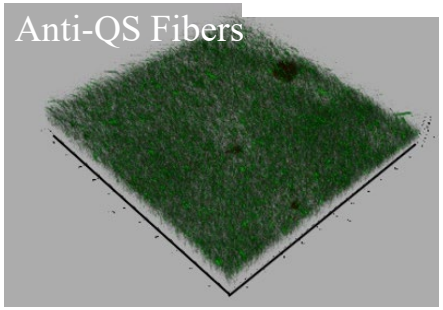
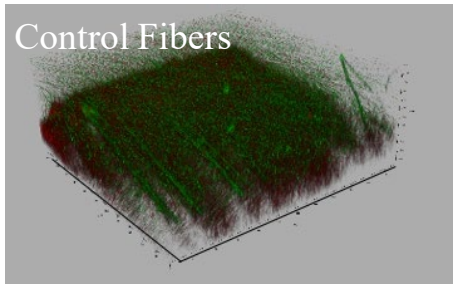
Evaluation: Nanofiltration Performances

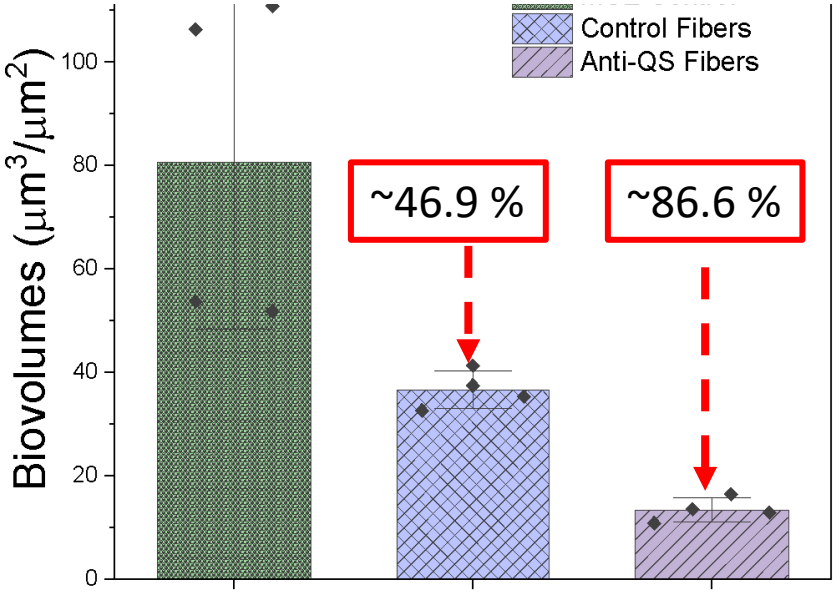












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Thank you!

Amos Taiswa, Jessica M. Andriolo, Jack L. Skinner (PI)

- Sincere thanks to **Dr. Katie Hailer.**
- Montana Tech Nanotechnology Laboratory (MTNL).