2nd Annual WIN Workshop, BGNDRF

10/28/2019

Electromagnetic Field Devices for Prevention of Membrane Fouling and Scaling

Wenbin Jiang, Xuesong Xu, Juliano Almeida,

David Johnson, Lu Lin, Huiyao Wang, Pei Xu

NM STATE

EnLiTe

Environmental Lab of Innovative Technologies

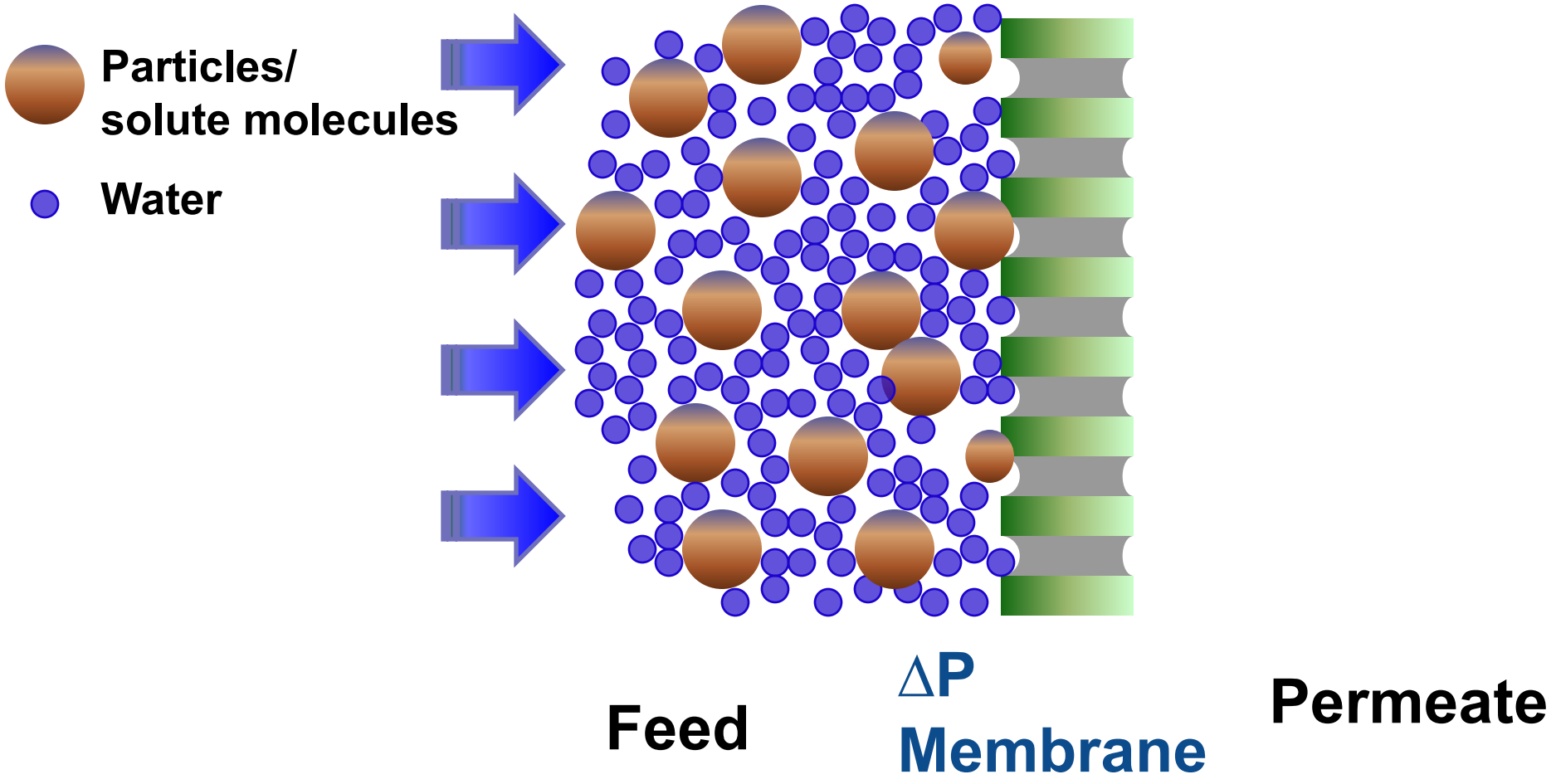
Acknowledgements

- BGNDRF
- HydroFLOW
- Eco1st
- AquaMembranes
- Bureau of Reclamation
- New Mexico Water Resources Research Institute

Outline

- Motivation
- Pilot testing at BGNDRF
- Ongoing bench-scale testing
- Summary
- Future research plan

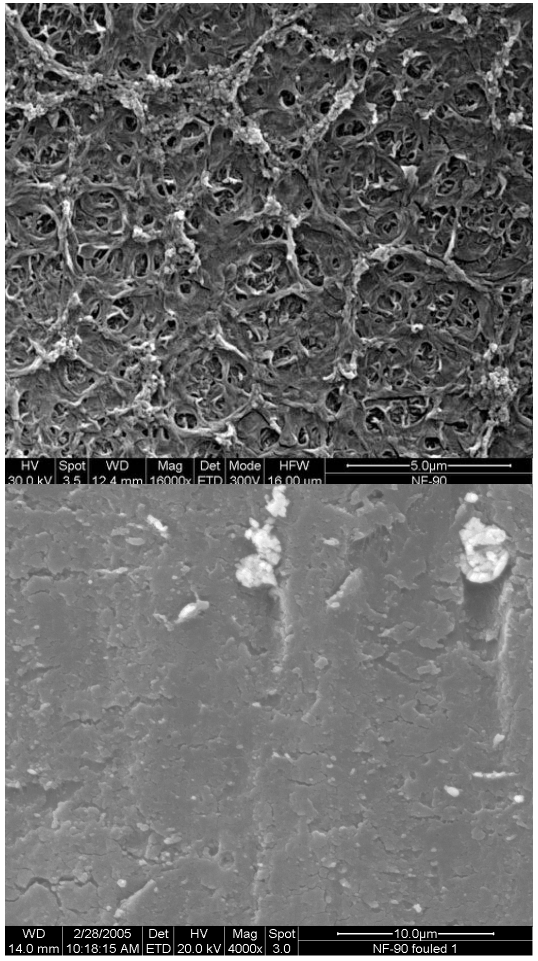
Pressure-Driven Membrane Separation



Pressure-Driven Membrane Separation

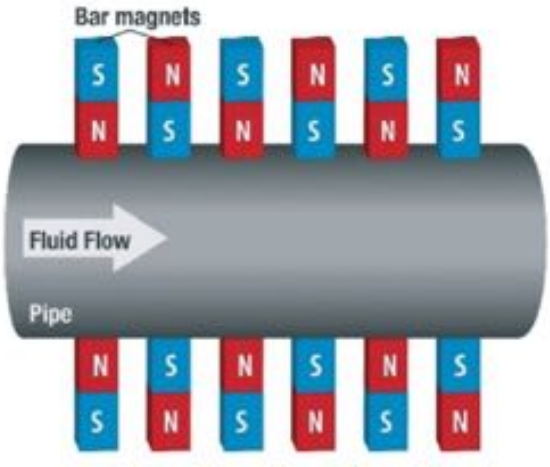
- Membrane fouling and scaling
- Higher energy demand
- Limited recovery
- Concentrate for disposal

- Extensive pretreatment for complex water chemistry

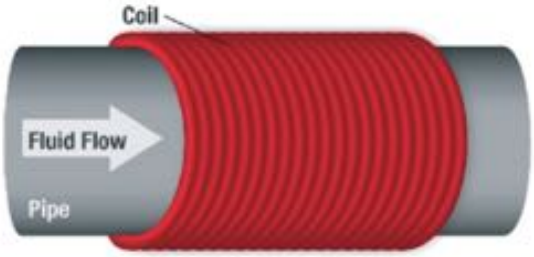


Xu & Drewes, Sep. Pur. Tech. 2006

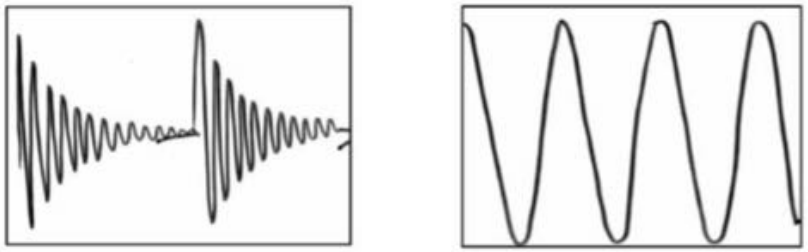
Non-chemical Fouling & Scaling Control – Electromagnetic Field (EMF)



(a) Permanent magnets



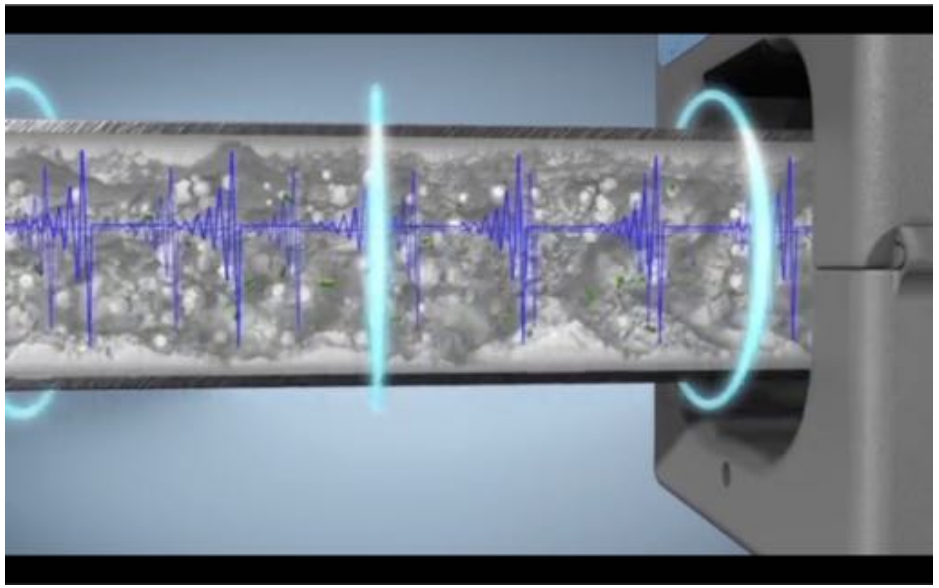
(b) Solenoid coil



(c) Schematic representations of wavesforms

Pilot Testing of EMF on RO Scaling Control during Brackish Groundwater Desalination at BGNDRF

- Two types of EMF devices tested
  - HydroFLOW: induce an electric signal of ±150 kHz in the liquid inside of a pipe on which they are installed. A specialized transducer connected to a ring of ferrites performs the electric induction

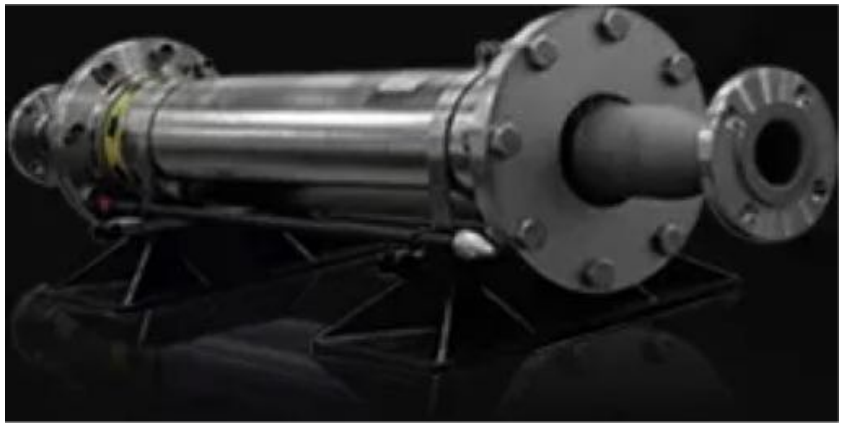


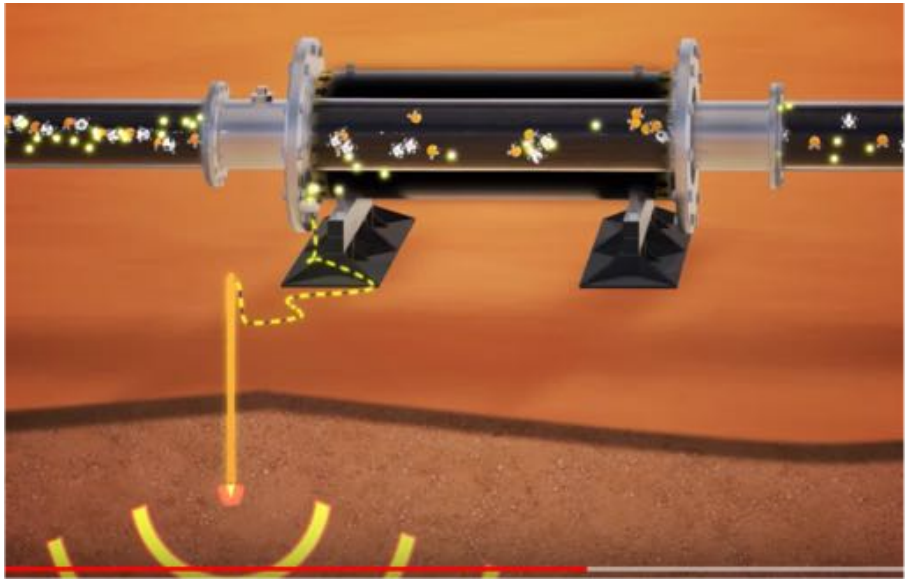
Pilot Testing of EMF on RO Scaling Control during Brackish Groundwater Desalination at BGNDRF

- Two types of EMF devices tested
  - HydroFLOW: HS48 was installed in the metal pipeline before the cartridge filter and S38 was installed in the inlet of the RO vessel.

Pilot Testing of EMF on RO Scaling Control during Brackish Groundwater Desalination at BGNDRF

- Two types of EMF devices tested
  - Eco1st Separation Enhancer: an inline fluid ionization system using electrochemical ionization principles. It induces EMF into the flowing fluid and discharges electrons from the molecules exist in the water. The free electrons will then be routed and drawn to a dedicated earth ground.





Pilot Testing of EMF on RO Scaling Control during Brackish Groundwater Desalination at BGNDRF

- Two types of EMF devices tested
  - Eco1st Separation Enhancer: installed before the cartridge filter of a 2-stage RO system.

Feed Water Quality

- Two types of groundwater used

Water quality parameter	Unit	Well 1	Well 2
Temperature	℃	21.3	27.0
pH	pH unit	7.74	7.17
Electrical conductivity	μmhos/cm	1840	6440
Total dissolved solids	mg/L	1260	5850
Langelier Saturation Index	SI	0.44	0.55
Total alkalinity (as $CaCO_3$)	mg/L	147	244
Chloride	mg/L	36	521
Sulfate	mg/L	723	3200
Total hardness (as $CaCO_3$)	mg/L	233	2550
Calcium	mg/L	66	501
Magnesium	mg/L	16	316
Potassium	mg/L	4.7	2.1
Silicon dioxide	mg/L	21.5	20.8
Sodium	mg/L	305	650
Strontium	mg/L	1.9	8.1

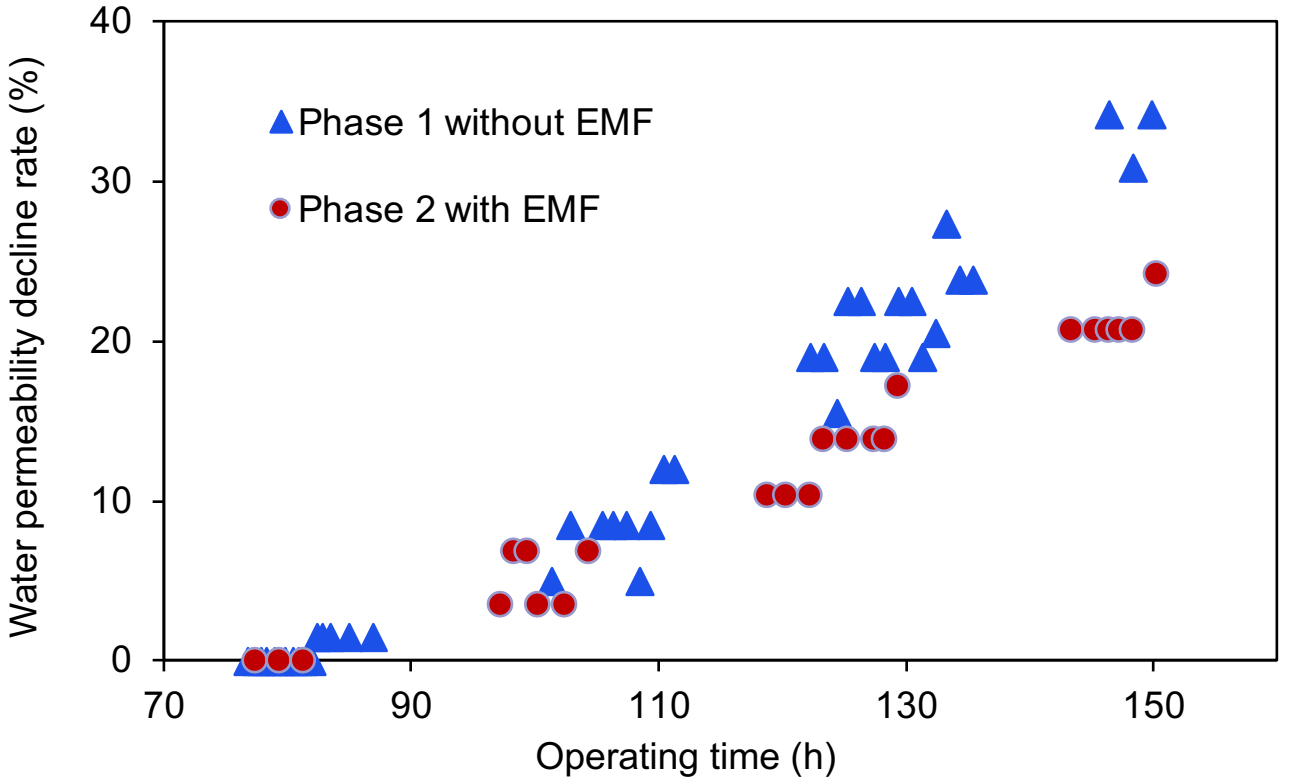
RO Scaling Simulation

- Scaling indices for the RO system based on the ROSA modeling: Well 2 water at 50% water recovery

Parameter	Feed Water	Concentrate
Langelier Saturation Index	1.07	1.80
Stiff & Davis Stability Index	0.69	1.16
Ionic Strength (Molar)	0.14	0.29
$CaSO_4$ (%Saturation)	105	238
$BaSO_4$ (%Saturation)	174	352
$SrSO_4$ (%Saturation)	71	150

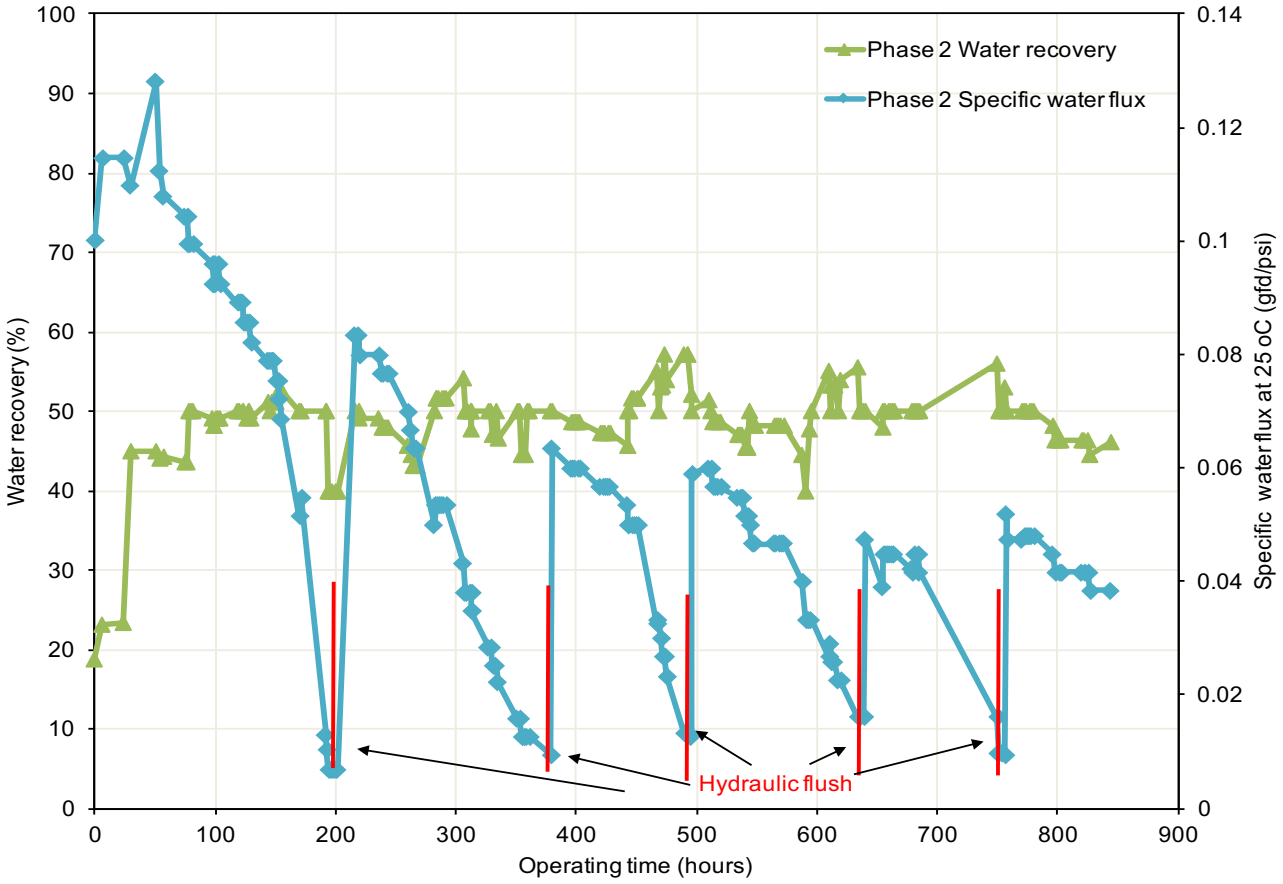
Pilot Testing Results - HydroFLOW

- Membrane flux declined during 150 hr desalination of Well 2 water at 50% water recovery without antiscalant



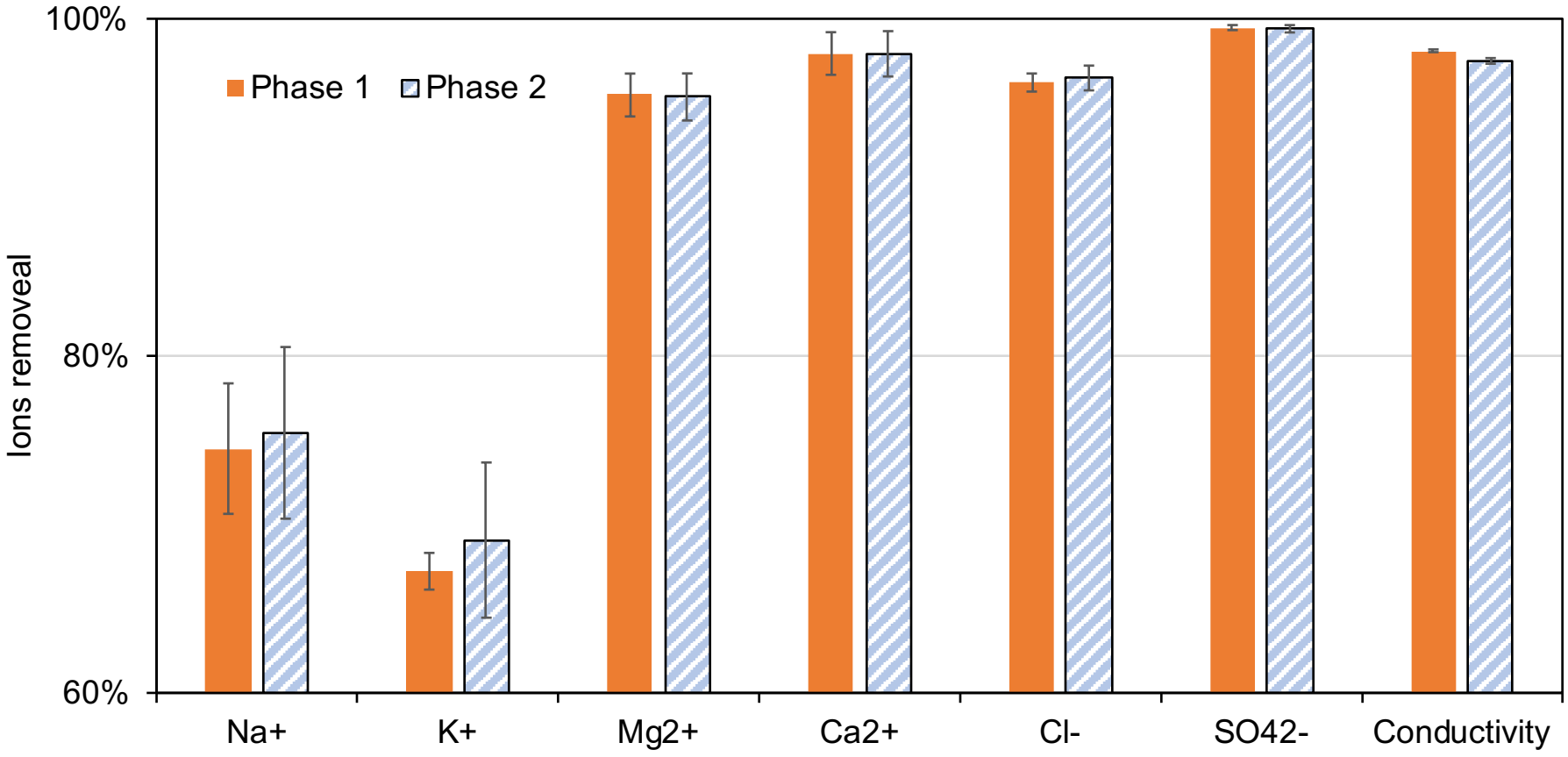
Pilot Testing Results - HydroFLOW

- HydroFLOW turned on from start of desalination of Well 2



Pilot Testing Results - HydroFLOW

- Product Water Quality

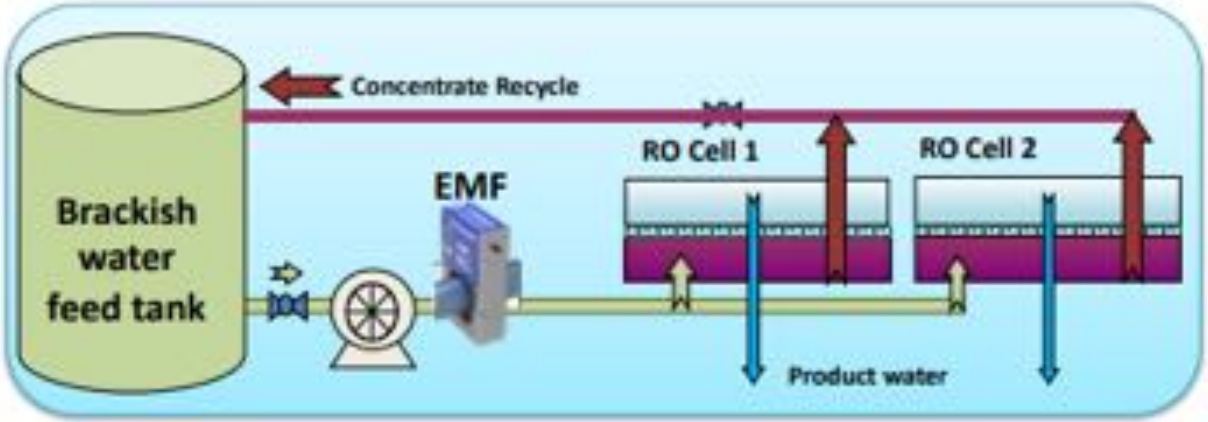


Pilot Testing Results

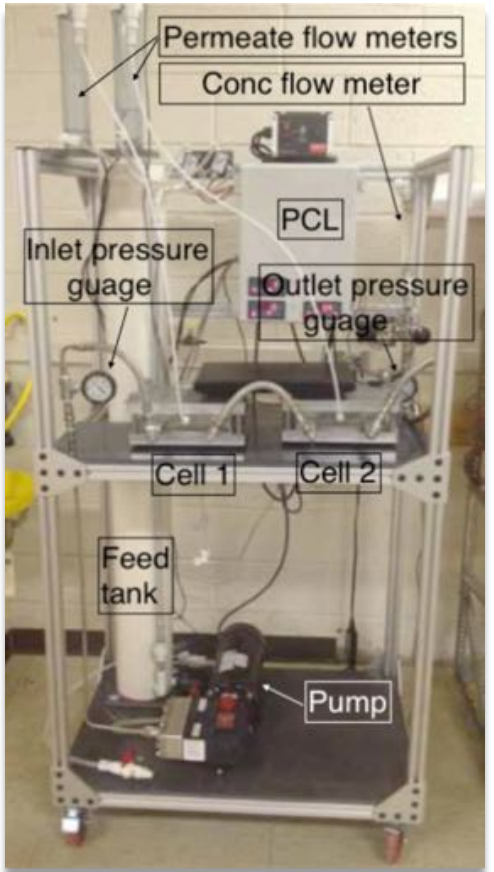
- Clean up the scales in the water pipelines

Bench Testing – Secondary Effluent

- Impact of EMF on RO membrane fouling during treatment of secondary effluent



Schematic Diagram



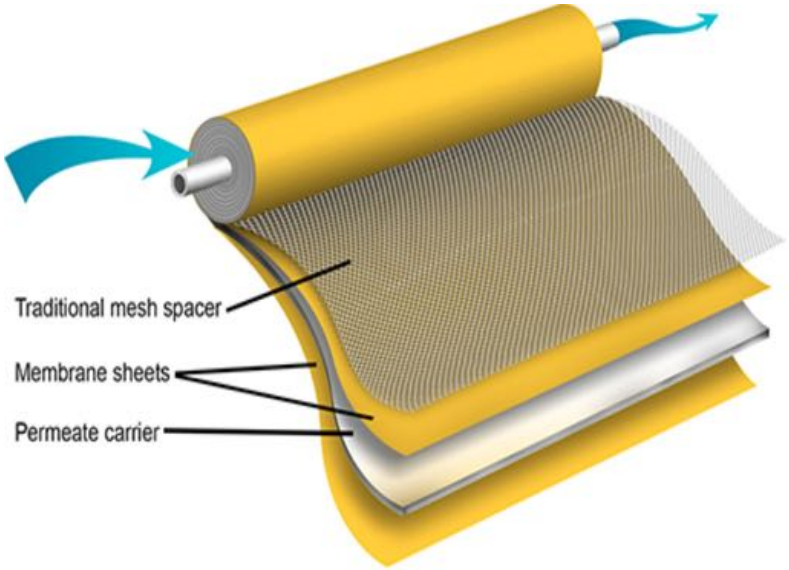
Summary

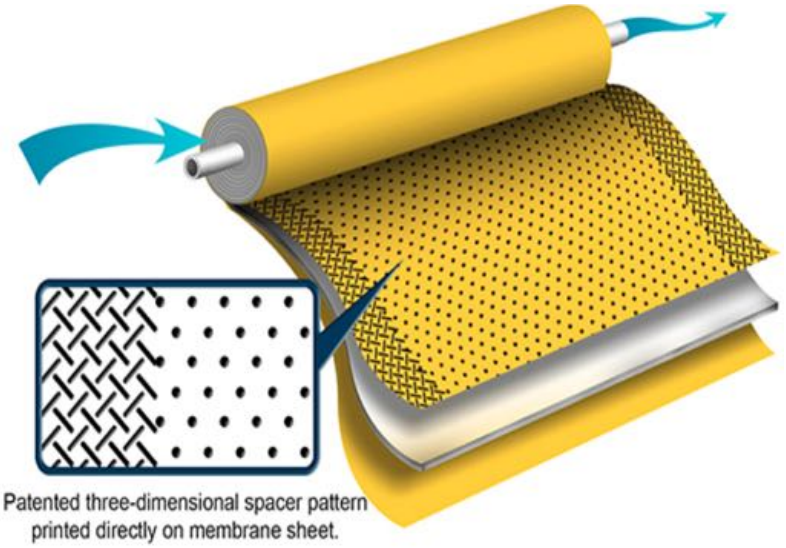
- EMF requires no or low energy.
- Reduce initial membrane scaling and fouling by 30-40%.
- Periodic hydraulic flushing can recover RO membrane performance by removing the foulants loosely accumulated on membrane surface and flow channels.
- Permeate water quality was not affected by the EMF devices.
- EMF is a promising technology to minimize membrane fouling.

Future work

- Further experiments are needed to evaluate EMF at bench- and pilot-scale
  - For different types of water at different water recovery with the addition of acids and antiscalants.
  - The effectiveness of combining EMF with hydraulic flushing at different strength and duration.
  - Evaluate the combination of EMF with 3D printed open flow channel RO membranes

Future work





Electromagnetic Field Scaling Control and 3D Printed Membrane Spacer

Thank you!

Pei Xu: pxu@nmsu.edu