OKLAHOMA NSF EPSCoR S^3OK RESEARCH

Focus Area 3:
Variable & Marginal Quality Water Supplies
(V-MQW)

Presenter:
Mark Krzmarzick, Associate Professor
Civil and Environmental Engineering
Oklahoma State University

V-MQW: REPRESENTING TEAM TODAY

OU: Robert Nairn, Leah Jackson, Jason Vogel, Tiantian Yang, Hank Jenkins-Smith, Carol Silva






OSU: Mark Krzmarzick, Clint Aichele, Prem Bikkina, Babu Fathepure, Seok-Jhin Kim, Mary Foltz, Kiran Mangalgiri and Kevin Wagner








New Hires!!

SWOSU: Tim Hubin

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VARIABLE & MARGINAL QUALITY WATER SUPPLIES

Goals and Objectives

The overall goal is to develop new engineering technologies and modeling schemes for more effective marginal quality water reuse and improve understanding of water treatment efficiencies that are beneficial to utility sectors and end-users.

Five objectives!

1. To investigate removal of contaminants of emerging concern (CEC) from wastewater and stormwater by passive treatment systems.
2. To determine removal of nitrogen and CEC from stormwater and wastewater effluent by active treatment systems.
3. To determine removal of hydrocarbons from produced water via active treatment systems.
4. To develop efficient and cost-effective high salinity carbonated produced water flooding technology.
5. To determine water storage and retention using hybrid grey and green infrastructure for resource augmentation.

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VARIABLE & MARGINAL QUALITY WATER SUPPLIES

Progress to Date – 1. To investigate removal of contaminants of emerging concern (CEC) from wastewater and stormwater by passive treatment systems.

Task: Internal Water Storage (IWS) Storage Zone Investigations (changed to Underdrain Orifice Size Investigations).

1. Artificial runoff experiments at research site in Grand Lake have been completed
2. CEC removal (neonicotinoids) are being tested
3. Hydrological analysis has found that the orifice diameter is critically important for cell operation.

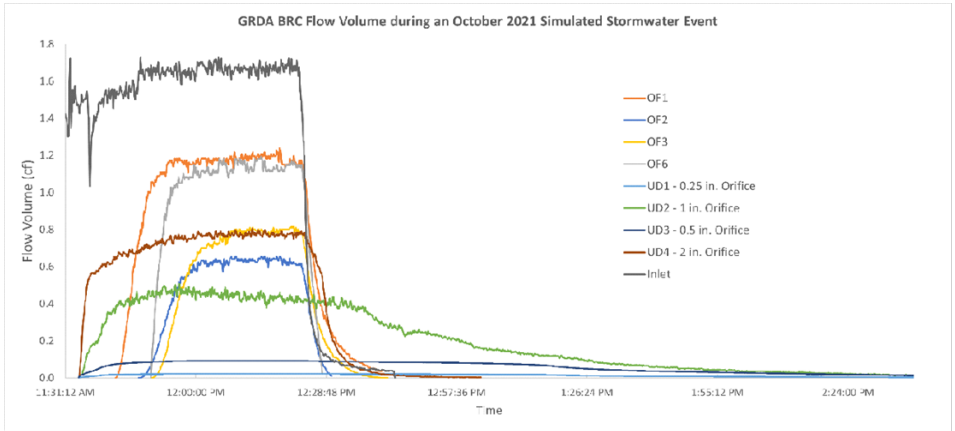

Figure VQMW-2. Flowrate versus time for various orifice sizes in research bioretention cells.

Grant Graves
Ph.D. Student

Kyle Mattingly
M.S. Student

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VARIABLE & MARGINAL QUALITY WATER SUPPLIES

Progress to Date – 1. To investigate removal of contaminants of emerging concern (CEC) from wastewater and stormwater by passive treatment systems.

Task: Industrial Byproducts in Underdrain Socks

1. Series of vertical column batch studies have been completed to test biochar, aggregated fly ash, and iron slag for removal of insecticides in underdrain socks.

Task: Removal of CECs in treatment wetlands

1. Location and set-up of wetland mesocosms has been determined, with better logistical operations and more robust experimental setup.

Task: Cataloguing CECs in wastewater effluent

1. Analysis of 50 constituents in secondary effluent at the NWRF completed.

Task: Detecting CEC degrading bacteria in passive systems

1. Methods for CEC degrading bacteria compiled, and quantitative PCR methods and standards developed.

Lela Merkel and Carly Noone
B.S. Students

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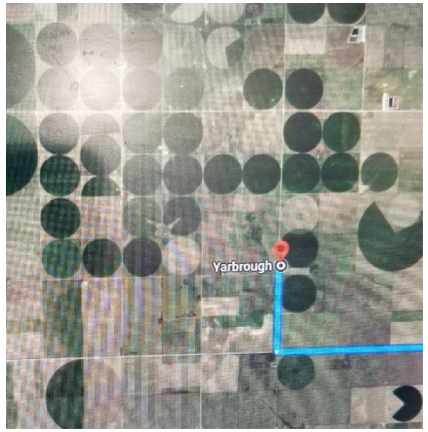
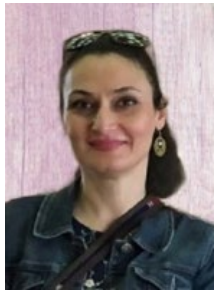
VARIABLE & MARGINAL QUALITY WATER SUPPLIES

Progress to Date – 2. To determine removal of nitrogen and CEC from stormwater and wastewater effluent by active treatment systems.





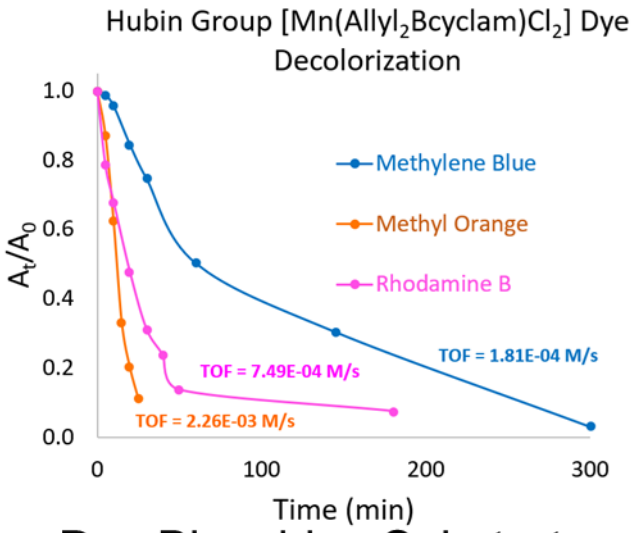
Raana Koushki
Ph.D. Student

Task: Determine distribution of Anammox and denitrification in N-impacted sediments

1. Methods for qPCR of N-cycling pathways identified and being tested.
2. First soil/sediment sampling complete in drainage pathway in western OK

Task: Synthesize, characterize and screen polymeric oxidation catalysts to remove CEC

1. Incorporation of ligands, metal complexes, and polymers are being developed and tested on dyes.



Dye Bleaching Substrates and Example of Data Obtained

Ashtyn McAdoo

Makynna Koper

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Elah Alcuitas

Leslie Garcia

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VARIABLE & MARGINAL QUALITY WATER SUPPLIES

Progress to Date – 3. To determine removal of hydrocarbons from produced water via active treatment systems

Task: Distribution and microbial ecology of produced waters.

1. Characterization of produced water and its microbial communities underway on samples collected in Kuwait and Oklahoma

Task: Microbial pretreatment of select produced water using halophilic hydrocarbon degraders

1. Isolation of a *Modicisalibacter tunisiensis* from an oil production water successful.
2. Bacteria exhibits high activity toward petroleum degradation and high salinity and heavy metal tolerances

Table VMQW-3. Laboratory assessment of BTEX degradation in the presence of heavy metals and 15% salt (NaCl) by strain Wilcox

Heavy metal	Maximum Concentration Tolerated (mM)	Maximum Concentration Tolerated (mM)	Complete Degradation of BTEX (weeks)
Arsenic	100	31,200	2
Manganese	100	16,902	2
Cadmium	12.5	2,291	2
Zinc	7	954	2
Lead	3	994	4
Selenium	3	789	4
Chromium	2	533	3
Cobalt	0.5	119	3
Nickel	0.5	119	2
Copper	0.25	43	4
Arsenic	100	31,200	5

Damilare Ajagbe
Ph.D. student

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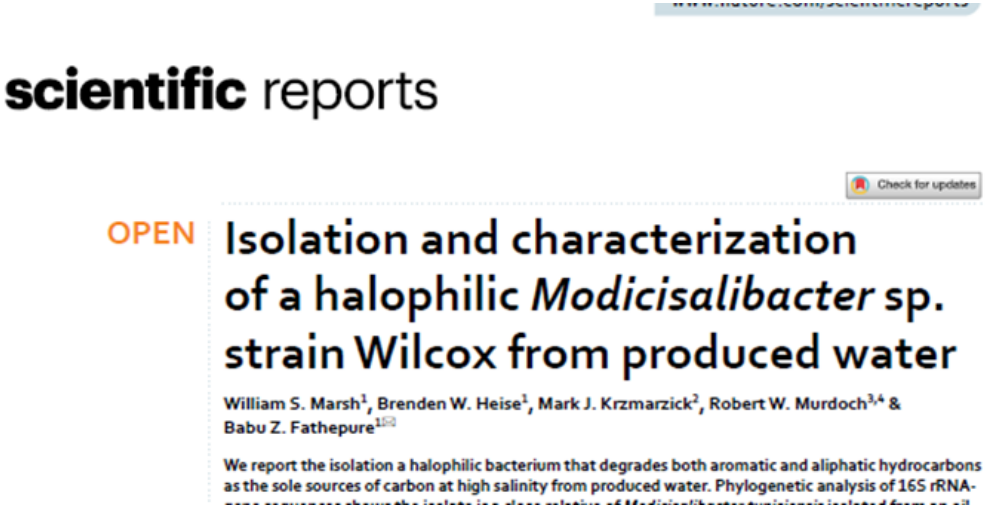
VARIABLE & MARGINAL QUALITY WATER SUPPLIES

Table VMQW-2. Laboratory assessment of the biodegradation ability of strain Wilcox[a]

Hydrocarbon Class	Hydrocarbons Degraded	Genome Predicted Degradation	Experimental Validation of Biodegradation
MAH	Benzene (20 - 40 µmol/bottle)	+	+
	Toluene (20 - 40 µmol/bottle)	+	+
	Ethylbenzene (20 -30 µmol/bottle)	+	+
	Xylenes (20 - 30 µmol/bottle)	+	+
	BTEX (combined)	+	+
	Phenol (2 mM)	+	+
	Benzoate (1 - 2 mM)	+	+
	Phenylacetate (2 mM)	+	+
Biphenyl	Biphenyl (2 mM)	+	+
PAH	Naphthalene (1 - 2 mM)	–	–
	Phenanthrene (1 - 2 mM)	–	–
n-Alkanes	Methane (100 uM)	–	–
	Hexane (5 mM)	–	–
	Decane (2 mM)	+	+
	Hexadecane (5 mM)	+	+
	Eicosane (2 mM)	–[c]	–
	Dotriacontane (2 mM)	–[c]	–

3. Genome sequenced and found to have multiple metal toxicity reducing mechanisms and hydrocarbon degradative pathways



scientific reports

Check for updates

OPEN

Isolation and characterization of a halophilic *Modicisalibacter* sp. strain Wilcox from produced water

William S. Marsh[1], Brenden W. Heise[1], Mark J. Krzmarzick[2], Robert W. Murdoch[3,4] & Babu Z. Fathepure[1]

We report the isolation a halophilic bacterium that degrades both aromatic and aliphatic hydrocarbons as the sole sources of carbon at high salinity from produced water. Phylogenetic analysis of 16S rRNA-

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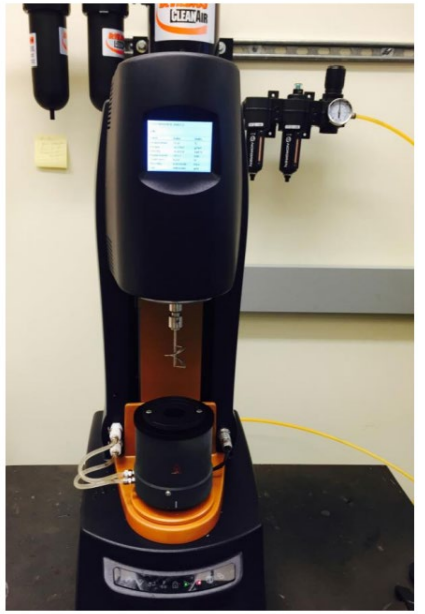
VARIABLE & MARGINAL QUALITY WATER SUPPLIES

Progress to Date – 3. To determine removal of hydrocarbons from produced water via active treatment systems

Task: Identify influence of produced water on interfacial properties in liquid-liquid dispersions

1. Dynamic interfacial tension measured through various needles
2. Produced water found to have lower surface tension than expected based on salinity, due likely to organic contaminants



Sample name	Density (g/cc)	Viscosity (cP)	pH	Sodium Chloride (%)	Surface Tension (mN/m)
Produced Water Sample 1 (Pre-Injection)	1.115	1.4	6.63	16.3	69.59
Produced Water Sample 2 (Pipeline)	1.115	1.6	6.87	16.5	70.13
Produced Water Sample 3 (Trash Tank)	1.070	1.2	6.53	10.2	69.78
Produced Water Sample 4 (Injection Pump)	1.115	1.5	6.43	16.7	67.47

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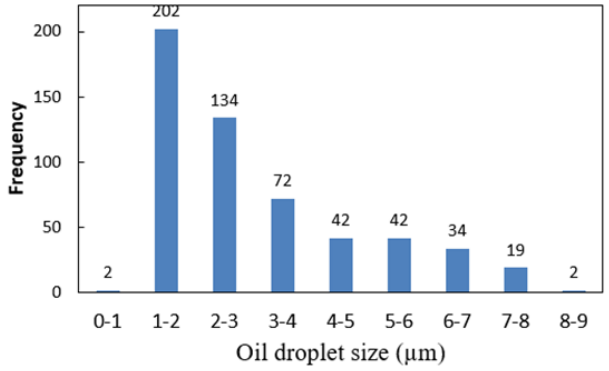
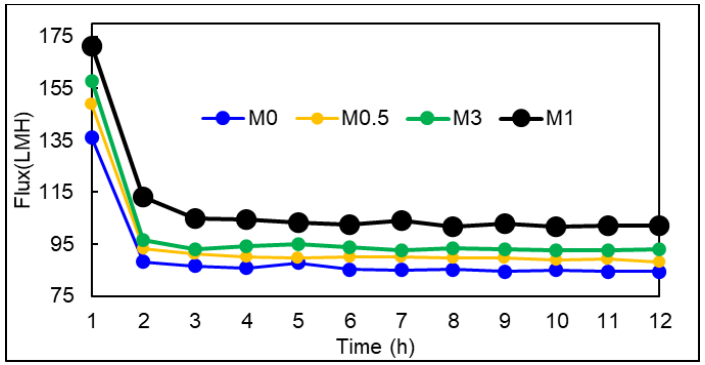
VARIABLE & MARGINAL QUALITY WATER SUPPLIES

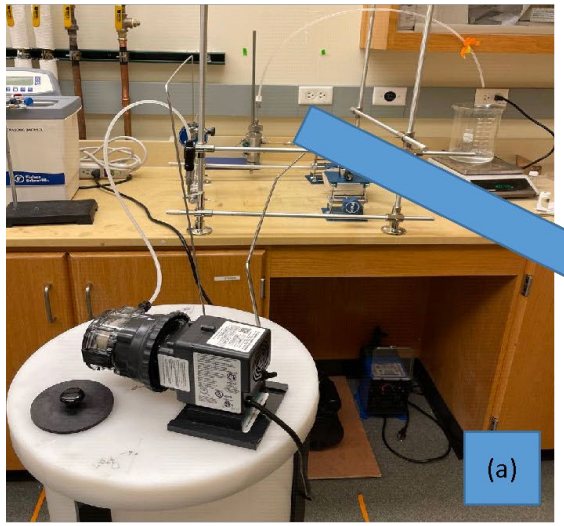
Progress to Date – 3. To determine removal of hydrocarbons from produced water via active treatment systems

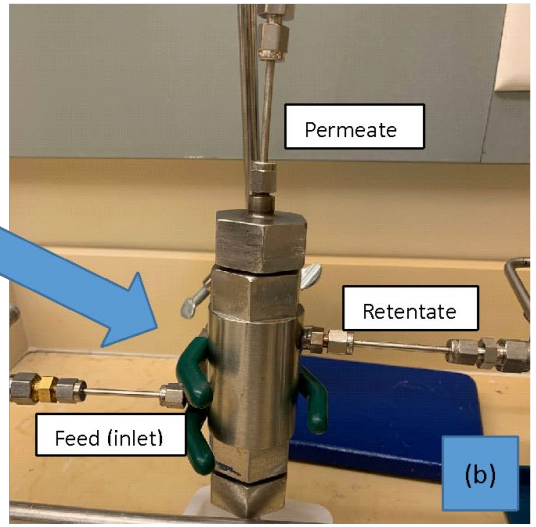
Task: Optimize nanoparticle properties that facilitate oil/water separation and develop anti-fouling membranes for produced water treatment

1. Cross-flow hydrophilic membrane systems have been set up and operated with various nanoparticle treatments tested.
2. Modified fumed silica particles were found to have the best affect on membrane performance.
3. 1% silica nanoparticles attached to α-alumina was found to increase flux across the membrane, with high rejection of oil emulsion









Michael Miranda,
Post-doc

water

Review

Treatment and Recovery of High-Value Elements from Produced Water

Michael Angelo Miranda [1], Anirban Ghosh [1], Ghader Mahmodi [1], Songpei Xie [1], Madelyn Shaw [2], Seokjhin Kim [1], Mark J. Krzmarzick [2], David J. Lampert [3,*] and Clint P. Aichele [1]

l of Chemical Engineering, Oklahoma State University, Stillwater, OK 74078, USA; an@okstate.edu (M.A.M.); anirban.ghosh@okstate.edu (A.G.); diako.mahmodi@okst ei.xie@okstate.edu (S.X.); seokjhin.kim@okstate.edu (S.K.); clint.aichele@okstate.edu l of Civil and Environmental Engineering, Oklahoma State University, Stillwater, OK lyn.shaw@okstate.edu (M.S.); mark.krzmarzick@okstate.edu (M.J.K.) tment of Civil, Architectural, and Environmental Engineering, Illinois Institute of Te go, IL 60616, USA spondence: dlampert1@iit.edu; Tel.: +1-312-567-3544

Anirban Ghosh,
Ph.D. student

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VARIABLE & MARGINAL QUALITY WATER SUPPLIES

Progress to Date – 4. To develop efficient and cost-effective high salinity carbonated produced water flooding technology.

Task: Selection of compositions of high salinity carbonated produced water based on stability, bulk, and interfacial properties.

Experimental setup for CO_2 solubility in oil has been built.

Task: Evaluation of the enhanced oil recovery potential of high salinity carbonated produced water flooding technology from pore to core scale at reservoir conditions

1. Microfluidic experiment has been setup.

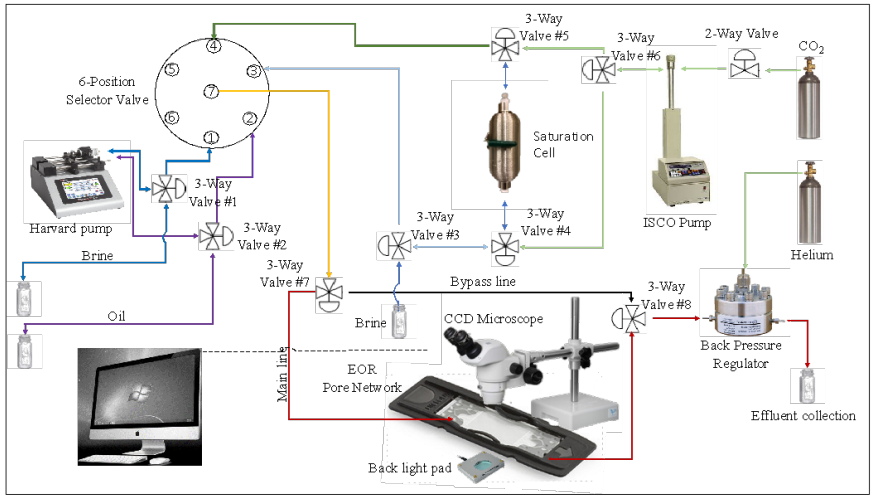
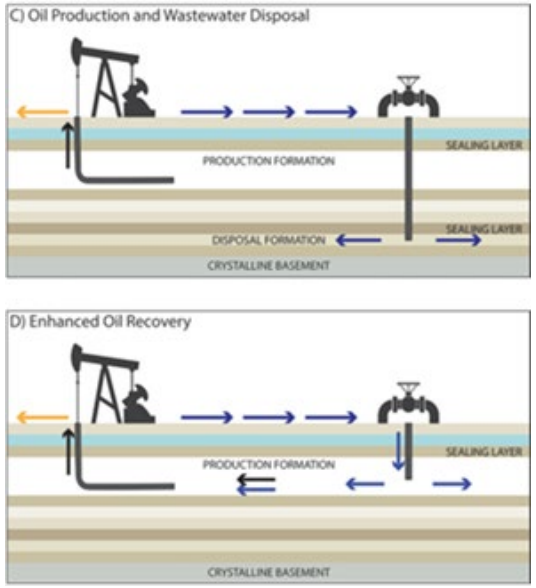
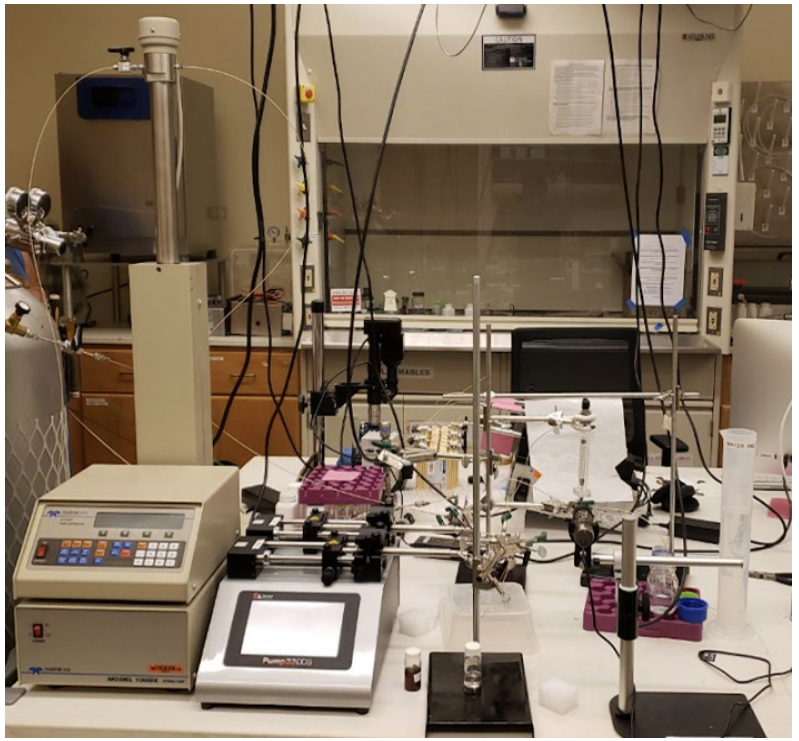
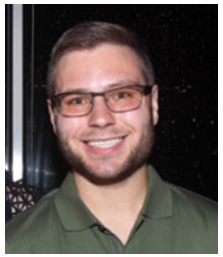


Figure VMQW-27 Flow Diagram of the Microfluidics Setup



Source: https://www.usgs.gov





Justin Gaddis,
M.S. student

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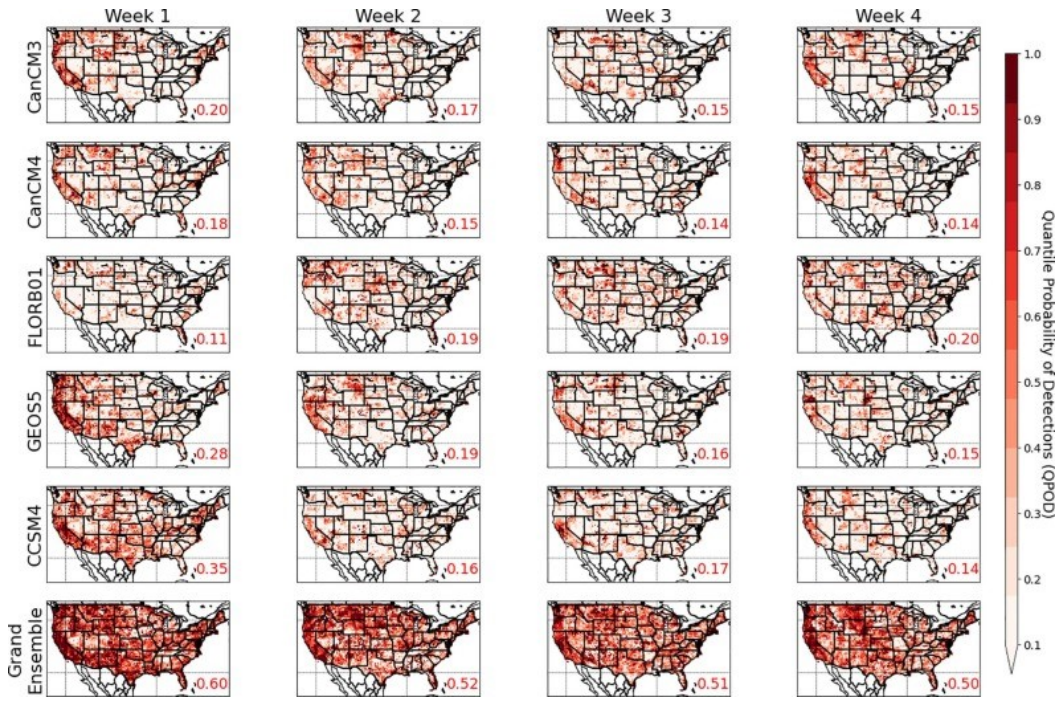
VARIABLE & MARGINAL QUALITY WATER SUPPLIES

Progress to Date – 5. To determine water storage and retention using hybrid grey and green infrastructure for resource augmentation

Task: S2S-informed water supply modeling and decision making

1. Forecasts data collected and prepped for experiments.
2. Data found to show strong seasonal and spatial variations in terms of forecast bias and skill
3. Cooler seasons in the west have had significantly overestimated precipitation events
4. Warmer seasons in the South and Central have had significantly underestimated precipitation events
5. Forecasts beyond 2 weeks are marginal

Lujun Zhang,
Ph.D. student



Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

ELSEVIER

Evaluation of Subseasonal-to-Seasonal (S2S) precipitation forecast from the North American Multi-Model ensemble phase II (NMME-2) over the contiguous U.S.

Lujun Zhang [a], Taereem Kim [a], Tiantian Yang [a,*], Yang Hong [a], Qian Zhu [b]

[a] The School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK, USA
[b] School of Civil Engineering, Southeast University, Nanjing, China

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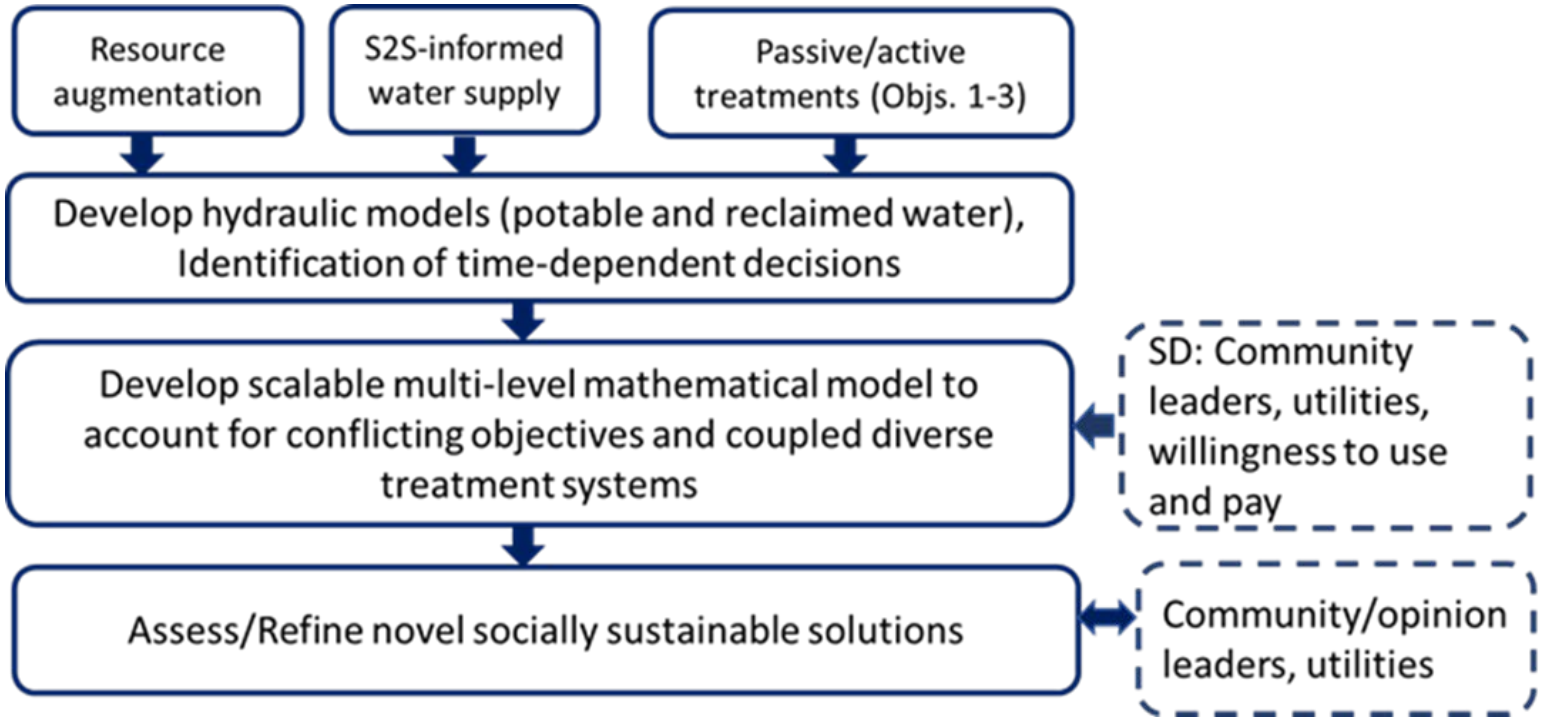
VARIABLE & MARGINAL QUALITY WATER SUPPLIES

Impacts of the Research

1. Address the need for ~600,000 acre-feet of water needs in Oklahoma over the next 40 years
2. Make water infrastructure more resilient to extreme weather and other events
3. Increase water security in a changing climate



Source: Rezaei, Diaz, *Mohebbi* et al. (2019)

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VARIABLE & MARGINAL QUALITY WATER SUPPLIES

Future Plans

- Insecticide removal data in passive systems being evaluated.
- Wetlands for passive treatment under construction in 2022.
- Numerous experiments now set-up will be started – i.e. CO_2 experiments using saltwater for enhanced oil recovery, use of molecular methods to study nitrogen cycling in agricultural runoff systems, analysis of CEC degrading bacteria in wastewater treatment plants
- Projects started by new faculty hires on nitrogen removal and active treatment of CECs
- New member (Leah Jackson) taking over tasks left after departure of a faculty member
- Number of students working on S3OK objectives to continue to increase.
- Continue developing collaborations with other focus areas. For example, use of SD information for developing planning and strategies for water reuse
- Little River Watershed becoming more implemented
- Machine learning applied to precipitation forecast data and other variables in weather in climate, to predict extreme precipitation events