Oklahoma Water Resources Research Institute
Division of Agricultural Sciences and Natural Resources

Annual Technical Report
2019

Products

Publications

- G. Mahmodi, S. Dangwal, P. Zarrintaj, M. Zhu, Y. Mao, D.N. Mcllroy, M.R. Saeb, V. Vatanpour, J.D. Ramsey, S.-J. Kim, NaA Zeolite-Coated Meshes with Tunable Hydrophilicity for Oil-Water Separation. Sep. Purif. Technol., 240 (2020) 116630.

- G. Mahmodi, P. Zarrintaj, N. M. Ghalehlari, S. Dangwal, A. Ronte, M. R. Ganjali, S. M. Hamad, S.-J. Kim, M. R. Saeb, From Microporous to Mesoporous Mineral Frameworks: An Alliance between Zeolite and Chitosan. Carbohydr. Res., 489 (2020) 107930.

- S. Dangwal, R. Liu, L. D. Bastatas, E. Echeverria, C. Huang, Y. Mao, D. N. Mcllroy, S.-J. Kim, ZnO Microfiltration Membranes for Desalination by a Vacuum Flow-Through Evaporation Method. Membranes, 9(12) (2019), 156

- D. Atoufi, H., and Lampert, D. J., "*Impacts of Oil and Gas Productions on Contaminants Levels in Sediments,"* **Current Pollution Reports**, 6, 43-53, 2020, https://doi.org/10.1007/s40726-020-00137-5.

Patents and intellectual property

- U.S. Provisional Patent Application No. 63/071,527, S.-J. Kim, D. Mcllroy S. Dangwal, Microfiltration Membranes, under filing

Presentations

- Reid, C. and C. Fontanier. 2019. Effects of deficit irrigation on warm-season turfgrasses under fairway maintenance. ASA-CSSA-SSSA Meetings. San Antonio, TX. Nov 10-13.

- McDonald, H., C. Fontanier, and L. Weaver. 2019. Minimal water requirements for warm-season turfgrasses under simulated gold cart traffic. ASA-CSSA-SSSA Meetings. San Antonio, TX. Nov 10-13.

- G. Mahmodi, S.-J. Kim, NaA Zeolite-Coated Meshes with Precisely Tunable Hydrophilicity for Oil-Water Separation, Oklahoma Governor's Water Conference, Midwest City, OK, December 2019.

- G. Mahmodi, S. Dangwal, S.-J. Kim, Produced Water Purification By a Vacuum Flow-through Evaporation, AIChE Annual Meeting, Orlando, FL, November 2019.

- D. Atoufi, H., and Lampert, D. J., "*Membrane Desalination to Prepare Produced Water for Reuse*," **World Environmental and Water Resources Congress 2020**, 8–15, 2020, https://doi.org/10.1061/9780784482988.002.

Other Products

- Socio economic and weather correlations across nine Oklahoma climate free interactive tool: http://www.hitechmex.org/OWRC_Project_2020/

Information Transfer Program

The OWRC utilizes its website (6,685 visits and 13,995 page-views in calendar year 2020), its quarterly *Currents* e-newsletter (1,300 recipients), and social media platforms to distribute relevant and timely information on water research findings, legislative updates, Oklahoma water faculty, partnerships, funding opportunities, and upcoming events. Newsletter distribution and social media activity significantly increased the past calendar year. Currently, there are 1,300 persons on the e-newsletter distribution list (an increase of nearly 20%); 529 persons like our Facebook page, a 37% increase; 906 Twitter followers, a 27% increase; 224 Instagram followers, a 190% increase; and 765 YouTube subscribers, a 36% increase.

The OWRC Director delivered 13 presentations to over 460 attendees on water reuse, public perceptions on water issues, grazingland management to improve water quality, partnerships/collaboration opportunities, program sustainability, risk management, ag irrigation water conservation, and other Oklahoma water issues, research needs, and opportunities. The OWRC Director also updated Oklahoma's Congressional delegation on OWRC activities in February 2020.

OWRC staff hosted several webinars on citizen science activities for youth programs, how to use citizen science for virtual research experiences, and demonstrating the Hydrologic and Water Quality System for Oklahoma (OK-HAWQS).

The OWRC and Oklahoma Water Resources Board co-hosted the *2019 Oklahoma Governor's Water Conference and Research Symposium*, drawing >400 water professionals, to exchange ideas and information on water issues, policy, and research.

The OWRC and Oklahoma Cooperative Extension Service co-hosted the *2019 Oklahoma Irrigation Conference*, providing >50 participants with the latest research-based insights and information on irrigation management strategies.

Student Support

Project Title/Function	Level and Department
Effects of Deficit Irrigation on Water Use of Warm Season Turfgrasses Under Fairway Maintenance	One MS Student and one undergraduate student, Department of Horticulture and Landscape Architecture, Oklahoma State University
Understanding Economic Impacts of Groundwater and Soil Moisture Interactions In Oklahoma – A Decision Support Tool for Sustainable Water Management	One undergraduate student, Department of Geography and Environmental Sustainability, University of Oklahoma
Four-Step PW Desalination Process with Zeolite and a-Alumina Membranes	One Ph.D. student in the School of Civil and Environmental Engineering, Oklahoma State University
Rational Design of Solar Energy-Combined Desalination Systems for Treatment of Produced Water	Two Ph.D. Students in the School of Chemical Engineering, Oklahoma State University
Student Writer: OWRC (2019 – present)	Undergraduate Senior, Department of Environmental Science, Oklahoma State University

Notable Achievements and Awards

- Seed funding from the USGS 104b Program provided a foundation for a $90,000 research grant to develop a treatment process for produced water funded by the Oklahoma Center for the Advancement of Science and Technology.

- Dr. Dave Lampert received the 2020 Early Career Award for Research from the Universities Council on Water Research.

Program Administration/Management Plan

Project Type: Annual Base Grant
Project ID: 2019OK215B

Project Impact:

The annual base grant supported 1) basic institutionalization of OWRC research and educational programs, 2) facilitation and development of collaborative efforts among water management entities, and 3) oversight and leadership of the program by OWRC staff.

The OWRC director participated in annual NIWR and UCWOR meetings for collaboration with other directors. OWRC also participated in state, regional, and national meetings of related organizations to publicize the Center's research programs and remain abreast of critical water research issues.

To assist in identifying state research needs, OWRC utilized its Water Research Advisory Board (WRAB) consisting of state agency leaders, policymakers, and other water resource professionals. The Board meets bi-annually to review grant proposals, make recommendations for funding, set funding priorities, and dialogue about new developments in water research. In PY20, 31 104b proposals were received (19 faculty/12 student) and five (3 faculty/2 student) funded. In PY21, 34 (28 faculty/6 student) were received and six (3 faculty/3 student) recommended for funding.

OWRC submitted 29 proposals and received federal and state funding for four, addressing key Oklahoma water resources issues including identifying Socially Sustainable Solutions for Water, Carbon and Infrastructure Resilience, developing the Oklahoma Hydrologic and Water Quality System, and Sustaining Agriculture through Adaptive Management to Preserve the Ogallala Aquifer under a Changing Climate.

The OWRC also facilitated submission of six 104(g) proposals. The proposal submitted by K.D. Hambright (OU), titled Harmful algal blooms and public safety: a monitoring and research program aimed at understanding cyanobacterial blooms and toxin production was selected for funding.

Information Transfer

Project Type: Annual Base Grant
Project ID: 2019OK216B

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Understanding Economic Impacts Of Groundwater And Soil Moisture Interactions In Oklahoma – A Decision Support Tool For Sustainable Water Management

Project Type: Annual Base Grant
Project ID: 2019OK217B

Project Impact:

The goal of the project was to improve understanding of groundwater and surface water interactions with socio-economic variables in nine climate regions in Oklahoma. By correlating temporal changes in groundwater well levels, soil moisture, and precipitation with drought events, regional long-term interactions between these variables were found. An interactive geospatial model was developed by means of the Keyhole Markup Language (KML), which can be used for educational purposes and for decision-support:

http://www.hitechmex.org/OWRC_Project_2020/

Correlations were calculated and analyzed for the following socio-economic variables in the time span 2003-2018 for the entire state of Oklahoma and for the respective counties and climate regions: gross domestic product (GDP), unemployment rates, price indexes for economic goods, consumer price index, producer price index, income per capita, population, and water withdrawals for different economic sectors (agriculture, industry, municipal use, energy generation).

The results show correlation values ranging with wide variability between -1 to 1, for different variables, and need to be analyzed for each variable separately. For instance, correlation coefficients for GDP show mostly negative correlations for all drought related variables (e.g., soil moisture, precipitation, and groundwater), although variability also exists in regard to the degree of negative correlations (strong vs weak). This variability can be tracked and analyzed interactively through the website and the interactive link provided above.

Four-step PW Desalination Process With Zeolite And AAlumina Membranes

Project Type: Annual Base Grant
Project ID: 2019OK218B

Project Impact:

Produced water from oil and gas operations contains many contaminants that can affect water resources. This study developed a treatment strategy for produced water. The design included softening with calcium hydroxide, suspended solids removal with activated carbon (AC), ultrafiltration (UF) method using a ceramic membrane, and reverse osmosis (RO) desalination using polyamide thin-film composite (PA-TFC) membrane. Performance was evaluated in terms of water flux (Equation 1). The flux was recorded using a Python code which collected data from a balance. In this equation, V (L) is the volume of permeate, A (m2) is the effective membrane area (for UF and RO is 0.0062 and 0.0042 m2), t (h) the time of operation under transmembrane pressure that was 3.5 bar, and 400 psi for the UF and RO cells, respectively.

$J(LMH)=V/(A\times t)$ Equation 1

For the UF system, the initial flux was 14.5 liters/m2/hour (LMH). Fouling decreased the flux to 6.41 LMH after 40 minutes of the experiment. For the RO system, the test cell was unable to run at the high pressure requirement. Conductivity in the treated water was substantially decreased, although equipment issues prevented measurement of cations in samples.

Support from the USGS 104b program has provided a foundation for produced water treatment research that could generate a significant new source of clean water for Oklahoma.

Rational Design Of SolarEnergy-Combined Desalination Systems For Treatment Of Produced Water

Project Type: Annual Base Grant
Project ID: 2019OK219B

Project Impact:

The overall goal of the proposed research is to develop novel, energy-efficient solar-energy-combined membrane processes for treating produced water (PW) to levels suitable for reuse. The first research objective is to develop solar evaporation and condensation system. A bench scale prototype solar desalination system for treating PW was constructed and tested. The design consisted of a water reservoir, a high surface area evaporation column, parabolic reflectors and a 500 W bulb that served as the heat source. Tests demonstrated that the solar evaporator produced 99.9% pure water. However, the evaporation rate was found to be slower than anticipated. The team found that the solar reflector should be redesigned with multiple elements that disperse the light uniformly across the evaporation column and the diameter of the outlet of the evaporation column should be increased.

The second objective is to synthesize ceramic membranes for desalination and organics rejection. The team developed flow-through pervaporation ceramic membranes coated with ZnO for 4–128 cycles via atomic layer deposition (ALD) technique to improve hydrophilicity and reduce mass transfer resistance. Analysis of membrane surface by contact angles measurements revealed that the hydrophilicity of the ZnO ALD membrane was enhanced with increasing the number of ALD cycles. Total Dissolved Solids (TDS) in PW is very high, 311388 ppm. Tests demonstrated that TDS decreased to 29634 ppm for 20-ALD-cycles membrane and decreased to 8 ppm for 100-ALD-cycles membrane, indicating that with more ZnO ALD cycles, TDS values decreased.

Effects Of Deficit Irrigation On Water Use Of Warm Season Turfgrasses Under Fairway Maintenance

Project Type: Annual Base Grant
Project ID: 2019OK220B

Project Impact:

This research aimed at developing targeted water conservation programs for golf fairway irrigation using reference ET-based scheduling. A field experiment was conducted at the Turfgrass Research Center in Stillwater, OK, to measure water requirements of eight fairway-type grasses (U-3, Celebration, Tifway, Latitude 36, TifTuf, Meyer, PremierPro, and OSU1403).

Significant differences in drought resistance were apparent during late July. Specifically, Meyer and OSU 1403 each showed drought stress at the 25% ETc levels, while other cultivars showed no indication of stress at these levels (under unrestricted rooting). Rootzone depth affected green coverage for 'Latitude 36', 'Meyer', 'OSU 1403', 'PremierPro', and 'Tifway'. In general, the shortened rootzones resulted in less green coverage than the unrestricted rootzone for these bermudagrasses. For Meyer, severe drought stress was typically observed across all rootzone depths, with the exception of the 25% ETc treatment in which case the 8-inch rootzone performed worst. This suggests Meyer did not substantially benefit from an unrestricted rootzone which is indicative of short-rooted plants. Soil water extraction rates seemed to confirm the shorter roots for both 'Meyer' and 'OSU 1403'. For 'Celebration', 'TifTuf', and 'U-3', rootzone did not have any visible effect on green coverage even in the 25% ETc treatment. These findings reinforce the superior drought resistance of these grasses compared to others tested and suggest their use in conjunction with deficit irrigation practices could reduce irrigation requirements by as much as 50% from typical practices in the region.