

**Nebraska Water Center**  
**Robert B. Daugherty, Water for Food Institute**

**Annual Technical Report**  
**2018**

# General Information

## Products

**1:** Data collection from this project ended on June 2019. Three journal articles will result from this project, the documents are under preparation: a. Treatment of meat processing wastewater with immobilized co-culture of microalgae and activated sludge bacteria; b. Effect of sodium hypochlorite treatment on pollutants removal by immobilized microalgae from meat processing wastewater; c. Impact of ozonation on meat processing wastewater treatment by immobilized microalgae

**2:** Abimbola, Olufemi P., Aaron R. Mittelstet, Troy E. Gilmore, Jesse T. Korus. Influence of watershed characteristics on streambed hydraulic conductivity across multiple stream orders. *Nature Scientific Reports*. (review complete, revisions requested, revisions submitted)

**3:** Presentations: a. T.L. Messer, M. Keilhauer<sup>2</sup>, D. Snow, and A. Mittelstet. 2019. Pesticide exposure in recreation lakes. 2019 American Society of Agricultural Engineering International Meeting, Boston, MA, July 7-10, 2019. b. T.L. Messer, M. Keilhauer<sup>2</sup>, D. Snow, and A. Mittelstet. 2019. Pesticide accumulation in recreation lakes. 2019 American Society of Ecological Engineers Annual Meeting, Asheville, NC, June 4, 2019. c. Satiroff, J.2, T.L. Messer, and A.R. Mittelstet. 2018. Removal of Common Use Pesticides by Floating Treatment Wetlands in the Midwest. Nebraska Water Center Symposium. 25 October, 2018. Lincoln, NE. Poster presentation. Upcoming Publication: Satiroff, J.2, T.L. Messer, A.R. Mittelstet, and D. Snow. Neonicotinoid Accumulation and Exposure in Recreational Lakes. *Journal of Environmental Science and Technology*. Expected Submission Winter 2019. In Prep. Upcoming Thesis: Satiroff, J.2, T.L. Messer, A.R. Mittelstet, and D. Snow. Neonicotinoid Accumulation and Exposure in Recreational Lakes. M.S. Environmental Engineering, UNL, Expected defense Spring 2020. Under Review Grant Applications: Data from the project was utilized as seed date into the following proposals: a. Tiffany Messer (PD), Funded, Treating Non-Point Source Cocktails: Pesticide Removal Utilizing In-stream Best Management Practices, Robert B. Daugherty Water for Food Global Institute at the University of Nebraska, \$10,800, 7/1/2019 – 6/30/2020. b. Tiffany Messer (PD), Under Review, CAREER: Impact of Pesticide and Antibiotic Cocktails on Nitrogen Removal Processes in Treatment Wetlands, NSF – CAREER, \$518,623, 7/1/2020 – 6/30/2025.

**4:** Peer-Reviewed Journal Manuscripts: Bhatti, S., D. M. Heeren, J. B. Barker, C. M. U. Neale, W. E. Woldt, M. S. Maguire, and D. R. Rudnick. 2019. Site-specific irrigation management in a sub-humid climate using a spatial evapotranspiration model with satellite and airborne imagery. *Agricultural Water Management* (initial review complete, in revisions).

Barker, J. B., S. Bhatti, D. M. Heeren, C. M. U. Neale, and D. R. Rudnick. 2019. Variable rate irrigation of maize and soybean in West-Central Nebraska under full and deficit irrigation. *Frontiers in Big Data* (revised manuscript in review).

O'Shaughnessy, S. A., S. R. Evett, P. D. Colaizzi, M. A. Andrade, T. H. Marek, D. M. Heeren, F. R. Lamm, and J. L. LaRue. 2019. Identifying advantages and disadvantages of variable rate irrigation – an updated review. *Applied Engineering in Agriculture* (in press), doi: 10.13031/aea.13128. Available at: <https://elibrary.asabe.org/abstract.asp?aid=50118>

Mendes, W. R., F. M. U. Araújo, R. Dutta, and D. M. Heeren. 2019. Fuzzy control system for variable rate irrigation using remote sensing. *Expert Systems with Applications* 124: 13-24, doi: 10.1016/j.eswa.2019.01.043. Available at: <http://digitalcommons.unl.edu/biosysengfacpub/597/>

Evett, S. R., P. D. Colaizzi, F. R. Lamm, S. A. O'Shaughnessy, D. M. Heeren, T. J. Trout, W. L. Kranz, and X. Lin. 2019. Past, present and future of irrigation on the U.S. Great Plains. *Transactions of the ASABE* (revised manuscript in review).

Thesis: Bhatti, S. 2018. Variable rate irrigation using a spatial evapotranspiration model with remote sensing imagery and soil water content measurements. M.S. thesis, Department of Biological Systems Engineering, University of Nebraska-Lincoln. Available at: <https://digitalcommons.unl.edu/biosysengdiss/83/>

Conference Proceeding: Woldt, W. E., C. M. U. Neale, D. M. Heeren, E. Frew and G. E. Meyer. 2018. Improving agricultural water efficiency with unmanned aircraft. Association for Unmanned Vehicle Systems International (AUVSI) XPONENTIAL trade show and conference, Denver, Colo. 8 pages. Available at: [https://www.researchgate.net/publication/325768366\\_Improving\\_Agricultural\\_Water\\_Efficiency\\_with\\_Unmanned\\_Aircraft](https://www.researchgate.net/publication/325768366_Improving_Agricultural_Water_Efficiency_with_Unmanned_Aircraft)

**5:** Eubanks, M. A., J.S. Bricker, S.L. Bartelt-Hunt, D.D. Snow. 2018. Microplastic Pollution in Nebraska's Water

Systems: Quantity and Composition. Poster with Abstracts 2018 NIWR Regional Symposium "Water Resources of the U.S. Great Plains Region: Status and Future," October 24-26 at Nebraska Innovation Campus in Lincoln, NE. Eubanks, M. A., J.S. Bricker, S.L. Bartelt-Hunt, D.D. Snow. 2019. Microplastic pollution in Salt Creek surface waters: quantity and composition. PROGRAM and PROCEEDINGS - THE NEBRASKA ACADEMY OF SCIENCES: 139th Anniversary Year, One Hundred-Twenty-Ninth Annual Meeting, April 12, 2019, Nebraska Wesleyan University, Lincoln, NE.

## Information Transfer Program

**1:** Findings from this project were presented in five scientific conferences as information transfer activities: 04/04/2019 Water for Food Research Forum; 04/15/2019 Research fair at University of Nebraska-Lincoln; 04/29/2019 2019 Water for Food Global Conference; 06/17/2019 9th International Conference on Algal Biomass, Biofuels and Bioproducts; 07/02/2019 IWA Conference on Algal Technologies and Stabilization Ponds for Wastewater Treatment and Resource recovery. Valladolid Spain

**2:** Results were presented at the ASABE meeting in Detroit, Washington in July 2018. Abimbola, O.\*, A.R. Mittelstet, T.E. Gilmore and J. Korus. 2018. Geostatistical features of streambed vertical hydraulic conductivity in the Frenchman Creek watershed in Western Nebraska. ASABE Annual International Meeting, Detroit, MI. Oral presentation.

**3:** Results from this project were presented at two national meetings in 2019: American Society of Agricultural and Biological Engineers; and American Society of Ecological Engineers. Findings were introduced in to PI Messer's wetlands course in the section covering the impact of emerging contaminants on wetland sustainability. Two graduate students and two undergraduate students took part in the sampling collection and data processing of this project. Currently results are being processed. Once this is complete, results will be published in a peer reviewed journal with the primary author one of the Master's students that was involved in the project. Results will also be incorporated into a statewide extension workshop in October and November for the Nebraska Natural Resource Districts and a webinar for the state of Tennessee Department of Water Quality in August 2019 by PI Messer. PI Messer is currently working with Dimensions Nature Explore classrooms and Lincoln Public School on a in class hands-on project for the fall of 2019 to learn about water quality in lakes and potential treatment practices. Findings from this project will be incorporated into these workshops.

**4:** Invited Presentations: Heeren, D. M., J. B. Barker, S. Bhatti, D. R. Rudnick, and F. Munoz-Arriola. February 26-27, 2019. Impact of variable rate irrigation (VRI) on consumptive use of water resources. Central Plains Irrigation Association (CPIA) Central Plains Irrigation Conference, Kearney, Nebr.  
Heeren, D. M., S. R. Melvin, and Troy Ingram. January 29, 2019. Trends in technology for irrigation scheduling. Nebraska Crop Management Conference, Kearney, Nebr.  
Heeren, D. M., J. B. Barker, S. Bhatti, M. S. Maguire, W. E. Woldt, and C. M. U. Neale. September 14, 2018. Variable rate irrigation (VRI): Benefits, limitations, and management practices. Delegation from Irrigation New Zealand, Lincoln, Nebr.  
Barker, J. B., S. Bhatti, D. M. Heeren, and C. M. U. Neale. June 6, 2018. VRI irrigation scheduling. Marena Oklahoma In Situ Sensor Testbed (MOISST) Workshop, Lincoln, Nebr.  
Conference Presentations: Bhatti, S., J. B. Barker, D. M. Heeren, C. M. U. Neale, D. R. Rudnick, W. E. Woldt, and A. L. Boldt. October 24-26, 2018. Variable rate irrigation with spatial evapotranspiration model using imagery from satellite and unmanned aerial systems. Nebraska Water Center (NWC) Great Plains Regional Water Symposium, Lincoln, Nebr. Poster presentations: Li, J., J. B. Barker, S. Bhatti, I. Possignolo, D. M. Heeren, A. L. Boldt, and H. Yan. October 24-26, 2018. Comparison of methods for calculating deep percolation. NWC Great Plains Regional Water Symposium, Lincoln, Nebr.  
Bhatti, S., D. M. Heeren, J. B. Barker, C. M. U. Neale, D. R. Rudnick, W. E. Woldt, Y. Ge, J. D. Luck, G. E. Meyer, F. Munoz-Arriola, A. L. Boldt, and M. S. Maguire. July 29-August 1, 2018. Variable rate irrigation management using a spatial evapotranspiration model. ASABE Annual International Meeting, Detroit, Mich.

**5:** Field sampling methodology and lab analysis techniques developed and streamlined during this research project are being integrated into the majors-level ecology course (BIO 4980: Ecology) taught fall 2019 semester at Nebraska Wesleyan University. Microplastic presence in the environment has gained increasing coverage in the popular press and makes an excellent topic to connect human activities to ecologic networks. BIO 4980 students will sample

localities in the Lancaster County, Nebraska, that weren't included in the current study. This will allow us to expand our understanding of the scope of microplastic pollution in Nebraska waterways.

## **Student Support**

1: One graduate student: Xijuan Hu, Ph.D. was partially supported by this grant

2: One graduate and two undergraduate students.

3: Graduate Students: a. Mary Keilhauer, MS in School of Natural Resources (graduated Summer 2019) b. Jessica Satiroff, MS in Environmental Engineering (Expected graduation Spring 2020)

Undergraduates: 2 a. Helen Little, BS in Biological Systems Engineering (Expected graduation Spring 2023) b. Ken Oathroat, BS in Biological Systems Engineering (Expected graduation Winter 2020)

4: This grant directly supported one MS student, Sandeep Bhatti, who graduated in December 2018 and is continuing irrigation research as a PhD student (advised by Dr. Heeren). This grant also supported one undergraduate research assistant in summer 2017, Isabella Possignolo, who is continuing irrigation research at UNL as an MS student (advised by Dr. Qiao).

5: Two part-time Nebraska Wesleyan senior undergraduate students were supported on this project.

## **Notable Achievements and Awards**

Second Place, student porter competition. Water for Food Global conference. April, 2019.

Funded project using seed data from the 104(b) funding: Tiffany Messer (PD), Funded, Treating Non-Point Source Cocktails: Pesticide Removal Utilizing In-stream Best Management Practices, Robert B. Daugherty Water for Food Global Institute at the University of Nebraska, \$10,800, 7/1/2019 – 6/30/2020.

Sandeep Bhatti. 2018-2019. Farmers National Company Fellowship. Derek Heeren. 2018. A. W. Farrall Young Educator Award. ASABE Annual International Meeting, Detroit, Mich.

## Projects

### Impact of Variable Rate Irrigation on Consumptive Use of Water Resources

**Project Type:** Annual Base Grant **Project ID:** 2017NE291B

**Project Impact:** Funding from the USGS 104(b) program supported two students and allowed us to continue our variable rate irrigation (VRI) field research (initially 2015 and 2016) at two field sites (Mead and Brule, NE) for another year (2017). Other funding sources allowed research to continue at the Mead field site into 2018. The primary products from this funding are two journal manuscripts (Bhatti et al., 2019; Barker et al., 2019). Another significant product is extension material specifically on the topic of consumptive use, which was presented at an extension conference (Heeren et al., 2019) and is being developed into an extension publication in cooperation with the Department of Natural Resources. Compared to well-managed conventional irrigation, VRI decreased irrigation amount in four cases, increased irrigation in five cases, and did not affect irrigation in six cases (total of 15 treatment-year combinations). It was originally hypothesized that, while VRI can be used to reduce pumping, it would not significantly reduce consumptive use. However, a key finding was that VRI did impact the consumptive use, with the change in consumptive use being approximately 60 to 80% of the change in irrigation amount (either positive or negative). This change in consumptive use did correlate to a change in yield, though differences in yield were usually not statistically significant. It is expected that, if VRI had been compared to common irrigation practices, VRI would have consistently resulted in reductions in irrigation amount, and that reductions

### Information Transfer Plan

**Project Type:** Annual Base Grant **Project ID:** 2016NE289B

**Project Impact:** Nebraska Water Center (NWC) experienced growth in staffing and a resulting increase in information transfer activities. Crystal Powers joined in April as the research & extension communication specialist and Jesse Starita joined in October as the public relations & engagement coordinator. These additions accompanied the addition of .20 FTE of Craig Eiting as NWC web developer & graphic design specialist. Overall, these staffing changes have increased communication and engagement with stakeholders. Veteran staff includes Chittaranjan Ray, Director and Patricia Liedle, Program Assistant with a combined 35 years at NWC. Keystone information transfer products in FY18 included the 2017-2018 (two calendar years) annual report and three Water Current newsletters. The 40-page annual report was mailed to approximately 3,000 recipients and broadly distributed in electronic format. It included 18 distinct articles on the center's research, teaching and outreach activities. The three 50th Anniversary issues of the Water Current newsletters focused on Nebraska irrigation history, Nebraska water policy and management and a general synopsis of current water research, respectively. Each one was mailed to approximately 2,700 recipients and distributed electronically as well as archived on the NWC website. Additionally, the NWC organizes an annual water and natural resources tour for approximately 50 individuals. This year's 2019 tour will be held from September 15 – 19 and will feature multiple destinations in northwestern Wyoming and southeastern Montana. In FY18, information transfer funds were used for travel, accommodation and contingencies for a tour scouting trip in May 2019 that included Starita and program assistant Tricia Liedle.

### Microalgae Treatment of Meat Processing Wastewater for Nutrient Removal and Water Reconditioning

**Project Type:** Annual Base Grant **Project ID:** 2018NE309B

**Project Impact:** Microalgae, have shown to be effective for wastewater treatment. Current studies are conducted at laboratory scale due to cost and difficulty of cell harvesting. Immobilizing microalgae cells into gel beads facilitate easy biomass recovery. Thus, in this project we assessed the effects of the synergistic relationship between activated sludge bacteria and microalgae in an immobilized system. Results showed that algal beads concentration had significant effect on microalgae growth and TN removal. Compared to 2% and 5% (v/v) algal beads, higher pollutants removal (79% COD, 69% TN and 89% TP-PO43-) and biomass (1377 mg dry microalgal biomass /L wastewater (DMB/L WW)) were achieved with 20% algal beads. But within each beads lower biomass was accumulated with 20% (0.17 mg DMB/bead) than 2% (0.46 DMB/bead) and 5% (0.36 DMB/bead). Pretreatment with sodium

hypochlorite and ozone improved wastewater quality. Compared to non-pretreat wastewater (1714 DMB/L WW, 82% COD, 75% TN and 92% TP-PO43-), disinfection of 0.2 mg/L free chlorine improved microalgae biomass (2026 mg DMB/L WW) and TN removal (80%) but reduced COD (72%), TP-PO43- (86%) removal. 0.5 min ozonation was found to be the most effective to increase pollutants removal ( 60% COD, 80%TN and 92% TP-PO43- ) and microalgal biomass (2402 mg DMB/L WW). Microalgae with and without nitrogen-starvation were found to contain 11% and 19% neutral lipid with 22% C16:0 and more than 44% C18:1, C18:2 and C18:3 fatty acids.

## **Pesticide Exposure of Recreational Lakes**

**Project Type:** Annual Base Grant **Project ID:** 2018NE310B

**Project Impact:** The proposed research goal was to investigate the state of recreational lakes in three distinct watersheds in Nebraska and provide one of the first evaluations of potential exposure to pesticide contamination in recreational lakes in the Midwest. Data was collected in this project found lakes in urban watersheds to have the highest concentrations of neonicotinoid pesticides in comparison with agricultural and herbaceous counterparts. Further, concentrations observed for imidacloprid exceeded invertebrate ecotoxicity levels in the urban and agricultural watersheds and were highest in the middle of the growing season. Findings were used to provide citizens and water resource managers guidance strategies for minimizing pesticide exposure. Results provided guidance to potential health concerns, next steps for pesticide best management practices (BMPs), and treatment strategies in recreational lakes using developed vulnerability maps for pesticide contamination of three recreational waters in intensive agriculture and/or urbanized watersheds. Seed data was used to apply for two nationally competitive funding sources. Two graduate students and two undergraduate students were trained on sampling protocol, analytical methods for pesticide analysis, and data management and processing. One student will utilize this dataset for her M.S. Thesis, which is expected to be completed in Spring 2020. Data collected during this project will be presented to the Nebraska Natural Resource Districts during an UNL Extension training session in October/November 2020 and a webinar for the state of Tennessee Department of Water Quality in August 2019. Lastly, findings are being incorporated into hands-on activities for Pre-K and Lincoln Public Schools for the fall of 2019.

## **Spatial Variability of Streambed Hydraulic Conductivity Across Multiple Stream Orders**

**Project Type:** Annual Base Grant **Project ID:** 2017NE308B

**Project Impact:** For the first part of the study, a new approach, Multi-Stemmed Nested Funnel (MSNF), was used to develop pedo-transfer functions (PTFs) capable of simulating the effects of complex sediment routing on Kv variability across multiple stream orders in Frenchman Creek watershed, USA. We find that using the product of Kv and drainage area as a response variable reduces the fuzziness in selecting the “best” PTF. We propose that the errors of prediction can be used in predicting the ranges of Kv values across multiple stream orders. For the second part of the study, Linear, Gaussian, exponential and spherical variogram models were used with Kriging gridding method for the ten sites. As a goodness-of-fit statistic for the variogram models, cross-validation results showed differences in the median absolute deviation and the standard deviation of the cross-validation residuals. Meandering channels showed a more heterogeneous distribution of streambed Kv when compared to straight channels. Within channel bends, higher spatial variability in streambed Kv was observed across stream channels than along stream channels. For meandering stream channels, higher streambed Kv values were observed at the erosional outer bends and the middle of the channels than at the depositional inner bends. At watershed-scale, geostatistical analysis shows that using the geometric means of the ten sites performs better than using either all the Kv values from the 93 permeameter tests or ten Kv values from the middle transects and center permeameters.

## **The Chemistry and Ecotoxicology of Microplastics-Water Quality Research Experience in Nebraska Waterways**

**Project Type:** Annual Base Grant **Project ID:** 2018NE312B

**Project Impact:** This project has identified the types and concentrations of microplastics characteristic of wastewater effluent to urban streams. Two undergraduate students were trained in field sampling methodology and lab analysis techniques, and these methods are being integrated into the majors-level ecology course for fall 2019 semester at

Nebraska Wesleyan University. The occurrence and ecological consequences of microplastics in the environment has gained increasing coverage in the popular press and makes an excellent topic to connect human activities to aquatic environments. Student scientists will continue to sample localities annually in Lancaster County, Nebraska, that weren't included in the current study. Continued work will expand our understanding of the scale and impact of microplastic pollution in freshwater systems.