Missouri Water Resources Research Center
Annual Technical Report
FY 2014

Introduction

WATER PROBLEMS AND ISSUES OF MISSOURI

The water problems and issues in the State of Missouri can be separated into three general areas: 1) water quality, 2) water quantity, and 3) water policy. Each of Missouri's specific problems usually requires knowledge in these three areas.

Water Quality

New media attention to the occurrence of pesticides in drinking water in the Midwest has raised a serious public concern over the quality of Missouri's drinking water and how it can be protected. With the large agricultural activity in the state, non-point source pollution is also of major interest. Because of several hazardous waste super-fund sites, hazardous waste is still of a concern to the public. The Centers research has been to evaluate the quality of current water sources and improve the methods to protect them. Areas of research for the past ten years have included (but are not limited to): erosion, non-point pollution reclamation of strip mine areas, hazardous waste disposal, nutrient management, water treatment and disinfection byproduct controls, acid precipitation, anthropogenic effects on aquatic ecosystems and wetlands.

Water Quantity

Missouri has a history of variable rainfalls. Because of the several drought years and major floods, water quantity has become a major topic of concern. The drought in 2012 was particularly notable with all counties in the State of Missouri being declared drought disaster areas with diminished agricultural and economic activities. Research is needed to better understand droughts and flood conditions. Also research is needed on water treatment/reuse coupled with nutrient management.

Water Policy

Policies and program need to be formulated that will ensure continued availability of water for designated uses, as new demands are placed on Missouri's water. The social and economic costs may no longer be held at acceptable levels if water becomes a major issue in cities and rural areas. Past droughts and possible lowering of the Missouri River have raised serious questions over states rights to water and priority uses. Best approaches for managing non-point source pollution need to be derived. Research areas in this program have included drought planning, legal aspects, perception and values, economic analysis, recreation, land/water use policy and legislation, and long-term effects of policy decisions.

Research Program Introduction

WATER PROBLEMS AND ISSUES OF MISSOURI

The water problems and issues in the State of Missouri can be separated into three general areas: 1) water quality, 2) water quantity, and 3) water policy. Each of Missouri's specific problems usually requires knowledge in these three areas.

Recent research activities include the following:

Stormwater Program

Federal regulations require MU, City of Columbia and Boone County to protect the quality of surface water from stormwater runoff. The Water Center has several projects to evaluate best management practices (BMPs) that will detain and filter the runoff. One project involves a diverse group from across campus to understand the best management practices for stormwater at the University of Missouri. The student team is laying groundwork to evaluate existing projects in preparation of data collection that will be used to inform future decisions. Allen Thompson, associate professor of biological engineering serves as principal investigator for the project. In addition, Bob Reed research associate professor, Enos Inniss, assistant professor and Robert Broz, extension assistant professor with agricultural engineering, round out the mentoring team.

Renewable Energy

Ground source heat pump technology is being studied with application to the agriculture sector. The constant temperature of the ground represents an incredible source of environmentally friendly, sustainable energy to heat and cool the buildings. Dr. Shawn Xu, Research Associate Professor with the Water Center, is installing ground source systems on turkey farms in Central Missouri. The energy system is part of a Department of Energy grant ($5,000,000) that Dr. Xu received to introduce the technology into agriculture applications. Another project supported by the USDA under Drs. Robert Reed and Shawn Xu is focused on energy efficiency and control of ammonia in turkey farms.

Drinking Water

The Water Resources Research Center is working with several Missouri communities to manage disinfection byproducts (DBPs) that are produced during the disinfection of drinking water. DBPs are regulated compounds and can cause cancer. Led by Assistant Professor Enos Inniss and Research Associate Professor Robert Reed, the MWRRC research teams analyze the chemical makeup of water within each community's treatment plant, water storage towers and distribution system throughout the year. The researchers then will test how certain chemicals affect the water samples in order to identify options for complying with EPA guidelines. Funding has been available from EPA, Mo DNR, and various Missouri communities. Another project on the control of DBPs is to develop advanced ultra-filtration membranes to remove natural organic matters (NOMs), supported partially by the Water Center with Dr. Hu being the PI. NOMs are precursors for DBP formation, and while nanofiltration and reverse osmosis are effective at removing NOMs, the cost is relatively high. Ultrafiltraion could be implemented at a much lower cross-membrane pressure and thus could be a cost-effective way for NOM removal and control of DBPs.

Wastewater Treatment

Water Center engineering researchers developed a portable wastewater treatment system for military bases that ultimately could produce water pure enough to drink. The portable treatment system treats the wastewater

with advanced membranes and disinfects chemically, producing reusable water that would save what often is a scarce resource as well as provide substantial savings. Zhiqiang Hu, associate professor led the Water Center team. The Leonard Wood Institute provided the funding for this project ($832,699).

Homeland Security

The Water Center worked with the Department of Homeland Security on three related projects on drinking water (Best Practice protocols for Response and Recovery Operations in Contaminated Systems, Understanding Economic Impacts of Disruptions in Water Service, and Studying Distribution System Hydraulics and Flow Dynamics to Improve Water Utility Operational Decision Making). Tom Clevenger and Bob Reed, College of Engineering and Tom Johnson, Truman Center, lead the Water Center team in working with the University of Kentucky, University of Louisville and Western Kentucky University.

Removal of NOMs by Advanced Thin Film Composite Membranes for the Control of Disinfection Byproducts

Basic Information

Title:	Removal of NOMs by Advanced Thin Film Composite Membranes for the Control of Disinfection Byproducts
Project Number:	2014MO145B
Start Date:	3/1/2014
End Date:	2/28/2015
Funding Source:	104B
Congressional District:	4
Research Category:	Water Quality
Focus Category:	Treatment, Water Quality, Nitrate Contamination
Descriptors:	None
Principal Investigators:	Zhiqiang Hu

Publications

1. Yin, J.; B. Deng, 2015, " *Polymer-matrix nanocomposite membranes for water treatment",* Journal of Membrane Science, 479, pp 256- 275.
2. Ding, C.; J. Yin; and B. Deng, 2014, *Effects of Polysulfone (PSF) Support Layer on the Performance of Thin-Film Composite (TFC),* Journal of Chemical and Process Engineering, Vol 1102, Pages 1-8.
3. Film Composite (TFC), *Journal of Chemical and Process Engineering,* Vol 1102, Pages 1-8.
4. Yang, Z.; J. Yin; and B. Deng. *Enhancing water permeability of thin-film nanocomposite (TFN) membrane by incorporation of bimodal silica nanoparticles* , (in preparation).
5. Hu, W.; J. Yin; B. Deng; and Z. Hu, *Nano TiO2 modified hollow fiber membranes with less fouling and their application in algal membrane bioreactors for high-density algae cultivation and wastewater polishing* , (in review).
6. Yang, Z., 2014, Novel thin-film nanocomposite (tfn) membrane embedded with bimodal silica nanoparticles for water purification , M.S. Thesis, Department of Chemical Engineering, University of Missouri, Columbia, MO, 46.
7. Wang, X. 2014, Ultrafiltration of surface water by poly(vinylidene fluoride) (PVDF)/TIO2 mixed matrix hollow fiber membranes (HFMs) with advanced antifouling properties under visible light irradiation , M.S. Thesis, Department of Chemical Engineering, University of Missouri, Columbia, MO, 58.

Removal of NOMs by Advanced Thin Film Composite Membranes for the Control of Disinfection Byproducts

Progress report:

The overall goal of this research is to develop high performance mixed matrix nano composite membranes (MMM) that could be used to effectively remove NOMs from the source water and thus decrease or eliminate the formation of DBPs during water chlorination. It has been well established that NOMs serve as precursors for the formation of DBPs so the removal of NOMs will result in the reduction of DBP formation potentials under otherwise the identical conditions. In the current project period, therefore, our research has focused on the development of advanced nanocomposite membranes and assessing their performance for water filtration, membrane anti-fouling characteristics, and capability for the removal of NOMs.

The progress was made in two aspects. First, nitrogen doped TiO_2 (N-TiO_2), a hydrophilic and visible light-active photocatalyst, was applied to prepare poly(vinylidene fluoride) (PVDF)/N-TiO_2 mixed matrix hollow fiber membranes (HFMs) by the phase inversion method. The membranes were characterized by scanning electron microscopy (SEM), contact angle measurement and UV-Vis absorbance. The membrane performances for treating surface water were evaluated based on the water flux, humic acid (HA) rejection and total organic carbon (TOC) rejection in surface water. Different water samples were collected from Eagle Bluffs, Missouri River and McBaine Water Treatment Plant in Columbia, MO. The results showed the pure water flux of PVDF-NTiO_2 membranes, which was about 28.5±0.3 L/m^2h at the transmembrane pressure (TMP) of 8 psi under visible light, was slightly higher than the flux of pure PVDF membranes around 25.6±0.4 L/m^2h. The contact angle of the PVDF-NTiO_2 membranes (about 43°) was smaller than the pure membranes' contact angle (about 55°), suggesting that the membrane hydrophilicity was significantly improved by incorporating TiO_2 nanoparticles into the PVDF HFMs. The as-prepared PVDF-NTiO_2 mixed matrix membranes removed over 40% of humic acid and 20% of TOC in the water samples collected from the Eagle Bluffs and Missouri River and rejected 20% of HA and TOC in water from the McBaine Water Treatment Plant, which were comparable to pure PVDF membranes. The mixed matrix membrane with N-TiO_2, however, showed much better resistance to membrane fouling. The study suggests that the PVDF-NTiO_2 membranes with enhanced water flux and anti-fouling characteristics could treat water more efficiently for control of natural organic matter.

Second, we continued the research with an ultrafiltration membrane prepared previously that contained oxidized multi-walled carbon nanotubes (OMWNTs) dispersed in polysulfone (PSU) polymer. The OMWNTs/PSU nanocomposite hollow fiber membranes had an improved water permeability and enhanced antifouling property, and comparable solute rejection characteristics in comparison with conventional PSU membranes. Our tests showed that nanocomposite membranes containing 0.5 wt% OMWNTs possessed enhanced water permeability compared to original PSU membranes. Meanwhile, they could still maintain the same NOM removal rates. When using river water as the feed solution, the H18 and H18-0.5% membranes had a UV_{254} removal rate around 38% and a DOC removal rate around 22%. When using the same feed solution, the H20 and H20-0.5% membranes had a UV_{254} removal rate around 52% and a DOC

removal rate around 30%. The corresponding total trihalomethanes (TTHMs) removal rates would be further analyzed to correlate them with the NOM removal rates.

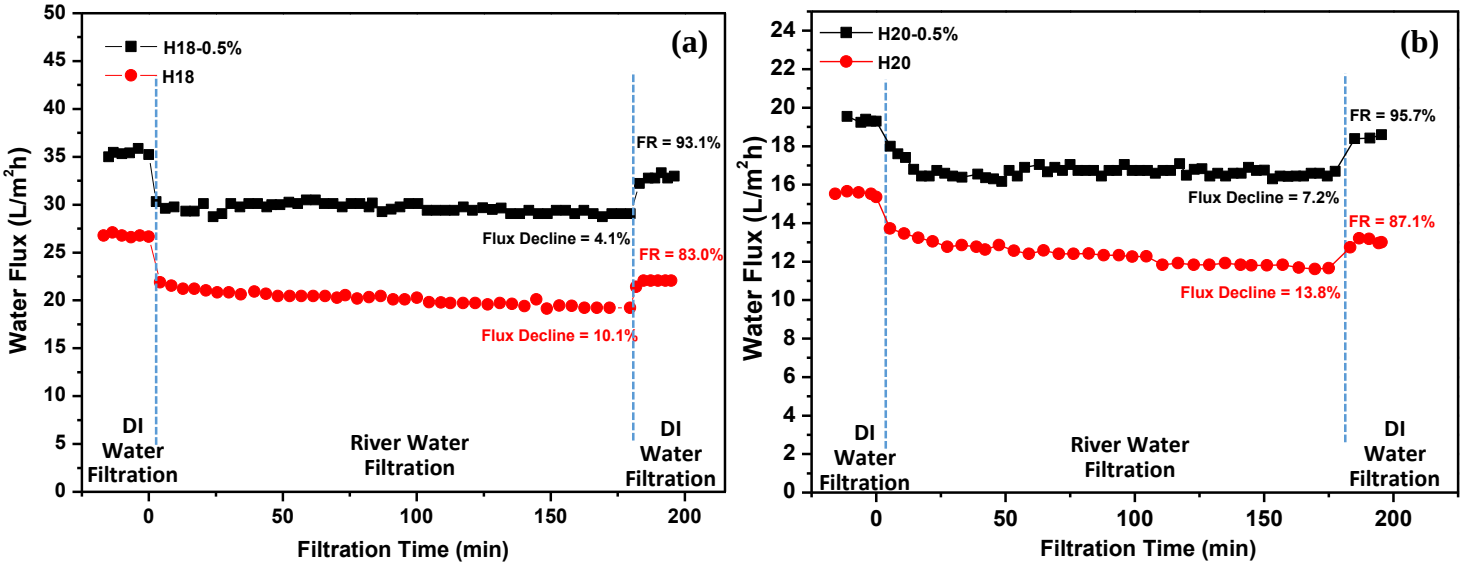

Figure 1. Fouling behaviors of membranes containing 18% PSU (a) and membranes containing 20% PSU (b) with filtration of river water. The transmembrane pressure (TMP) is 10 psi. Nanocomposite membranes containing 0.5% OMWNTs (H18-0.5% and H20-0.5%) showed higher water flux, less flux decline and improved flux recovery (FR) compared to the control membranes (H18 and H20).

Student support

The project provided support for research by two students:

Weiming Hu, PhD student
Zhengyang Wang, PhD student

Publications

Yin, J.; B. Deng, 2015, *Polymer-matrix nanocomposite membranes for water treatment"*, Journal of Membrane Science, 479, pp 256-275.

Ding, C.; J. Yin; and B. Deng, 2014, *Effects of Polysulfone (PSF) Support Layer on the Performance of Thin-Film Composite (TFC),* Journal of Chemical and Process Engineering, Vol 1102, Pages 1-8.

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Hu, W.; J. Yin; B. Deng; and Z. Hu, *"Nano TiO2 modified hollow fiber membranes with less fouling and their application in algal membrane bioreactors for high-density algae cultivation and wastewater polishing"*, (in review).

M.S. Theses:

Yang, Z., 2014, "Novel thin-film nanocomposite (tfn) membrane embedded with bimodal silica nanoparticles for water purification", M.S. Thesis, Department of Chemical Engineering, University of Missouri, Columbia, MO.

Wang, X. 2014, "Ultrafiltration of surface water by poly(vinylidene fluoride) (PVDF)/TIO2 mixed matrix hollow fiber membranes (HFMs) with advanced antifouling properties under visible light irradiation", M.S. Thesis, Department of Chemical Engineering, University of Missouri, Columbia, MO.

Information Transfer Program Introduction

The Missouri Water Resources Research Center"s objectives are: 1) to establish active research programs to aid in understanding and solving Missouri's and the Nation's water problems, 2) to provide education opportunities in research for students with an interest in water resources and related fields, and 3) to be actively dedicated to the dissemination of information through all aspects of the media.

The goal of the Information Transfer Program is to meet objective 3, dissemination of information through all aspects of the media.

The Center maintained an active information transfer program that included: 1) coordination of the University of Missouri seminar program, 2) publication of Water Center newsletter, 3) interaction with state and federal water agencies, 4) Director served on various national and local water related boards, organizations and committees, 5) continued cooperation with district USGS office (representative on advisory committee), 6) maintenance and expansion of comprehensive web site, 7) making available of Center's publications, 8) responding to public requests and questions, 9) meeting with advisory committee to improve information transfer activities.

Technology Transfer

Basic Information

Title:	Technology Transfer
Project Number:	2014MO143B
Start Date:	3/1/2014
End Date:	2/28/2015
Funding Source:	104B
Congressional District:	4
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	None
Principal Investigators:	Baolin Deng

Publications

There are no publications.

Information Transfer Program Introduction

This year's primary focus of the Information Transfer Program was on the items listed above, with an emphasis on the 50th Anniversary Symposium.

During the symposium Dr. Tom Clevenger was recognized for his 30 years of service as the Director of the Missouri Water Resources Research Center. He spoke at the Conference about the achievements of the Water Center over the past 30 years and the challenges and opportunities that we may be facing in the future.

1) Conferences & Symposiums

The Water Center held a symposium entitled, "Missouri Water Resources Research Center Symposium: Water Challenges & Opportunities" which was held on October 7-8, 2014 at the MU Memorial Union.

The symposium was held to celebrate the 50th anniversary of the National Water Resources Research Act which created a network of Water Resources Research Centers in each of the 50 states and territories. One of the main goals of the symposium was to focus on increasing collaborations between universities, key researchers, public and private sectors and federal and state agencies.

In order to solve future water problems, interdisciplinary cooperation will be needed. The symposium brought together the key water experts in Missouri for two days to consider current, and more importantly, future water challenges and opportunities. It is hopeful that this will be the start of new efforts. One new effort that is starting is the energy-water-food nexus which attempts to bring the scientists in these areas together to consider how their efforts affect other areas of society. During the symposium, one morning was devoted to the energy-water-food nexus.

This symposium stressed the identification of key current and future issues and resources needed to address the challenges and opportunities in the following sectors: Water Quality, Water Management, Nutrient Management, Energy-Water-Food Nexus, Water Security, Climate Variability, and Water Policy. The symposium brought together a diverse group with over 40 organizations represented, scientists from MU, Washington University in St. Louis, Missouri S&T, Missouri State University, UMKC and the Water Resources Research Center Advisory Committee that includes members from all the state universities, water policy related state agencies, and the US Geological Survey.

The four sessions in the 2-day symposium focused on the following areas:

Session 1 – Water Quality

The Session Chair for this session was Dr. Jianmin Wang, Associate Professor of Civil & Environmental Engineering, from Missouri University of Science & Technology.

During this session, presentations were presented by state, university, private sector, and federal scientists on factors affecting drinking water, wastewater, and emerging contaminants.

John Madras, Director, Water Protection Issues Program, Missouri Department of Natural Resources, spoke on Missouri Drinking Water & Wastewater Protection Issues and gave a brief review of the past four decades of clean water and drinking water administration of federal and state statutes; advances in assessment and management of contaminants; changing perspectives on priorities and resource goals; challenges that are new and some that are old and persistent.

Session 2 – Water Management

This session was chaired by Dr. Amanda Cox, Assistant Professor of Parks College of Engineering, Aviation and Technology from St. Louis University.

This session allowed the various federal agencies, USDA, USGS, and DNR to discuss with the different professors from the different universities and public sector regarding issues regarding nutrient management, soil health, and watershed and groundwater management.

Session 3 –Energy, Water & Food Nexus

This session was chaired by Dr. Cerry Klein, Lapierre Professor of Industrial Engineering and Facilitator of Mizzou Advantage Sustainable Energy at the University of Missouri.

This session was devoted to the energy-water-food nexus which results from the high levels of energy used for water supply, and wastewater collection and treatment, and food production and processing. The other major component of this nexus is the high level of water used for energy and food production. It is anticipated that this multi-disciplinary area will be a major research area in the future. As a result of this session, a statewide research team has been formed to look in into further funding for the energy-water-food-nexus.

Session 4 – Water Policy

This session was chaired by Dr. Carlos Sun, Attorney and Associate Professor of Civil Engineering at the University of Missouri.

Missouri is in the process of updating its state water plan. Speakers from Colorado were invited to speak on issues and lessons that they have learned. Missouri officials benefited from the insights shared by the Colorado speakers. The session was finished by Dr. Peter Davis, Professor Emeritus in Law who gave a history of water law in Missouri and offered his insight as to future water issues that Missouri will have to consider.

Training for Operators

Additionally, the Missouri Water Resources Research Center collaborated with the Missouri Department of Natural Resources Water Protection Program to provide the opportunity for operators to receive 12 credit hours of Operator Certification Training.

Funding

Award Funding for Program Coordinator

Ms. Karen Turner was awarded a $2,000 Staff Interdisciplinary Development Award which was used towards the funding of the symposium. The award is intended to help staff better position themselves

for interdisciplinary endeavors in Mizzou Advantage areas listed below. The award enhanced her ability to network with researchers, to connect with other resources on campus, and better position her for interdisciplinary endeavors.

Dr. Baolin Deng, the new Director of the Water Center, also received a Mizzou Advantage Award to help defray the cost of the symposium, which helped make this symposium possible, and be able to bring in key researchers to the symposium.

Mizzou Advantage is a University Program that fosters interdisciplinary collaboration among faculty, staff, students and external partners to address and solve real-world needs and problems in four areas of strength identified at the University of Missouri:

•Food for the Future: The culture, economics and production of healthy, affordable food
•Media of the Future: New ways to communicate, educate and market
•One Health/One Medicine: The convergence of animal and human health
•Sustainable Energy: Developing and distributing renewable energy sources

In addition, the University of Missouri Chancellor's Distinguished Speaker Program provided support to Dr. Glenn Daigger, the keynote speaker for the symposium.

Below is the program for the Water Challenges & Opportunities Symposium and the invited speakers. Most of the PowerPoint presentations for the talks listed below can be accessed by going to the Missouri Water Resources Research Center website at water.missouri.edu and clicking on the title of the presentation.

MOWRRC
Missouri Water Resources Research Center

Water Challenges and Opportunities

A symposium in celebration of 50th Anniversary of
Missouri Water Resources Research Center
Sponsored by Mizzou Advantage & the Chancellor's Distinguished Speakers Program

October 7-8, 2014
Agenda

OCTOBER 7, 2014

Room N201/202 - Mark Twain Ballroom
Memorial Union

7:30-8:00 a.m.	Registration	
8:00-8:20 a.m.	Welcome	Baolin Deng, Director, MOWRRC University of Missouri

8:20-8:50 a.m.	The Early Years – Past Achievements To Present	Tom Clevenger, Director Emeritus, MOWRRC, University of Missouri

SESSION 1 - Water Quality

Session Chair: Jianmin Wang, Associate Professor of Civil & Environmental Engr., Missouri University of Science & Technology

8:50-9:20 a.m.	Missouri Drinking Water & Wastewater	John Madras, Director, Water Protection Issues Program, Missouri Department of Natural Resources
9:20-9:40 a.m.	Taming the DBP Beast – How University Water Utility Partnerships Work to Achieve Regulatory Compliance	Enos Inniss, Assistant Teaching Professor, of Civil & Environmental Engr., MU
9:40-10:00 a.m.	***Break***	
10:00-10:20 a.m.	Onsite Wastewater Treatment	Randy Miles, Associate Professor, Soil, Environment & Atmospheric Science, MU
10:20-10:40 a.m.	New Ammonia Criteria & Treatment Challenges	Tim Canter, Application Segment Manager, EDI
10:40-11:00 a.m.	Treatment Technologies	Zhiqiang Hu, Associate Professor, Civil & Environmental Engineering, MU
11:00-11:20 a.m.	Contaminants of Emerging Concern in Water: Challenges & Directions for	Don Tillitt, Branch Chief, USGS Columbia Environmental Research Center Solutions
11:20-11:40 a.m.	Veterinary Antibiotics in the Environment: Challenges, Solutions & Future Directions	Keith Goyne, Associate Professor, Soil & Environmental Science, MU
11:40-12:00 p.m.	Missouri Reservoirs: Future Quantity & Quality Concerns	Dan Obrecht, Sr. Research Specialist, Fisheries & Wildlife, MU
12:00-1:00 p.m.	***Lunch***	

SESSION II – Water Management

Session Chair: Amanda Cox, Assistant Professor of Parks College of Engineering, Aviation and Technology, St. Louis University

1:00-1:20 p.m.	USDA Perspective: NRCS Efforts to Combat Sediment & Nutrient Migration	Steve Hefner, Water Quality Conservationist, USDA-NRCS

1:20-1:40 p.m.	Stream Gaging in Missouri	Shane Barks, USGS Deputy Director MO Water Science Ctr., MO DNR
1:40-2:00 p.m.	Missouri's Groundwater Observation	Scott Kaden, Ground Water Section Chief, Well Network Water Resources Center, Missouri DNR
2:00-2:20 p.m.	***Break***	
2:20-2:40 p.m.	Decade of Watershed Science and Applications in Southwest Missouri	Marc Owen, Assistant Director, Ozarks Environmental & Water Resources Institute, Missouri State University
2:40-3:00 p.m.	Soil Health – Future Implications for Environmental Quality	Bob Kremer, Professor of Soil Microbiology, MU
3:00-3:20 p.m.	MU Nutrients Management Efforts	Bob Broz, Assistant Professor, Ag Ext-Food Science & Nutrition, MU
3:20-3:40 pm.	Spatial Data Types, Sources, and Interpretation	Tim Haithcoat, Director, Geographic Resources Center/Missouri Spatial Data Information Service, MU

TECHNICAL SEMINAR

Ketcham Auditorium – Lafferre Hall

4:00-5:00 p.m.	***Global Water Trends, Opportunities & Solutions***	***Glen Daigger, Senior Vice President, CH2M Hill***
5:00-6:30 p.m. Reception	***Dr. Tom Clevenger's Retirement***	***Stotler 2 – Memorial Union***
6:30-8:00 p.m.	***Dinner Banquet***	***Stotler 1 – Memorial Union***
	Keynote Banquet Speaker	***Glen Daigger, Senior Vice President & Chief Water Technology Officer for CH2M Hill***

OCTOBER 8, 2014

Room N214/215 - Bingham Ballroom
Memorial Union

7:30-8:00 a.m. ***Breakfast***

SESSION III – Energy, Water & Food Nexus

Session Chair: Cerry Klein,

		Lapierre Professor of Industrial Engr., and Facilitator, Mizzou Advantage Sustainable Energy, MU
8:00-8:20 a.m.	Energy, Water & Food Nexus	Robert Reed, Director of Midwest Energy Efficiency Research Consortium, MU
8:20-8:40 a.m.	Renewable Energy for Food Sector	Leon Schumacher, Professor & Chair, Agriculture Systems Management, MU
8:40-9:00 a.m.	Zero Discharge Aquaculture	Dave Brune, Professor of Bioprocess & Bioenergy Engineering Agricultural Systems Management, MU
9:00-9:20 a.m.	An Integrated Water, Food, Electricity & Sanitation System	Ron Wood, Retired President & CEO of Black & Veatch Energy
9:20-9:40 a.m.	Discussion	
9:40-10:00 a.m.	***Break***	
10:00-10:20 a.m.	Wastewater Energy Audits - The Process and the Opportunity	Randy Chann, President & CEO of Environmental Dynamics International
10:20-10:40 a.m.	On Farm Energy Initiative	Troy Chockley, Environmental Engineering, USDA, Natural Resources Conservation Service
10:40-11:00 a.m.	Missouri's Biggest Climate Challenge	Pat Guinan, Extension/State Climatologist, MU
11:00-11:20 a.m.	The Effects of 2012 Drought on Missouri Agriculture	Joe Horner, Dairy & Beef Economist, Commercial Agriculture Program, MU
11:20-11:40 a.m.	Art & Science in River Restoration: Examples from the Missouri River	Robert Jacobson, *Research Hydrologist,* USGS
11:40-1:00 p.m.	***Lunch***	

SESSION IV – WATER POLICY

Session Chair: Carlos Sun, Associate Professor of Civil Engineering, MU

1:00-1:20 p.m.	Water Resources Planning in Missouri	Ryan Mueller, Director of the Water Resources Center, DNR

1:20-1:40 p.m.	Colorado Water Management Plan	Louis Meyer, PE, President & CEO of Schmueser Gordon Meyer, Inc.
1:40-2:00 p.m.	Missouri Department of Natural Resources & Water Conservation Program	Colleen Meredith, Director of Soil & Water, DNR
2:00-2:40 p.m.	Missouri & Mississippi River Management	Karen Rouse, Interstate Waters Section Chief, Water Resources Center, Missouri Department of Natural Resources
2:40-3:00 p.m.	***Break***	
3:00-3:20 p.m.	Urban Watershed Management, Challenges in Supporting Evolving Stormwater Policy Initiatives	Kate Trauth, Associate Professor of Civil & Environmental Engr., MU & Environmental Engr., MU
3:20-3:40 p.m.	Current & Future Status of Water Law in Missouri	Peter Davis, Professor Emeritus of Law, Law School, MU
3:40-5:00 p.m.	Panel Discussion Summarizing Symposium	

2) Coordination of Seminar Program

The Water Resources Research Center hosted a joint University of Missouri-Columbia seminar series with Civil & Environmental Engineering & Chemical Engineering throughout the year. In addition, other special seminars included speakers from out of state and internationally to speak on a variety of topics:

1) Dr. Alan T. Stone, John Hopkins University, "Redox Reactions Between Metal Species and Organics During Drinking Water Treatment and Conveyance: Unintended Consequences."

2) Glen Daigger, Senior Vice President and Chief Water Technology Office, CH2M Hill, "Global Water Trends, Opportunities, and Solutions."

3) Dr. Jun Yin, University of Missouri, "Designing Nanocomposite Membranes for Efficient Water Treatment and Reuse."

4) Dr. Maria M. Fidalgo, University of Missouri, "Closing the loop on the TiO2 nanoparticles life cycle: transport and interaction during treatment and discharge of NP containing wastewaters."

5) Pamela Brown, University of Missouri, "Evolution of Diverse Mechanisms for Bacterial Elongation and Morphology."

6) Dr. Julian Fairey, University of Arkansas, "Occurrence of regulated and emerging disinfection by-products in drinking water."

7) Dr. Winston, Ho, Chemical & Bimolecular Engineering, Ohio State University, "New Developments on Membranes for CO_2 and Water Separations."

8) Dr. Zhiqiang Hu, Associate Professor, Civil & Environmental Engineering, University of Missouri, "New Applications of Nanomaterials for Wastewater Treatment and Other Sectors."

9) Dr. Yangchuan (Chad) Xing, Chemical Engineering, University of Missouri, "Clean Energy and the Environment: What, Why, and How."

10) Dr. Christine Costello, "Defining and Evaluating the Environmental Sustainability of Agricultural Products, Processes and Systems."

3) Publication of the Water Center Newsletter

The Water Center newsletter is a yearly publication. The purpose of the Center's newsletter is to inform the scientific community as well as the public, or the activities of the Center, i.e., new research projects funded, and upcoming conferences. The Center's primary focus is on its own information transfer activities and the general scope of the projects that were funded. Highlights of the 2014 Newsletter included:

Dr. Tom Clevenger Retires after Serving 30 Years as Director of the Missouri Water Resources Research Center

Fifty years ago when the Water Center started, some key research areas funded included: droughts, floods, soil transport, lead mining, phosphate removal/reduction. Many of the same issues as today. We have made major progress in most cases. In several cases we have done the easy 90% but still have to do the difficult remaining 10%. Throughout my 30 years as Director of the Water Center I have worked on many environmental issues including: lead, dioxin, PCB's, PCP, sludge, drinking water, technology transfer (China), and final research projects in homeland security.

Tom E. Clevenger remains active as Director Emeritus for the Missouri Water Resources Research Center and Professor Emeritus in the Civil and Environmental Engineering Department at the University of Missouri. After 30 years at the helm, Dr. Clevenger established the first American environmental technology office in China with a grant from the U.S. Department of Commerce, providing educational and training resources to those interested in advanced American technologies. Clevenger's research has been funded by the Electric Power Research Institute, the U.S. Marine Corp-Quantico, the Environmental Protection Agency, the Department of the Interior and the U.S. Geological Survey.

The Appointment of Dr. Baolin Deng as the new Director of the Missouri Water Resources Research Center

Chemical Engineering Department Chairman Baolin Deng, also a professor of civil and environmental engineering, was named the new director of the Missouri Water Resources Research Center, effective March 1, 2014.

As it celebrates its 50th anniversary, the Missouri Water Resources Research Center is entering a new era of leadership.

Baolin Deng began his tenure as the center's new director on March 1, replacing University of Missouri in Civil and Environmental Engineering Professor Emeritus Tom Clevenger, who stepped down from his post after 30 years at the helm.

C.W. LaPierre Professor Deng also is a civil engineer and additionally serves as chair of the Chemical Engineering Department. He said serving as director of the statewide agency is a challenge he is honored to undertake.

"I'm looking forward to working with people across the campus and across the state and federal agencies to build a strong Water Resources Research Center," Deng said.

The Missouri Water Resources Research Center is one of 54 such entities — one in each state in the U.S., the District of Columbia, the U.S. Virgin Islands, Puerto Rico and Guam — under the umbrella of the federal National Institutes for Water Resources. The MOWRRC was established in 1964 following the enactment of the National Water Resources Research Act with the goal of sponsoring and administering research and research projects on Missouri's water and related environmental problems.

MOWRRC serves as a connection between researchers and potential research beneficiaries, as well as working in conjunction with the state to provide data to agencies such as the Missouri Department of Natural Resources and Department of Conservation for their use in solving water-related issues. The

institute also partners with federal agencies, local companies, area universities and private organizations.

“The goal is really to bring researchers, especially working in academia, together to understand the challenges and what kinds of opportunities we have to serve the state’s water-resource needs, and to help the state maintain water quality,” Deng said.

Deng originally had plans to work in geology when he first began his education, but he said he later came to the realization that his interests had shifted to how the environment impacts health and quality of life, thus beginning his work with water quality. He began working with the MOWRRC in 2006.

In the near future, a workshop and meeting are being planned as part of the 50th anniversary of the MOWRRC. Deng said he’d like to see the group tackle issues including maintaining an adequate water supply through times of drought and making sure the group is properly connected with all its stakeholders. But first and foremost, Deng wants to get settled and familiarized with his role as quickly as he can.

“I’m pretty much honored to be able to serve the state as the director. Dr. Clevenger has been the director for 30 years during this 50 years of history and has been doing a wonderful job for that many years,” Deng said. “They’re big shoes to fill, a lot of things for me to learn.”

Missouri Water Resources Research Center turns 50

Glen T. Daigger, senior vice president and chief technology officer of CH2M Hill, delivered the MOWRRC symposium’s keynote lecture, discussing the future of water in the world, as well as the priorities among those in the water profession.

In commemoration of its 50th anniversary, the Missouri Water Resources Research Center (MOWRRC) held a symposium featuring speakers from all over central Missouri on topics including Missouri water issues, water management and water conservation. The event was held on the University of Missouri campus Oct. 7 and 8.

Former center director Tom Clevenger, who served as director for more than 30 years before stepping down in 2014, presented a retrospective of MOWRRC at the beginning of the symposium. He later was recognized at a retirement reception later that night.

Glen T. Daigger, senior vice president and chief technology officer of CH2M Hill, delivered the symposium's keynote lecture, discussing the future of water in the world, as well as the priorities among those in the water profession.

4) A new Advisory Committee was established due to retirements of different board members. Dr. Deng has taken this opportunity expand the multi-disciplinary expertise of the Committee. Below is a list the new Advisory Board Members:

Bob Broz	brozr@missouri.edu	Bob Broz Ag Ext-Food Science & Nutrition 205 Agricultural Engineering Columbia, MO 65211 (573) 882-0085
Joel Burken	burken@mst.edu	Professor Civil, Arch & Environ Engineering 224 Civil Engineering Rolla, MO 65409 573/341-6547
Randy Chann	Randy.chann@wastewater.com	President & CEO Environmental Dynamics International 5601 Paris Rd, Columbia, MO 65202 (573) 474-9456
Amanda Cox	coxal@slu.edu	Assistant Professor Parks College of Engineering, Aviation & Technology Saint Louis University 3450 Lindell Boulevard St. Louis, Missouri 63103 314-977-8324
Keith Goyne	goynek@missouri.edu	Associate Professor of Soil and Environmental Sciences Associate Director, CAFNR Center for Watershed Management and Water Quality University of Missouri Department of Soil, Environmental and Atmospheric Sciences 302 ABNR Bldg. Columbia, MO 65211-7250 Telephone: (573) 882-0090 Fax: (573) 884-5070
Megan Hart	hartme@umkc.edu	School of Computing & Engineering 370C R. H. Flarsheim Hall Kansas City, MO 64110 816-235-1270
Rob Jacobson	rjacobson@usgs.gov	Supervisory Research Hydrologist Chief, River Studies Branch US Geological Survey - CERC

		4200 New Haven Road Columbia, MO 65201 office: 573-876-1844 mobile: 573-864-6183
Mike McKee, Resource Scientist	Mike.McKee@mdc.mo.gov	Aquatic Health Unit Resource Science Center Department of Conservation 1110 South College Avenue Columbia, MO 65201 Phone: (573) 882-9909 ext. 3255 Fax: (573) 882-4517
Ryan Mueller	Ryan.mueller@dnr.mo.gov	Water Resources Center Director Missouri DNR P.O. Box 176 Jefferson City, MO 65102 (573) 751-1134
Patrick Osborne	Osbornepl@missouri.edu	Associate Director & Adjunct Associate Professor Biology 224 Research Bldg. UMSL (314) 516-5219
Dick Purcell	dick.purcell@mo.usda.gov	State Conservation Engineer USDA-NRCS Missouri State Office Parkade Center, Suite 250 601 Business Loop 70 W Columbia, Missouri 65203 Office: (573) 876-0910 Cell: (573) 355-0583
John Schumacher	jschu@usgs.gov	USGS—Water Resources 1400 Independence Road MS-100 Rolla, MO 65401 (573) 308-3678
Paul Schweiger	pschweiger@MissouriState.Edu	Missouri State University 901 South National Avenue Temple Hall 273 Springfield, Missouri 65897 417-836-5062
Rao Surampalli	surampalli.rao@epa.gov	US EPA - Region 7 WWPD/WIMB 901 North 5th Street Kansas City, Kansas 66101-2728 Phone: 913.551.7453 Fax: 913.551.7765

5) Training Opportunities

The Water Center, in collaboration with the Missouri Department of Natural Resources Water Protection Program, provide the opportunity for operators to receive 12 credit hours of Operator Certification Training associated with the Water Challenges and Opportunities Symposium.

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	0	0	0	0	0
Masters	0	0	0	0	0
Ph.D.	2	0	0	0	2
Post-Doc.	0	0	0	0	0
Total	2	0	0	0	2

Notable Awards and Achievements

Zhengyang Wang: Graduate Student Award, College of Engineering at the University of Missouri (2014).

Green Roof Leachate Water Quality presented at the Research Day at the Capitol (March 2015.

Tyler Hall, (Northeastern University) Investigating and Analyzing the Energy Performance of an Experimental Green Roof System Installed on an Institutional Facility in Rolla, Missouri Marshall Usrey, (University of Tulsa) Valuating the Environmental Benefits of Experimental Green Roof Technology Both Supported by NSF award EEC-1157001.

As part of the Green Roof project, the following awards were achieved:

Awards: Madison Gibler 2nd place in Best Paper competition, EWRI-ASCE 2015. Comprehensive Benefits of Green Roofs' Madison Gibler Top Poster Presentation, EmCon 2014: Fourth International Conference on Occurrence, Fate, Effects & Analysis of Emerging Contaminants in the Environment. Iowa City Iowa (2014) Grace Harper Honorable Mention (4th place) in Campus Chancellors' Fellows Research Conference (2013

Publications from Prior Years

1. 2011MO122B ("Urban Water Quality: Value of Green Roof Technology") - Articles in Refereed Scientific Journals - Harper G. E., Limmer, M.A. Showalter, E., Burken, J.G. (2015) Green Roof Water Impacts and Climate-based Modeling, Journal of Ecological Engineering Volume 78, May 2015, Pages 127 133.
2. 2011MO122B ("Urban Water Quality: Value of Green Roof Technology") - Articles in Refereed Scientific Journals - Gibler, M. Limmer, M.A. Showalter, E., Burken, J.G. GREEN ROOF VALUATION: SAVING POULLUTANTS AND ENERGY (in preparation).
3. 2004MO35B ("Experimental Analysis of Nutrient Uptake in Streams ") - Articles in Refereed Scientific Journals - Niyogi, D.K., J.M. Bandeff, C. Selman, and D.E. Menke, 2010, Nutrient flux, uptake, and transformation in a spring-fed stream in the Missouri Ozarks, USA, Aquatic Sciences, 72:203-212.