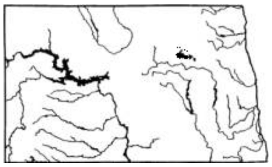
2018-2019

North Dakota Water Resources Research Institute

North Dakota State University, Fargo, ND 58108-6050



https://www.ndsu.edu/wrri/

From the Director

Welcome to the 2018-2019 issue of North Dakota Water Resources Research Institute (NDWRRI) Newsletter. It is my privilege and honor to serve as the new Director of NDWRRI. This is the first newsletter from me. After serving as the Director of the Institute for three years, Dr. Eakalak Khan left North Dakota State University (NDSU) and joined the University of Nevada, Las Vegas in 2018. I would like to take this opportunity to thank Dr. Khan for his leadership, efforts, and contributions to the Institute.

This newsletter introduces the fifteen 2019-2020 NDWRRI Fellows and highlights the 2018-2019 and 2017-2018 graduate fellowship research projects and the related findings and accomplishments achieved by the Fellows and their advisors. Particularly, this newsletter presents a featured study conducted by Alec Lackmann (Ph.D. student and NDWRRI Fellow) and Drs. Mark Clark and Malcolm Butler (his advisors). Their research findings have been published in Communications Biology, showing that a Bigmouth Buffalo fish could live up to 112 years, which more than quadruples all previous age estimates for this species. This issue features four Institute affiliated faculty in the section of “Meet Our Faculty,” including Dr. David Steward (Civil & Environmental Engineering, NDSU), Dr. Haochi Zheng (Earth System Science & Policy, UND), Dr. Trung Bao Le (Civil & Environmental Engineering, NDSU), and Dr. Matthew Smith (Biological Sciences, NDSU). Other sections include the information on the 2018 NIWR Regional Symposium—Water Resources of the U.S. Great Plains Region: Status and Future in Lincoln, NE and the 7th NDWRRI Distinguished Water Seminar hosted by the Institute. In addition, you will find the details on the 1st NDWRRI Special Water Resources Seminar. Four keynote speakers from the USGS and ND state agencies talked about the major water resources issues in ND, current state and federal efforts in ND, challenges, research needs and priorities, and potential collaboration opportunities. Nine NDWRRI Fellows also presented their current research. The last section lists the recent publications and presentations by the Institute Fellows and affiliated faculty, the NDWRRI technical reports, the Fellows’ thesis and dissertations, as well as the recent USGS ND-related reports and the ND State Water Commission publications.

As the Director of the Institute, I would like to gratefully acknowledge the supplemental support for the graduate research fellowship program from ND State Water Commission, and thank the three State Advisory Committee members: Steven Robinson (USGS Dakota Water Science Center), Andrew Nygren (ND State Water Commission), and Peter Wax (ND Department of Health) for their continuous support, advice, and guidance on the Institute’s research priorities and Fellowship funding allocation, as well as all Fellows and affiliated faculty for their contributions to the success of NDWRRI.

Xuefeng (Michael) Chu, Ph.D.
Professor, Civil & Environmental Engineering

Inside this issue:

The Institute Awarded Fifteen Graduate Fellowships for Year 2019-2020

The North Dakota Water Resources Research Institute announced its Graduate Research Fellowship recipients for the year 2019-2020. The fellowships were awarded to fifteen graduate students, including nine Ph.D. and six M.S. students, who will conduct water resources research at NDSU and UND. These fifteen graduate research projects are supported with the annual base (104b) federal grant, and an additional fund from North Dakota State Water Commission. The 2019-2020 NDWRRI Fellows, and their faculty advisors, academic programs, and research projects are listed as follows:

Fellow: Erika Olson **Advisor:** Dr. Christina Hargiss
Program: Natural Resource Management, North Dakota State University
Title: Understanding E. coli and Water Quality in Stormwater Retention and Detention Basins in Fargo as part of the Red River Watershed

Fellow: Mohammad Hadi Bazrkar **Advisor:** Dr. Xuefeng Chu
Program: Civil & Environmental Engineering, North Dakota State University
Title: Drought Identification and Prediction for Cold Climate Regions

Fellow: Hakan Kadioglu **Advisor:** Dr. Halis Simsek
Program: Agricultural & Biosystems Engineering/Natural Resource Management, North Dakota State University
Title: Effect of Different Water Table Levels on Canola Growth and Quality Parameters

Fellow: Hoang Nu Kim Pham **Advisor:** Dr. Achintya Bezbaruah
Program: Civil & Environmental Engineering/Environmental & Conservation Science, North Dakota State University
Title: Application of Green Iron Nanoparticles Synthesized using Barley Polyphenols to Combat Lake Eutrophication

Fellow: Jiyang Zhang **Advisor:** Dr. Haochi Zheng
Program: Earth System Science and Policy, University of North Dakota
Title: Evaluation of the Costs between Devils Lake Flooding Adaptations and Sheyenne River Salinity Damages resulted from Devils Lake Outlet Operations

Fellow: Justin Waraniak **Advisor:** Dr. Craig Stockwell
Program: Biological Sciences/Environmental & Conservation Science, North Dakota State University
Title: Natural and Anthropogenic Landscape Effects on Amphibians in the Northern Great Plains: Genetic Population Structure, Connectivity, and Local Adaptation in Northern Leopard Frog (*Rana Pipiens*)

Fellow: Mathew Cox **Advisor:** Dr. Yeo Howe Lim
Program: Atmospheric Sciences, University of North Dakota
Title: Developing Design Guidelines for Spur Dikes in Curved Trapezoidal Channels Based on a Validated Two-Dimensional HEC-RAS Model

Fellow: Pavankumar Challa Sasi **Advisor:** Dr. Feng Xiao
Program: Civil Engineering, University of North Dakota
Title: Enhanced Removal of Poly- and Perfluoroalkyl Substances from Water

Fellow: Rebecca Bradley **Advisor:** Dr. Matthew Smith
Program: Biological Sciences, North Dakota State University
Title: Influence of wetland water quality on amphibian stress and reproductive success in Eastern North Dakota

Fellow: Talon Mack **Advisor:** Dr. Xinhua Jia
Program: Agricultural & Biosystems Engineering, North Dakota State University
Title: Using UAV and Thermal Imaging to Determine Soil Moisture in Red River Valley

Fellow: Tonoy K Das **Advisor:** Dr. Achintya Bezbaruah
Program: Civil & Environmental Engineering/Environmental & Conservation Science, North Dakota State University
Title: Fabrication of Point of Use Treatment Systems for Aqueous Arsenic and their Evaluation

Fellow: Tong Lin **Advisor:** Dr. Zhulu Lin
Program: Agricultural & Biosystems Engineering/Environmental & Conservation Sciences, North Dakota State University
Title: Water Resources Impacts and Management in the Bakken Region of Western North Dakota

Fellow: Lan Zeng **Advisor:** Dr. Xuefeng Chu
Program: Civil & Environmental Engineering, North Dakota State University
Title: Development of a Puddle-based-unit Oriented SWAT (SWAT-PBU) Model and Its Application in North Dakota

Fellow: Matthew Tuftedal **Advisor:** Dr. David Delene
Program: Civil Engineering, University of North Dakota
Title: Precipitation Evaluation of the North Dakota Cloud Modification Project (NDCMP) using Rain Gauge Observations

Fellow: Zachary Phillips **Advisor:** Dr. Stephanie Day
Program: Geosciences/Environmental & Conservation Sciences, North Dakota State University
Title: Interdisciplinary Approach to Understanding Fluvial Geomorphology of Post-glaciolacustrine Meandering Rivers: A Case Study of the Red River

2018 — 2019 NDWRRI Fellowship Research Highlights

Examining the Impact of Devils Lakes Outlets on Flood Risk and Water Quality of the Sheyenne River

Afshin Shabani *(Fellow) &* ***Xiaodong Zhang*** *(Advisor), University of North Dakota*

◊ A coupled SWAT and CE-QUAL-W2 model was developed to simulate Devils Lake water levels and sulfate distribution.

◊ The coupled SWAT and CE-QUAL-W2 model showed that sulfate concentration in Devils Lake increased from west to east, which made the operation of the east outlet more of a concern for degrading the water quality in the Sheyenne River.

◊ A SWAT model was developed for the Sheyenne River watershed to simulate daily discharge.

◊ The Sheyenne River SWAT model was linked to the Devils Lake coupled SWAT and CE-QUAL-W2 model to simulate the impact of diverted water on the river discharge and sulfate concentration.

◊ The results of the hydrologic and water quality modeling showed that the impact of the outlet operation on the Sheyenne River discharge was within confines of two-year flood (36 $m^3 s^{-1}$), while the river sulfate concentration increased from 125 mg l^{-1} to ≥ 750 mg l^{-1}.

◊ Using an optimization model and actual outlet schedule an optimal management was determined, which mitigated the Sheyenne River discharge and sulfate concentration to ≤ 26 $m^3 s^{-1}$ and ≤ 650 mg l^{-1}, respectively.

2018 — 2019 NDWRRI Fellowship Research Highlights

Bigmouth Buffalo Ictiobus Cyprinellus Sets Freshwater Teleost Record as Improved Age Analysis Reveals Centenarian Longevity

***Alec Lackmann** (Fellow) & **Malcolm Butler, Mark Clark** (Advisors), North Dakota State University*

We found Bigmouth Buffalo *Ictiobus cyprinellus* can live beyond 110 years, surpassing all other freshwater teleosts (~12,000 species) by nearly 40 years. We conclusively validated these ages via bomb radiocarbon analysis, making Bigmouth Buffalo the oldest age-validated freshwater fish. These age-data alone have potential to transform the management of this species, and change the perception of other closely-related taxa. For several endemic populations, spans of four and eight decades with no representative year classes suggest long term recruitment failure on a regional level. This paradigm-shifting life history data comes at a crucial point in this species' history. Current harvest of Bigmouth Buffalo is almost completely unregulated across the USA, even as Bigmouth Buffalo are declining and are well-known scientifically as competitors with several of North America's most invasive carp species. In addition, Bigmouth Buffalo face mounting threats. Not only are they valued as a food fish to both Native Americans and commercial harvesters, they are now also popular bowfishing targets. Bowfishing at night is a new, virtually unstudied, yet obviously growing form of harvest. Almost all US states do not require a bowfishing license, and most species targeted are native fishes with no limits established on their take, including Bigmouth Buffalo. There is also no mechanism in place for bowfishers to report their harvest. Thus, little is known regarding this new, and growing form of exploitation. Our findings reveal Bigmouth Buffalo and other catostomids require urgent attention.

We also report on novel, age-related external markings that accrue on Bigmouth Buffalo. These orange and black spots highly correlate with the age of the fish, providing a non-lethal means of age estimation as well as aid recognition of individual fish. We found that Bigmouth Buffalo reach asymptotic adult size around the age of 30-40 years, and there is a pronounced sexual dimorphism in their size structure (females are much larger than males at maturity). In addition, there is marked variation in adult size within each sex. Mature males typically range in size from 4-8 kg, and females in the range of 8-25 kg. Thus, a 4 kg, male Bigmouth Buffalo could be 100 years old. In fact, the oldest specimen in our research paper (taken by a bowfisher in 2018), was 112 years old. She was only 9.8 kg and 87 cm total length, on the smaller end of the mature females.

Overall, little was known about this North American species. Careful examination has revealed discoveries overlooked and management dilemmas that can arise as a consequence of the ecological neglect underappreciated species.

Co-authored with Drs. Mark Clark and Malcolm Butler (his advisors), Alec Lackmann (Ph.D. student and NDWRRI Fellow) published their research findings in Communications Biology, showing that a Bigmouth Buffalo fish could live up to 112 years! The related work recently has received a lot of attention in the press (please see the following details). Congratulations to Alec, Mark, and Malcolm!

Communications Biology: https://www.nature.com/articles/s42003-019-0452-0

National Geographic: https://www.nationalgeographic.com/animals/2019/08/oldest-freshwater-fish-discovered-radiocarbon-dating/

Minnesota Public Radio: https://www.mprnews.org/story/2019/06/10/new-appreciation-for-a-minnesota-fish-long-considered-junk

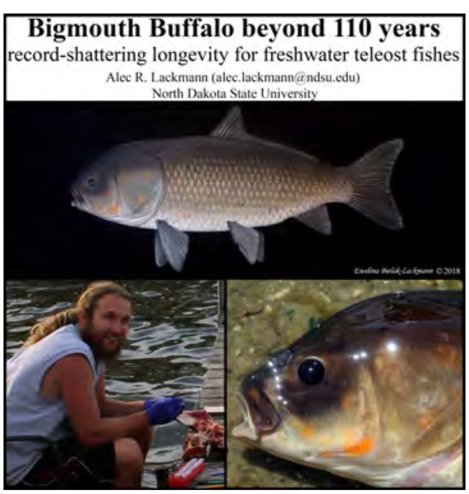
Minneapolis *Star Tribune*: http://www.startribune.com/record-catch-at-112-years-minnesota-fish-is-the-oldest-freshwater-fish-ever-verified/525677101/

Newsweek: https://www.newsweek.com/bigmouth-buffalo-this-record-breaking-fish-was-alive-when-theodore-roosevelt-was-president-1452520

Science Alert: https://www.sciencealert.com/grandma-fish-is-so-much-older-than-we-thought-freshwater-fish-could-be

SYFY Wire: https://www.syfy.com/syfywire/112-year-old-fish-minnesota

Newswise: https://www.newswise.com/articles/ndsu-research-proves-midwestern-fish-species-lives-beyond-100-years



Featured Research

2018 — 2019 NDWRRI Fellowship Research Highlights

Assessing Effect of Precise Evapotranspiration Measurement on Crop Coefficient and Water Use

Ali Rashid Niaghi (Fellow) & Xinhua Jia (Advisor), North Dakota State University

It is crucial to accurately measure the ETc from dominant vegetation surfaces in agricultural land management. Among different methods used to measure the ETc, above ground energy balance method is superior, especially in areas with shallow groundwater. In this project, corn ETc was measured using the near-surface energy balance with EC and BREB systems in a tile drained field. After analyzing the data during the growing season, the measured H with EC and the calculated latent heat flux (LE) using the residual method decreased with increasing the crop ground coverage. The results showed that the residual method was useful for closing the energy balance equation if the data were screened properly and the system was maintained in an acceptable condition. The diurnal analysis of H showed that the H measured by the EC and BREB agreed well with each other in July and August and similar in June and September, which resulted in a better estimation of LE and ETc. The developed Kc values using the EC system with the residual method can be as accurate as the result obtained from the BREB system. Therefore, they can be used for agricultural water management in the Red River Valley.

Performance of a Retrofit Detention basin in Fargo, ND

Cole Huggins (Fellow) & Stephanie Day (Advisor), North Dakota State University

◊ The Rabanus detention basin (Fargo, ND) was retrofitted from a traditional concrete-lined channel and mowed grass basin to a basin with an earthen-channel, sediment forebay, and native vegetation.

◊ The goals of the study were to assess the performance between pre-retrofit concrete-lined channel and post-retrofit earthen-channel with respect to flood frequency for small storms, and to estimate ponding time, infiltration, and evaporation of the retrofit basin for various storm sizes/intensities.

◊ Monitoring occurred between May 1, 2018 and September 30, 2018 using an Onset HOBO Weather Station and various in-channel Onset HOBO Water Level Loggers. A drone flight and manual survey of the channel and sediment forebay were also conducted in order to estimate a DEM from structure-from-motion techniques within Pix4D.

◊ HEC-RAS was used to estimate and compare post-retrofit channel flow with pre-retrofit channel capacity of small storms.

◊ The ArcMap's ModelBuilder was used to estimate hourly ponded volume and ponding time of each storm.

◊ Hydrus-1D was used to estimate infiltration and evaporation during ponding time of the select storms. The Penman-Monteith equation for evaporation was also solved within Hydrus-1D using the monitored weather data.

◊ The northern-most post-retrofit channel behaves similarly to the pre-retrofit channel in terms of flood frequency due to increased erosion of the earthen-channel. The southern post-retrofit channel floods significantly more often than the pre-retrofit channel, leading to a potential increase in ponding time, infiltration, and evaporation.

◊ 50% of the storms had a ponding time equal to or greater than 9 hours, while 40% of the storms had a ponding time equal to or greater than 12 hours. It is apparent that sediment re-mobilization occurred, and the sediment was deposited at the outlet.

◊ Combined total infiltration and evaporation for ponding time of the selected storms averaged 7.90% of the respective peak ponded volume. Evaporation was relatively negligible in comparison to infiltration.

2018 — 2019 NDWRRI Fellowship Research Highlights

Estimation of Freshwater Harmful Algal Blooms Using Multilayer Perceptron Neural Network Model

Haci Osman Guzel *(Fellow) &* ***Halis Simsek*** *(Advisor), North Dakota State University*

Excess nutrients in a freshwater environment stimulate blue-green algae, which rapidly increase and accumulate in lakes and rivers when favorable environmental conditions are met. Blue-green algae produce toxins and cause a wide range of problems including oxygen depletion, fish kills, harm or death to other aquatic organisms, and subsequent habitat loss. Cyanobacteria are a type of prokaryotic blue-green algae that can form harmful algal blooms (HABs) in water ecosystems and sometimes called CyanoHABs. The development of a HAB early-warning system is highly dependent on reliable modeling methods that predict HAB occurrence with a high accuracy. In this study, artificial intelligence techniques, particularly multilayer perceptron (MLP) neural network model were used to estimate blue-green algae fluorescence for the year-round data collected in 2016 and 2017 from western Lake Erie, USA. Eight input parameters including phosphorous, nitrogen, chlorophyll-a, air temperature, water temperature, turbidity, wind speed, and pH were used to run the model. Five different learning algorithms were tested, and the Levenberg-Marquardt algorithm resulted in the highest R^2 values of 0.98 and 0.72 for eight, and three (phosphorous, nitrogen, and chlorophyll-a) input parameters, respectively. The eight input parameters produced the best estimation.

Application of Green Iron Nanoparticles Synthesized using Barley and other Plant-borne Polyphenols to Combat Lake Eutrophication

Hoang Nu Kim Pham *(Fellow) &* ***Achintya Bezbaruah*** *(Advisor), North Dakota State University*

The extract of barley *(Hordeum vulgare* L.) was used for synthesizing iron nanoparticles (Fe-NPs) and the synthesized particles were used for phosphate removal. Green tea polyphenol based Fe-NPs were used in the control experiment. While the particle size of NPs synthesized with the green tea extract ranged from 3 to 11 nm, barley extract produced particles >3 nm. The barley-based Fe-NPs did not show metallic properties (based on XRD data) as the particles were coated with plant materials. However, the phosphate removal capacity of barley-based Fe-NPs was higher than that of the green tea based Fe-NPs. The nanoparticles (3 g/L) were also used to remove phosphate from municipal wastewater (5-7 mgP/L initial concentration), and up to 98% phosphate removal was achieved. The mechanism of nanoparticle formation was also examined. This study indicates that the barely-based nanoparticles are useful for phosphate recovery from waters. The next phase of experiments will look into the reuse of the nanoparticle-sorbed phosphate for agricultural applications.

2018 — 2019 NDWRRI Fellowship Research Highlights

Assessment of Agricultural Impact on Biotic Components of North Dakota Wetland Resources Using Landscape Genomics of Northern Leopard Frog (Rana Pipiens)

Justin Waraniak *(Fellow) &* ***Craig Stockwell, David Mushet*** *(Advisors), North Dakota State University*

In this project, microsatellite genotypes of northern leopard frog populations around the state of North Dakota were analyzed. It was discovered that the population structure of *R. pipiens* was strongly associated with river basins and that the Missouri River acted as a major barrier restricting gene flow between populations on different sides of the river. It was estimated that the population division caused by the Missouri River occurred ~18,000 years ago as glaciers receded out of northeastern North Dakota. Population subdivisions by river basin were estimated to occur mostly between 8000 - 5000 years ago during the mid-Holocene. This was a period characterized by extreme droughts in the Northern Plains, which isolated *R. pipiens* in deep-water habitats causing the population sub-structuring by the river basin. This research forms an important baseline of knowledge to conduct more fine-scale genetic analyses of *R. pipiens* populations in North Dakota. Field sampling of *R. pipiens* in North Dakota was completed to examine the ecological and evolutionary impacts of intensive agriculture on populations. Tissue samples for genomic analysis were collected from 632 frogs at 36 sample sites across the state. DNA extractions from these samples were completed. The SNP markers were used to detect signatures of selection due to compromised water quality in areas with intensive agriculture, to estimate the rates of gene flow and identify habitats important for biotic connectivity in the Prairie Pothole Region, and to infer demographic history.

Evaluating the Response of Diatoms and Cladocerans Communities to Climate Change over the Last Century in Lake P1, North Dakota

Kui Hu *(Fellow) &* ***Jon Sweetman*** *(Advisor), North Dakota State University*

Prairie pothole wetlands play a significant role in providing important freshwater resources and vital ecosystem services in North Dakota, including habitat for waterfowl and other biodiversity, carbon sequestration and flood abatement. The climate in the Prairie Pothole Region (PPR) is highly variable, with multiyear periods of drought and periods of excess precipitation occurring over the past century, which have markedly influenced the wetland ecosystems. This study aims to evaluate the past climate change effects on biological assemblages (i.e., diatoms) in the prairie pothole wetland ecosystem by combining long-term historical meteorological datasets with sediment records from a prairie pothole lake. Initial results suggest that nutrient availability is the main factor that drives diatom assemblage changes over the past century. Diatoms in the sediment record show a shift from primarily benthic species to more planktonic taxa since 1966, which corresponds to the increased water levels in 1967-1972 (i.e., a relatively wetter period). These results imply that water level changes result in habitat changes due to climate change and can have important implications for biological community structure and wetland functioning. This research helps to test how the PPR's primary producer communities have responded to changes in the frequency and duration of the wet and dry cycles. A clear understanding about the dynamics of the PPR wetland ecosystem in response to climate variability helps policy and decision makers propose appropriate management strategies to cope with the changing climate of the future.

2018 — 2019 NDWRRI Fellowship Research Highlights

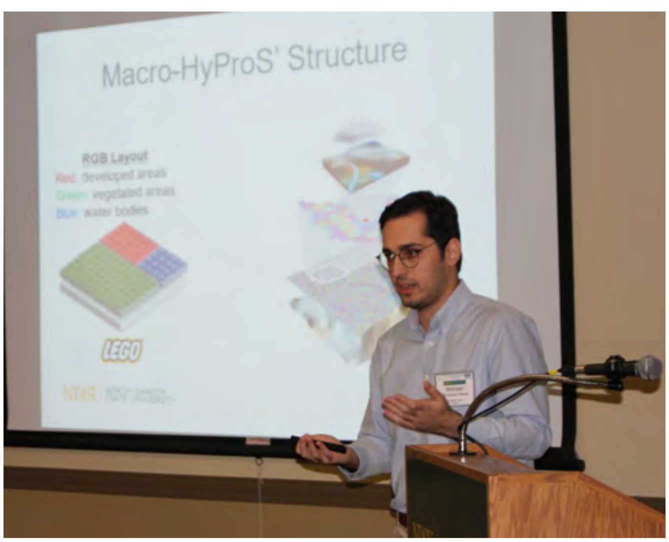
Treatment of Produced Water for Discharge to Surface Waters and Non-potable Uses

***Zachary Ranisate** (Fellow) & **Feng Xiao** (Advisor), University of North Dakota*

Unconventional oil production from the Bakken region in North Dakota has been rising significantly since 2006 because of the development of the hydraulic fracturing and horizontal drilling technologies. The fracking produced water is typically injected back to underground disposal well, discharged to a nearby surface water body, discharged to municipal wastewater treatment/shallow groundwater, or reused for future fracking. The produced water is high in salinity and contains a number of toxic trace elements and naturally occurring radioactive material. Therefore, the direct discharge of the produced water to surface water/groundwater may cause the impairment of the water quality and be threatening to the local ecosystem and the public health. This project explored an alternative way of disposal of fracking-produced water. 38 elements in a couple of produced water samples collected from the North Dakota oilfield were measured by using a Thermo Scientific iCAP Qc ICP-MS equipped with a Teledyne CETAC ASX560 Autosampler. Nickel sampler and skimmer cones, a Microflow PFA-ST nebulizer, and a quartz cyclonic spray chamber were used for all experiments. Grade 5 helium was utilized as an inert gas in kinetic energy discrimination mode. It was found that the concentrations of certain elements were elevated in the produced water, especially some heavy metal ions. The concentrations of major elements were strongly correlated with each other, suggesting that these elements were from the same source(s). Caustic softening can efficiently reduce the concentrations of multivalent metal ions. The removal efficiency correlates well with the solubility product constants of metal hydroxides.

Development of the Macro-Scale Hydrologic Processes Simulator (Macro-HyProS) and Applications in the Red River Basin and North Dakota

***Mohsen Tahmasebi Nasab** (Fellow) & **Xuefeng Chu** (Advisor), North Dakota State University*



◊ Micro-topographical characteristics and indices such as hierarchical relationships of depressions, ponding storage, ponding area, and topographic wetness index were utilized to establish a second-order multiple regression model, which provided a dynamic relationship between the ponding area and different topographic indices. The developed regression model was tested on several sample surfaces within the Red River basin. Results indicated that the regression model was statistically helpful for prediction of the ponding area. The results also suggested that variations of the ponding area over the study area can be explained by using ponding storage and other topographic indices such as topographic wetness index.

◊ The modeling results revealed that Macro-HyProS improved the physically-based representation of the snowmelt processes. The model was applied to the Missouri River basin for water years 2011 and 2012, which represent historic wet and dry years, respectively. The snowmelt simulations suggested that the daily snowmelt simulations were profoundly affected by the sub-daily temperature fluctuations, while the monthly and annual snowmelt results were less prone to such changes.

◊ The improved Macro-HyProS developed in this one-year project can be used to simulate a variety of hydrologic processes specifically in depression-dominated cold climate regions. The improved methodologies and simulations from the Macro-HyProS can be used to provide the required information for decision makers, as well as researchers. The model simulates daily, monthly and yearly summaries and animations of different hydrologic processes to assist management of agricultural activities. The topo-statistical analyses used to develop the regression model can also be used in other macro-scale hydrologic models to improve the modeling for depression-dominated regions.

2018 — 2019 NDWRRI Fellowship Research Highlights

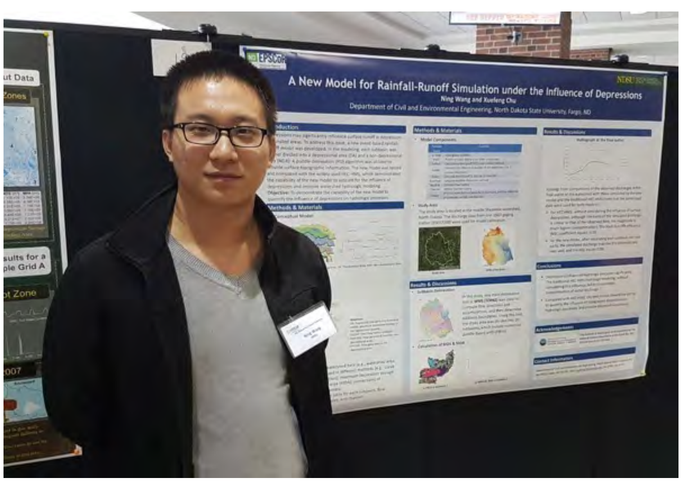
Enhanced Removal of Heavy Metals from Stormwater by Bioretention Cells

Nicholas Peterson *(Fellow) &* ***Feng Xiao*** *(Advisor), University of North Dakota*

The objective of this project was to determine what materials had the greatest ability at sequestering copper (II) ions from aqueous solution. Potential sorbent materials were selected. Batch-scale experiments were performed on the sorption of cupper ions (Cu(II)) by different materials, including flocs formed during coagulation/flocculation of surface water treatment, biochar, biomass materials, sand, and iron-modified sand. In addition, laboratory column tests packed with the materials selected for the batch-scale experiments, including flocs and iron-modified sand, were also performed. It was found that high modified iron-coated (MIC) sand was capable of retaining copper (II) ions passed through the column or removing the influent copper (II) ions. The primary discovery gained from the fixed-bed column experiments was that the majority of the sorbent materials were less efficient than the iron-modified sand. This was of particular interest because many of the materials such as tap water flocs had high maximum adsorption capacity values in the batch experiments, which could only be explained by the limited contact time and preferential contaminant flow paths. The major findings from this research include (1) the ranking of materials for maximum adsorption capacity and (2) the materials possessing the greatest retention capacity with contact time constraints.

Development of a New Depression-oriented Hydrologic Modeling System (HYDROL-D)

Ning Wang *(Fellow) &* ***Xuefeng Chu*** *(Advisor), North Dakota State University*



This project focuses on the development of a new semi-distributed, physically-based modeling system (HYDROL-D) for continuously simulating hydrologic processes in depression-dominated areas. HYDROL-D has a unique model structure to handle surface runoff routing across depressional surfaces. In the HYDROL-D system, a watershed is delineated into a number of subbasins, each of which is further divided into a main channel and many puddle-based units (PBUs), off-stream channel-based units (CBUs), and on-stream CBUs. Surface runoff generated in all PBUs and off-stream CBUs flows into their associated downstream units and then into the on-stream CBUs. The runoff water in the on-stream CBUs of a subbasin eventually flows into the main channel, which is further routed in the model. HYDROL-D system has a unique model structure that facilitates the simulation of water movement along the vertical direction. Specifically, each modeling unit (e.g., a PBU) consists of four zones, including canopy zone, snow zone, surface zone, and soil zone. All units in a subbasin share a common shallow groundwater zone. The HYDROL-D system was applied to five upstream subbasins in the Devils Lake watershed in the Prairie Pothole Region (PPR) to analyze the impacts of depressions on hydrologic processes on a daily time scale. The model was calibrated and validated by comparing the simulated and observed discharges. This study demonstrated the improved applicability and capability of the HYDROL-D modeling system, especially for depression-dominated regions.

2018 — 2019 NDWRRI Fellowship Research Highlights

An Integrated Social and Ecological Model for Stream Flow Simulation

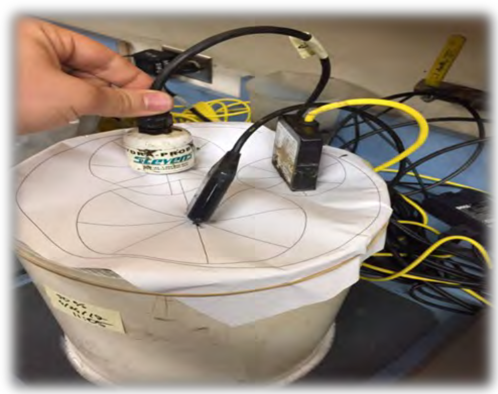
Tong Lin *(Fellow) &* ***Zhulu Lin*** *(Advisor), North Dakota State University*

Unconventional oil production at the Bakken Shale of western North Dakota has increased nearly ten-fold from 2008 to 2014. During this period, Bakken Shale was drilled approximately 10,000 horizontal wells and the average water use was around 2.0×10^6 gal/well. The rapid expansion of unconventional oil and gas extraction and the cumulative water needs for hydraulic fracturing (HF) have raised concerns in surface water resources management in some local areas. The Little Muddy River, the second most frequently used surface water sources for HF, was chosen for this project. To address the potential HF water stress on the regional surface water resources, two steps were implemented. Firstly, a SWAT model was developed to simulate the hydrological processes of the Little Muddy River basin. Secondly, an agent-based model of HF water use was integrated with the SWAT model to simulate the changes in the river discharge. The results indicated that the streamflow was not influenced by the water use for hydraulic fracturing. Even when the total HF water use increased up to 100 times, this HF water use would still not have significant impact on the river in both wet and dry periods when streamflow is greater than 1.0 cms. This coupled human and nature system improves the understanding of the dynamics of the HF impact on local streams in the region. It also helps policy and decision makers devise appropriate policy tools to manage the regional water resources for long-term and sustainable use.

Response of Soybean Growth, Yield, and Some Quality Parameters to Different Water Table Depths

Yavuz Fatih Fidantemiz *(Fellow) &* ***Halis Simsek*** *(Advisor), North Dakota State University*

Water table contribution to plant water use is a significant element in improving water use efficiency (WUE) for agricultural water management. This project focused on determining groundwater contributions to soybean water use and the soybean response to different water table levels. The specific objectives of the study are: (1) to determine crop water of soybean from different water table depths (WTD) without irrigation, (2) to determine the effects of shallow groundwater on soybean growth and yield parameters, and (3) to determine the effect of groundwater depth on the root distribution of soybean. In this study, lysimeter experiments were conducted in a controlled environment to investigate the response of soybean water uptake and growth parameters under water table depths of 30, 50, 70, and 90 cm. Further analysis of the root mass and proportional distribution among different soil layers indicated that the lysimeters with WTD of 70 and 90 cm had greater root mass with higher root distribution at 40–75 cm of the soil layer. The results also indicated that the WTD of 70 and 90 cm yielded higher grain yield and biomasses with greater WUE and better root distribution than the irrigated or shallow WTD treatments. This research provides farmers with the valuable information about soybean tolerance on water depths, which helps minimize the risk of yield reduction in the field. The comprehensive data collected also help design field-scale tile drainage system.



2018 — 2019 NDWRRI Fellowship Research Highlights

Paleoflood and Glacial Isostatic Adjustment (GIA) Influence on Fluvial Geomorphology of the Red River Basin

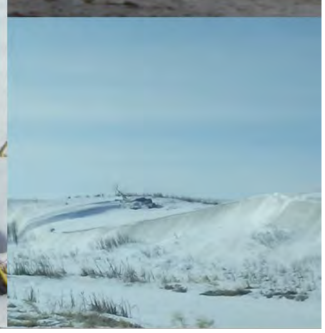
Zachary Phillips *(Fellow) &* ***Stephanie Day*** *(Advisor), North Dakota State University*

This project focuses on how rivers and their basins have changed since deglaciation and the draining of Lake Agassiz by (1) analyzing and interpreting landforms recorded in digital elevation data, (2) studying erosional processes of river ice at laboratory and field scales, and (3) using numerical simulations to reconstruct and erode landscapes of the Red River Basin 12,000 years ago. Interdisciplinary field, laboratory, and computer modeling methods were used to study how erosional processes led to the changes in the river or landscape. Although the Red River was established entirely on the bed of Lake Agassiz, there was evidence of glacial moraines influencing river incision and making meander cutoffs greater relief. It was demonstrated that the frozen/thawed conditions of the river banks were a product of the temperature conditions and timing/character of ice breakup. Floods in the Red River basin, because of the low relief landscape, occurred over multi-week time periods. Even if the river banks were frozen when flooding started and ice floe began, they were thawed only a few days after flooding began. This research revealed that the relative timing of the Grand Marais Creek/Red Lake River avulsion was about 500-600 years after Lake Agassiz receded from that area. This project also demonstrated the methods for running Landscape Evolution Modeling experiments on a real DEM-based landscape. This research showed that most of the significant landscape evolution and river path changes were taking place early in the Holocene.

2017 — 2018 NDWRRI Fellowship Research Highlights

Hydrological Responses to Climate Change in a Terminal Lake Basin

Diane Van Hoy *(Fellow) &* ***Taufique Mahmood*** *(Advisor), North Dakota State University*



The field observations and physically based snow simulations clearly identify the areas of snow source and sink and improve our understandings on snow redistribution processes. Distributed snow simulations indicated that the areas of highest, longest enduring snow accumulation are the higher elevation regions on the eastern and western edges of the basin. The recent wetting is clearly influencing the hydro-climatic responses in the Devils Lake Basin area. Generally, the increase in precipitation is expected to amplify the streamflow volume. However, this study shows that the recent increase in precipitation caused streamflow surges till 2011. After 2011, despite the continued increase in precipitation, the streamflow is reduced significantly and substantial increases of evapotranspiration are observed in this study. Increases in fall precipitation elevate soil moisture conditions that contribute to changes in the frozen soil condition by creating larger more persistent layers of ice in the winter. These ice layers reduce the infiltration capacity of the soil during spring melt and are important factors in flood years similar to 2009, 2011 and 2017. We believe 2011 can be considered as a major hydro-climatic marker and the hydro-climatic responses before and after 2011 will help us to better understand future cold region responses. Our findings are of special scientific interest as the Devils Lake region is expected to experience short duration precipitation extremes and continued wetting till ~2038. The continued wetting in the future would generate local and regional flooding similar to 2009 and 2011, which would have devastating impacts on regional economic and agricultural practices.

2017 — 2018 NDWRRI Fellowship Research Highlights

Assessing Devils Lake Water Quality with Remote Sensing and Coupled SWAT and CE-QUAL-W2 Model

***Afshin Shabani** (Fellow) & **Xiaodong Zhang** (Advisor), University of North Dakota*

◊ Developed a coupled SWAT and CE-QUAL-W2 model to simulate water levels and sulfate concentrations of Devils Lake.

◊ Developed a coupled SWAT and HEC-RAS model to simulate the Sheyenne River streamflow and floodplain in presence and absence of Devils Lake outlets operation.

◊ The coupled SWAT and CE-QUAL-W2 model showed that operating two outlets lowered Devils Lake water level by ~1 m for the time period from 2005 to 2016.

◊ The coupled SWAT and CE-QUAL-W2 model showed that operating Devils Lake outlets increased the Sheyenne River sulfate concentration from 100 to >500 mg l^{-1}. However, the simulation shows an increase in sulfate concentration of Devils Lake from west to east, which makes the operation of the east outlet more of a concern for degrading the water quality in the Sheyenne River.

◊ The general operation of the outlets follows the following criteria: (1) no operation during the winter frozen time, (2) minimum or no operation during the early spring when flash floods tend to occur, and (3) maximum operation during the summer and fall seasons when the streamflow is typically low.

◊ The result of the coupled SWAT and HEC-RAS models showed that diverting water from Devils Lake caused a maximum impact on the Sheyenne River floodplain, which, in terms of either areal extension of the floodplain or the increased flow rates or elevated river water level, is within the historical confines of the two-year flood. In addition, the maximum impacts occurred only 4% of the time when the outlets operated with their total capacity during the 5-year combined outlet operation (2012-2016) and 0.4% of the time of their entire operation period (2005-2016).

◊ Currently, two outlets are operating under a revised sulfate standard of 750 mg l^{-1}. Imposing the state-wide sulfate standard of 450 mg l^{-1} would dramatically reduce the efficiency of the outlets and increase the Devils Lake water level by at least 0.54 m.

Crop Evapotranspiration Measurement by Eddy Covariance, Bowen Ratio, and Soil Water Balance for a Control Drained and Subirrigated Field

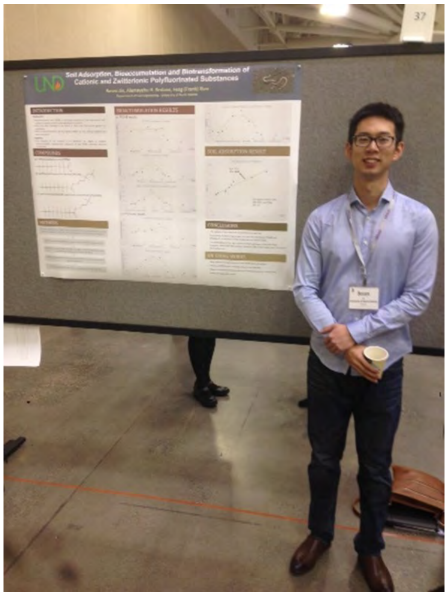
***Ali Rashid Niaghi** (Fellow) & **Xinhua Jia** (Advisor), North Dakota State University*

Crop evapotranspiration (ET_c) is defined as the combination of water losses through evaporation from soil and water surfaces and transpiration from vegetation. Accurate ET_c estimate is very important in crop water management and irrigation scheduling. Because of the wide range of complexities in quantifying ET_c, direct methods provide more accurate ET_c measurement. Therefore, comparison among the ET_c by eddy covariance (EC), Bowen ratio energy balance (BREB), and soil water balance methods can provide an accurate on-site ET_c measurement. Due to the energy balance closure problems in the EC method, addition of an independently measured Bowen ratio by the BREB system can overcome this problem and provide better ET_c estimates. In this study, an EC, a BREB, and a SWB systems were utilized in a soybean field to measure the surface energy and evapotranspiration rates over the 2017 growing season. The overall results indicated that the average ET_c obtained from the EC method was 25.9% higher than that from the BREB method. By using the measured Bowen ratio from the BREB, the error of estimation by the EC was reduced to 6.9%, which was a significant improvement on ET_c estimation.

2017 — 2018 NDWRRI Fellowship Research Highlights

Poly- and Perfluoroalkyl Substances (PFASs) in Surface Runoff and Soil and Their Fate and Effects

Bosen Jin (Fellow) & Feng Xiao (Advisor), University of North Dakota



Per- and polyfluoroalkyl substances (per- and poly-PFASs) are emerging organic contaminants that are toxic, persistent, and present ubiquitously in the environment. Per-PFASs such as perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) have been measured in fish, birds, mammals, drinking water, municipal wastewater, surface runoff, and human blood samples at numerous sites in the United States. Very recently numerous emerging poly-PFASs have been identified in the environment, and some of them are potential PFOS and PFOA precursor compounds. The goal of the project is to investigate the fate and transport of per- and poly-PFASs in surface runoff and the bioconversion of poly-PFASs in earthworms. A group of PFASs with different chain lengths and functional groups were monitored in stormwater runoff from five precipitation events (2017-2018) at various locations corresponding to different watershed land uses. We detected PFASs in all of the runoff samples. Monitoring results and statistical analysis show that PFASs in stormwater runoff from residential areas mainly came from rainfall. On the other hand, non-atmospheric sources at both industrial and commercial areas contributed PFASs in surface runoff. The mass flux of PFASs from stormwater runoff in the Grand Forks and Fargo metropolitan areas is estimated to be ~2.6 kg/year. The results of this study contribute to previously very limited knowledge of the level and fate of a major group of emerging contaminants in North Dakota. The insight gained from this project may provide a foundation for strengthening stormwater best management practices (BMPs) to remove PFASs from non-point sources and enhancing drinking-water treatment processes to safeguard the drinking water against PFASs.

Molecularly Imprinted Polymers for Phosphate Removal from Eutrophic Surface Water

***Cody Ritt** (Fellow) & **Achintya Bezbaruah** (Advisor), North Dakota State University*

Wastewater effluents and agricultural runoff are major sources of phosphorus overloading in surface waters. Phosphorus overloading ignites eutrophication, which devastates aquatic ecosystems. On the other hand, phosphorus, which is currently produced from phosphate rock, is a critical component of fertilizer mixes. However, the world is predicted to face a shortage of phosphate supply beyond 2033 due to unsustainable mining. This research aims to develop a polymeric sorbent that recovers low-concentration phosphorus for eutrophication prevention and fertilizer reuse. Available polymer-based products have underwhelmed expectations by having poor selectivity or lacking appropriate biodegradation rates. This research identified molecularly imprinted polymers (MIPs) as possible sorbents for overcoming the deficiencies of reported technologies. Screening of several MIPs resulted in one potentially feasible MIP for phosphate sorption. Further studies showed a sorption capacity of ~28 mg PO_4^{3-}-P/g and partial phosphate-selectivity. Potential phosphate removal mechanisms were identified, providing foresight into MIPs' viability as phosphorus sorbents.

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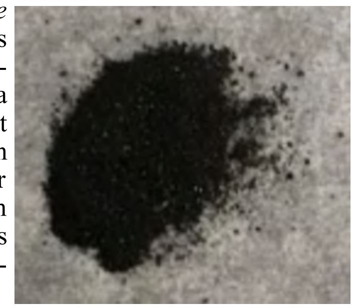
Application of Green Iron Nanoparticles Synthesized Using Barley Polyphenols to Combat

Hoang Nu Kim Pham *(Fellow) &* ***Achintya Bezbaruah*** *(Advisor), North Dakota State University*

This project includes four research tasks:

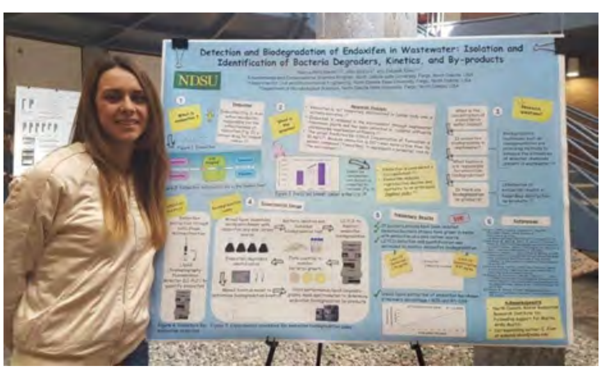
- ◊ Task 1: Barley extract preparation
- ◊ Task 2: Synthesis of iron nanoparticles
- ◊ Task 3: Characterizations
- ◊ Task 4: Batch experiments

Iron nanoparticles (Fe-NPs) are widely synthesized by using polyphenols in plant extracts. Polyphenols ingredients in plants act as reducing/stabilizing agents. The extract of barley (*Hordeum vulgare* L.) was used for synthesizing Fe-NPs in this experimental study. A sample of Fe-NPs synthesized from green tea *(Camellia sinensis)* and a conventional sample of nanoscale zero-valent iron (NZVI) prepared via $NaBH_4$ reduction method were used as controls. Research has optimized the green synthesis process to attain better yield and control size. The XRD picture of barley-based Fe-NPs indicated a presence of Strontium Iron Oxide, but no Fe pure. Although the useful properties in phosphate removal of barley Fe-NPs had been described, the mechanism involved phosphate removal as well as polyphenol-Fe NPs synthesis still has been ambiguous, and further studies are needed in the project.



Photodegardation of (E)-and (Z)-endoxifen in Wastewater Treatment Plants at North Dakota: Kinetics, By-products Identification and Toxicity Assessment

Marina Arino Martin *(Fellow) &* ***Eakalak Khan, John McEvoy*** *(Advisors), North Dakota State University*



During the last decade, the presence of cytostatic drugs in the environment has been a growing concern worldwide. The abundance of these chemotherapy drugs in the environment is related to the frequency of their consumption. Endoxifen is the effective metabolite of tamoxifen, a widely consumed cytostatic drug used to treat endocrine positive breast cancer. The recent detection of endoxifen in the final effluent of a municipal wastewater treatment plant (WWTP) has brought a need for research. The antiestrogenic activity of endoxifen potentially produces negative effects on aquatic lives. Therefore, there is an urgent need to remove endoxifen from wastewater in order to reduce the potential release of endoxifen into the environment. However, studies reporting information about endoxifen removal in WWTPs are scarce.

This research investigated the use of ultraviolet radiation (253.7 nm) and natural sunlight to photodegrade endoxifen in water and wastewater. The research result elucidates potential treatments to eliminate endoxifen from wastewater. An effective treatment technique for endoxifen would be useful in reducing its release to the aquatic environment and in turn potential toxicological effects on aquatic lives or even humans. In addition, the identification of potential photodegradation by-products (PBPs) and their toxicity lead to a better understanding of the fate of endoxifen in wastewater and receiving surface water and the potential effect of generated PBPs in the aquatic environment.

2017 — 2018 NDWRRI Fellowship Research Highlights

Development of a Macro-Scale Physical-Based Gridded Hydrologic Model (GHM) and Applications in North Dakota

Mohsen Tahmasebi Nasab *(Fellow) &* ***Xuefeng Chu*** *(Advisor), North Dakota State University*

◊ A macro-scale Grid-based Hydrologic Model (GHM) was developed and used to provide spatio-temporal hydrologic processes simulations for macro-scale basins. The developed GHM possesses unique features to cope with the cold climate condition and the flat topography of North Dakota. In addition, the GHM can take advantage of downscaled meteorological datasets to simulate hydrologic processes based on future climate scenarios.

◊ The GHM was tested by applying it to the Red River basin and the state of North Dakota. These macro-scale study areas were selected on account of their long winters and depression-dominated topography, to highlight the unique capabilities of the GHM. The required input data such as land use and land cover, soil type distribution, meteorological, and topographic datasets were obtained from different federal agencies and were processed to a compatible format for the GHM.

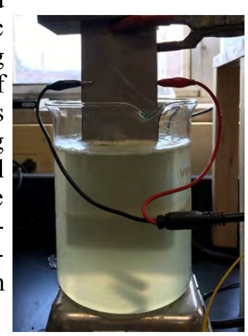
◊ The grid-based simulation results from the macro-scale GHM were used to describe the localized hydrologic processes, and analyze their spatio-temporal variations and trends in the Red River basin and North Dakota. The results showed the importance of the depression-dominated topography of North Dakota and indicated the effects of the cold climate processes such as snowmelt and the frozen soil on variations of hydrologic variables (e.g., surface runoff).

◊ Results from the GHM can be linked to other models (e.g., ecological, agricultural and climatic models) to provide the required information for decision makers, as well as researchers. Specifically, the model can provide county-based summaries and animations of different hydrologic processes, which are beneficial for planning and management of agricultural fields.

Nutrient Removal from Domestic and Livestock Wastewaters Using Integrating Electro-Coagulation and Biological Processes

Swati Sharma *(Fellow) &* ***Halis Simsek*** *(Advisor), North Dakota State University*

Agricultural and domestic wastewaters contain high concentrations of organic matter, nitrogen, and phosphorous. The excessive discharge of such deleterious matter results in surface and groundwater contamination. Reduction of carbon and nitrogen is crucial especially for nutrient sensitive receiving waters. An integrated model using electrocoagulation (EC) and biological treatment of livestock and domestic wastewater to reduce chemical oxygen demand and remove nutrients has been proposed. The livestock wastewaters contain high concentration of organic compounds with high turbidity and color. Hence, direct application of biological treatment methods to raw livestock wastewater is challenging. EC has been efficient as a pretreatment method in the removal of color as well as reduction of organic carbon concentration in various wastewaters including livestock and domestic wastewaters. Degradation of nitrogen compounds through biological treatment has been widely accepted in domestic wastewater. Thus, it is anticipated that integrating these two methods for treatment of wastewater derived-nutrients could be successful in improving the quality of surface waters. An effort to further present a comparative study of batch and continuous operation has been made to optimize the removal efficiency of both methods in the degradation of organic nitrogen and carbon. The continuous study was conducted in terms of solids retention as well as hydraulic retention times. The study was also conducted for both livestock and domestic wastewaters.



2017 — 2018 NDWRRI Fellowship Research Highlights

Capturing the Lost Phosphorus by Enhanced Bioretention Cells Amended with Low-cost Adsorbents

Nicholas Lindstrom *(Fellow) &* ***Feng Xiao*** *(Advisor), University of North Dakota*

As an agrarian state, North Dakota purchases and consumes ~257,300 tons of phosphorus (P)-fertilizers annually for growing crops. P-fertilizers are also heavily used in lawns and gardens in rural and urban areas. Continuous use of conventional, highly soluble (quick-release) fertilizers, however, has deleterious long-term effects on the soil fertility and water quality. The runoff of phosphorus (P) from agricultural and urban lands is a major contributor to the impairment of 24,403 acres of lakes of reservoirs in North Dakota. This project proposes to develop and experiment with an enhanced bioretention cell amended with low-cost waste materials that can strongly retain P and reduce P loadings to surface water. This approach may also be applied to other popular BMPs, including biofilters (swales and strips). The specific objectives of this project are to 1) study the adsorption of phosphate on the low-cost adsorbents in batch adsorption studies; and 2) investigate the removal of PO4-P in bioretention cells amended with the adsorbents. Bench-scale and column experiments have been performed on the adsorption of PO4-P on a range of low-cost materials. Contradictory to the literature reports, we found that iron oxides and iron-based materials are not an effective adsorbent of P. We also found that flocs generated during water treatment processes, however, can effectively remove P to a level below the detection limit. Flocs from the hydrolysis of FeCl3 perform better than those from alum. We then performed systematical batch and column studies to evaluate the performance of flocs for P retention. Samples were analyzed for PO4-P according to Standard Methods section 4500-PE (ascorbic acid) with a minimum detection limit of 10 µg PO_4-P/L. Adsorption kinetics, effects of humic and fulvic acids, and effects of pH were determined. Adsorbed concentrations (Cs) were calculated by mass balance. Batch adsorption isotherms were fitted to the Freundlich model.

Study On-farm Evaluation of Interactive Effect of Subsurface Tile Drainage, Tillage and Crop Rotation on Nitrate Leaching

Umesh Acharya *(Fellow) &* ***Amitava Chatterjee*** *(Advisor), North Dakota State University*

Subsurface drainage is popular around the Red River Valley in Fargo clay soil to remove excess water from soil profile to make soil feasible for crop production. Although subsurface drainage has many benefits, it also may increase nitrate N losses through the root zone and to surface waters. Loss of nitrate through subsurface drainage depends on its interaction with the amount of fertilizer N applied, crop rotation and tillage practices. The goal of this research project is to understand the interactive effects of (i) drainage system (surface vs. subsurface), (ii) crop rotation (corn-soybean vs. continuous corn), and (iii) tillage (chisel plow vs. no-till) on nitrate leaching loss through the subsurface drainage system. The research objectives are (a) to study the effect of tile drainage system, tillage and crop rotation on nitrate leaching loss under tile drainage, and (b) to understand and estimate soil inorganic N content under different tile drainage, tillage, and crop rotation.

This study shows that surface drainage plots increase N mineralization due to enough moisture for a long period when compared with controlled subsurface drainage. There was no significant difference in residual soil NO_3 among the drainage, rotation and tillage in corn plots. Precipitation patterns and residues from previous growing season affected the leachate NO_3^- concentration, but no specific trend was observed in rotation and tillage for different drainage methods.

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Removal of Trichloroethylene and Fluoride from Water by Nanoscale Zero-Valent Iron Supported on Novel Activated Carbon

Umma Salma Rashid *(Fellow) &* ***Achintya Bezbaruah*** *(Advisor), North Dakota State University*

Trichloroethylene (TCE) has been found in at least 60% or 861 of the NPL (National Priorities List) or Superfund sites and there are tens of thousands of other cleanup sites across the country (USEPA, 2011). Due to prior disposal by industries, landfills and factories, the groundwater in Valley City, ND has been found adversely affected by TCE contamination (USEPA, 2010). The Sheyenne River in Valley City has TCE levels beyond the acceptable limits (5 µg/L). A huge contaminated site was found in West Fargo (ND). The leak from a dry cleaning facility caused this contamination. In addition, there are concerns about fluoride in North Dakota as well. Eight counties have a fluoride (F^-) level higher than 4 mg/L and fifteen counties have a fluoride level higher than 1.5 mg/L. Nanoscale zero-valent iron (NZVI) is an effective reducing agent for removing trichloroethylene (TCE) and an effective adsorption material for fluoride removal from groundwater. However, bare NZVI agglomerates settle down very quickly and lose their reactivity in an aqueous environment. A wood-based activated carbon (AC) was prepared by chemical activation with different metal salts (KCl and NaCl) to get higher surface area, pore volume and organized pore structure in AC. To check and compare the quality of AC produced, methylene blue removal study was conducted at two different initial concentrations. At the lower concentration (200 mg/L) all the AC samples showed the same amount of removal, but at the high concentration (500 mg/L) potassium salts showed better removal than sodium salts. NZVI was supported in the AC by mixing prepared activating carbon with ferrous sulfate heptahydrate followed by chemical reduction with $NaBH_4$. The batch studies were used to evaluate the TCE and fluoride removal efficiency of NZVI-AC. In addition, the effects of initial TCE and fluoride concentration and pH were investigated. Adsorption isotherm study was conducted to determine the equilibrium adsorption capacity and mechanisms of adsorption of fluoride onto NZVI-AC. Additionally, commercial activated carbon was modified with citric acid (CA) to increase fluoride removal efficiency. Fluoride removal studies were conducted with different concentrations of F^-. The effect of pH, temperature, natural organic matter (NOM), and other ions were also investigated. Different equilibrium isotherms were used to model the experimental data and Langmuir isotherm was found to fit the data better. Adsorption mechanisms were also investigated using an intraparticle diffusion model.

Effect of water table on soybean growth and yield parameters

Yavuz Fidantemiz *(Fellow) &* ***Halis Simsek*** *(Advisor), North Dakota State University*

In this study, the effects of different water table depths on soybean growth and yield parameters and groundwater contributions to plants were investigated. At the beginning of the experiments, hydraulic properties of soil such as soil moisture release curve (SRC) and hydraulic conductivity were determined. The values of field capacity, critical point and permanent wilting point were determined. Based on the data from SRC, irrigation time and amount was scheduled. Results showed that, since the water table was fixed at the top of the columns to provide moisture for germination before planting, similar moisture percent was monitored at the 30-cm depth for the first month. In addition, similar plant heights and stages were observed at the 30-, 50-, and 70-cm water table depths. However, the minimum plant heights were observed at the 90-cm water table depth. More results were obtained at the end of the experimental study. Major findings include:

- ◊ Highest evapotranspiration rate was found at the 30- and 50-cm water table depths, according to the measured data from the Mariotte bottles.
- ◊ No stress was observed on treatments for the 30-day experimental period.
- ◊ Based on the sensor readings, for all treatments the soil moisture levels were between the field capacity and critical point (50%). However, the moisture contents of all treatments decreased gradually.

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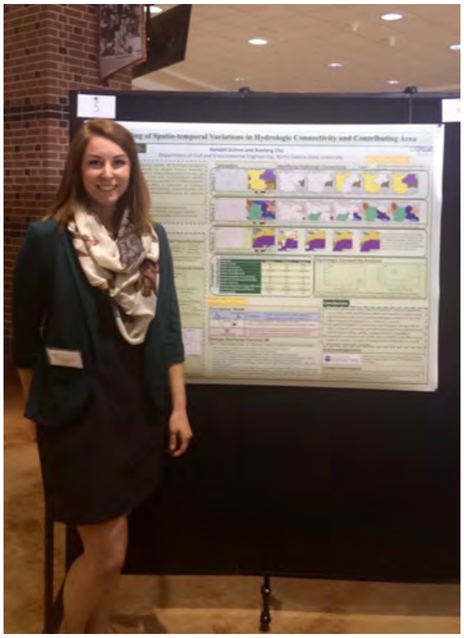
Modeling of Runoff Contributing Areas and Hydrologic Connectivity and Applications in North Dakota

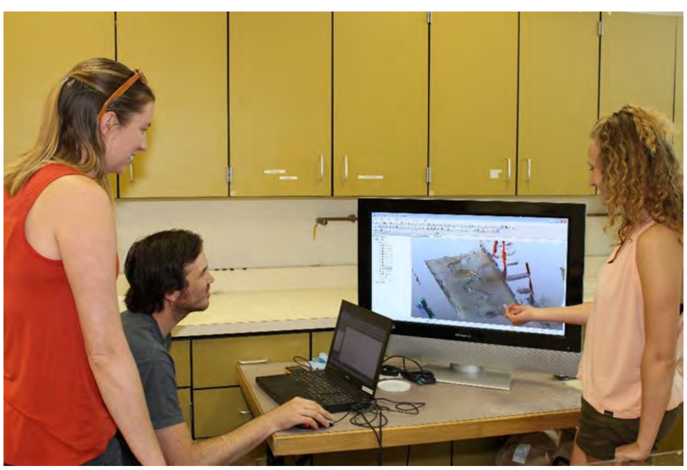
Kendall Grimm *(Fellow) &* ***Xuefeng Chu*** *(Advisor), North Dakota State University*



Many hydrologic models (e.g., HEC-HMS) utilize delineation results from traditional methods, in which surface depressions are fully filled, creating a hydrologically connected drainage system. However, in depression-dominated areas the topographic characteristics of depressions are vital to modeling unique hydrologic processes associated with the puddle-to-puddle (P2P) dynamics. Therefore, the objectives of this study were (1) to improve the HEC-HMS hydrologic model, and (2) to highlight the impacts of the P2P processes and dynamic contributing area on outlet discharge. To address these objectives, an improved HEC-HMS model for depression-dominated areas was created by incorporating a depression threshold control proxy and an improved conceptual framework, and was compared against the basic HEC-HMS model. The depression threshold control proxy uses a storage-discharge function to simulate the unique P2P dynamics for a study area. The improved conceptual framework counteracts the effect of full hydrologic connectivity created by traditional delineation methods on modeling results by introducing depressional area (DA) and non-depressional area (NDA) to each subbasin, and routing the runoff from the DA to a depression threshold control proxy for each subbasin. Thus, dynamic contributing area was introduced into the improved HEC-HMS model. The basic HEC-HMS model was found to overestimate peak discharge, but overestimate or underestimate the total discharge, depending on the rainfall distribution of a storm event. In contrast, the improved HEC-HMS model provided accurate simulations of peak discharge and total discharge by controlling the release of water specified by the depression threshold control proxy. Thus, the consideration of P2P processes and dynamic contributing area was found to be essential to hydrologic modeling for depression-dominated areas. Accuracy of the modified model was tested and found to be acceptable using three popular statistical measures for streamflow simulations. The methodology proposed in this study has the ability to be implemented into other traditional models to improve hydrologic modeling and management of depression-dominated areas.

Palaeoflood and Glacial Isostatic Adjustment (GIA) Influence on Fluvial Geomorphology of the Red River Basin

Zachary Phillips *(Fellow) &* ***Stephanie Day (****Advisor), North Dakota State University*

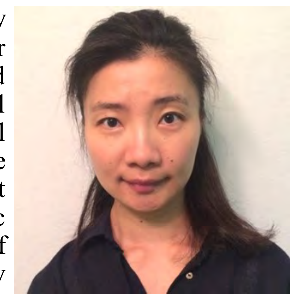


This research studies the responses of post-glacial rivers to climate change, post-Glacial Isostatic Adjustments (GIA), changing sediment characteristics, and human impacts using the Red River as a case study. The interdisciplinary methods are used for interpreting fluvial systems and deposits as they correlate to the Holocene and late-Pleistocene history. The floodplain topography of the Red River was explored by using the Geographic Information Systems (GIS) and a set of methods were developed to extract the areas of meander-cutoff topography from the digital elevation model (DEM). The spatial distribution of the meander-cutoffs, as well as their relief and distance from the modern channel (DMC) were used as interpretive tools to suggest how meandering of the Red River has changed since the draining of Lake Agassiz. This research is significant because it helps people understand the modern effects of climate change and its interactions with rivers and humans. More specifically, regarding the Red River, this research is important because the Red River is a unique, clay-controlled meandering river, which is both important and damaging to its floodplain residents. The highlights of this research project include the improvement of the Holocene interpretation of the Red River fluvial geomorphology, the better understanding of a unique, meandering fluvial system, and the production of methods necessary to extract meander-cutoff polygons in GIS and calculate their relief and distance from the river.

Meet Our Faculty

Dr. David R. Steward, Walter B. Booth Distinguished Professor, is Professor and Chair of the Department of Civil and Environmental Engineering at North Dakota State University. Dr. Steward leads a research program addressing the grand challenge of water resources for society through two complementary approaches. One research focus is interdisciplinary water resources studies. Professor Steward has collaborated with colleagues across agriculture, architecture, arts & sciences, education, engineering, and veterinary medicine. These endeavors have been funded by over $18 million in research grants, where Dr. Steward has served as lead or co-principal investigator from funding agencies such as NSF, USDA, US EPA, and many other local and international agencies and consulting firms, including co-PI of the recent NSF grant NRT-INFEWS: Preparing future leaders: Rural resource resiliency (R3). The second research focus is development of advanced methods of mathematical analysis for engineering problems using the Analytic Element Method. The AEM has emerged over 25 years of groundwater studies, and enables nearly exact solutions to study complicated interactions of flow through aquifer features, and will be disseminated further in a forthcoming textbook. Discovery of the critical factors that control water resources systems have been identified through these collective interactions, and results have been communicated with a wide range of water stakeholders. Dr. Steward is a Fellow of the American Society of Civil Engineers, and is licensed as a Professional Engineer (license number 27726, North Dakota; license number 54874, Minnesota) and a Professional Geoscientist (license 3957, Texas).

Dr. Haochi Zheng is an Associate Professor in Department of Earth System Science and Policy (ESSP) at the University of North Dakota. She joined ESSP in 2010 as an assistant professor after receiving her Ph.D. degree from the University of Minnesota with a major in Agricultural and Applied Economics and a minor in Conservation Biology. She finished her undergraduate study in International Economics from Fudan University, China and her Master degree in Economics at Yokohama National University, Japan. Dr. Zheng's academic interest focuses on environmental and natural resource economics and ecological economics with a specific emphasis on the institutions and mechanisms that guide human behavior on natural resource use and management. She is mostly interested in the economic decision-makings of land use and land management and their impacts on the provision and value of ecosystem services. Some of her recent research topics include: land use change related to water quality and quantity, pollination services, crop production, and renewable energy productions.



Dr. Trung Bao Le is an Assistant Professor in the Department of Civil and Environmental Engineering at North Dakota State University. Before joining NDSU in August 2018, Dr. Le has worked at several universities including the University of Minnesota, Stony Brook University, Thuy Loi University and the Medical College of Wisconsin/Marquette University. After completing his Bachelor degree (2003) in Water Resources Engineering at Thuy Loi University (Hanoi, Vietnam), he completed his Master degree (2005) in Water Resources Engineering and Management at Asian Institute of Technology (Bangkok, Thailand). He came to the University of Minnesota in 2006 under the guidance of Professor Fotis Sotiropoulos at Saint Anthony Falls Laboratory and received his PhD in December 2011 with a major in Civil Engineering and a minor in Applied Mathematics. Dr. Le's research interests span a range of problems in computational fluid dynamics, including computational methods for fluid-solid interaction with applications in hydraulics, environmental and physiological flows. His techniques involve the development for scalable numerical algorithms that can run from desktop computer to supercomputers. He is the author of 18 peer-reviewed publications (total citations of 688; H-index of 13) and a reviewer of 16+ academic journals (+52 manuscripts). He teaches Fluid Mechanics (undergraduate) and Hydraulics (graduate) at NDSU.

Dr. Matthew Smith is an Associate Professor of Practice in Biological Sciences at North Dakota State University. His research group is broadly focused on how organisms subsist in an ever changing environment. Matt's lab combines field and laboratory experiments to study how organisms (mainly reptiles and amphibians) deal with variation in environmental and resource conditions and the ecological and evolutionary consequences of those responses. His lab is currently focusing on how habitat and water quality influence the success of amphibian breeding across North Dakota. Matt received his Bachelors of Science in Zoology and his M.S. in Biology from North Dakota State University. He then went on to obtain his Ph.D. from the University of Arkansas. After he completed his Ph.D., Matt returned to NDSU to give back to the University that shaped his academic career.

National Institutes for Water Resources Regional Symposium Water Resources of the US Great Plains Region: Status and Future

Organized by the Nebraska Water Center, the 2018 NIWR Regional Symposium was held on October 24-26 at Nebraska Innovation Campus Conference Center in Lincoln, NE. The symposium brought together water leaders, scientists, managers, students, and stakeholders within the Missouri and Arkansas River basins. Federal representatives from the USDA and USGS provided overviews of the basin-wide challenges, research, and funding opportunities. The symposium also brought together Water Resources Research Institute directors from nine states, including Nebraska, South Dakota, North Dakota, Missouri, Montana, Oklahoma, Kansas, Arkansas, and Iowa. The key topics covered include nutrient loading, harmful algal blooms, agricultural water use, surface and groundwater contamination and depletion, industrial and municipal water use, impacts of climate change on water resources, aquifer management, and ecosystems within the two basins and beyond.

The directors from the Water Resources Research Institutes of those states shared their unique challenges, and also discussed common water resources issues. Dr. Zhulu Lin, Dr. Xuefeng Chu, and Tong Lin (NDWRRI Fellow) attended and presented at the symposium.

Water Quantity and Quality Issues in Western North Dakota: Overview and Two Case Studies

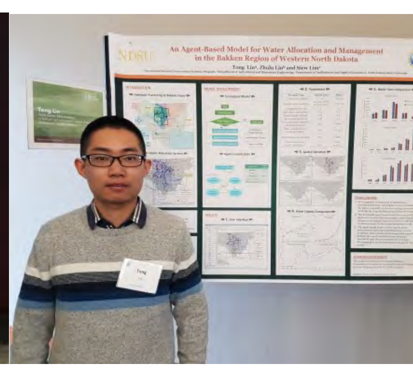
Part 1: Delineation and Modeling of PPR Potholes and Wetlands, Dr. Xuefeng Chu, Civil and Environmental Engineering, NDSU
Part 2: Water Supply and Management Related to Oil Production, Dr. Zhulu Lin, Agricultural & Biosystems Engineering, NDSU

Energy (oil and natural gas production) and agriculture are essential to the North Dakota's economy. Both rely on water resources and, meanwhile, affect water quantity and quality especially in western North Dakota. The anthropogenic activities further affect the unique ecosystems of the Prairie Pothole Region (PPR) in the upper Missouri Basin. This talk focuses on: (1) delineation and modeling of PPR wetlands and (2) water use and reuse for Bakken shale oil development. The first study aims to develop modeling tools for delineating prairie potholes and wetlands, characterize their dynamic hydrotopographic properties, and further quantify their threshold behaviors and spatio-temporal variability in hydrologic connectivity. The application in the PPR highlighted the crucial role of topographic characteristics in the formation, evolution, and connectivity of prairie potholes, and demonstrated their dynamic filling-spilling-merging-splitting processes. The modeling tools can be used for ecohydrologic modeling and assessment, especially for the depression-dominated PPR. In the second study, an agent-based model was developed for the water-depot system that has emerged to distribute a large quantity of freshwater for Bakken shale oil development in western North Dakota. The model was then used to evaluate the adopted water policies. From 2008 to 2014, the annual total industrial water uses for Bakken shale oil development increased from 3.0 to 40%. However, the impact on the region's water supply was limited. The authorization of the Western Area Water Supply Project, implementation of the "In-Lieu-Of Irrigation" program, and an accelerated issuance of temporary surface water permits were the most important water policies.

Poster Presentation

An Agent-based Model for Water Allocation and Management in the Bakken Region of Western North Dakota

Tong Lin (Ph.D. Student, NDWRRI Fellow), Zhulu Lin, and Siew Lim

Dr. Zhulu Lin Tong Lin Dr. Xuefeng Chu

7th NDWRRI Distinguished Water Seminar

The NDWRRI Distinguished Water Seminar Series brings eminent professionals to NDSU to give presentations with focus on emerging issues, challenges, and new research directions in hydrology, aquatic ecology and water resources.

The 7th Distinguished Water Seminar sponsored by the Institute was held on February 28, 2018. The featured speaker was Dr. Doug Chivers. Dr. Chivers is a Distinguished Professor in the Biology Department at the University of Saskatchewan, where he has worked since 1999. He teaches courses in Ichthyology and Animal Behavior and he has supervised numerous graduate students and postdocs. He and his students and collaborators conduct basic and applied research on the behavioral ecology of fishes including how anthropogenic disturbance influences anti-predator behavior of fishes in the wild. He has published over 240 papers in high impact journals, which have been cited over 13,000 times. Early in his career he was awarded a prestigious New Investigator Career Award by the Animal Behaviour Society. In 2016 he was as an Elected Fellow of the Animal Behaviour Society.

Abstract: Due to the unforgiving nature of predation, prey animals have evolved an astonishing array of antipredator responses that act to thwart would-be predators. However, various anthropogenic stressors compromise prey risk assessment systems. The talk will explore how ocean acidification, rising sea temperatures, and coral degradation alter prey behaviour and ultimately predation dynamics in coral reef systems.

1st NDWRRI Special Water Resources Seminar

To help understand the water resources issues in North Dakota and improve the collaborations between the federal/state agencies and NDSU/UND, NDWRRI organized its 1st Special Water Resources Seminar on November 9, 2018. Four keynote speakers from the USGS and ND state agencies talked about the major water resources issues in ND, current state and federal efforts in ND, challenges, research needs and priorities, and potential collaboration opportunities. Nine NDWRRI Fellows also presented their current research.

Keynote Speakers

Steve Robinson Deputy Director for Data, U.S. Geological Survey, Dakota Water Science Center, Bismarck

Steve has worked for the U.S. Geological Survey for over 33 years in North Dakota and Illinois and is currently the Deputy Director for Data in the USGS Dakota Water Science Center. Steve has spent those 33+ years working in the hydrologic data collection unit and has been involved in all aspects of that work. He started his career with the USGS as a student running routine field data collection duties to currently supervising over 35 staff and managing a two-state data collection unit with over 350 data collection locations. Steve has been participated in the data collection efforts for many extreme flood events as well as numerous studies during his time with the USGS.

Title: Hydrology Monitoring for the Future

Joel Galloway Section Chief, U.S. Geological Survey, Dakota Water Science Center, Bismarck

Joel has worked for the U.S. Geological Survey for 25 years in North Dakota, Arkansas, South Dakota, Iowa, and Wyoming and is currently a Hydrologic Studies Chief for the USGS Dakota Water Science Center. He has a Master of Science degree in environmental/civil engineering from the South Dakota School of Mines and Technology and a Bachelor of Science degree in geology from the University of North Dakota. Joel has authored or coauthored over 40 scientific reports and journal articles on different water-quality, ground-water, and surface-water topics.

Title: USGS Science in North Dakota

1st NDWRRI Special Water Resources Seminar

Keynote Speakers

Andrew Nygren Hydrologist, Water Appropriations, North Dakota State Water Commission, Bismarck

Andrew has worked for the North Dakota State Water Commission (NDSWC) for 13 years initially as a Water Resource Engineer with the NDSWC Development Division Investigations Section, and for the past 12 years as a Hydrologist with the NDSWC Water Appropriation Division Groundwater Section. He has a Master of Science and Bachelor of Science in Geological Engineering from University of North Dakota.

Title: Water Resource Challenges and Opportunities

Mike Hargiss Red River Basin Coordinator, Division of Water Quality, North Dakota Department of Health

Mike has worked for the North Dakota Department of Health for 13 years as the Red River Basin Coordinator in the Division of Water Quality. He has a Master of Science degree in Natural Resource Management from North Dakota State University.

Title: Water Quality Challenges and Opportunities

1st NDWRRI Special Water Resources Seminar

NDWRRI Fellows' Presentations

Topic 1 Hydrologic Modeling

Afshin Shabani: Water Quality Conservation in Mitigating Devils Lake Flooding

Mohsen Tahmasebi Nasab: Development of the Macro-Scale Hydrologic Processes Simulator (Macro-HyProS) and Applications in the Red River Basin and North Dakota

Topic 2 Water Quality

Nick Peterson: Removal of Heavy Metals from Stormwater Runoff

Topic 3 Aquatic Science and Ecological Processes

Justin Waraniak: Landscape Genomics: Assessing Environmental Health through Local Adaptation and Connectivity

Alec Lackmann: Bigmouth Buffalo in the Red River of the North Basin: Endemic, Underappreciated, and Unexpected

Kui Hu: A long-term Investigation of Salinity Change under a Highly Variable Climate in North Dakota

Topic 4 Energy and Water Resources Management

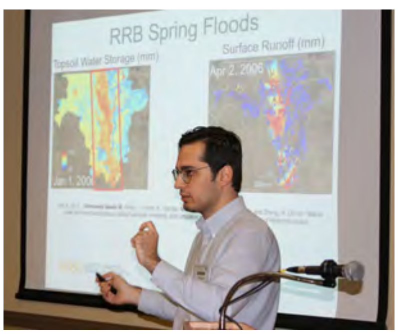
Tong Lin: Water Resources Impacts and Management in the Bakken Region of Western North Dakota

Topic 5 Agricultural Water Management

Ali Rashid Niaghi: Assessing Various Evapotranspiration Measurement Methods for Crop Water Management

Topic 6 Geomorphology and Erosion

Zachary Phillips: Holocene River Planform Changes in the Red River Basin



Recent Publications and Presentations by Institute Fellows and PIs

Peer-reviewed Journal Papers

Chu, X., Lin, Z., Tahmasebi Nasab, M., Zeng, L., Grimm, K., Bazrkar, M. H., Wang, N., Liu, X., Zhang, X., and Zheng, H. 2019. Macro-scale grid-based and subbasin-based hydrologic modeling: joint simulation and cross-calibration. *Journal of Hydroinformatics*, 21(1), 77-91, doi:10.2166/hydro.2018.026.

Fidantemiz, Y.F., Jia, X., Daigh, A.L.M, Hatterman-Valenti, H., Steele, D.D., Niaghi, A.R., and Simsek, H. 2019. Effect of water table depth on soybean water use, growth, and yield parameters. *Water*, 11(5), 931, doi: 10.3390/w11050931.

Grimm, K. and Chu, X. 2018. Modeling of spatiotemporal variations in runoff contribution areas and analysis of hydrologic connectivity. *Land Degradation & Development*, 29(8), 2629-2643, doi:10.1002/ldr.3076.

Grimm, K., Tahmasebi Nasab, M., and Chu, X. 2018. TWI computations and topographic analysis of depression-dominated surfaces. *Water*, 10, 663, 1-12, doi:10.3390/w10050663.

Lackmann, A.R., Andrews, A.H., Butler, M.G., Bielak-Lackmann, E.S., and Clark, M.E. 2019. Bigmouth Buffalo Ictiobus cyprinellus sets freshwater teleost record as improved age analysis reveals centenarian longevity. *Communications Biology*, doi: 10.1038/s42003-019-0452-0.

Lin, Z., Lin, T., Lim, S.H. Hove, M.H., and Schuh, W.M. 2018. Impacts of Bakken shale oil development on regional water resources. *Journal of the American Water Resources Association,* 54(1), 225-239, https://doi.org/10.1111/1752-1688.12605.

Niaghi, A.R., Jia, X., Scherer, T.F., and Steele, D.D. 2019. Measurement of non-irrigated turfgrass evapotranspiration rate in the Red River Valley. *Vadose Zone Journal*, doi: 10.2136/vzj2018.11.0202.

O'Brien, P.L., Acharya, U., Alghamadi, R., Niaghi, A.R., Sanyal, D., Wirtz, J., Daigh, A.L.M., and DeSutter, T.M. 2018. Hydromulch application to bare soil: soil temperature dynamics and evaporative fluxes. *Agricultural and Environmental Letters Abstract-Research Letters*, 3(1), doi:10.2134/ael2018.03.0014.

Tahmasebi Nasab, M., Grimm, K., Bazrkar, M., Zeng, L., Shabani, A., Zhang, X., and Chu, X. 2018. SWAT modeling of non-point source pollution in depression-dominated basins under varying hydroclimatic conditions. *International Journal of Environmental Research and Public Health*, 15, 2492, 1-17, doi:10.3390/ijerph15112492.

Wang, N., Zhang, X., and Chu, X. 2019. New model for simulating hydrologic processes under influence of surface depressions. *Journal of Hydrologic Engineering*, 24(5), 04019008, 1-13, doi:10.1061/(ASCE)HE.1943-5584.0001772.

Waraniak, J.M., Fischer, J.D.L., Purcell, K., Mushet, D.M., and Stockwell, C.A. 2019. Landscape genetics reveal broad and fine scale population structure due to landscape features and climate history in the northern leopard frog (*Rana pipiens*) in North Dakota. *Ecology and Evolution*, 9(3):1041-1060.

Conference Proceedings

Tahmasebi Nasab, M. and Chu, X. 2018. Topo-statistical analyses of ponding area versus ponding storage of depression-dominated regions for macro-scale hydrologic modeling, p415-424. In: *Watershed Management, Irrigation and Drainage, and Water Resources Planning and Management, Proceedings of the 2018 ASCE World Environmental and Water Resources Congress*, edited by Sri Kamojjala, American Society of Civil Engineers, doi: 10.1061/9780784481400.

Conference/Seminar Presentations

Bazrkar, M. H., Tahmasebi Nasab, M., Zeng, L., Grimm, K., Wang, N., and Chu, X. 2018. Drought identification in cold climate regions: How can macro-scale hydrologic models assist drought analysis? 16th Annual Climate Prediction Applications Science Workshop, May 22-24, 2018, Fargo, ND (Oral Presentation).

Chu, X., Lin, Z., Tahmasebi Nasab, M., Zeng, L., Grimm, K., Bazrkar, M. H., Liu, X., and Wang, N. 2018. Joint grid-based and subbasin-based hydrologic modeling and application. ASCE 2018 World Environmental and Water Resources Congress, June 3-7, 2018, Minneapolis, MN (Oral Presentation).

Recent Publications and Presentations by Institute Fellows and PIs

Conference/Seminar Presentations

Fidantemiz, Y.F., Jia, X., Daigh, A.L., Hatterman-Valenti, H., Steele, D.D., Niaghi, A.R., Simsek, H. 2018. Effect of different water table levels on soybean water use and growth parameters. ICSAE 2018 5th International Conference on Sustainable Agriculture and Environment, Oct. 8-10, Hammamet, Tunisia.

Fidantemiz, Y.F., Steele, D.D., Jia, X., Tuscherer, S., Niaghi A.R., Simsek, H. (2018). Laboratory performance of three commercial soil moisture sensors. 1st Annual Gamma Sigma Delta, North Dakota State University Chapter Faculty and Student Symposium, April 12, 2018, Fargo, North Dakota.

Fidantemiz, Y.F., Steele, D.D., Jia, X., Tuscherer, S., Simsek, H. 2018. Performance of three different soil moisture sensors in laboratory conditions. ND EPSCoR 2018 State Conference, April 17, 2018, Grand Forks, ND (Poster Presentation).

Guzel, H.O., Cemek, B., Steele, D.D., Simsek, H. 2018. Prediction of freshwater harmful algal blooms in Western Lake Erie using artificial neural network modeling techniques. ICSAE 2018 5th International Conference on Sustainable Agriculture and Environment, October 8-10, 2018, Hammamet, Tunisia.

Hu, K. 2018. A long term investigation of salinity change under a highly variable climate in North Dakota. 1st NDWRRI Special Water Resources Seminar. North Dakota State University, Fargo, ND (Oral Presentation).

Lackmann, A.R. 2019. Centenarian longevity for Bigmouth Buffalo. Minnesota and Dakota Chapter of the American Fisheries Society. Fargo, ND.

Lackmann, A.R. 2018. Bigmouth Buffalo, a North American Treasure. American Fisheries Society Subunit. Valley City State University, Valley City, ND (Oral Presentation).

Lackmann, A.R. 2018. Bigmouth Buffalo in the Red River of the North Basin: endemic, underappreciated, and unexpected. 1st NDWRRI Special Water Resources Seminar. North Dakota State University, Fargo, ND (Oral Presentation).

Lackmann, A.R. 2018. What you can do with accurate age data. Pelican Lake Property Owner’s Association (PLPOA) Subcommittee Angler’s Meeting, Detroit Lakes, MN (Featured Presenter).

Lackmann, A.R. 2018. What’s the value in aging fish? Pelican Lake Property Owner’s Association (PLPOA) 85th Annual Spring Meeting, Detroit Lakes, MN (Featured Presenter).

Lackmann, A.R. 2018. Can Bigmouth Buffalo live 100 years? Preliminary evidence of 80-year recruitment failure in Minnesota. Brown Bag Seminar, University of Minnesota, St. Paul, MN.

Lackmann, A.R. 2018. Can Bigmouth Buffalo live 100 years? Preliminary evidence of 80-year recruitment failure in this native fish. Northern Plains Biological Symposium, Fargo, ND.

Lin, T., Lin, Z., and Lim, S.H. 2018. Water resources impacts and management in the Bakken region of western North Dakota. 1st NDWRRI Special Water Resources Seminar. North Dakota State University, Fargo, ND (Oral Presentation).

Lin, T., Lin, Z., and Lim, S.H. 2018. Developing an agent-based model for water allocation and management at the Bakken Shale in western North Dakota. 2018 National Institutes for Water Resources Regional Symposium, October 24-26, 2018, Lincoln, Nebraska (Poster Presentation).

Lin, Z., Lim, S., Lin, T., and Borders, M. 2018. A multi-agent system of water allocation and management in the Bakken region. 9th International Congress on Environmental Modelling and Software, June 24-28, 2018, Fort Collins, Colorado.

Niaghi, A.R., and Jia, X. 2018. Assessing various evapotranspiration measurement methods for crop water management. 1st NDWRRI Special Water Resources Seminar. North Dakota State University, Fargo, ND (Oral Presentation).

Niaghi, A.R., and Jia, X. 2018. Evapotranspiration rate and energy flux comparisons of eddy covariance and Bowen ratio methods in the Red River Valley. ASABE Annual Meeting. July 31, 2018, Detroit, MI.

Niaghi, A.R., Jia, X., Scherer, T.F., and Steele, D.D. 2018. Effect of controlled drainage and subirrigation on corn evapotranspiration. Transforming Drainage Meeting, April 2018, Raleigh, NC.

Recent Publications and Presentations by Institute Fellows and PIs

Conference/Seminar Presentations

Pham, H., Brueggeman, R., and Bezbaruah, A. 2018. Barley-iron nanoparticles for phosphorus remediation. 7th Sustainable Nanotechnology Organization Conference, November 2018, Washington, D.C. (Oral presentation).

Pham, H. 2018. The synthesis of Fe-polyphenol nanoparticles and their potential application for plant nutrition, Environmental and Conservation Sciences Seminar, North Dakota State University, November 2018, Fargo, North Dakota (Oral Presentation).

Pham, H. and Bezbaruah, A. 2018. Biosynthesis of iron nanoparticles using green tea extract for the removal of phosphorus from aqueous solution, North Dakota Water Quality Monitoring Conference, March 2018, Bismarck, North Dakota (Poster Presentation).

Phillips, Z.R., 2018. Landscape Evolution Modeling of GIA-assisted channel avulsions in low-relief, post-glaciolacustrine rivers, Geological Society of America 130th Annual Meeting, November 4-7, 2018, Indianapolis, IN.

Shabani, A, Zhang, X., Ell, M., and Dodd, T.P. 2018. Examining the impact of Devils Lake outlets on flood risk of the Sheyenne River. Bismarck, ND Water Quality Monitoring Conference, March 6-8, 2018, Bismarck, ND.

Shabani, A., Zhang, X., Chu, X., Zheng H., and Dodd, T.P. 2018. Improving Devils Lake outlets management to reduce environmental impacts on the Sheyenne River. American Geophysical Union Fall Meeting, December 10-14, 2018, Washington D.C.

Tahmasebi Nasab, M., and Chu, X. 2019. Developing Macro-HyProS: A macro-scale hydrologic processes simulator. ASCE 2019 World Environmental and Water Resources Congress, May 19-23, 2019, Pittsburgh, PA (Oral Presentation).

Tahmasebi Nasab, M. and Chu, X. 2019. Impacts of sub-daily temperature fluctuations on macro-scale snowmelt simulations in the Missouri River basin. ND EPSCoR 2018 State Conference, March 27, 2019, Fargo, ND (Poster Presentation).

Tahmasebi Nasab, M. and Chu, X. 2019. A new macro-scale hydrologic model for depression-dominated cold climate regions. 111th Annual Meeting, North Dakota Academy of Science, March 8, 2019, Grand Forks, ND (Oral Presentation).

Tahmasebi Nasab, M., and Chu, X. 2018. Development of the macro-scale hydrologic processes simulator (Macro-HyProS) and applications in the Red River basin and North Dakota. 1st NDWRRI Special Water Resources Seminar. North Dakota State University, Fargo, ND (Oral Presentation).

Tahmasebi Nasab, M., and Chu, X. 2018. Topo-statistical analyses of ponding area versus ponding storage of depression-dominated regions for macro-scale hydrologic modeling. ASCE 2018 World Environmental and Water Resources Congress, June 3-7, 2018, Minneapolis, MN (Oral Presentation).

Tahmasebi Nasab, M., Grimm, K., Bazrkar, M.H., and Chu, X. 2018. Hydrologic and water quality modeling in depression-dominated basins. ND Water Quality Monitoring Conference, March 6-8, 2018, Bismarck, ND (Oral Presentation).

Wang, N., Zhang, X., and Chu, X. 2018. A new model for rainfall-runoff simulation in depression dominated areas. ASCE 2018 World Environmental and Water Resources Congress, June 3-7, 2018, Minneapolis, MN (Oral Presentation).

Wang, N., and Chu, X. 2018. A novel modeling framework for simulating dynamic water release from depressions. ND EPSCoR 2018 State Conference, April 17, 2018, Grand Forks, ND (Poster Presentation).

Wang, N., and Chu, X. 2019. A new daily semi-distributed hydrologic model for depression dominated areas. ND EPSCoR 2019 State Conference, March 27, 2019, Fargo, ND (Poster Presentation).

Waraniak, J.M. 2018. Landscape genomics: Assessing environmental health through local adaptation and connectivity. 1st NDWRRI Special Water Resources Seminar. North Dakota State University, Fargo, ND (Oral Presentation).

Waraniak, J.M. 2019. Landscape genomics of northern leopard frog populations in the northern Great Plains. Environmental and Conservation Sciences Seminar, Fargo, ND. (Oral presentation)

Institute Publications

The Institute publications can be accessed at the NDWRRI website: https://www.ndsu.edu/wrri/

Fidantemiz, Yavuz Fatih and Simsek, Halis. 2019. Response of Soybean Growth, Yield and Some Quality Parameters to Different Water Table Depths. Technical Report No: ND19-01. North Dakota Water Resources Research Institute, Fargo, ND.

Guzel, Haci Osman and Simsek, Halis. 2019. Estimation of Freshwater Harmful Algal Blooms Using Multilayer Perceptron Neural Network Model. Technical Report No: ND19-02. North Dakota Water Resources Research Institute, Fargo, ND.

Leelaruban, Navaratnam, Padmanabhan, G., and Akuz, Adnan. 2018. A Study of the Spatial and Temporal Characteristics of Drought and Its Impact in North Dakota. Technical Report No: ND18-01. North Dakota Water Resources Research Institute, Fargo, ND.

Theses and Dissertations

Guzel, Haci Osman. 2019. Prediction of Freshwater Harmful Algal Blooms in Western Lake Erie Using Artificial Neural Network Modeling Techniques. M.S. Thesis. Natural Resources Management, College of Graduate and Interdisciplinary Studies, North Dakota State University, Fargo, ND.

Grimm, Kendall. 2018. Modeling of Dynamic Hydrologic Connectivity: How Do Depressions Affect the Modeling of Hydrologic Processes?" Ph.D. Dissertation. Civil Engineering, North Dakota State University, Fargo, ND.

Fidantemiz, Yavuz F. 2018. Effect of Water Table Level on Soybean Water Use, Growth and Yield Parameters. M.S. Thesis. Agricultural & Biosystems Engineering, North Dakota State University, Fargo, ND.

Shabani, Afshin. 2018. Mitigating Environmental Impacts of Terminal Lake Flooding: A Case Study of Devils Lake, North Dakota. Ph.D. Dissertation. Earth System Science & Policy, University of North Dakota, Grand Forks, ND.

Recent USGS Reports

Davis, K.W., and Long, A.J., 2018, Construction and calibration of a groundwater-flow model to assess groundwater availability in the uppermost principal aquifer systems of the Williston Basin, United States and Canada: U.S. Geological Survey Scientific Investigations Report 2017–5158, 70 p., https://doi.org/10.3133/sir20175158.

Kolars, K.A., Vecchia, A.V., and Galloway, J.M., 2019, Stochastic model for simulating Souris River Basin regulated streamflow upstream from Minot, North Dakota: U.S. Geological Survey Scientific Investigations Report 2018–5155, 24 p., https://doi.org/10.3133/sir20185155.

Lundgren, R.F., York, B.C., Stroh, N.A., and Vecchia, A.V., 2019, Water-balance modeling of selected lakes for evaluating viability as long-term fisheries in Kidder, Logan, and Stutsman Counties, North Dakota: U.S. Geological Survey Scientific Investigations Report 2019–5007, 22 p., https://doi.org/10.3133/sir20195007.

Nustad, R.A., Damschen, W.C., and Vecchia, A.V., 2018, Interactive tool to estimate groundwater elevations in central and eastern North Dakota: U.S. Geological Survey Open-File Report 2018–1185, 24 p., https://doi.org/10.3133/ofr20181185.

Valder, J.F., Carter, J.M., Robinson, S.M., Laveau, C.D., and Petersen, J.A., 2018, Quality-assurance plan for groundwater activities, U.S. Geological Survey Dakota Water Science Center: U.S. Geological Survey Open-File Report 2018–1103, 28 p., https://doi.org/10.3133/ofr20181103.

Recent ND State Water Commission Publications

State Water Commission and Office of the State Engineer, The 2019-2021 Strategic Plan
http://www.swc.nd.gov/info_edu/reports_and_publications/strategic_plans/pdfs/2019.pdf

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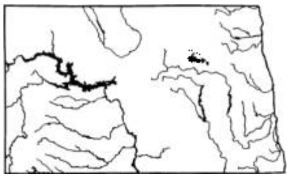

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North Dakota Water Resources Research Institute (NDWRRI)

The Institute was founded in 1965 by authority of Congress as one of the 54 Institutes throughout the nation and is administered through the United States Geological Survey. The NDWRRI receives funding through section 104 of the Water Resources Research Act of 1984 and it applies its Federal allotment funds to research that fosters: A) the entry of new research scientists into the water resources field, B) training and education of future water resources scientists, engineers, and technicians; C) the preliminary exploration of new ideas that address water problems or expand understanding of water and water-related phenomena; and D) the dissemination of research results to water managers and the public.