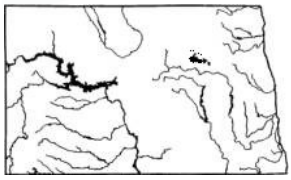
October 2024

North Dakota Water Resources Research Institute
North Dakota State University
Fargo, ND 58108-6050



Newsletter

NIWR
The National Institutes for Water Resources

http://www.ndsu.edu/wrri

From the Director

This newsletter for the 2022-2023 period introduces the 24 NDWRRI Fellows for 2023-2024 and highlights the nine graduate fellowship research projects from 2022-2023, along with the related findings and achievements of the Fellows and their advisors.

Over the past few years, we have welcomed several new junior faculty members with expertise in water-related issues who have joined the two research universities in the state. They are recognized as Institute-affiliated faculty, and two of them are introduced in the "Meet Our Faculty" section. This edition also introduces two esteemed Institute-affiliate faculty members: Dr. Kelsey Griesheim, Assistant Professor of Soil Fertility in the School of Natural Resource Sciences (SNRS) at North Dakota State University (NDSU), and Dr. Mahmut Selim Ersan, Assistant Professor in the Department of Civil Engineering at the University of North Dakota (UND).

Additional sections provide information about the NDWRRI State Advisory Board Committee. The Institute has consistently benefited from the guidance and assistance of the State Advisory Committee, which includes Dr. Karen Ryberg from the United States Geological Survey (USGS) ND Water Science Center, Mr. Andrew Nygren from the ND Department of Water Resources (DWR), Mr. Peter Wax from the ND Department of Environmental Quality, and Mr. Aaron Larsen from the North Dakota Game and Fish Department. Their insightful direction, especially in determining research priorities, allocating Fellowship funding, and aiding in securing support from ND DWR, has been instrumental in the Institute's success.

Furthermore, you will find lists of recent water-related publications from the USGS, DWR, and the Institute.

In the 2022-23 fiscal year, the Institute received full base grant funding from the USGS, along with supplementary support from the North Dakota DWR. This supplementary grant, which demonstrates a strong commitment from the ND DWR to supporting research on water resources in the state, has been entirely allocated to support Graduate Fellowships. The Institute extends its appreciation to ND DWR for this invaluable support.

Water is a vital resource for the growth and prosperity of North Dakota. It is

Inside this issue:

indispensable for the thriving agriculture and industry sectors of the state, as well as for municipal and domestic consumption. The Institute remains steadfast in its commitment to supporting research, education, training, and outreach that contribute to the benefit of water resources in the state.

The Institute has met the mandates required by Section 104 of the Water Resources Research Act of 1984 through a range of research, education, training, and outreach activities addressing water issues in the state. This newsletter, though a small part, is a testament to these efforts.

With the guidance and strong support from the Research and Creative Activity Office at NDSU, four faculty members were selected as Faculty Fellows for NDWRRI. These fellows are expected to provide interdisciplinary and transdisciplinary research-based solutions to water quality and water access problems for the state and the nation. Several focused events have taken place in the NDWRRI due to the expanded team, including hosting events and preparing proposals.

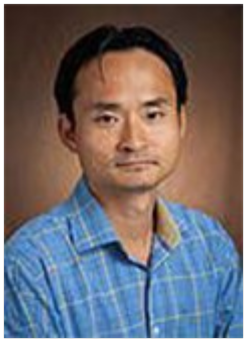
To address workforce shortages in the state, a new water resources certificate program was developed and launched in Fall 2024.

Thank you for your interest in the Institute, and to those of you who have been a part of it. I hope you find this newsletter informative and enjoyable.

Best regards,
Xinhua Jia, Ph.D., P.E.
Director of NDWRRI
North Dakota State University

NDWRRI Faculty Fellows

The ND Water Resources Research Institute has four NDSU assistant professors currently serving as Faculty Fellows. These experts provide water research leadership and information to NDSU while providing interdisciplinary and transdisciplinary research-based solutions to water quality and water access problems for the state and the nation.



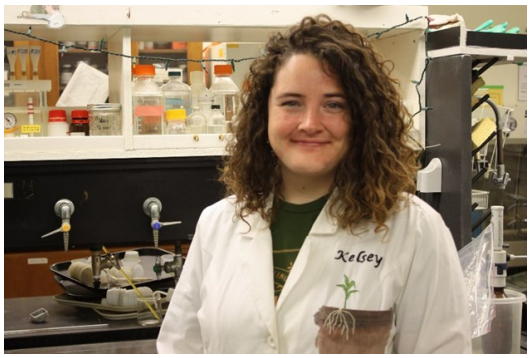
Trung Le, Department of Civil, Construction and Environmental Engineering, specializes in high performance computing, computational fluid dynamics, and fluid-structure interaction.

Shuning Lu, Department of Communication, focuses on public communication about water-related research issues and policy.

Dane Mataic, Department of Sociology and Anthropology, specializes in law and society, social movements, and social group perspectives.

Travis Seaborn, School of Natural Resource Sciences, focuses on management and conservation as species face changing environments, emphasizing how human actions can influence outcomes of fish, wildlife, and people.

Meet Our New Faculty



Dr. Kelsey Griesheim began as Assistant Professor of Soil Fertility in the School of Natural Resource Sciences (SNRS) in Feb. 2023 after completing a B.Sc. in Crop Sciences and a M.Sc. and PhD in soil fertility/chemistry at the University of Illinois in Champaign, Urbana. Her research focuses on identifying management practices that benefit both the farmer and the environment, specifically as it pertains to nitrogen fertilizer management. She uses fertilizer N uptake efficiency as a means of identifying these techniques because more fertilizer N sequestered in the crop means less remaining in the soil as a potential source of pollution. Conducting ^{15}N field, lab, and greenhouse experiments, she continues to work answering the simple question of where our fertilizer inputs are going and how we might redirect them, which is undoubtedly tied to nutrient cycling in soil systems. In addition to research, Dr. Griesheim also teaches Introduction to Soil Science (SOIL 210) and will begin teaching Soil Fertility and Fertilizers (SOIL 422/622) in the Spring 2025 semester.

Dr. Mahmut Selim Ersan is an Assistant Professor in the Department of Civil Engineering at the University of North Dakota. Dr. Ersan received his Ph.D. from the Department of Environmental Engineering and Earth Sciences at Clemson University in 2017. From 2017 to 2018, he worked as a Postdoctoral Fellow on a project funded by USEPA, focusing on the impact of wildfires on surface water quality and the subsequent formation of disinfection by products. From 2018-2020, Dr. Ersan joined Southern Nevada Water Authority as a Postdoctoral Researcher, where his research delved into controlling the occurrence and formation of emerging contaminants in potable water reuse applications. In 2020, Dr. Ersan joined the School of Sustainable Engineering and the Built Environment as an Assistant Research Professor. His research interests lie in the fundamentals and applications of physico-chemical processes in natural and engineered environmental systems. He has made significant contributions to the scientific understanding and removal of organic contaminants and harmful emerging contaminants (e.g., disinfection by-products, poly- and perfluorinated alkyl substances, pharmaceuticals, and endocrine-disrupting compounds) in water and wastewater treatment, as well as water reuse applications. Dr. Ersan's research team at the University of North Dakota focuses on developing novel treatment and regeneration technologies for sustainable futures, as well as sensing technologies for cost-effective, chemical-free, and real-time analysis of emerging compounds in water systems. Dr. Ersan teaches undergraduate and graduate courses, including Unit Operations in Water and Wastewater Treatment (CE 437/537), Environmental Chemistry (CE 436/536), and Environmental Engineering Laboratory (CE 431L).

Water Talk Seminars

We have hosted four Water Talk seminars for NDWRRI-affiliated faculties to introduce their research, foster collaboration, and encourage networking. The seminars include:

1. February 9, 2023, Xuefeng Chu from Civil, Construction and Environmental Engineering and Xinhua Jia from Agricultural and Biosystems Engineering, NDSU.
2. March 9, 2023, Jiale Xu and Trung Le from Civil, Construction and Environmental Engineering, NDSU.
3. April 12, 2023, Peter Oduor from Earth, Environmental & Geospatial Sciences, and Christina Hargiss from School of Natural Resource Sciences, NDSU.
4. May 10, 2023, Mark A. Kaemingk from Biology, and Howe Lim from Civil Engineering, UND.

Water Resources Certificate Program

The Water Resources Certificate is an interdisciplinary program for undergraduate students in their junior and senior years, focusing on water's journey and its impact on the environment. The certificate requires 12 credits across key areas in hydrology, soil and water quality, and technology. The program aims to equip students with the skills to effectively address water resource challenges.

Program Description

The Water Resources Certificate Program requires students to complete 12 credits selected from a total of 26 courses (79 credits), grouped into three categories: hydrology, soil and water quality, and technology. This program trains students to manage limited water resources for maximum beneficial use. The certificate prepares students for careers in hydrology and water resources management.

Program Requirements

The Water Resources Certificate requires completing a minimal 4 courses (12 credits) from 26 upper-division courses across three areas, with a "C" or better in each and an overall GPA of at least 3.0 to qualify for the certificate.

HYDROLOGY

1-ABEN 464: Resource Conservation and Irrigation Engineering. 4 Crs.

2-ABEN 484: Drainage and Wetland Engineering. 3 Crs.

3-CE 421: Open Channel Flow. 3 Crs.

4-CE 474: Groundwater Sustainability Design. 3 Crs.

5-CE 477: Applied Hydrology. 3 Crs.

6-GEOL 414: Hydrogeology. 3 Crs.

7-NRM 402: River and Stream Resource Management. 3 Crs.

8-NRM/SOIL/RNG 454: Wetland Resources Management. 3 Crs.

9-NRM/RNG 453: Rangeland Resources Watershed Management. 3 Crs.

SOIL & WATER QUALITY

1-CE 408: Water Resources and Supply. 3 Crs.

2-CE 478: Water Quality Management. 3 Crs.

3-ENVE 460: Environmental Fate and Transport. 3 Crs.

4-GEOL 410: Sedimentology and Stratigraphy. 4 Crs.

5-GEOL/ GEOG 412: Geomorphology. 3 Crs.

6-GEOL 428: Geochemistry. 3 Crs.

7-SOIL 410: Soils and Land Use. 3 Crs.

8-SOIL 433: Soil Ecohydrology and Physics. 3 Crs.

9-SOIL 444: Soil Genesis and Survey. 3 Crs.

TECHNOLOGY

1-ABEN 482: Instrumentation & Measurements. 3 Crs.

2-CE 476: Watershed Modeling. 3 Crs.

3-GEOL/GEOG 465: Remote Sensing of the Environment. 3 Crs.
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4-GEOL/ GEOG 470: Remote Sensing. 3 Crs.

5-GEOG 455: Intro to GIS. 4 Crs.

6-GEOG 456: Advanced GIS. 3 Crs.

7-GEOG 480: GIS Pattern Analysis and Modeling. 3 Crs.

8-SOIL 447: Microclimatology. 3 Crs.

The Institute Awarded 24 Graduate Fellowships for the Year 2023-2024

The North Dakota Water Resources Research Institute announced its Graduate Research Fellowship recipients for the year 2023-2024. The fellowships were awarded to 24 graduate students, including 18 Ph.D. and 6 M.S. students, who will conduct water resources research at NDSU and UND. These 24 graduate research projects are supported with the annual base (104b) federal grant and an additional fund form North Dakota Department of Water Resources. The 2023-2024 NDWRRI Fellows and their faculty advisors, academic programs, and research projects are listed as follows:

Fellow: Adewale Ajao (Ph.D. student) **Advisor:** Yeo Howe Lim
Program: Civil and Environmental Engineering, UND
Title: Sustainable management of dams and reservoirs in North Dakota: sediment transport characterization

Fellow: Mousa Almousa (Ph.D. student) **Advisor:** Yeo Howe Lim
Program: Civil and Environmental Engineering, UND
Title: Salts removal as an effective and economical method of Bakken formation treatment

Fellow: Beverly Alvarez-Torres (Ph.D. student) **Advisor:** Thomas DeSutter
Program: Soil Sciences, NDSU
Title: Polyelectrolyte biopolymers (PEBs) for chloride remediation in water and soils impacted by brine spills

Fellow: Kyle D. Boutin (Ph.D. student) **Advisor:** Marinus Otte
Program: Environmental and Conservation Sciences, NDSU
Title: Evaluating the impact of constructed wetlands at the watershed scale

Fellow: Christine Cornish (Ph.D. student) **Advisors:** Marinus Otte and Jon Sweetman
Program: Environmental and Conservation Sciences, NDSU
Title: Reconstructing glyphosate use in the Prairie Pothole Region: A paleolimnological approach

Fellow: Jordan Dahle (M.S. student) **Advisor:** Benjamin Laabs
Program: Environmental and Conservation Sciences, NDSU
Title: Using InSAR, repeat photography, and GPS to monitor landslides in North Dakota

Fellow: Isra Awad Omer Elsamani (Ph.D. student) **Advisor:** Yun Ji
Program: Chemical Engineering, UND
Title: Wastewater evaporation mechanism and system dynamics model

Fellow: Aditya Goyal (Ph.D. student) **Advisor:** Achintya N. Bezbaruah
Program: Civil, Construction and Environmental Engineering, NDSU
Title: Activated carbon modified chitosan membranes/beads for bromate removal from drinking water

Fellow: Julia Hampton (M.S. student) **Advisor:** Mark A. Kaemingk
Program: Biology, UND
Title: Detecting scale-specific changes in wetland water quality and ecological communities

Fellow: Arvin Samadi Koucheksaraee (Ph.D. student) **Advisors:** Xuefeng Chu and Marinus L. Otte
Program: Civil, Construction and Environmental Engineering, NDSU
Title: Enhancing machine learning methods for rainfall-runoff forecasting

Fellow: Berkay Koyuncu (Ph.D. student) **Advisor:** Trung Bao Le
Program: Civil, Construction and Environmental Engineering, NDSU
Title: Cross-stream shear stress distribution in ice-covered rivers

Fellow: Fangtian Li (Ph.D. student) **Advisor:** Yun Ji
Program: Chemical Engineering, UND
Title: Data mining of hybrid processes for microplastics treatments in wastewater and landfill leachate

The Institute Awarded Nine Graduate Fellowships for the Year 2023-2024

Fellow: Rehnuma Mobin Maisha (Ph.D. student) **Advisor:** Dean Steele
Program: Agricultural and Biosystems Engineering, NDSU
Title: Building NRCS technical capacity in irrigation water management for variable rate irrigation

Fellow: Dauda Mohammed (Ph.D. student) **Advisor:** Jiale Xu
Program: Environmental and Conservation Sciences, NDSU
Title: Enhanced removal of organic micropollutants in agricultural runoff and wastewater effluent by novel KrCl* excimer lamp (222 nm)

Fellow: Muhammad Ali Moriyani (Ph.D. student) **Advisor:** Chau Le
Program: Civil, Construction and Environmental Engineering, NDSU
Title: Social sensing for supporting water infrastructure resilience

Fellow: Md Ashif Islam Oni (Ph.D. student) **Advisor:** Shuvashis Dey
Program: Electrical and Computer Engineering, NDSU
Title: Towards a low-cost, pervasive metasurface-based dielectric resonator wireless soil salinity and moisture sensing system for precision agriculture

Fellow: Hannah Patenaude (M.S. student) **Advisor:** Achintya Bezbaruah
Program: Civil, Construction and Environmental Engineering, NDSU
Title: Looking ahead: a sustainable approach to PFAS removal from drinking water

Fellow: Tiansong Qi (Ph.D. student) **Advisor:** Xuefeng Chu and Marinus L. Otte
Program: Civil, Construction and Environmental Engineering/Biological Sciences, NDSU
Title: Development of a joint modeling framework for assessing the impacts of wetland restoration on hydrologic processes in an impaired wetland-influenced watershed in North Dakota

Fellow: Md Mirazur Rahman (Ph.D. student) **Advisor:** Shuvashis Dey
Program: Electrical and Computer Engineering, NDSU
Title: Smart radiometer for soil moisture detection in view of an efficient irrigation system

Fellow: Michael Rosati (Ph.D. student) **Advisor:** Yeo Howe Lim
Program: Civil and Environmental Engineering, UND
Title: Determination of water quality parameters in small waterbodies using UAV hyperspectral remote sensing

Fellow: Whitney Sauskojus (M.S. student) **Advisor:** Marinus Otte and Jon Sweetman
Program: Environmental and Conservation Sciences and Biological Sciences, NDSU
Title: Aquatic macroinvertebrates as indicators of restoration success in Prairie Pothole Region wetlands

Fellow: Bhuwan Prasad Shah (M.S. student) **Advisor:** Xinhua Jia
Program: Agricultural and Biosystems Engineering, NDSU
Title: Automated irrigation for commercial production of watermelon, squash, and muskmelon cultivars in Oakes

Fellow: Sai Sri Sravya Vishnumolakala (Ph.D. student) **Advisor:** Xinhua Jia
Program: Agricultural and Biosystems Engineering, NDSU
Title: Utilizing remote-controlled drip irrigation for high tunnel tomato and pepper productions in North Dakota

Fellow: Xiaomo Zhang (M.S. student) **Advisor:** Zhulu Lin and Xin Sun
Program: Natural Resources Management, NDSU
Title: Developing machine learning and deep learning soil moisture models for precision agricultural applications

2022-2023 NDWRRI Fellowship Research Highlights

Per and polyfluoroalkyl substances (PFAS) leaching from yard waste compost

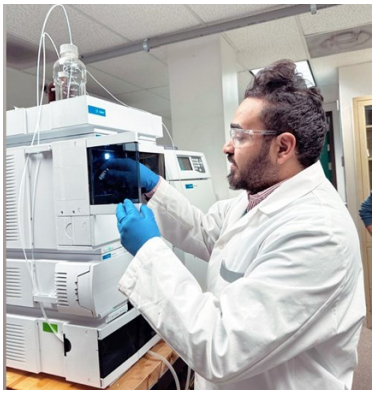
Biraj Saha (Fellow) & Dr. Syeed Md Iskander (Advisor), North Dakota State University

Per- and polyfluoroalkyl substances (PFAS), commonly referred to as "forever chemicals," are persistent organic pollutants that are widespread in the environment. Despite yard waste compost being widely recognized for its purity, the discovery of PFAS within it is unexpected and warrants thorough investigation to curtail the spread of PFAS through compost. Our preliminary research uncovered total PFAS levels of 18.53 ± 1.5 μg kg^{-1} in this compost, with PFCAs and PFSAs being the predominant classes. Additionally, a vertical distribution pattern of PFAS was also observed in a mature compost pile. So, the proposed study is motivated by initial findings that suggest PFAS can migrate downwards through compost piles, driven by moisture. Our research will explore how the chemical characteristics of both PFAS and compost influence PFAS leaching. Additionally, we will closely examine the effect of freeze-thaw cycles on this process. Such cycles are frequent in North Dakota, potentially aiding in the release of PFAS from compost and their downward movement as ice thaws. Therefore, our study aims to understand the dynamics of PFAS leaching from compost, considering both its chemical properties and the impact of freeze-thaw cycles. This understanding is crucial for developing effective strategies to mitigate PFAS pollution. The anticipated outcomes include a comprehensive insight into PFAS leaching behaviors, which will be communicated to the public and state agencies in North Dakota. These findings will guide the development of measures to reduce PFAS contamination, ultimately improving water quality, protecting ecosystems, and safeguarding vulnerable populations.

Synthesis and Performance Evaluation of Novel Carboxyl-Based Grafted Polyacrylamide fibers for Ions Removal from Produced Water (PW)

Nadhem Ismail (Fellow) & Dr. Ali Alshami (Advisor), University of North Dakota

Reported Produced Water (PW) spills from disposal sites lead to surface water, ground water, and soil contamination due to high salts and other harmful substances content. This necessitates advances in sustainable treatments for PW reuse/recycle options and contaminants removal. This work focuses in developing biopolymer-based platforms as mineral scale inhibitors for Produced Water (PW) management. To guide the synthesis, we have procured and analyzed eight (8) PW samples from different wells within the Williston Basin. Results revealed very high concentrations of sodium, calcium, potassium, and magnesium, with traces of other ions where the average total dissolved solids (TDS) concentration is more than 270,000 ppm. This directed our formulation development to target carbonate, sulfate, and sulfide scalants while utilizing ICP-OES results for the guided brine water synthesis used in inhibition tests. We developed the first formulation, poly (acrylamide-co-malonic acid), which was tested against calcium carbonate and iron sulfide scales, yielding very good results at different temperature and pH. The second formulation was produced by modifying an abundant biopolymer, carboxymethylcellulose (CMC) in a free radical graft copolymerization reaction, characterized and tested yielding better inhibition results than raw CMC. We have also developed a new fluorescent quantum dots-based formulation that was very effective for calcium sulfate inhibition under harsh environments. This work has broader impact on, oil and gas industry, food and beverage industry, water treatment and desalination, pulp and paper industry, and mineral processing industry in view of the fact that all these industries handle water and are susceptible to mineral scaling.



2022-2023 NDWRRI Fellowship Research Highlights

Comparative analyses of soil water sensors for irrigation water management

Rehnuma Mobin Maisha (Fellow) & Dr. Dean Steele (Advisor), North Dakota State University

Six soil water sensors, i.e., Acclima TDR-310H, CropX, FarmQA AquaSpy, FieldNet with Watermark blocks, Valley Aqua Trac Lite with Sentek, and Aqua Trac Pro with Watermark blocks were assessed in this study at four depths (15, 46, 76, and 107 cm) in 2021, 2022, and 2023 growing seasons at three farmers' field sites with their crop management. Acclima sensor was calibrated in the same fields where the sensors were installed and considered as the reference standard for comparing with other sensors. Soil water characteristic curves were developed to convert the matric potential from the Watermark blocks to volumetric water content (θ_v) using HYPROP and WP4C. Considering the mean bias error, all sensors showed both over and under estimation throughout the seasons. Overall, Lindsay (R^2 = 0.03 to 0.97) showed higher correlation at shallower depths i.e., 15 and 46 cm. Aqua Trac Lite (R^2 = 0.31 to 0.99), CropX (R^2 = 0.03 to 0.99) and Aqua Trac Pro (R^2 = 0.02 to 0.96) showed higher correlation at deeper depths i.e., 76 and 107 cm. From two-way ANOVA, no statistical significance ($p > 0.05$) was found between the interaction of sensor type and sample timestamp. However, the main factors i.e., sensor type and sample timestamp had significant effect ($p < 0.05$) on the θ_v measurements. The results from this study will help farmers and crop consultants understand the performance of the soil water sensor and make informed decisions on the soil water sensor selection in production fields with similar soil textures.

Wetland restoration in the North Dakota Prairie Pothole Region: A macroinvertebrate community perspective

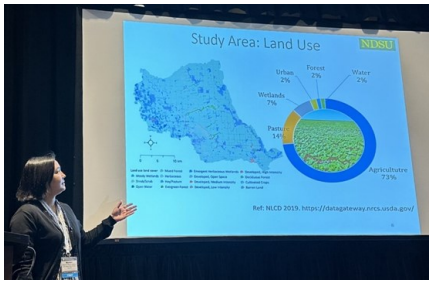
Whitney Sauskojus (Fellow) & Drs. Jon Sweetman and Marinus Otte, North Dakota State University

This study assessed the long-term recovery of aquatic macroinvertebrate communities to wetland restoration. Previous research has suggested that even after a decade post restoration, macroinvertebrate communities may not fully resemble those of undisturbed reference sites, and how effective wetland restorations are in recovering macroinvertebrates is unclear. To assess macroinvertebrate recovery to restoration over long-time frames, thirteen restored and five reference wetlands were sampled in the North Dakota Prairie Pothole Region during July and August of 2019. Restored wetlands ranged from 20 to 32 years post-restoration, within restoration dates spanning between 1987-1999. Differences were examined between reference and restored sites, along with differences between four age categories: 20-26 years (n = 4), 29 years (n = 4), 31-32 years (n = 5) and reference sites (n = 5). No significant differences were found in aquatic macroinvertebrate richness and diversity between reference and restored wetlands, or among restoration age groups. Community composition was also similar among all restoration age groups, with no apparent influence from measured chemical and physical water variables and soil organic matter. These results suggest, within the Prairie Pothole Region, that restored wetlands contain diverse macroinvertebrate communities that resemble undisturbed reference sites after 20 to 32 years post-restoration.

2022-2023 NDWRRI Fellowship Research Highlights

Assessing the role of wetlands in reducing sediment and nutrient loads from an impaired watershed in North Dakota

Mosammat Mustari Khanaum (Fellow) & Drs. Xuefeng Chu and Marinus Otte, North Dakota State University



Wetlands perform as a "buffer" zone by retaining water and providing an environment for the hydrogeochemical functions of a watershed. Few studies have addressed the restoration of past wetlands using wetland-corrected land-use land-cover (LULC) datasets. The aim of this study is to assess the impacts of wetlands on discharge and loading of non-point source pollutants to improve the water quality of a 303(d) listed impaired watershed, the Upper Turtle River (UTR) watershed in ND through restoring past wetlands. To achieve this goal, a GIS-based raster processing procedure was proposed for generating a wetland-corrected LULC dataset to mimic the 1970s wetlands restoration. An integrated watershed-scale hydrologic and water quality model, including the Soil and Water Assessment Tool (SWAT) enhanced by DEM-based wetland delineation, was developed and utilized to assess the effects of wetlands on discharge and water quality. The model was calibrated and validated using daily average discharge, total nitrogen (TN), total phosphorus (TP), and sediment concentration data obtained from the USGS and NDDEQ. This study demonstrated that wetlands acted as a hydrologic regulator, controlling surface runoff and peak flows, and reducing nutrient and sediment loadings. This study showed that by restoring past wetlands the average annual surface runoff, peak flows, TN, TP, and sediments were reduced 8%, 32%, 26%, 31%, and 3%, respectively. The study highlighted the necessity of using the wetland-corrected proxy LULC dataset to improve hydrologic and water quality modeling, as SWAT tended to overestimate 7-13% peak flows and 9-111% nitrate, ammonia, organic nitrogen, and TN without the correction for wetlands. In addition, the impacts of hydroclimatic variability on hydrology and water quality were evident from the analysis, as dissimilar magnitudes and variations in peak flows and nutrients loads were observed for wet and dry years. During wet years, the reduction rates of peak flows and TN were 33% and 26%, respectively, while 25% and 17% of reduction rates were observed for dry years. The study highlighted the necessity of restoring wetlands to reduce flood risks and improve the water quality in polluted watersheds.

Reconstructing glyphosate use in the Prairie Pothole Region: A paleolimnological approach

Christine Cornish (Fellow) & Drs. Marinus Otte and Jon Sweetman, North Dakota State University

Glyphosate is the most commonly used herbicide worldwide, and its use has substantially increased over the decades. As a result, it often enters aquatic ecosystems, where it can accumulate in wetland sediments. Its main metabolite aminomethylphosphonic acid (AMPA) also accumulates in sediments, where both compounds can persist over time leaving aquatic biota vulnerable to exposure. Paleolimnology can provide long-term perspectives on past glyphosate loading, in addition to biological responses. Monitoring records for wetlands are often limited, and this approach to evaluating past contaminant histories can be valuable. I will conduct a paleo-ecotoxicological study to reconstruct glyphosate use and microbial community shifts over time. Two wetland sediment cores, one from an agriculturally-dominant watershed and a second from an agriculturally-undisturbed watershed, will be analyzed for glyphosate and AMPA residues, and eDNA, as well as 210Pb and 137Cs for chronological records. This research will combine multiple techniques to assess the persistence of glyphosate and AMPA in sediments, and their potential long-term effects on wetland microbial communities.

2022-2023 NDWRRI Fellowship Research Highlights

Landfill leachate plastics: occurrence, transformation, fate, and environmental implications

Himani Yadav (Fellow) & Dr. Syeed Md Iskander (Advisor), North Dakota State University

Plastics pollution is a major problem facing humanity. Global annual production of plastics is predicted to reach 12 billion metric tons by 2050, and approximately 21 - 42% of generated plastic is stored in landfills. These landfilled plastics are broken down through biochemical reactions, having detrimental environmental and human health impacts. Plastic particles smaller than 100 nm are classified as nanoplastics, which end up in landfill leachate and proliferate in the environment. Given the small size of nanoplastics and complex leachate matrix, identification and quantification of nanoplastics in leachate are really difficult. The widely used Fourier Transform Infrared Spectroscopy cannot be applied for identification of a mixture of different polymers in nanoscale. Thus, we have developed a technique using pyrolysis along with gas chromatography and mass spectrometry to quantify different polymer concentrations in landfill leachate in nanoscale. The process requires a significant pretreatment steps before pyrolysis as leachate is high in organics. We applied advanced oxidation with different doses of oxidant to remove the organics from leachate followed by multiple concentrations steps. We developed a wide array of pretreatment techniques to understand the impact on identification and quantification of leachate nanoplastics in pyrolysis-GC-MS. We have developed a protocol for leachate nanoplastics quantification that can be applied to other wastewaters. Our effort will help the ongoing fight against plastics pollution by better understanding the plastics presence in the environment.

Treatment and reuse of produced water through the measurement and elimination of coagulated petrochemicals/hydrocarbons in inorganic and organic aqueous solutions

Fafa Tackie-Otoo (Fellow) & Dr. Hallie Boyer Chelmo (Advisor), University of North Dakota

The wastewater from the petroleum industry contains high salt loading and complex organic mixtures with hydrocarbons that harm the environment and inhibit potential reuse of freshwater. To deal with oily waste/wastewater, past research has been insufficient due to lack of characterization of these complex and highly concentrated solutions. In this project we demonstrated a new approach to probe chemical and physical properties of aqueous solutions in two steps. Step 1: instead of studying bulk solution, we create solution microdroplets and levitate them. The instrument we use is an electrodynamic balance. When levitated, they access well into super-saturated concentrations. It is likely these droplets attain concentrations even higher than real produced water. Step 2: using a well-studied NaCl solution, we monitored water uptake of a 5% wt NaCl solution microdroplet to understand its hygrosocopic behavior and crystallization. NaCl crystallizes at relative humidities well below the minimum bulk water activity. With this demonstrated method, more complex solutions can be studied in the future, towards achieving chemical thermodynamic measurements in the super-satured regime for any salty/organic mixture.

Environment friendly phosphate removal and recovery from surface and agricultural waters

Malachi Graupman (Fellow) & Dr. Achintya Bezbaruah (Advisor), North Dakota State University

Phosphorus is a non-renewable natural resource that is used extensively as a fertilizer. Much of the phosphorus used in agriculture finds its way into surface waters where it permanently resides, leading to devastating effects on the aquatic ecosystem through the eutrophication of the waterbodies. In this research, a simple iron-modified biochar and a novel biochar-supported green nZVI were produced for aqueous phosphate removal. The phosphate removal performance and mechanism of the modified biochars were evaluated in relevant conditions. The modified biochars showed successful phosphate removal with adsorption capacities of 9.12 mg/g for the simple iron-modified biochar and 14.31 mg/g for the green tea biochar, and kinetic data for both biochars best fit the pseudo-second-order model indicating the mechanism of removal was chemisorption. There were negligible interferences in the presence of potential coexisting ions (SO42-, NO3-, Cl-, F-) at environmentally relevant concentrations. The modified biochars show potential for field application.

Recent Publications and Presentations by Institute Fellows and PIs

Journal Papers

Cornish, C.M., & Sweetman, J.N. (2023). A perspective on how glyphosate and 2,4-D in wetlands may impact climate change. *Frontiers in Environmental Science,* 11.

Cornish, C.M., Bergholz, P., Schmidt, K. & Sweetman, J. (2023). How benthic sediment microbial communities respond to glyphosate and its metabolite: a microcosm experiment. *Microbial Ecology* 86(4), 2949-2958.

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Yadav, H., Khan, M.R.H., Quadir, M., Rusch, L.A., Mondal, P.P., Orr, M., Xu, E.G., & Ishander, S.M. (2023). Cutting boards: an overlooked source of microplastics in human food? *Environmental Science & Technology,* 57(22), 8225-8235.

Conference Papers

Ismail, N., & Alshami, A. (2024). CaCO3 Crystallization in the Presence of Polycarboxylated CMC: Insights into Kinetics, Mechanisms, and Crystal Morphology. *2024 AIChE Annual Meeting*. https://aiche.confex.com/aiche/2024/meetingapp.cgi/Paper/691633.

Ismail, N., Alshami, A., Sun, D., & Zhao, J. (2023). Fluorescent Carboxyl Silicon Quantum Dots (CSiQDs) As an Efficient Scale Inhibitor and the Scale Inhibition Mechanism. *2023 AIChE Annual Meeting*. https://aiche.confex.com/aiche/2023/meetingapp.cgi/Paper/668878.

Recent Publications and Presentations by Institute Fellows and PIs

Conference/Seminar Presentations

Ismail, N. & Alshami, A. (2024). Operational Window of Green Antiscalants: Structural Effects on Carboxymethylcellulose Performance. *North Dakota Academy of Science 2024 Meeting.* https://www.ndacadsci.org/annual-meeting/2024-proceeding.

Ismail, N. & Alshami, A. (2024). Mineral Scale Formation and Control. *UND Chemical Engineering Department Seminar*. March 12, 2024.

Khanaum, M.M., Qi, T., Boutin, K.D., Otte, M.L., Lin, Z., & Chu, X. (2023). GIS-based Data Processing Approach for Improving Hydrologic and Water Quality Modeling. South Dakota Student Water Conference, Oct 10, 2023, Brookings, SD.

Khanaum, M.M., Qi, T., Boutin, K.D., Otte, M.L., & Chu, X. (2023). Assessing the Impact of Wetland Location on Discharge and Nutrient Attenuation of a Watershed. ASCE 2023 World Environmental and Water Resources Congress, May 21-24, 2023, Henderson, NV.

Khanaum, M.M., Qi, T., Boutin, K.D., Otte, M.L., & Chu, X. (2023). SWAT Modeling: Influences of Land Use and Land Cover on Streamflow and Water Quality. North Dakota Established Program to Stimulate Competitive Research (ND EPSCoR) 2023 State Conference, March 29, 2023, Fargo, ND.

Saha, B. & Iskander, S.M. (2023). Microplastics and PFAS in yard waste compost: occurrence and degradation. AEESP Research & Education 2023 Conference, June 20-23, 2023, Northeastern University, Boston.

Sauskojus, W.M., Sweetman J.N., Yuan Y., & Otte M.L. (2023). Assessing aquatic macroinvertebrate community recovery across restoration ages in Prairie Pothole Region wetlands. Society of Wetland Scientists Annual Meeting, June 26-30, 2023, Spokane, WA

Sauskojus, W.M., Sweetman J.N., Yuan Y., & Otte M.L. (2022). Aquatic macroinvertebrates as indicators of restoration success in the Prairie Pothole Region. Joint Aquatic Sciences Meeting, May 14 -20, 2022, Grand Rapids, MI

Sauskojus, W.M., Sweetman J.N., Yuan Y., & Otte M.L. (2022). Aquatic macroinvertebrates as indicators of restoration success in the Prairie Pothole Region. North Dakota Water Quality Conference, March 21- 23, 2022, Bismarck, ND

Sauskojus, W.M., Sweetman J.N., Yuan Y., & Otte M.L. (2022). Aquatic macroinvertebrates as indicators of restoration success in the Prairie Pothole Region. Environmental & Conservation Sciences Greenbag Seminar, Feb. 24, 2022, Fargo, ND

Theses and Dissertations

Cornish, C. (2024). Anthropogenic stressors on freshwater wetlands: a microbial perspective. Ph.D. Dissertation. Environmental and Conservation Sciences, College of Graduate and Interdisciplinary Studies, North Dakota State University, Fargo, ND (available at: https://hdl.handle.net/10365/33965).

Sauskojus, W.M. (2024). Wetland restoration in the North Dakota Prairie Pothole Region: a macroinvertebrate community perspective. M.S. Thesis. Environmental and Conservation Sciences, College of Graduate and Interdisciplinary Studies, North Dakota State University, Fargo, ND (available at: https://library.ndsu.edu/ir/handle/10365/33927).

Tackie-Otoo, F. (2023). Studying phase and morphology of hydrocarbon petrochemicals in inorganic and organic microdroplets using an electrodynamic balance. M.S. Thesis. Mechanical Engineering, University of North Dakota, Grand Forks, ND (available at: Studying Phase and Morphology of Hydrocarbon Petrochemicals in Inorganic and Organic Microdroplets Using an Electrodynamic Balance - ProQuest).

Recent Publications and Presentations by Institute Fellows and PIs

Reports

Ali, M.A. & & Xiao, F. (2022). A review of the fate and transport of microplastics in the natural environment. ND EPSCoR 2022, Established Program to Stimulate Competitive Research (Virtual), April 6-22, Grand Forks, ND.

Awards

Mosammat Mustari Khanaum: 2023, Environmental and Conservation Sciences (ECS) Travel Award to support the attendance and presentation at ASCE 2023 World Environmental and Water Resources Congress, May 21-24, 2023, Henderson, NV.

Mosammat Mustari Khanaum: 2023, Outstanding Oral Presentation Award at the South Dakota Student Water Conference, Oct 10, 2023, Brookings, SD.

Nadhem Ismail: 2024, North Dakota Academy of Sciences Award, 2nd Place in Oral presentation.

Nadhem Ismail: 2023, University of North Dakota Travel Award.

Nadhem Ismail: 2022, University of North Dakota Travel Award.

Whitney Sauskojus : 2023, Cross Ranch Fellowship.

Whitney Sauskojus: 2023, Shockey-Scoby Travel Award.

NDWRRI Education and Outreach Activities

Fargo-Moorhead Area Diversion Conference: The Fargo-Moorhead Area Diversion Conference was held on August 19, 2024, at the NDSU campus, bringing together a multidisciplinary audience of experts from agencies, industry, and academia to learn about the project's status, social impact, and unique engineering design. Mr. Kris Bakkegard, Metro Flood Diversion Authority director of engineering, opened the conference with an overview of the FM Diversion (picture on the left), followed by discussions on the social and environmental impacts on the Fargo-Moorhead community. Dr. Karen Ryberg from USGS delivered a keynote speech titled, "Why Do We Need the Fargo-Moorhead Area Diversion?" Industry representatives and academic faculty also gave lightning talks on various aspects of the project, and the final session focused on the unique engineering designs involved.

The event was fully packed, with 55 attendees, and 9 participants joined a tour of the FM Area Diversion the following day. A group photo on the right shows the tour group with the inlet structures in the background.

Details about the events, along with presentations and/or videos, can be found on the NDWRRI's website.

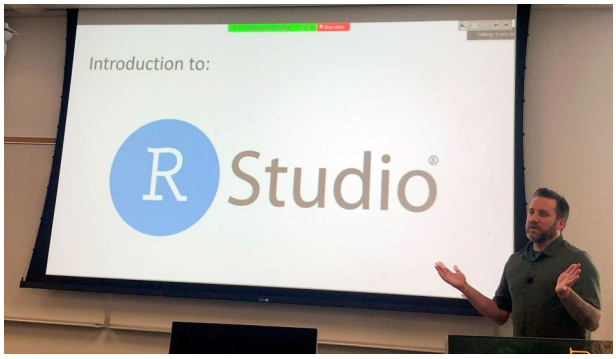
NDWRRI Education and Outreach Activities

PFAS: On January 24, 2024, NDWRRI hosted its first ND PFAS (Per- and Polyfluoroalkyl Substances) Conference, focusing on the emerging threats PFAS pose to North Dakota's water, food, and environment. The event aimed to raise awareness, share the latest research findings, and explore potential collaborations to address these pressing issues. Senator Ronald Rorvaag delivered the opening remarks, followed by Dr. Sara Lupton from USDA ARS, who presented "PFAS in the U.S. and Importance in Agriculture," providing an overview of PFAS concerns across the United States. Ms. Madeline Beal from the EPA delivered a keynote presentation on "PFAS Risk Communication and Health Impacts" (pictured in the right).

The conference provided updates on emerging issues, facilitated discussions on understanding PFAS threats across North Dakota, and examined impacts on people, animals, plants, water, and food sources. A key outcome of the conference was the establishment of a PFAS research agenda for faculty at NDSU and UND as well as for personals from state and federal agencies. The conference drew 44 attendees, including faculty and research scientists from NDSU and UND, and representatives from state and federal agencies such as the ND Department of Water Resources, Department of Environmental Quality, Department of Agriculture, USGS, USDA ARS, and EPA.

On June 20, 2024, Mr. Adam Schanen from Metrohm visited NDSU and provided a history of PFAS measurement and showcased its novel techniques in PFAS monitoring (see picture on the left). The event had 24 attendees from NDSU, UND, USGS, USDA ARS, and ND Department of Environmental Quality.

R Workshop: Dr. Travis Seaborn, NDWRRI Faculty Fellow and Assistant Professor in the School of Natural Resource Sciences, held a two-day workshop on R Statistics and R Studio for 22 faculty, staff, and graduate students on August 8 and 9, 2024. The workshop offered attendees a hands-on experience and inspired many to use R. Dr. Seaborn also provided numerous resources for those interested in continuing to use R in their research.



Details about the events, along with presentations and/or videos, can be found on the NDWRRI's website.

Recent USGS Publications

USGS Dakota Water Science Center Publications can be found at https://www.usgs.gov/centers/dakota-water/publications:

Redoloza, F.S., Williamson, T.N., Headman, A.O., & Allred, B.J. (2023). Machine-learning model to delineate subsurface agricultural drainage from satellite imagery. Journal of Environmental Quality. 52, 907-921. 10.1002/jeq2.20493

Woods, T.E., Eng, K., Carlisle, D., Cashman, M.J., Meador, M., Ryberg, K.R., & Maloney, K.O. (2023). Assessing the added value of antecedent streamflow alteration information in modeling stream biological condition. Science of the Total Environment, 908, 168258. doi: 10.1016/j.scitotenv.2023.168258

Galloway, J.M., Nustad, R.A., & Wheeling, S.I. (2024). Water-quality characteristics of the Red River of the North and tributaries in the Fargo-Moorhead metropolitan area, North Dakota, 2019–22. USGS Scientific Investigations Report 2023-5136. doi: 10.3133/sir20235136.

Galloway, J.M. (2024). Dissolved oxygen monitoring on the Souris River, 2019-23. USGS Scientific Investigations Report 2024-1043. doi: 10.3133/ofr20241043.

Ryberg, K.R. (2024). Why snow is crucial for water supply – and what will happen when it becomes scarce. USGS Scientific Investigations Report 70254946. doi: 10.1038/d41586-024-01239-6

Recent ND Department of Water Resources Publications

North Dakota Department of Water Resources Biennial Report 2021-2023. https://www.swc.nd.gov/info_edu/reports_and_publications/biennial_reports/pdfs/2021-2023.pdf

North Dakota Department of Water Resources 5 Year Strategic Plans 2022 – 2027. https://www.swc.nd.gov/info_edu/reports_and_publications/strategic_plans/pdfs/2022_5_year_strategic_plan.pdf

North Dakota Department of Water Resources Alternative Funding Sources. https://www.swc.nd.gov/pdfs/funding_general_supply.pdf

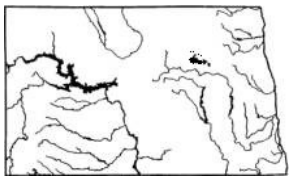
NDWRRI State Advisory Board Committee

Karen Ryberg, Deputy Director, U.S. Geological Survey, Dakota Water Science Center, Bismarck, ND

Andrew Nygren, Hydrologist, Water Appropriation Division, North Dakota Department of Water Resources, Bismarck, ND

Peter Wax, Environmental Scientist, North Dakota Department of Environmental Quality, Bismarck, ND

Aaron Larsen, Conservation Biologist with the North Dakota Game and Fish Department, Bismarck, ND



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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.