North Dakota Water Resources Research Institute (NDWRRI)

2023-2024 Annual Report

History

The NDWRRI was established in 1965 under the Water Resources Research Acts, administered through the US Geological Survey. It's part of the National Institutes for Water Resources, focusing on fostering new research, training future water resources professionals, exploring new ideas to address water issues, and disseminating research results. The institute emphasizes cooperation with colleges and regional organizations to solve water and land-related problems at state and regional levels. The NDWRRI is currently housed at the North Dakota State University in the Office of the Vice President for Research and Creative Activity.

Mission

The mission of the NDWRRI focuses on facilitating research to address water problems, support the education and training of future water resources professionals, explore innovative ideas related to water and its phenomena, and disseminate findings to water managers and the public. It aims to enhance statewide efforts in resolving water and related land issues through collaboration with colleges and regional organizations, promoting effective water management and sustainability efforts.

Research

The North Dakota Water Resources Research Institute (NDWRRI), part of the National Institutes for Water Resources, is committed to addressing North Dakota's critical water challenges through research, education, and collaboration. Established in 1965 and administered by the US Geological Survey under NDSU's Vice President for Research and Creative Activity, NDWRRI funds Graduate Research Fellowships focused on priority issues set by the Advisory Board. Additionally, the Institute has developed a Water Resources Certificate Program for undergraduate students at NDSU, aiming to train future water professionals and encourage innovative solutions to water issues. Each year, a State Advisory Committee identifies research priorities, and competitive fellowships are offered to graduate students at NDSU and UND. These fellowships provide opportunities for students to address water-related topics, advance knowledge, and develop the skills needed to tackle regional water challenges. NDWRRI also promotes information exchange through seminars, conferences (including PFAS abatement and the Fargo-Moorhead area diversion project), and its website and newsletter.

The NDWRRI is instrumental in developing a skilled workforce for water resources and addressing North Dakota's pressing water issues. By supporting graduate fellowships, the Institute drives impactful research with implications for water management, conservation, and policy. Through outreach initiatives like monthly seminars and the Water Resources Certificate program, the Institute enhances knowledge dissemination and strengthens state agency capabilities. Collaborative NDWRRI-funded projects contribute to sustainable water management solutions, inform policy, and prepare students for careers in industry, government, and academia, ultimately benefiting North Dakota's communities and ecosystems.

Technology and Information Transfer

The North Dakota Water Resources Research Institute (NDWRRI) is dedicated to advancing water resource knowledge and addressing critical issues in North Dakota through outreach and

communication. Key initiatives include maintaining an updated website that serves as a hub for research, project updates, resources, events, and funding opportunities for the public and stakeholders. The Institute publishes annual newsletters to spotlight research projects and the graduate research fellowship program.

NDWRRI also sponsors events such as the North Dakota Water Quality Monitoring Conference and the South Dakota Student Water Conference, fostering collaboration among experts, researchers, and students. Fellows and faculty are encouraged to share findings in peer-reviewed journals and at various conferences. In fall 2023, eight faculty presented at monthly Water Talk seminars, with a Distinguished Water Seminar held in January 2024 on PFAS, alongside other workshops and conferences that support knowledge sharing.

The Institute's LinkedIn page, launched in March 2024, features weekly posts and has attracted 286 followers as of August 2024.

NDWRRI's outreach strengthens sustainable water management practices in North Dakota. By engaging diverse audiences through its digital and in-person efforts, the Institute disseminates essential research, particularly on PFAS. These activities build partnerships, support workforce development, and promote innovative water solutions, benefiting North Dakota's communities, ecosystems, and resources. NDWRRI ensures that water-related knowledge reaches those who can make a meaningful impact.

Education and Outreach

Establishing education and outreach for the NDWRRI is essential for addressing water-related challenges and promoting sustainable practices in North Dakota. Approved in spring 2024, NDWRRI's Water Resources Certificate Program is set to launch in fall 2024, covering hydrology, water quality, irrigation, and conservation. This program provides specialized training to prepare students across majors for careers in water resources and environmental science. To support NDWRRI's Water Initiative, which addresses critical issues like water availability, drought, and quality, NDWRRI has organized seminars, funding opportunities, and special-topic conferences to foster collaboration. As the lead organization, NDWRRI encourages affiliated faculty to collaborate with government, academia, industry, and communities, promoting innovative research and practical solutions through various events and campaigns.

The NDWRRI communication staff manages public communications and the website, while an undergraduate student maintains LinkedIn. Two graduate students in communication contributed literature reviews on PFAS and submitted eight LinkedIn posts. Four Water Fellows, hired in spring 2024, assist with outreach, including conference organization, Certificate Program support, and data collection for program development and policy recommendations. They also document outreach outcomes, analyze data, and propose solutions. Together, the Certificate Program and Water Initiative reflect NDWRRI's commitment to education, research, and collaboration, paving the way for sustainable water management and resilience in North Dakota.

Projects funded in 2023-2024

The NDWRRI has awarded 24 projects for 2023-2024 Graduate Research Fellowship program. The fellowships with the funding from the USGS 104b and ND Department of Water Resources ranged from $2,500 to $5,552 and were for 19 doctoral and 5 master's degree students.

The students will conduct water resources research at NDSU and the University of North Dakota. Fellows, their academic programs, university, faculty advisers and research projects are:

Name: Md Mirazur Rahman, Ph.D. Student

Title: Smart radiometer for soil moisture detection in view of an efficient irrigation system

Program: Electrical and Computer Engineering, NDSU

Advisor(s): Shuvashis Dey

Summary: This project is about making a special tool called a radiometer that helps farmers see how wet or dry their soil is. Knowing this is really important because it helps them water their plants just right. In North Dakota, farming can be hard because sometimes it rains too much, or not enough, or the soil gets too salty. These problems make it tough to grow plants. The radiometer uses a special antenna to check the water in the soil. It can move up and down and turn around to see different areas. Experimentations involves different kinds of soil to make sure it works well. This will help farmers know how wet or dry their soil is right away. Using this tool will help farmers save water, grow more food, and keep the soil healthy. It will be helpful for farmers in North Dakota and other places with the same problems. A journal paper is in progress to be published in IEEE OJAP which will include the analysis and results of the designed prototype.

Name: Arvin Samadi Koucheksaraee, Ph.D. Student

Title: Enhancing Machine Learning Methods for Rainfall-Runoff Forecasting

Program: Civil, Construction and Environmental Engineering, NDSU

Advisors: Xuefeng Chu

Summary: Streamflow prediction is important in the field of hydrology. We need the information for the purposes of flood warnings and water management. Current water problems make it more urgent. Machine learning models have been used to predict river flow. But they have some problems and limitations. Generally, we need to choose the best model settings and make sure they work under different conditions. We also need to check the data used for the model. So, it is a difficult task to get good predictions. This study aims to overcome some related problems. We developed a hybrid machine learning model to predict daily streamflow. We used a feature selection method to find the best model input. We then used a decomposition method to break down the best input to manage the complicated input data. The hybrid machine learning model combined linear and nonlinear models. We also used an optimizer to find the best parameters for our model. In this study, we tested the new hybrid model in the Upper Turtle River watershed in North Dakota. We predicted water flow of the river. We also compared our new model with some existing models. The results highlighted the unique features and capability of the new model. We demonstrated that the new machine learning model can be used for improved streamflow prediction. Government agencies can use the modeling results for flood protection and water resources management.

Name: Beverly Alvarez-Torres, Ph.D. Student

Title: Polyelectrolyte biopolymers (PEBs) for chloride remediation in water and soils impacted by brine spills

Program: Soil Sciences, NDSU

Advisors: Thomas M. DeSutter

Summary: The process of extracting oil and gas in the Williston Basin brings up brine water, which is mostly made of salt (sodium chloride or NaCl). This salty water is harmful to both soil and water quality because it can have up to 757 times more chloride (Cl-) than what the Environmental Protection Agency (EPA) allows for safe drinking water. Sometimes, brine spills accidentally happen, which adds chloride to the soil, water, and the food chain of animals living in the area. Right now, the main way to fix this problem is to remove the contaminated soil and take it to special landfills. But due to the environmental impact, soil scientists are looking for ways to clean the soil without removing it. One possible solution is to use bio-based materials, which are natural materials that can help reduce the harmful effects of chloride. To see how well these materials work, this research project is doing soil-water-plant experiments to understand how they can reduce the bioavailability of chloride for living organisms. The results of these studies could lead to a new way to clean up land that has been affected by brine spills, which is very important for protecting plants and animals, keeping water clean, and making the land productive again.

Name: Aditya Goyal, Ph.D. Student

Title: Activated Carbon Modified Chitosan Membranes/Beads for Bromate Removal from Drinking Water

Program: Civil, Construction and Environmental Engineering, NDSU

Advisors: Achintya Bezbaruah

Summary: Our project focuses on removing phosphate from water using calcium peroxide nanoparticles. Excess phosphate, often from fertilizers, detergents, and wastewater, can harm natural water sources by causing algae blooms. These blooms reduce oxygen levels in the water, killing fish and plants, and make lakes and rivers unsafe for people. Finding ways to remove phosphate is important for protecting the environment and public health.

Initially, we worked on using chitosan beads to remove a contaminant called bromate from water. However, the beads did not effectively remove bromate, so we decided to focus on phosphate removal instead. In this project, we are using calcium peroxide, a substance that gradually releases oxygen when added to water. As it breaks down, it also produces compounds that can bind with phosphate, helping to remove it from the water.

We hope our work will offer a simple and efficient method for water treatment, especially in areas with limited access to advanced technology. This research can help prevent pollution from harming lakes and rivers, ensuring healthier ecosystems and safer water for communities.

Name: Hannah Patenaude, MS Student

Title: Looking Ahead: A Sustainable Approach to PFAS Removal From Drinking Water

Program: Civil, Construction and Environmental Engineering, NDSU

Advisors: Achintya Bezbaruah

Summary: PFAS, also known as “forever chemicals,” are a group of man-made substances found in products like non-stick cookware, waterproof clothing, and firefighting foam. They don’t break down easily, so they build up in the environment and drinking water over time. PFAS have been linked to serious health problems, including cancer, thyroid disease, and developmental issues in children. In North Dakota, PFAS have been found in water sources at multiple sites, creating a need for effective ways to remove them.

This project explores a new method to remove PFAS from drinking water using modified activated carbon. Activated carbon has long been used in water treatment because of its ability to trap contaminants. We aim to improve its performance by enhancing its ability to capture PFAS, especially the short-chain types that are harder to remove. Our approach is both sustainable and scalable, making it suitable for widespread use.

The results could provide a reliable, cost-effective solution for PFAS removal, helping to protect public health and the environment. By improving water quality, this research supports clean water access for communities and aligns with broader efforts to address emerging contaminants in drinking water.

Name: Whitney Sauskojus, MS student

Title: Aquatic macroinvertebrates as indicators of restoration success in Prairie Pothole Region wetlands

Program: Environmental and Conservation Sciences and Biological Sciences

Advisor: Marinus Otte and Jon Sweetman

Summary: This study assessed the long-term recovery of 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 how macroinvertebrates have recovered over longer time-frames post-restoration, I sampled thirteen restored and five reference wetlands in the North Dakota Prairie Pothole Region were sampled during July and August of 2019. Restored wetlands ranged from 20 to 32 years post-restoration, within restoration dates spanning between 1987-1999. I examined differences 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). I found no significant differences in aquatic macroinvertebrate richness and 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 OM. 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.

Name: Muhammad Ali Moriyani, Ph.D. Student

Title: Social Sensing for Supporting Water Infrastructure Resilience

Program: Civil, Construction and Environmental Engineering

Advisors: Chau Le

Summary: Flooding in North Dakota causes so much damage to various homes, roads, and water systems; repairs cost millions of dollars. Currently available tools (i.e. remote sensors) gives the direct impacts of floods by determining the depth of flood but they do not give a full view of what are the indirect effects such as impact on the affected community. Social media, like X (formally Twitter), has increasingly served as a useful avenue through which real-time information is disseminated during disaster events. People update what they witness and experience. As a first step towards understanding the use of social media for disaster impacts, this project develops a detailed review of the existing studies that utilize tweets for information gathering concerning the impact on the infrastructure. From such analyses, we can determine where the damage is occurring and how it's impacting the local communities. This enables decision makers and emergency workers involved to act faster and more appropriately against the flooding problems. The review of 231 papers published on this topic highlights that social media has been used for different purposes during the disasters such as understanding the sentiments of the public, highlighting main public concerns, determining the locations of events and more. The outcome of this work provides a better understanding of real-time flood impacts within communities for the decision-makers in North Dakota.

Name: Sai Sri Sravya Vishnumolakala, Ph.D. Student

Title: Utilizing remote-controlled drip irrigation for high tunnel tomato and pepper productions in North Dakota

Program: Agricultural and Biosystems Engineering, NDSU

Advisors: Xinhua Jia

Summary: This project is about setting up an automated drip irrigation system to help grow tomatoes and peppers inside and outside a high tunnel in North Dakota. Drip irrigation is a way of watering plants slowly and directly at their roots, making sure they get the right amount of water without wasting it. The system will be automated, which means it will run on its own without needing someone to turn it on or off all the time. Sensors can be used to measure how dry the soil is and adjust the watering accordingly. The goal is to make growing tomatoes and peppers easier and more efficient, especially in North Dakota's changing weather. High tunnels are like greenhouses that protect plants from the cold, wind, and other extreme conditions. With the automated drip system, the plants inside the tunnel and those outside will get just the right amount of water they need to grow strong and healthy. By using this system, farmers and gardeners will save time and effort because they won't have to water the plants by hand. It also helps save water, which is important for the environment, and ensures that the plants get the perfect amount of moisture to grow well. This project can lead to better crops, less waste, and healthier plants, helping people grow more food with less work and fewer resources.

Name: Jordan Dahle, Ph.D. Student

Title: InSAR, Repeat Photography, and GPS to Monitor Landslides in North Dakota

Program: Environmental and Conservation Sciences, NDSU

Advisors: Benjamin Laabs

Summary: Changes in climate and precipitation patterns are increasing landslide risks in North Dakota. This endangers important infrastructure. Landslides could cause damage to roads, railroads, and property. Early detection is key to preventing severe damage. Scientists are developing new tools to spot these hazards. One promising method uses remote sensing technology. It can detect small changes on the Earth surface. Satellite data has worked well in other places for tracking landslide motion. Now it is being tested in western North Dakota to track early signs of slow landslides.

Landslides that occur in North Dakota tend to begin at a slow pace. Landslides along hill slopes start with slow down-slope movements. These small shifts can build up over time until a large failure occurs. If the slow movements before the large failure can be detected, damage can be minimized.

The northern Great Plains present unique challenges. These include long periods of snow cover and dense vegetation. Research methods must be adapted to local needs. We use data from the Sentinel-1 satellite (2014-2024) to study past landslides. By studying past landslide sites, we aim to identify warning signs and understand causes. The goal is to create a reliable method to detect landslides along rivers in western North Dakota. This would aid hazard management and help leaders protect at-risk areas. By staying ahead of landslides, the state can reduce damage and promote a safer future.

Name: Dauda Mohammed, Ph.D. Student

Title: Enhanced Removal of Organic Micropollutants in Agricultural Runoff and Wastewater Effluent by Novel KrCl* Excimer Lamp (222 nm)

Program: Environmental and Conservation Sciences and Civil, Construction and Environmental Engineering

Advisors: Jiale Xu

Summary: The study investigated the removal of toxic organic micropollutants (OMPs) from agricultural runoff and wastewater effluents using a KrCl* excimer lamp (222 nm). OMPs are group of environmental contaminants that poses high risks to both human and the aquatic environment, thus making their removal from water critical. KrCl* excimer lamp has shown promise for OMP degradation in water through direct photolysis and advanced oxidation processes. This study primarily focused on understanding how background water constituents, particularly nitrate, affect OMP removal with KrCl* excimer lamp emitting at 222 nm. The study evaluated the degradation of five OMP compounds including sulfamethazole, atrazine, 2,4-dichlorophenoxyacetic acid, ibuprofen, and 4-chlorophenol in the presence of varying nitrate concentrations. Results indicated that nitrate concentrations up to 5 mg/L NO_3^--N improves

OMP degradation by 1.2 to 6 times. However, at concentrations exceeding 5 mg/L NO_3^--N, the degradation rates decreased. The enhanced degradation was attributed to the formation of reactive oxygen species, particularly hydroxyl radicals (•OH) and nitrating agents, as a result of nitrate photolysis. Radical scavenger experiments and kinetic modeling confirmed that •OH was the primary agent responsible for the transformation of OMPs.

Research Impact: This research successfully demonstrated how nitrate influences OMP removal using 222 nm UV light. The findings provide valuable insights into optimizing treatment processes for wastewater and agricultural runoff. The ability of the KrCl* excimer lamp to enhance OMP degradation, especially in the presence of nitrate, offers a cost-effective and environmentally friendly solution to reduce the impact of persistent organic pollutants in agricultural and wastewater effluents, benefiting both environmental sustainability and public health.

Name: Tiansong Qi, Ph.D. Student

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

Program: Civil, Construction and Environmental Engineering/Biological Sciences, NDSU

Advisors: Xuefeng Chu

Summary: Wetlands have important impacts on stream flow. Watershed models can be used to address such wetland impacts. Surface depressions are common in North Dakota. They make it hard to apply traditional models for this purpose. We wanted to improve the modeling methods. And we wanted to develop a new method to solve the problem. We used a surface delineation tool. We first identified unique features of wetlands and surface depressions. Then, we incorporated the information into a watershed hydrologic model. We applied our new modeling method to the Upper Turtle River watershed in North Dakota. We got better results. Using our new model, we studied the wetland impacts. We divided the natural wetlands by size into three groups. We also set up a constructed wetland case. We added ten constructed wetlands in the watershed. We used our new method to explore the impacts of the natural wetlands. We also did the same thing for the constructed wetlands. We found that smaller natural wetlands impact stream flow as well due to their larger number. We also saw that constructed wetlands could help regulate stream flow. Our study highlighted the benefits of the new method. It adopted the actual topography and wetlands. So, it avoided misestimating the wetland parameters.

Name: Christine Cornish, Ph.D. Student

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

Program: Environmental and Conservation Sciences/Biological Sciences, NDSU

Advisors: Marinus Otte and Jon Sweetman

Summary: Wetland restoration in the Prairie Pothole Region is a common management practice to facilitate habitat and ecosystem recovery after degradation or drainage. While recovery of

vegetation, fish, and invertebrates are often studied, very little is known about the recovery of sediment microorganisms, which are critical for overall ecosystem health. We collected benthic sediments from semi-permanent (discharge) natural and restored wetlands to analyze microbial communities. Restorations had occurred 26 – 33 years ago. We used 16S rRNA gene sequencing to investigate differences in microbial structure and function among natural and restored wetland groups. Water pH, conductivity, temperature, and major ions were also measured to investigate differences among wetland groups, as well as to evaluate their potential influences on microbial community composition. We found no significant differences in any microbial community metric or environmental variables among wetland groups. There were also no significant environmental influences on microbial composition. Overall, our results suggest that 26 years allows ample time for microorganisms to recover and resemble natural wetland communities. These findings could indicate that subsequent ecosystem functions may also recover within this time frame.

Name: Kyle D. Boutin, Ph.D. Student

Title: Evaluating the Impact of Constructed Wetlands at the Watershed Scale

Program: Environmental and Conservation Sciences, NDSU

Advisors: Marinus Otte

Summary: The construction of wetlands is a commonly used approach to reduce the loads of sediments and nutrients that degrade water quality, but little is known about the ability of wetlands to mitigate aquatic pollutants at the watershed scale. We used a watershed planning tool: the Prioritize, Target, and Measure Application to construct and evaluate three wetland scenarios each in three impaired watersheds in North Dakota and Minnesota. Total Nitrogen, Total Phosphorus (TP), and Sediment loads were investigated, with a focus on TP, the impairment common to all three watersheds. Scenarios were as follows: 1 large wetland at the watershed outlets, 10 wetlands placed on tributaries contributing high TP loads to watershed outlets and 100 wetlands placed on smaller-order tributaries contributing high TP loads to the watershed outlets. Our objectives were to determine the relative efficiency of each scenario and to estimate whether pollutant reduction targets could be met in these watersheds using wetlands alone. Wetland pollutant removal rates were estimated via a statistical distribution of removal rates from the literature. Results varied by watershed, with wetland efficiency being highest in Scenario "10" in the watershed with the most concentrated pollutant sources. TP load reduction goals were met under Scenario "1" in all watersheds. Results indicate that optimal wetland placement for pollutant reduction depends on the location and distribution of pollutant sources, and that it is theoretically possible to meet watershed pollutant reduction goals using constructed wetlands alone. Watershed TP reduction targets were achieved with conversion of 0.47% to 2.25% of watershed area to constructed wetlands.

Name: Bhuwan Prasad Shah, MS Student

Title: Automated irrigation for commercial production of watermelon, squash, and muskmelon cultivars in Oakes

Program: Agricultural and Biosystems Engineering, NDSU

Advisors: Xinhua Jia

Summary: This project aimed to design and test an automatic drip irrigation system for growing watermelon, muskmelon, and winter squash in North Dakota. The system was remote-controlled and used soil moisture sensors to determine when and how much to water. Over two years, the project studied different watering schedules and how they affected the yield and quality of the crops. The results showed that different irrigation methods did not significantly change crop yield or quality. This suggests that water usage can be reduced without negatively impacting the crops, which is important for saving water in regions with limited water resources. The project helps farmers manage water more efficiently while maintaining good crop production, which can lead to better farming practices and increased crop viability in areas with short growing seasons.

Name: Xiaomo Zhang, MS Student

Title: Developing Machine Learning and Deep Learning Soil Moisture Models for Precision Agricultural Applications

Program: Natural Resources Management, NDSU

Advisors: Zhulu Lin & Xin (Rex) Sun

Summary: This project focuses on predicting soil moisture to optimize the timing and amount of irrigation using machine learning models. We developed multilinear regression, support vector machine, and Gaussian process regression models using meteorological, soil physical properties, location, time, and remote sensing data from 29 North Dakota Agricultural Weather Network stations located in the Red River Valley of the North and the surrounding area. Our findings showed that the Gaussian process regression outperformed the other machine learning models and all machine learning models worked better in predicting soil moisture in the deeper soils (20-100 cm) compared to the surface soils (0-10 cm). By providing more accurate soil moisture predictions, this research will help farmers improve irrigation water management through the application of smart agriculture technology.

Name: Berkay Koyuncu, Ph.D. Student

Title: Cross-stream shear stress distribution in ice-covered

Program: Civil, Construction and Environmental Engineering, NDSU

Advisors: Trung Bao Le

Summary: In northern hemisphere, rivers begin to freeze as early as November due to significant drops in winter temperatures. Ice cover alters flow dynamics, affecting factors such as flow velocity, and secondary flow patterns (flow movement perpendicular to the main flow direction) in rivers. This project aims to investigate the impacts of the ice cover on depth-averaged velocity profile. We propose a theoretical method based on the Shiono and Knight Model (SKM) for estimating flow velocity with minimal field data collection. The proposed theoretical model is then validated with numerical simulations and field measurement data. Fieldwork was conducted in the fall and winter in 2020, 2021, 2022, and 2023 on the Red River of the North (Lindenwood Park) in Fargo, ND. Field campaigns were carried out to measure bathymetry and velocity profiles to provide validation data for theoretical models. Our results

show that our theoretical model is capable of calculating depth-averaged profiles based on depth and soil type under ice-covered conditions. Both the field data and the proposed model show similar velocity profiles beneath the ice, validating the approach for ice-covered flows. Our numerical simulations are able to capture secondary flow patterns, which were derived by the ice cover. Instead of a single and dominating circulation from bank to bank commonly seen under the open-surface condition, double and smaller circulations at multiple locations are visible under the ice cover. Our results suggest that these secondary vortices might relate to lateral sediment movement towards river banks. This implies a significant difference between ice-covered and open-surface condition in terms of sediment transport. Our results reveal the importance of large-scale flow structures that cannot be fully captured through field surveys alone. Our model contributes to a significant improvement in the understanding of river ice dynamics during winter. This improvement is crucial for addressing ice-related challenges such as ice jams and ice dams, which might help managing floods and mitigating erosion risks in early spring.

Name: Rehnuma Mobin Maisha, Ph.D. Student

Title: Building NRCS Technical Capacity in Irrigation Water Management for Variable Rate Irrigation

Program: Agricultural and Biosystems Engineering, NDSU

Advisors: Dean D. Steele

Summary: Increasing population and climate variability are pressuring freshwater resources. Agriculture consumes more than 60% of water, now diverted towards domestic and industrial use. There is a need to conserve water resources, and variable-rate irrigation can help maintain efficient water use. Optimization of irrigation water using advanced technologies can increase irrigation water use efficiency. In this study, we installed six different sensors on three field sites located in southeastern North Dakota. The sensors include CropX, AquaSpy, FieldNet with Watermark, AquaTrac Pro with Watermark, AquaTrac Lite with Sentek, andAcclima TDR-310H. Each site consists of one main station and four secondary stations. We installed the sensors with their telemetry systems in the main station and the Acclima sensor in the secondary stations. We collected soil moisture data for the 2021, 2022, and 2023 growing seasons. We have calibrated the Acclima sensor, and we will use the calibrated Acclima to compare the other sensors. The findings of this study will provide valuable insights into the effectiveness of soil moisture monitoring solutions under field conditions.

Name: Md Ashif Islam Oni, Ph.D. Student

Title: Towards a Low-cost, Pervasive Metasurface-based Dielectric Resonator Wireless Soil Salinity and Moisture Sensing System for Precision Agriculture

Program: Electrical and Computer Engineering, NDSU

Advisors: Shuvashis Dey

Summary: This project helps farmers check the water and salt levels in their soil. Both of these are important for growing healthy crops. If there is too much salt, plants can’t take in the water

they need, which makes it hard for them to grow. It is helpful for farmers to know how much water is in the soil so they can decide when to water their crops. This way, they don't waste water and can keep their plants healthy.

The project's goal is to make a sensor that is cheap and easy to use. The sensor will be placed in the soil and measure the water and salt levels. It will send this information wirelessly to a computer or phone, so farmers can see what is happening with their soil right away. This helps them decide when and how much to water.

After testing in the lab, the sensor will be used on real farms to see how well it works in different types of soil. The goal is for farmers to use this tool to grow more crops, save water, and take better care of the environment.

Name: Adewale Ajao, Ph.D. Student

Title: Sustainable Management of Dams and Reservoirs in North Dakota: Sediment Transport Characterization

Program: Civil and Environmental Engineering, UND

Advisors: Yeo Howe Lim

Summary: Many of the large reservoirs in the US, designed for 150–200 years have had their lifetime reduced by 50–100 years due to sedimentation. The need arises to perform a comprehensive sedimentation survey of reservoirs and dams in North Dakota to enable us to determine the state of the reservoirs, amount of sediments, geometry change, water storage capacity, and many other factors that could hinder their functionality. Larimore dam in the state of North Dakota was surveyed to assess its storage capacity, sedimentation characteristics, and potential for leakages. The purpose of the study was to understand the dynamics of reservoir sedimentation in North Dakota and its effect on resiliency and sustainability. The HYCAT, which is an autonomous surface vehicle, was interfaced with a side scan sonar and global positioning system. The side scan sonar soundings at a determined frequency were used to measure reservoir bed level and deposited sediments while the positioning system provided information along the grid lines. This bathymetry data was compared to previous survey data from reliable databases to evaluate storage capacity and storage loss or gain over the years.

Name: Mousa Almousa, Ph.D. Student

Title: Salts Removal as an Effective and Economical Method of Bakken Formation Treatment

Program: Civil and Environmental Engineering, UND

Advisors: Yeo Howe Lim

Summary: In the Bakken oilfield of North Dakota, we find a lot of water mixed with salt deep underground, which comes out during oil and gas production. This water has more salt than seawater and needs careful handling to protect the environment and our health. Our project looked at the best ways to clean this salty water so it can be reused for things like farming, drinking after further treatment, or helping with oil drilling, which can save money and reduce harm to the environment.

We tested different methods using simple substances like lime and baking soda to remove unwanted metals and salts from the water. These cleaned-up salts can also help clean other wastewaters by taking out harmful substances, making them safer to return to rivers and lakes.

By finding ways to reuse this salty water and recover valuable materials from it, our work helps make oil production more eco-friendly. It reduces the need for fresh water in oil drilling and supports recycling efforts, which is good for our planet and can also help oil companies save money.

Name: Fangtian Li, Ph.D. Student

Title: Data mining of hybrid processes for microplastics treatments in wastewater and landfill leachate

Program: Chemical Engineering, UND

Advisors: Yun Ji

Summary: The gasification process can recover energy from biosolids produced in wastewater treatment. This project developed a stoichiometric thermodynamic equilibrium model for biosolid gasification based on the biosolid properties, thermodynamic database, and equilibrium constants. If the calculation result showed that the quantity of char was negative, the quantity of char was put to zero, and the simulation was carried out again. The model was first verified by woody gasification under isothermal conditions, and the influence of a given temperature on biosolid gasification was simulated. The model further investigated the effects of different feedstock types, moisture contents, equivalence ratios, and reaction extensions on the adiabatic temperature, exergy efficiency, and syngas properties under autothermal conditions. The four factors were all the main factors for adiabatic temperature. The exergy efficiency depended more on the operation conditions than on the feedstock type. The H2 concentration of the dry syngas in biosolid gasification exhibited a curve both against the given temperature under isothermal conditions and against the moisture content under autothermal conditions.

Name: Michael Rosati

Title: Determination of Water Quality Parameters in Small Waterbodies using UAV Hyperspectral Remote Sensing

Program: Civil and Environmental Engineering, UND

Advisors: Yeo Howe Lim

Summary: This project focuses on improving water quality monitoring in the Red River basin, a region affected by agricultural runoff. Nutrients such as nitrates and phosphates from field runoff contribute to water impairment and can lead to harmful algal blooms. When field data is unavailable or there are gaps in the data for various reasons, remote sensing and machine learning provide an alternative for monitoring water quality.

To address this, the project utilizes hyperspectral data and a random forest machine learning model to estimate nutrient concentrations. The model is trained on the GLORIA (Global River Water Quality Archive) dataset and fine-tuned using historical water quality data and collected

ground truths. This approach offers a novel method to estimate nutrient concentrations without the need for manual sampling, providing higher spatial resolution and faster data collection than traditional techniques.

Name: Isra Awad Omer Elsamani, Ph.D. Student

Title: Wastewater Evaporation Mechanism and System Dynamics Model

Program: Chemical Engineering, UND

Advisors: Yun Ji

Summary: Microplastics (MPs) are plastic particles less than 5 mm and become a good carrier and vectors for contaminants in the environment. Current wastewater treatment technologies, including preliminary treatment, primary treatment, secondary treatment, and tertiary treatment, have a certain removal efficiency for MPs or nano-scale plastic particles. The settling treatment is employed in several wastewater treatment processes. This work built a settling model based on Reynolds number, drag coefficient and settling mechanism to predict the microplastics removal efficiency. Microplastics with larger density deference with wastewater, larger size, and CSF is closer to 1 are easily captured and have a higher removal efficiency. The calculated removal efficiency according to density, size distribution, different shape, and the surface loading rate in the operation of wastewater treatment is in a reasonable removal efficiency range. The removal efficiency increases when the surface loading rate decreases. The settling model was developed based on Reynolds number, drag coefficient and settling mechanism to predict the microplastics removal efficiency. The calculated removal efficiency according to density, size distribution, different shape, and the surface loading rate in the operation of wastewater treatment is in a reasonable removal efficiency range. The removal efficiency increases when the surface loading rate decreases.

Name: Julia Hampton, MS Student

Title: Detecting Scale-Specific Changes in Wetland Water Quality and Ecological Communities

Program: Biology, UND

Advisors: Mark Kaemingk

Summary: North Dakota has many types of waterbodies, from small ponds or wetlands to big lakes. Climate and human activities, like farming, affect water availability and what kinds of animals and plants live there. When water levels go down, it can make ponds smaller and reduce the space for plants and animals to live. When water levels go up, it can make ponds bigger and create more space for diverse animals. We explored relationships between waterbody size and aquatic communities. We used images taken from airplanes to measure the size of waterbodies. We paired those size measurements with measurements of water quality, water insects, fishes and birds collected from the United States Geological Survey. We found important thresholds along a waterbody size gradient to determine specific waterbody size categories (i.e., small, large, etc.). We then determined if there were differences in the quality of the water or the types of animals found in each size category. We found that small waterbodies had unique animals compared to large waterbodies. Our next goal was to evaluate changes in aquatic communities

during high and low water level years over 11-years. We found that a large ecosystem change occurred between high- and low- water years, which is called a regime shift. This project helped us understand how aquatic wetlands respond to changes in water levels.

Peer Reviewed Publications and Conference Proceedings:

Almousa, M., Lim, Y.H., & Tomomewo, O.S. (2024). Selective recovery and recycling of lithium from produced water Bakken oilfield in North Dakota. ASCE Wrold Environmental and Water Resources Congress 2024. May 16, 2024.

Almousa, M., Olusegun, T.S., Lim, Y.H., Khraisat, I., & Ajao, A. (2023). Groundwater management strategies for handling produced water generated prior injection operations in the Bakken oilfield. International Geomechanics Symposium, Al Khobar, Saudi Arabia, October 2023. Paper Number: ARMA-IGS-2023-0048. Cornish, C. M., Johnson, O. F., Bansal, S., Meier, J. A., Harris, T. D., & Sweetman, J. N. (2024). Common use herbicides increase wetland greenhouse gas emissions. *Science of The Total Environment*, 933, 172881.

Cornish C.M. and Sweetman J.N. (2023) A perspective on how glyphosate and 2,4-D in wetlands may impact climate change. *Frontiers in Environmental*, 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, 2949-2985.

Koyuncu, B., Akerkouch, L., & Le, T. (2024). On the depth-averaged models of ice-covered flows. *Environmental Fluid Mechanics.* Https://doi.org/10.1007/s10652-024-10003-3.

Le, T.B., & Koyuncu, B. (2024). Three-dimensional structures of ice-covered flow in a river bend. In River Flow 2022, edited by da Silva, S.M.F., Rennie, C., Gaskin, S., Lacey, J., & MacVicar, B. CRC Press. London, UK.

Li, F., Zhang, X., & Ji, Y. (2024). Settling model to predict microplastics removal efficiency in wastewater treatments. *Environmental Progress & Sustainable Energy.* 2024; e14506

Li, F., Zhang, X., & Ji, Y. (2024). Biosolid gasification performance prediction using a stoichiometric thermodynamic model, *ACS omega*, 9(30), 32639-32650.

Shah, B. P., Vaddevolu, U. B. P., Jia, X., Hatterman-Valenti, H., & Scherer, T. F. (2023). Yield Responses of Watermelon, Muskmelon, and Squash to Different Irrigation Treatments in a Mulched Sandy Soil. In 2023 ASABE Annual International Meeting, American Society of Agricultural and Biological Engineers.

Torres, B.A., Ramirez, D.R.S., Chacon, J.P.C., Rodriguez, G.M., Alegriz, L.R.P., & DeSutter, T.M. (2023). An alternative method to measure electrical conductivity (EC) and sodium adsorption ratio (SAR) in salt-affected soil extracts. *Front. Environ. Sci*. 11-2023.

Zhang, X., Lin, Z., & Sun, X. R. (2023). Developing Machine Learning and Deep Learning Soil Moisture Models for Precision Agricultural Applications. In 2023 ASABE Annual International Meeting (p. 1). American Society of Agricultural and Biological Engineers.

Future Research Priority

Emerging contaminants like PFAS and infrastructure projects like the Fargo-Moorhead Flood Diversion are the two key focus areas, addressing persistent pollutants and flood risk management to safeguard communities and water quality.

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