North Dakota Water Resources Research Institute (NDWRRI)

2022-2023 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

NDWRRI's research encompasses planning and conducting comprehensive studies to foster the entry of new scientists into the water resources field, train future professionals, explore new ideas addressing water problems, and understand water-related phenomena. It collaborates closely with academic institutions and organizations to develop programs targeting state and regional water and land problems, aiming for a broad impact on water management, sustainability, and policy development. This initiative ensures the dissemination of research results to both water managers and the public, promoting informed decision-making and effective water resource management.

Technology and Information Transfer

NDWRRI emphasizes technology and information transfer by disseminating research findings to water managers and the general public. This involves sharing the latest developments and innovations in water resource management through various channels, including social media, publications, seminars, and workshops. The goal is to ensure that the most current water management strategies and research outcomes are accessible to those who can apply them practically, thereby enhancing water resource sustainability and addressing water-related challenges effectively.

Education

NDWRRI's educational mission includes fostering new research scientists in the water resources field and training future water resources scientists, engineers, and technicians. This is achieved

through planning and conducting research, as well as by arranging educational opportunities that prepare students for careers in water management and research. The institute aims to enhance the understanding of water and water-related phenomena, contributing to the development of knowledgeable professionals ready to address water challenges. A new Water Resources Certificate Program has been developed and would begin in fall 2024.

Projects funded in 2022-2023

The NDWRRI has awarded nine projects for 2022-2023 Graduate Research Fellowship program. The fellowships with the funding from the USGS 104b and ND Department of Water Resources ranged from $3,000 to $17,304 and were for 5 doctoral and 4 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: Biraj Saha, Ph.D. student
Title: Per and polyfluoroalkyl substances removal from landfill leachate by coagulation
Program: Civil, Construction and Environmental Engineering, NDSU
Advisor: Syeed Md Iskander
Summary: In North Dakota, per and polyfluoroalkyl substances (PFAS) have become a significant environmental concern, particularly around military sites. This is due to practices like fire drilling and the storage and release of hazardous chemicals, which have led to PFAS contamination in groundwater—a crucial drinking water source for over half the state's population. The presence of PFAS in drinking water raises serious health concerns. The North Dakota Department of Environmental Quality has detected PFAS in various regions' drinking water, leachate, and wastewater. The U.S. Environmental Protection Agency acknowledges the enduring nature of many PFAS compounds in the environment and their potential health risks, including high blood pressure, pregnancy complications, reduced vaccine effectiveness, and certain cancers—a stance supported by North Dakota authorities. This study explores the challenging task of removing PFAS from landfill leachate, a significant environmental source of these pollutants. We examined the effectiveness of coagulation treatments using Ferric Chloride, Alum, and Polyaluminum Chloride to separate PFAS from leachate. Our investigation focused on various factors, such as initial pH, chemical oxygen demand, coagulant dosage, reaction time, and the chemical properties of PFAS. While thermal treatment at high temperatures can eliminate some PFAS from settled sludge, coagulation alone may not be sufficient for effective PFAS removal from leachate, highlighting the complexity of addressing PFAS contamination in landfill leachate.

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

Name: Fafa Tackie-Otoo, M.S. student
Title: Treatment and reuse of produced water through the measurement and elimination of coagulated petrochemicals/hydrocarbons in inorganic and organic aqueous solutions
Program: Mechanical Engineering, UND
Advisor: Hallie Boyer Chelmo
Summary: 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 micro-droplets 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.

Name: Himani Yadav, Ph.D. Student
Title: Landfill leachate plastics: occurrence, transformation, fate, and environmental implications
Program: Civil, Construction and Environmental Engineering, NDSU
Advisor: Syeed Md Iskander
Summary: 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.

Name: Malachi Graupman, M.S. student
Title: Environment friendly phosphate removal and recovery from surface and agricultural waters
Program: Civil, Construction and Environmental Engineering, NDSU
Advisor: Achintya Bezbaruah
Summary: 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.

Name: Mosammat Mustari Khanaum, Ph.D. student
Title: Assessing the role of wetlands in reducing sediment and nutrient loads from an impaired watershed in North Dakota
Program: Environmental and Conservation Sciences and Civil, Construction and Environmental Engineering, NDSU
Advisors: Xuefeng Chu and Marinus Otte
Summary: Wetlands are important because they help regulate water flow and improve water quality. However, in North Dakota, we have been losing wetlands due to farming and other human activities, which affects the environment and the health of ecosystems. To make things better, we studied one of the 303(d) listed impaired watersheds - Upper Turtle River watershed in North Dakota. We wanted to see if bringing back the lost wetlands in that area would help clean the water and control water flow. To do this, we used a model called the Soil Water Assessment Tool (SWAT) and proposed a new method to recreate land use as it used to be with many wetlands. When we brought the wetlands back, we noticed that they could help in reducing water flow on lands and in channels, which further minimizes the risk of flooding. Also, wetlands help naturally filter out excess agricultural nutrients and hence protect our water resources from pollution. So, by restoring wetlands, we can improve the water quality in polluted watersheds.

We also found that our new method for processing land use data is useful when studying wetland restoration as it helps improve the modeling results. So, we suggest bringing back more wetlands to reduce flood risks and keep our water clean.

Name: Nadhem Ismail, Ph.D. student
Title: Synthesis and performance evaluation of novel carboxyl-based grafted polyacrylamide fibers for ions removal from produced water (PW)
Program: Chemical Engineering, UND
Advisor: Ali Alshami
Summary: Water is essential in North Dakota's oil and gas industry, primarily for hydraulic fracturing, which creates high volumes of Produced Water (PW). Reported 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 begins by chemical analysis of real field PW samples, followed by a guided synthesis of formulations based on the inferred treatment requirements. We have procured eight (8) PW samples from different wells within the Williston Basin. All samples were analyzed using ICP-OES for ion concentrations, followed by a thorough analysis to determine total alkalinity, hardness, inorganic carbon, organic carbon, turbidity, and conductivity. 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. Scaling (hard minerals precipitation) predictions through thermodynamic calculations revealed that carbonate, and sulfate minerals are at high risk. This directed our formulation development to target those 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.

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
Advisor: Dean 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, and Acclima 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: Whitney Sauskojus, M.S. student
Title: Aquatic macroinvertebrates as indicators of restoration success in Prairie Pothole Region wetlands
Program: Environmental and Conservation Sciences and Biological Sciences, NDSU
Advisors: Marinus Otte and Jon Sweetman
Summary: The Prairie Pothole Region is a landscape scattered with thousands of depressional wetlands called "potholes". These wetlands are home to a variety of wildlife including waterfowl, other birds, and amphibians, and also provide various ecosystem services such as flood protection and the improvement of water quality. Due to the public's knowledge of their importance growing over recent decades, there has been an increase in wetland restoration. The goal of wetland restoration is to return function to that similar of their previous state, as if they were never destroyed or altered in the first place. With this increase, we require a tool to make sure we're restoring the wetlands correctly and efficiently as possible. With this research, we are investigating if aquatic macroinvertebrates (macro = large enough to see with the naked eye, invertebrates = animals without a backbone) can be used as an indicator of restoration condition. Overall, this will help the people who manage and monitor restored wetlands by providing more information on if the restorations are successful, and therefore how they go about restoring wetlands.

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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