ILLINOIS GROUNDWATER ASSOCIATION

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Hybrid Fall Meeting: November 19, 2021

In-person at Southern Illinois University Student Center

https://studentcenter.siu.edu/

and Virtual via Zoom

Program Speakers/Topics:

8:30 AM — Early check in (online and in-person)

9:00 AM — **Chris Greer, IGA Chair** — Opening Remarks

9:15 AM — **Alyssa Graveline, NIU MSc Student** – “Transport of Polyethylene Microplastic Spheres in a Sandy Aquifer”

9:45 AM — **David R. Steward, PhD, PE, PG, F.ASCE** – “Exploring Hydrogeologic Interactions using The Analytic Element Method and a Nearly Exact, Open-Source Framework”

10:45 AM — *Break*

11:00 AM — **Abigail Heath, MSc, Ph.D. Candidate** – “Natural Nitrate Removal in Shallow Subsurface Stream Flows.”

11:30 AM — **Scott D. Hamilton-Brehm, Ph.D.** – “The Mysterious World of Groundwater Microbiomes: Exploring Their Unique Traits and Newfound Efficacy In Helping Sequester Carbon from Our Atmosphere and Avert Global Climate Change.”

12:15 PM — **Joseph Krienert, MSc —** “Touring the Henry Aquifers Formation and Future in Gallatin County, Illinois”

12:30 PM — **Chris Greer, IGA Chair** — 2022 Election Results and Closing Discussions

12:45 PM — Meeting Adjourned

12:45 PM — *Lunch*

1:15 PM — Depart SIUC for Field Trip

4:30 PM — *Estimated End of Field Trip*

Transport of Polyethylene Microplastic Spheres in a Sandy Aquifer

Alyssa Graveline, M.S.
Department of Geology and Environmental Geosciences
Northern Illinois University, 2021
Melissa Lenczewski, Director

Microplastic particles are currently listed as a Contaminant of Emerging Concern (CEC) since they have infiltrated much of Earth's natural water systems, and recent inquiry probes indicate plastic particles can carry toxic contaminants. Microplastics (MP) are defined as plastic particles under 5 mm in length and have been found in worldwide surface waters as well as some groundwater sources. Currently, there is a paucity of data on the transport of MPs in the subsurface. This study investigated the transport, filtration, retardation, and influence of transporting 5-100um plastic polyethylene (PE) spheres in a shallow sandy aquifer over the short distance of 1m by utilizing two forced gradient tracer studies with hydraulic conductivity testing prior and subsequently. Results show that: (i) PE microplastic spheres travel with major losses due to filtration in aquifer material and longer experiment run time could improve transport results; (ii) PE microsphere transport is delayed compared to the conservative solute; (iii) smaller PE spheres had higher success rate of transport; and (iv) the local hydraulic conductivity has potential to vary after PE injection. These results demonstrate the necessity for more extensive research investigating the many parameters of MP transport in the subsurface.

Exploring Hydrogeologic Interactions using The Analytic Element Method and a Nearly Exact, Open-Source Framework

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This presentation is focused on hydrogeologic problems that occur across the Illinois, central plains landscape, and understanding that becomes evident through modeling investigations. A novel methodology is presented to study hydrogeologic interactions across interfaces and boundaries of both aquifer and soil features with nearly exact computational precision. Examples illustrate typical flow problems, including: groundwater/surface water interactions both in terrestrial recharge and through streambeds, heterogeneous flow through soils and aquifers features with different hydraulic conductivity, and interactions of wells.

This formulation is developed through use of a parsimonious representation of a modeling domain, by discretizing hydrogeologic features, each with its own geometry and mathematical representation, following Steward (2020), "Analytic Element Method: Complex Interactions of Boundaries and Interfaces". Examples provide solutions illustrating that the interface and boundary conditions are met with nearly exact precision for both saturated groundwater and the unsaturated vadose zone. Open-source solutions are illustrated (*available at the Oxford University Press companion site*) to a wide range of hydrogeological problems, and they also have related interdisciplinary applications in problems for electrical conduction, wave propagation, and elastic deformation.

Natural Nitrate Removal in Shallow Subsurface Stream Flows

Abigail Heath, MS, PhD candidate, aheath1@mines.edu
Colorado School of Mines and Technology
Formerly at Illinois State University

As agricultural growth increases across the planet, more anthropogenic nitrate from fertilizers and sewage effluent is contributed to the aquatic system, exacerbating both ecosystem- and human-health issues. Nitrate is naturally processed and removed within the environment, and those processes have been observed in a segment of substrata and porewater below streams called the hyporheic zone (HZ). The interaction of stream water with groundwater can promote denitrification; however, the rate of nitrate removal within the HZ is unknown. This study determined the extent of surface water-groundwater interactions in a HZ and assessed the nitrate removal in this zone via monthly sampling of three wells inserted along the length of T3, a stream located in the agriculturally dominated, Central Illinois landscape. Samples were taken from 10, 20, 30, and 50 cm below the streambed, the stream, and a groundwater well from spring to fall of one year to assess the full mixing patterns and nitrate contributions of the landscape to the stream system. The chemical composition of the stream water, groundwater, and HZ waters were analyzed using an Ion Chromatograph and applied in a mixing-model.

Results show that stream water and groundwater contribute proportionally inverting amounts to water flow through the depth of the HZ. The conservative ion chloride is a chemical indicator of mixing in waters, and in the studied HZ, chloride concentrations were 48.8% higher in surface water than groundwater, and a gradient of change between these two endmembers was observed along depth throughout the HZ. Decreasing nitrate as nitrogen (NO_3-N) levels along depth can be positively correlated to this gradient of mixing in the HZ. This relationship supports that the mixing of surface water and groundwater that occurs along the depth of the HZ thoroughly circulates surface water and removes its excess nitrate. A better understanding of how different water sources contribute to the HZ and how that water flows through this zone will better equip regulators and remediators to use streams and their hyporheic zones to remove excess nitrate from agricultural runoff, contributing to healthier ecosystems and drinking water.

The Mysterious World of Groundwater Microbiomes: Exploring Their Unique Traits and Newfound Efficacy In Helping Sequester Carbon from Our Atmosphere and Avert Global Climate Change.

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Microorganisms dominate all aspects of the earth, from heralding the emergence of life to managing all major biogeochemical cycles on this planet. Paradoxically the smallest lifeform has caused the most profound changes. Our knowledge of microorganisms is surface-centric, which provides a myopic view of the microbial world since most microorganisms reside deep underground. The vast majority of subsurface microorganisms remain unexplored and uncharacterized, the latest knowledge obtained largely via cultivation-independent techniques that rely on sequencing and screening of the 16S rRNA gene. Deep subsurface (>500 meters) geochemical properties are typically characterized by very stable anaerobic, nutrient limited, high pressure, and alkali environments, with varying geothermal gradients. Many subsurface microorganisms are polyextremophilic, meaning they manage life's biochemistry under one or more of these extreme conditions. Microorganisms from deep ground water systems are increasingly sought for research, though a major restriction is consistent access to the subsurface. The scientific hints that have been obtained reveal complex untapped potential for industrial, medical, and remediation applications.

Ground water samples from Southern Nevada, South Africa, and Southern Illinois have yielded success in isolating, sequencing, and culturing unique subsurface microorganisms. Unconventional water sample collection and culturing techniques may have greatly enhanced the success of culturing these new species of microorganisms all of which have thus far been novel to science. Their genomes possessed unique features not common to surface microorganisms. Interestingly, subsurface microbial communities, reveal a robust capacity to adjust their community structure within a sediment matrix in response to challenging or toxic carbon and energy sources.

Complex carbon streams, such as those generated by Oxidative Hydrothermal Dissolution, which can convert any biomass into a variety of water-soluble carbon molecules, are biologically amenable to be consumed by subsurface microbial communities. Enlisting unique subsurface microorganisms to metabolize complex carbon streams may be a solution to safely store carbon as a counter carbon flux to anthropogenic carbon emissions.

Touring the Henry Aquifers Formation and Future in Gallatin County, Illinois

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The Henry Aquifer is a galciofluvial sand and gravel deposit that fills many of the paleo river carved valleys of Southeastern Illinois. This groundwater system has become an important reservoir for potable and agricultural use, despite the looming risk of contamination from neglectfully stored coal waste nearby. This presentation uncovers the aquifers formation and future use with a fascinating story of a regions thirst for sustainable groundwater. Following the presentation, interested members are welcomed to join a caravan tour of the scenery and services associated with the Henry Aquifer in Gallatin County, Illinois.