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The Water bLog

a newsletter of the

Utah Center for Water Resources Research

at Utah State University

Welcome!

The Water bLog is the semi-annual newsletter of the Utah Center for Water Resources Research (UCWRR), housed at the Utah Water Research Laboratory. The center supports the development of applied research related to water resources problems in Utah and promotes instructional programs that will further the training of water resource scientists and engineers. Each issue of The Water bLog reports on a small selection of the current or recently completed research projects conducted at the center. More information is available online at:

http://uwrl.usu.edu/partnerships/ucwrr

INSIDE:

UtahStateUniversity

Message from the Director

Mac McKee, Director

Water doesn't just run through our lives, it interacts in myriad ways, receiving and releasing, eroding and extending, impeding and empowering.

At the UCWRR we work every day to better understand water's many interactions and find solutions to difficult environmental and social challenges. The more we understand about the processes involved, the more we can improve our interactions with this critical natural resource. This issue of the Water bLog highlights two current projects that explore some of the ways surface water and groundwater interact. The first looks at the biogeochemical processes that govern the release of arsenic to groundwater from natural geologic formations. The second explores ways to better forecast water availability in the Sevier River Basin, while maximizing agricultural and other benefits and minimizing resulting soil and water salinity.

These projects represent only a small fraction of the active research ongoing at the UCWRR that are finding practical solutions to natural resources challenges throughout the state. ■

RESEARCH HIGHLIGHT

Release of Arsenic from Aquifer Solids

UCWRR researchers are gaining an improved understanding of the biogeochemistry governing the behavior of arsenic in subsurface environments undergoing reducing conditions that may lead to groundwater contamination.

Groundwater is a common source of agricultural and urban water worldwide. However, in many locations, the natural geologic formations and conditions in and around these groundwater aquifers can lead to elevated and sometimes toxic levels of arsenic in the water. Arsenic is a known cancer causing agent, but it is also one of the most frequently detected individual contaminants in domestic private wells used for household drinking water and public water supplies in the U.S. In fact, 10% of the domestic wells tested in basin-

Xianyu Meng and Joan E. McLean assessing a sediment core sample in Cache Valley, UT

fill aquifers of California, Nevada, Utah, Arizona, and New Mexico had arsenic in excess of the drinking water limit (10 µg/L). The Utah Geologic Survey found elevated concentrations of arsenic in well water in Salt Lake and Utah counties, with 17% of the well water in Cache County, Utah containing levels of arsenic that exceeded the drinking water limit.

Many geologic formations in Utah contain arsenic, but are stable and pose no threat to humans or the environment. In other locations, arsenic is released to groundwater resources, but the processes leading to this release are not well understood.

Research

UCWRR researcher Joan McLean and her graduate students are investigating conditions that lead to arsenic release to groundwater at a sampling location in the Cache Valley Basin.

- Sediment cores (6 m in depth) were collected from a site in the center of the Cache Valley basin-fill aquifer.
- Samples from the soil surface to the depth of groundwater were analyzed using chemical extraction and molecular-scale high-energy x-ray absorption spectroscopy.
- A conceptual model was developed to identify the sources and sinks of arsenic down the profile and the biogeochemical processes that controls the solubility of arsenic.

Results showed that arsenic is deposited on the soil surface as primary and secondary arsenic minerals derived from volcanic rock in the surrounding mountains.

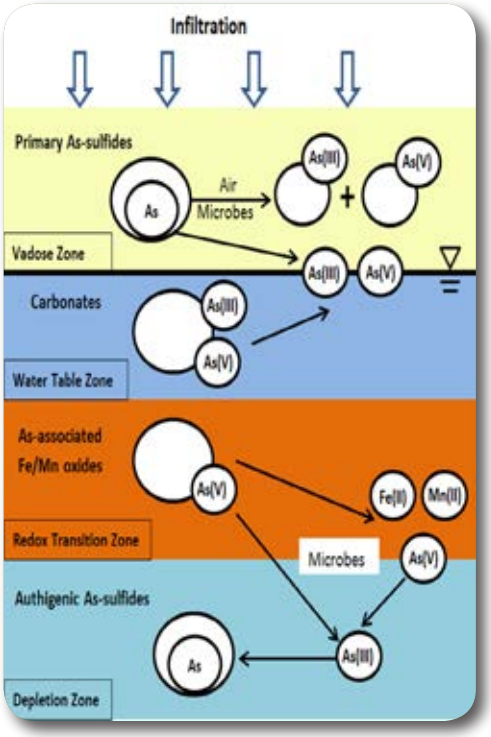
- Arsenic is released to solution when these reduced minerals are oxidized and solubilized under near surface soil conditions.
- This arsenic is transported down the profile or is retained by iron oxide and carbonate minerals in the water table zone.
- Under highly reducing conditions, arsenic is again retained by insoluble minerals deep in the profile.

Abundant carbonate minerals are characteristic of semi-arid and arid environments. With a rising and lowering water table, the sequestered mineral phase arsenic may be released to the groundwater as the carbonates and iron oxides dissolve under water-inundated conditions. This zone has the highest potential to release arsenic to groundwater.

Understanding and controlling this critical zone would prevent arsenic release to the groundwater.

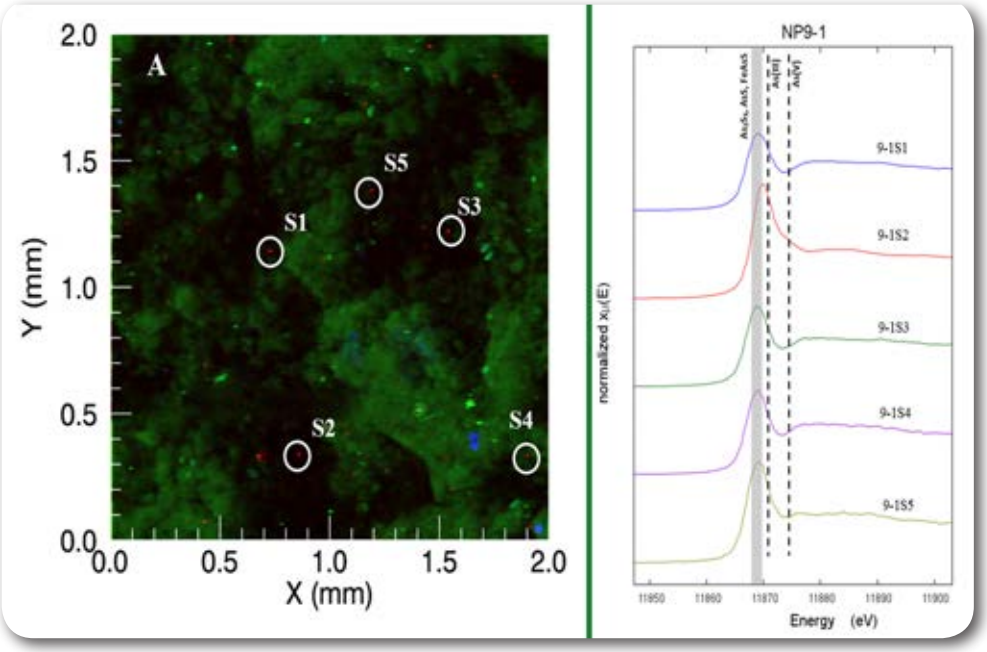
Benefits to the State

Arsenic contamination in groundwater is a worldwide problem, and Utah is no exception. The results of this project will:



Conceptual model showing the processes controlling arsenic solubility for a sediment core from the Cache Valley basin-fill aquifer.

- Improve our understanding of the biogeochemistry governing the behavior of arsenic in subsurface environments undergoing reducing conditions.
- Contribute to protection of groundwater resources throughout Utah.



µX-ray fluorescence map of surface soil for arsenics (red), iron (green), and manganese (blue). Circled regions represent the area where µ-XANES spectra were collected (A), and µXANES spectra show that the surface soil contain arsenic sulfide minerals (B)

Looking to the Future

This research will continue to investigate the biogeochemical factors that lead to the release of arsenic to groundwater from native geologic materials, in particular the role of carbonate minerals. These investigations include developing more sensitive molecular tools to identify the microbial communities mainly responsible for arsenic mobilization in this region. ■

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RESEARCH HIGHLIGHT

Water Allocation and Salinity Impacts in the Sevier River Basin

Given the dominance of agriculture in Utah, especially in rural communities, accurate estimation of water availability based on snowfall measurements in the winter and prior year information is crucial to water managers. UCWRR researchers are developing a model that will provide those estimates, along with information for managing salinity levels in the Sevier River.

The Sevier River Basin in south central Utah covers 12.5% of Utah's land area and provides water for agricultural, domestic, and industrial uses. Much of the water in the upper basin comes from winter snowfall and spring snowmelt runoff.

Water allocation is a challenge to water managers each year because the expected spring runoff, and the amount of water available in any given growing season, is highly uncertain. Agricultural water is typically allocated during early spring based on available reservoir volumes and the anticipated runoff for the coming year, which will not actually occur until May or June.

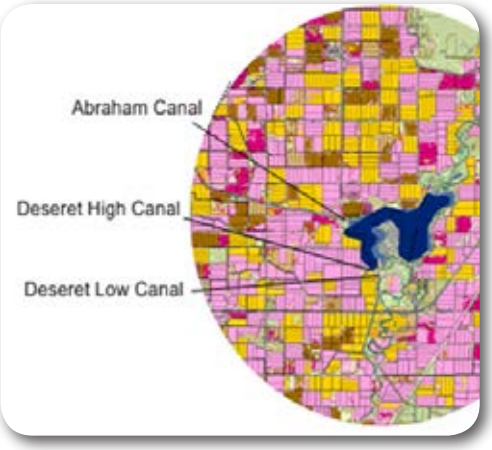
Irrigation return flows from the upper basin result in high soil salinity in the lower basin, leading to reduced crop yield. Farmers in the lower Sevier River basin currently use groundwater as an additional water source to reduce surface water salinity.

Utah's Sevier River Basin relies on spring runoff from winter snowfall to provide water for the region's agricultural, domestic, and industrials water needs

Research

UCWRR researchers are working on a three-phase project to improve water management in the basin:

- Phase 1 is developing a reliable hydrologic model to predict water availability and expected reservoir volumes using prior year information and measured snow data.
- Phase 2 is developing an efficient and low-cost approach to validate FAO's AquaCrop model using remote sensing (RS) estimates instead of crop ground measurements. This approach uses Landsat images and regional crop information to predict canopy cover (CC) and above-ground biomass (AGB) and identify the impacts of salinity on crop yield.
- Phase 3 will use the forecasted water availability to identify the optimal surface water / groundwater use that will maximize farmers' profits.



Example of agricultural crop allocation near Delta, UT

Benefits to the State

Utah's many rural agricultural communities could benefit from this research.

- Accurate estimates of water availability based on snow measurements and prior year information are crucial to Utah water managers.
- A successful model for the Sevier River Basin, with managed flows from multiple reservoirs, could be extended to benefit other locations in Utah and the United States.

Looking to the Future

Model development is well underway. Information from the first two phases will be used to evaluate the crop yield for a given water allocation, irrigation schedule, and soil and water salinity.

An optimization method will predict the optimal crop/land use combination to maximize profit and determine risk exposure due to crop price fluctuations and climatic changes. This analysis will also provide the optimal combination of surface water and groundwater to be used to maximize profit given the cost of ground water pumping and potential reduction of crop yield due to existing salinity. ■

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In the News — Agreement with Peru

Institutional representatives meet to sign the agreement in Salt Lake City

On September 12, 2014, Dr. Christine Hailey, Dean of the College of Engineering at USU, and Dr. Mac McKee, UCWRR Director, met with Harold Forsyth Mejia, Ambassador of Peru to the United States, and other officials to sign a four-year inter-institutional technical cooperation agreement that will, in part, combine the resources of the Utah Water Research Laboratory with the Peruvian National Water Authority (the Authority) to jointly design and establish an applied water research capability in Peru.

This agreement will apply the expertise of UCWRR engineers, scientists, and other professionals in research, capacity building, and training of the Authority professionals in matters such as wastewater, surface and groundwater, water treatment, water monitoring, computer testing and modeling, hydraulic engineering, hydrologic studies, and water quality research, among others.

The Authority is the highest water resources technical and regulatory authority in Peru. It aims to introduce and promote the actions necessary for sustainable use of river basin water resources as part of the integrated management of natural resources and environmental quality. ■

Future Issues

Research Highlights:

"Orthorectified Mosaics"
(Novel computer vision techniques are generating real-time orthorectified mosaic maps using images from a UAV system)

"ASR Protocol and Decision Support"
(UCWRR researchers have created a model to optimize aquifer storage and recovery in Utah)

News:

2015: Year of Water

Far Afield

The UCWRR welcomed visitors from Afghanistan, India, Nepal, and Pakistan as part of the Department of State's International Visitor Leadership Program and the Utah Council for Citizen Diplomacy. Discovery Channel even paid us a visit to film a future broadcast for Daily Planet that will feature UCWRR faculty member Blake Tullis demonstrating a 1/45 scale model of the Lake Isabella dam at the Utah Water Research Laboratory, home of the UCWRR. Our faculty have also traveled far and wide conducting and presenting their research and sharing their extensive water resources expertise.

Recent Destinations:

Bari, Italy
Basel, Switzerland
Brisbane, Australia
Cairo, Egypt
Copenhagen, Denmark
Crete, Greece
Lausanne, Switzerland
Quebec City, Canada
Spa, Belgium
Vancouver, Canada

Low barrage on the Nile River near Cairo, Egypt

Dr. Jagath J. Kaluarachchi, Senior Associate Dean of the College of Engineering at USU, and other UCWRR faculty recently collaborated with US and Egyptian government and education leaders to address the future of water management in Egypt.

Part of an NSF-funded project, the workshop addressed existing and future water-related issues facing the country. The team shared known research strategies for working with non-conventional water resources, remote sensing in irrigation water management, impacts of climate change, and transboundary issues. ■

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