Trace Element Compositions in Spring Waters in Southern Nevada: An Avenue to Train Young Hydrologists in Nevada

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Southern Nevada springs support agriculture, domestic water supplies, and wildlife, which includes a number of threatened and endangered species in the Moapa Valley National Wildlife Refuge. With the effects of climate change and rapid population growth in Nevada, understanding groundwater systems is even more critical to thoughtfully managing the state’s water resources. A key component of ensuring proper groundwater management is determining the sources and mixing pathways of the groundwater systems. “The chemistry of spring water is a product of the rock units that it has passed through since first entering the groundwater system, the order in which it passes through them, and the contact time with each unit,” explains Dr. Shichun Huang, one of the

UNLV geology students collecting water samples from Nesbitt Lake for the pilot study (photo courtesy of the project PIs).
principal investigators (PIs) of the project, which also includes co-PIs Dr. Michael Nicholl and Dr. Ganqing Jiang. “Therefore, the trace element composition of a spring acts as a ‘fingerprint,’ representing a history of water-rock reaction from precipitation to discharge.”

Because of the arid climate, spring waters in southern Nevada reflect a groundwater source area that covers hundreds of square kilometers and varies significantly in precipitation, elevation, rock properties, and other factors that affect water chemistry. Previous collaborations between Desert Research Institute (DRI) and the University of Nevada, Las Vegas (UNLV) pioneered the concept of using water chemistry to evaluate springs in southern Nevada (Johannesson et al., 1997, 1999, 2005). This project, “Trace Element Compositions in Spring Waters in Southern Nevada,” takes the processes developed in the previous studies and applies significantly more advanced technology. “This new technology will allow us to obtain improved resolution at lower costs than those previous studies, and on much smaller sample volumes,” Huang adds.

The researchers will use an inductively coupled plasma-mass spectrometer (ICP-MS) to determine the elements present in the spring water samples. Recent advancements in ICP-MS technology have also increased the number of elements that can be detected in a sample and lowered the detection limit for less common elements. “This increased resolution greatly improves our ability to ‘fingerprint’ the samples, particularly for younger springs with relatively low solute concentrations,” Nicholl explains. “Being able to characterize more elements, we expect to better characterize the springs in the valley and better constrain their sources and pathways.”

During the pilot study, the team measured 53 element compositions of 18 springs in the Moapa Valley that feed the headwaters of the Muddy River, which eventually empties into Lake Mead. Because some elements stay together as they pass through a groundwater system (correlated
elements) and others separate (uncorrelated elements), the researchers can see which springs are connected by determining the elements in the spring samples using the ICP-MS. The results from the pilot study showed that some elements were highly correlated, which suggests the springs are connected or they go through the same type of bedrock; some elements were highly correlated in most but not all of the springs; and some elements were not correlated at all, which suggests there were multiple sources for those elements. “The correlation between pairs of elements depends on many factors, including rock-water interaction, so identifying correlated and uncorrelated element pairs provides insight into the processes at work,” Jiang explains. “It also gives us a way to become familiar with the geochemical data and educate students on some basic hydrogeochemistry concepts.” Understanding these correlations provides insights into the springs’ sources and pathways, as well as the possible effects of human use on the groundwater systems. For this project, the researchers expanded the number of springs sampled to 30. The samples were collected from May to September in 2021 to assess any possible seasonal and annual climate variations that might provide further insights into the spring sources and pathways.

A main focus of this project is to provide graduate, undergraduate, and high school students with opportunities to get hands-on experience that will prepare them for water-related careers. The project supports graduate and undergraduate students from the UNLV Departments of Geoscience and Civil and Environmental Engineering and Construction, including Hyejeong Lee, Hayley Dallman, George William Kajumba, Susan Lederer, Thomas Mattison, Candice Renkiewicz, and Wildlife Refuges Specialist Dr. David Stone (center, back) gives a lecture to UNLV geology students at the Moapa Valley and Pahranagat National Wildlife Refuges (photo courtesy of the project PIs).

“The students receive basic instruction on the hydrology and geology of southern Nevada, rock-water interactions, field sampling, and ICP-MS measurement protocols. They also gain practical experience in spring sampling and measuring the elemental compositions of their own samples using the iCAP Qc ICP-MS in UNLV’s Nevada Plasma Facility Laboratory.”
– Shichun Huang
Kimberly Savage, and Christopher DeFelice. Emmett Seto and Anya Zhang, who are students at Ed W. Clark High School in Las Vegas, are also participating in the project.

The students learn about multiple phases of the study, from sample collection to data interpretation, which allows them to see how a scientific study addresses a real-world water problem. “The students receive basic instruction on the hydrology and geology of southern Nevada, rock-water interactions, field sampling, and ICP-MS measurement protocols,” Huang says. “They also gain practical experience in spring sampling and measuring the elemental compositions of their own samples using the iCAP Qc ICP-MS in UNLV’s Nevada Plasma Facility Laboratory.” The students then present their interpretations to their classmates and the PIs, which gives them the opportunity to practice presenting scientific findings. In 2022, some of the students presented their work at the Nevada Water Resources Association conference. Because this is an ongoing project, the researchers anticipate being able to provide many students with the opportunity to get this valuable experience.

The long-term goals of this project are to better understand the source area of springs in southern Nevada as well as test seasonal and annual variations in spring water. “The data we collect will help constrain groundwater pathways that need protection, identify current human-use inputs, and provide baseline information for predictive modeling of future climate change,” Nicholl says. “We also hope to use these data to better understand the timing of groundwater recharge from snowmelt under climate change conditions. This information will be useful for making policies regulating the use of water resources in Nevada.” As the project goes on, the researchers anticipate there will be opportunities to further collaborate with DRI, the Southern Nevada Water Authority, and the United States Geological Survey to address Nevada’s water concerns. “We also see this project as a way to recruit Clark County School District, Nevada State College, and College of Southern Nevada students into STEM fields by integrating multiple disciplines to address a problem of obvious regional importance,” Jiang adds.

References


Student Interview: George William Kajjumba

We asked George William Kajjumba, who worked on the NWRRRI project “Trace Element Compositions in Spring Waters in Southern Nevada” and successfully defended his PhD dissertation recently, about his current studies and plans for the future. Here’s what he had to say:

1) What field are you currently studying, and what sparked your interest in that field?

I am a civil and environmental engineer focusing on water resources. Water-related diseases are responsible for millions of deaths worldwide every year and they have claimed several people in my community in Uganda. I want to find ways to ensure the safety of water resources so that they can be a conduit for achieving good health and community sustainability.

2) What research project are you currently working on and what research are you doing?

My current research focuses on treating wastewater, retrieving essential nutrients such as phosphorus, and using the retrieved materials to support farming. In the race to promote water reuse in the face of climate change, I have been able to craft and test several materials that can treat wastewater. I have also been able to capture phosphorus from wastewater and make phosphorus fertilizers that can be used to promote food production.

3) What do you hope to learn more about from this project?

My project acts as a foundation for using emerging water-treatment materials, such as lanthanides. The project establishes the performance of emerging water coagulants, as well as their mechanisms, toxicity, and application in water reuse as we promote sustainable cities and communities.

4) What are you looking forward to most about working on this project?

Our generation is faced with 17 significant challenges, spanning from poverty and hunger to life below water and on land. Therefore, the United Nations (UN) has outlined 17 sustainable development goals (SDGs) to end hunger and other deprivations, improve community health and economic growth, and address climate change while preserving our natural resources. My project helps to achieve UNSDG 6 (clean water and sanitation), UNSDG 2 (zero hunger) by improving food production, UNSDG 1 (no poverty), UNSDG 11 (sustainable communities and cities), and UNSDGs 14 and 15 (life below water and on land).

5) What are your goals for the next steps in your studies/career?

Having successfully treated wastewater and captured nutrients from it, I plan to push my project to

“I want to find ways to ensure the safety of water resources so that they can be a conduit for achieving good health and community sustainability.”

– George William Kajjumba
the product-development phase. I will continue to work on water treatment as I capture minerals that can be reused to promote food production.

6) What is one of your favorite movies, TV shows, or books and why?

“Breaking Bad” is one of my favorite shows. The theme that ensuring family survival can bring out the good and bad in all of us is very interesting to me.

7) What is something that we might not know about you (hobbies, interests, etc.)?

I love swimming, even though I don’t know how to swim.

8) If you were shipwrecked on a deserted island, but all of your human needs (food, water, etc.) were taken care of, what would you want to have with you?

I would want to have a means of communication. A deserted island won’t be a prison if I can communicate with the rest of the world.

Postdoc Interview: Dr. Guo Yu

We asked postdoctoral fellow Dr. Guo Yu about his current research and continuing research plans. Here’s what he had to say:

1) What field are you currently studying and what sparked your interest in that field?

My research mainly focuses on the modeling and analysis of extreme rainfall and floods using a variety of tools, including rain gages, ground-based weather radar, and hydrological and climate models. Extreme rainfall and flood events are complex physical phenomena that need to be better understood because riverine floods are the most common and devastating natural disasters.

2) What kinds of research are you currently working on and what have you learned so far from this research?

I am currently attempting to understand the nonstationarities in flood hydrology in the Las Vegas watershed. What I’ve found so far is that urbanization, especially the installation of channel networks, has increased hydrologic effectiveness, which causes higher flood magnitudes compared with a few decades ago. Besides urbanization, flood drivers in this watershed have also changed. One take away is that Las Vegas will be experiencing more winter floods than summer floods in the future, although uncertainties are also involved.

3) What do you hope to learn more about from the research you are doing?

The Las Vegas watershed shares some common features with other urbanized watersheds in the arid, southwestern United States. Cities such as Los Angeles, Phoenix, and Tucson are growing and expanding toward natural boundaries (e.g., the ocean or mountains). I’m interested in applying what I learn from the Las Vegas watershed to other southwestern watersheds to better understand urbanized flood hydrology in arid regions.

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4) What do you find most interesting about water resources research, particularly working in an arid/semiarid environment such as Nevada?

   It is surprising that the largest floods (with respect to watershed size) actually occur in the arid Southwest rather than in the wet eastern United States. One example is the catastrophic flood in Eldorado Canyon in 1974, which is located a few miles south of Las Vegas. The peak flow for this event was estimated to be 2,152 cubic meters per second, which is close to the mean streamflow at the mouth of Mississippi River.

5) What are some of your other research interests? Do you have any goals for incorporating those interests into your work as you continue in your career?

   There is a lot to learn to understand what causes extreme flood events in arid regions and how will they change in the future. I plan on collaborating closely with hydrologists and meteorologists at DRI to better understand the severity and likelihood of extreme flood events in the Southwest and future changes in these events stemming from climate change and rapid urbanization.

6) Do you have a favorite dish that you like to make and why is it your favorite?

   Hot pot is my favorite dish. It’s a traditional Chinese food comprised of a boiling soup and a variety of vegetables and meats that can be added to it. It’s also perfect for a gathering of friends and family.

7) What is something that we might not know about you (hobbies, interests, etc.)?

   I play badminton regularly and hope more people at DRI will join me.

“Extreme rainfall and flood events are complex physical phenomena that need to be better understood because riverine floods are the most common and devastating natural disasters.” – Guo Yu

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Events List Continued

The Second National Chapman Conference: Justice in Geoscience
August 14-17, 2022
Washington DC
www.agu.org/Plan-for-a-Meeting/AGUMeetings/Chapman-Conferences

SEG AAPG International Meeting for Applied Geoscience & Energy
August 28-September 2, 2022
Houston, TX
www.imageevent.org/

Meeting the Challenges of Groundwater in Fractured Rock
September 12-13, 2022
Burlington, VT
www.ngwa.org/detail/event/2022/09/12/default-calendar/22sep5017

NWRA Fall Week of Water
September 19-22, 2022
Reno, NV
www.nvwra.org/

GSA Connects
October 9-12, 2022
Denver, CO
community.geosociety.org/gsa2022/home

2022 ASA, CSSA, SSSA International Annual Meeting
Communication and Public Engagement for Healthy People and a Healthy Planet
November 6-9, 2022
Baltimore, MD
www.acsmeetings.org/

AWRA 2022 Annual Water Resources Conference
November 7-9, 2022
Seattle, WA
www.awra.org/Members/Events_and_Education/Events/2022_Annual_Conference/2022_AC.aspx

Groundwater Week
December 6-8, 2022
Las Vegas, NV
groundwaterweek.com/

AGU Fall Meeting 2022
December 12-16, 2022
Chicago, IL
www.agu.org/Fall-Meeting

Photo by Jesse Juchtzer
Success and the dedication to quality research have established the Division of Hydrologic Sciences (DHS) as the Nevada Water Resources Research Institute (NWRRI) under the Water Resources Research Act of 1984 (as amended). As the NWRRI, the continuing goals of DHS are to develop the water sciences knowledge and expertise that support Nevada’s water needs, encourage our nation to manage water more responsibly, and train students to become productive professionals. The work conducted through the NWRRI program is supported by the U.S. Geological Survey under Grant/Cooperative Agreement No. G21AP10578. The Desert Research Institute (DRI) administratively houses and logistically supports the operations of the NWRRI.

About DRI

The Desert Research Institute (DRI) is a recognized world leader in basic and applied environmental research. Committed to scientific excellence and integrity, DRI faculty, students who work alongside them, and staff have developed scientific knowledge and innovative technologies in research projects around the globe. Since 1959, DRI’s research has advanced scientific knowledge on topics ranging from humans’ impact on the environment to the environment’s impact on humans. DRI’s impactful science and inspiring solutions support Nevada’s diverse economy, provide science-based educational opportunities, and inform policymakers, business leaders, and community members. With campuses in Las Vegas and Reno, DRI serves as the nonprofit research arm of the Nevada System of Higher Education. For more information, please visit www.dri.edu.

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Banner photo: April storm in Amargosa Valley by Detra Page.
Pages 1-4: Project photos courtesy of the project PIs.
Page 5: Photo courtesy of George William Kajumba.
Page 6: Photo courtesy of Guo Yu.
Events list, page 6: Vinnie the dachshund by Jesse Juchtzer.