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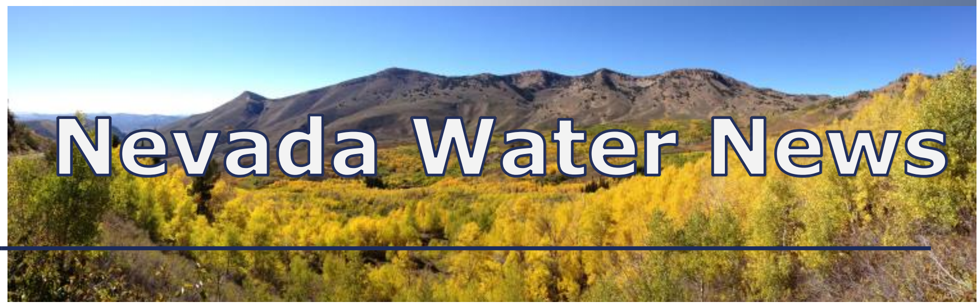

Nevada Water News

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RFPs

If you have questions about submitting a NWRRI proposal, email Amy Russell (Amy.Russell@dri.edu).

For current RFP information, visit the NWRRI website (www.dri.edu/nwrri).

Director's Letter

As climate and population changes continue to affect the availability of potable water resources, research into finding better ways to preserve these resources is even more critical. As the Executive Director of the Division of Hydrologic Sciences (DHS) at Desert Research Institute (DRI), I'm proud of the research our institute is conducting as the Nevada Water Resources Research Institute (NWRRI). In particular, the most recent projects funded through the National Institutes of Water Resources (NIWR) program focus on determining and removing various harmful compounds that are present in wastewater to improve water treatment processes and protect water quality.

Dr. Erick Bandala's project "Degradation of Emerging Contaminants in Treated Wastewater using Immobilized Nanoscale Zero-valent Iron," which is featured in this issue, will develop a novel water treatment prototype that uses nanoscale zero-valent iron (nZVI) embedded in a porous matrix to remove emerging contaminants (ECs) from treated wastewater. Because current wastewater treatment processes do not effectively treat all of the ECs of concern, the goals of this project are to develop a matrix that efficiently uses nZVI to treat ECs and to assess the feasibility of incorporating these novel materials into existing wastewater treatment processes.

Dr. Henry Sun's project "Improving Wastewater Treatment using Biofilms that Degrade Phenolic and Aromatic Contaminants" also focuses on improving the removal of harmful compounds during wastewater treatment processes. Although wastewater treatment facilities use oxidation ponds to

(Director's Letter continued)

remove organic materials from the treated water, these ponds aren't capable of removing some harmful phenolic and aromatic compounds that pollute the environment. The goal of Dr. Sun's research is to generate a new technology to improve wastewater treatment in Nevada by creating a biofilm that can remove these toxic compounds. The researchers will grow a monospecies biofilm using *Bacillus mojavensis* and test its capability to degrade phenol, bisphenol, and Congo Red. They will then raise a complex natural biofilm using water from the Las Vegas Wash to evaluate the biofilm's maximum degradation efficiency.

Dr. Xuelian Bai's project "Evaluation of Antibiotic Resistance Genes (ARGs) in the Urban Wetland Ecosystem: Las Vegas Wash" focuses on identifying antibiotic resistance, which is a growing global human health problem. Sewage and livestock waste entering the urban water cycle encourage the growth of antibiotic resistant bacteria and increase the spread of antibiotic resistance. This project will focus on the Las Vegas Wash, which is an urban wetland ecosystem. The researchers will take water and sediment samples from the wash to evaluate the fate of ARGs in the ecosystem and the effects of elevated antibiotic concentrations. This project will provide insight into the prevalence and spread of antibiotic resistance in urban water supplies and its effect on natural environments and human health.

Preparing students to enter various scientific fields is an important aspect of the NIWR program. I'm proud that the work DHS conducts as the NWRRI provides opportunities for students to gain first-hand experience in cutting-edge research fields. For example, Dr. Sun's project will support a postdoctoral student and train an undergrad student in multidisciplinary research. And the students working on Dr. Bandala's project will develop skills in the synthesis, characterization, and potential application of novel materials.

With the effects that humans and climate change have on water resources and the increasing demands for potable water, finding innovative technologies that can preserve water quality is critical. I look forward to sharing more of the advanced water research that DHS is conducting, as well as profiles of the researchers and students participating in the NIWR program.

Sincerely,

Kumud Acharya ■

Degradation of Emerging Contaminants in Treated Wastewater using Immobilized Nanoscale Zero-valent Iron

In arid and semiarid regions, developing new ways to conserve and extend the limited available water resources is vital, particularly with changes in climate and growing populations making the reliability of those resources uncertain. One potential source to extend those resources is treated wastewater. "The increasing effects of climate change on rainfall patterns, which are compounded by limited opportunities for the further expansion of conventional water sources, have made wastewater a reliable alternative for enhancing urban water supply," says Dr. Erick Bandala, the PI of this project that also includes graduate student researchers Ahdee Zeidman and Helga Sato from the University of Nevada, Las Vegas (UNLV), and intern Juan Guzman from Nevada State College (NSC), as well as Dr. Jaeyun Moon of the Department of Mechanical Engineering at UNLV. "However, urban watersheds are also highly affected by wastewater contaminants. The widespread production and use of various synthetic chemicals (e.g., pharmaceuticals and personal care products) has led to the ubiquitous presence of these chemicals in wastewater effluents, surface water, and drinking water, which raises concerns about emerging contaminants (ECs) entering water supply reservoirs and the potential risks they pose to human and environmental health."

Water supply reservoirs in arid and semiarid regions, such as Lake Mead in Nevada, often receive various forms of treated urban

(Project Spotlight continued)

effluent, but most wastewater treatment plants in the United States are not required to meet specific reduction guidelines for ECs, and these chemicals can be difficult to remove. "Except for the most biodegradable and/or hydrophobic compounds, treated wastewater will inevitably contain a suite of ECs at trace concentrations," Bandala says. "And many ECs have also been recognized as endocrine disrupting chemicals (EDCs), which pose potential risks to human health at part-per-trillion levels. Therefore, before the effects of climate change make reusing water a necessity, cost-effective water treatment processes that target ECs need to be developed and proper safeguards, policies, and practices need to be established" (Brausch *et al.*, 2012; Cunningham *et al.*, 2009).

The Las Vegas Wash discharges into Lake Mead, which is the primary source of water for the Las Vegas Valley. Ensuring that emerging contaminants are treated before they reach the wash is vital for protecting the lake's water quality.

Studies conducted over the past two decades have shown continuous endocrine disruption in common carp (*Cyprinus carpio*) and largemouth bass (*Micropterus salmoides*) in the Lower Colorado River, and the Las Vegas Wash was found to have a significantly high estrogenicity response, which indicates a high potential for endocrine disruption (Patino *et al.*, 2003; Patino *et al.*, 2015; Goodbred *et al.*, 2015). "Without finding ways to appropriately manage ECs in wastewater, we could potentially squander the opportunity to use it as an available water resource in many urban areas," Bandala says. "Finding technologies that can be incorporated into current wastewater treatment processes to treat ECs is vital for conserving our water resources while maintaining human and environmental health, and that is the purpose of our project."

For this project, Bandala and his team will use nanoscale zero-valent iron (nZVI) embedded in a porous medium to produce a water treatment prototype that can remove ECs in treated wastewater. They will also alloy the nZVI with other metals that function as catalysts to increase its reactivity. "Embedding the nZVI in a porous material significantly increases its surface and improves its degradative performance," Bandala explains, "and we have previously alloyed the nZVIs with palladium and platinum to enhance its reactivity, which also successfully improved its remediation of organic compounds." The research team will then assess the feasibility of using this prototype in environmental remediation applications. Nanoscale zero-valent iron has gained interest in the scientific community over the last few years because of its ability to reduce or oxidize pollutants, particularly contaminants found in water. However, the main drawback of using nZVI is its tendency to agglomerate, which affects its durability and limits its use in full-scale water treatment applications. "Mesoporous materials have been reported to successfully prevent nZVI agglomeration and enhance its capability to degrade organic

(Project Spotlight continued)

compounds as much as 96 percent within a few minutes of treatment," Bandala adds (Mortazavian *et al.*, 2017). "But despite these promising results, relatively few reports are available on the characterization and assessment of using nZVI immobilized on mesoporous materials for environmental applications, and little is known about the mechanisms involved in the degradative process."

In a previous study, the research team—which also included student researchers Soroosh Mortasavian from UNLV and Alejandro Ortiz from UPEMOR (Universidad Politécnica del Estado de Morelos, Mexico)—modified the structure of a porous medium, which significantly increased the surface area and improved nZVI performance (Mortazavian *et al.*, 2017). "We immobilized nZVI in silica-based mesoporous material (SBA-15) that was synthesized using the two-solvent method," Bandala explains. "Three different samples were synthesized

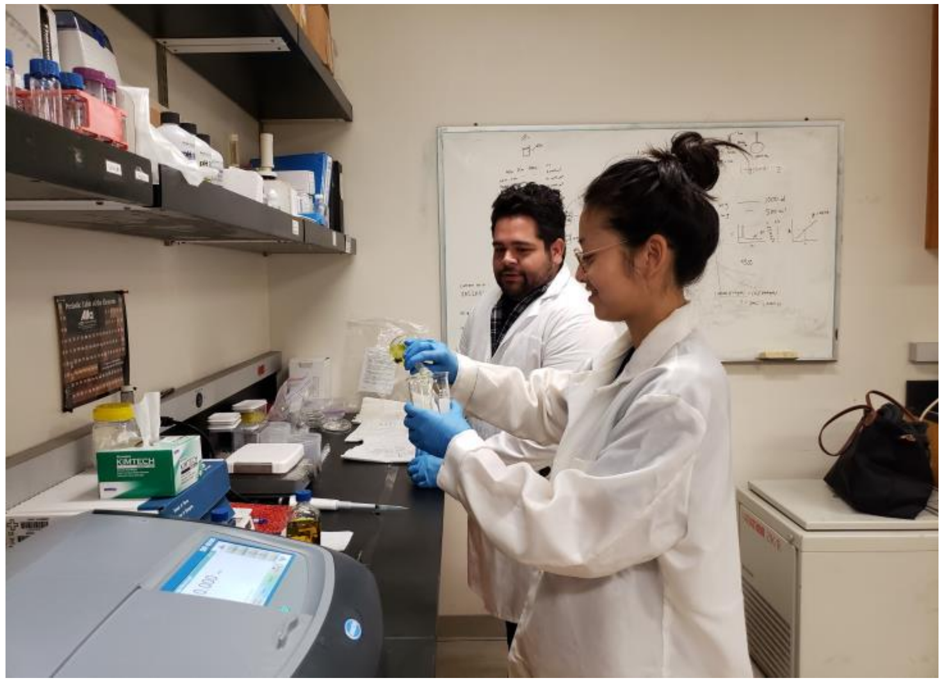
Ahdee Zeidman (left)—a graduate student of hydrology from UNLV—and Juan Guzman (right)—a student at NSC who is completing an internship at DRI—working in the lab's fume hood, which is an essential piece of equipment for any chemical lab because it protects the researchers from exposure to hazardous vapor, gas, or dust.

> ***"Without finding ways to appropriately manage ECs in wastewater, we could potentially squander the opportunity to use it as an available water resource in many urban areas."***
>
> ***– Erick Bandala***

with different iron to silicon (Fe/Si) weight ratios of 5.58, 8.96, and 12.84. The synthesized materials were evaluated for hydroxyl radical (•OH) production through N,N-dimethyl-p-nitrosoaniline bleaching. The results revealed that nZVI/SBA-15 with a ratio of 8.96 produced the highest •OH, particularly when 80 mg L-1 of the sample was used." The research team then added hydrogen peroxide to the reaction mixture, which resulted in a significant increase in •OH production. "The best reaction conditions were obtained when combining nZVI/SBA-15 with hydrogen peroxide (H_2O_2) and UV radiation, which showed that increasing UV intensity above 24 W m-2 did not enhance •OH production significantly, whereas increasing temperature enhanced •OH production," Bandala says. The experimental data was then evaluated using two different kinetic models and the proposed water treatment process was assessed based on its ability to discolor Congo Red azo dye (3,3'-bis4-aminonaphthalene-1-sulfonic acid, sodium salt) in an aqueous phase. "The results showed Fenton reaction catalyst characteristics that are worth assessing for other environmental applications, such as soil treatment, site restoration, or the removal of contaminants from wastewater," Bandala adds.

In another study, the team used nZVI/SBA-15 as a Fenton reaction catalyst to degrade sodium dodecyl sulfate (SDS) in an aqueous phase (Mortazavian *et al.*, 2018). Various doses of the synthesized catalyst were investigated alone and combined with H_2O_2 and peroxymonosulfate (PMS)

(Project Spotlight continued)



Helga Sato (right)—a graduate student of biology at UNLV—and Juan Guzman conducting experiments to quantify the production of hydroxyl radicals, which are the transient chemical species involved in advanced oxidation processes used to removed contaminants from water.

as oxidizing agents to evaluate their effects on the degradation efficiency. “The SDS degradation results revealed that 1.5 g/L nZVI/SBA-15 degraded 97.8 percent of SDS after 60 minutes without using oxidizing agents,” Bandala says. “Using H_2O_2 alone resulted in almost negligible SDS degradation, whereas PMS alone effectively degraded SDS. Combining nZVI/SBA15 with oxidant agents improved the degradation process. After 60 minutes, 1.5 mg/L nZVI/SBA-15 combined with 0.88 g/L H_2O_2 resulted in 99.6 percent SDS degradation, whereas 1.5 mg/L nZVI/SBA-15 combined with 0.10 g/L PMS degraded 99.9 percent of SDS after 20 minutes.” The reaction kinetics were then evaluated using a pseudo-first-order model to estimate the reaction rate constants and compare the various experimental conditions. The team then measured the degree of mineralization using the best reaction conditions, which was up to 80 percent.

The goal of this project is to establish a reliable method for synthesizing an nZVI-embedded porous matrix to promote oxidation/reduction processes that can be incorporated into existing water treatment processes. Part of this project will also include pioneering the preparation of nZVI particles that have a well-controlled particle size and structure, as well as testing their production of advanced oxidation or reduction processes. “Zero-valent iron is widely known to act in reduction or oxidation processes, depending on the availability of dissolved oxygen (DO), which has been reported to induce different anodic/cathodic reactions during the iron corrosion process depending on its presence or absence,” Bandala explains. “However, more research is still needed to reach an overall conclusion. This is the type of research we plan on developing in this project, which is very exciting.” Nanoscale zero-valent iron has been well-documented to have a higher reduction efficiency, more stable performance, and easier integration into the advanced reduction processes used to remove contaminants (Mortazavian *et al.*, 2017). The research team will test the enhanced capability of nZVI to generate advanced oxidation processes, as well as identify the effects of different water parameters on the efficiency of those processes and any reaction by-products.

For southern Nevada, finding ways to remove ECs from wastewater effluents is particularly important. “The Las Vegas Valley is located in a drainage basin and approximately 88 percent of the area’s water supply is drawn from Lake Mead and the rest is obtained from groundwater in the basin,” Bandala says. “Used household water, which is approximately 40 percent of the total, is collected and sent to wastewater treatment and reclamation plants and the effluents are then discharge into the Las Vegas Wash. Water used outdoors, which is approximately 60 percent of the total, usually returns to the atmosphere through evapotranspiration or flows to the Las Vegas Wash” (SNWA, 2015). The reclaimed wastewater entering the Las Vegas Wash is treated to a high standard via nutrient and dissolved solid reduction, primary

(Project Spotlight continued)

settling, biological treatment, and chemical-enhanced filtration and disinfection, but these treatments aren't designed to remove ECs. "Although the Las Vegas Wash effluent only accounts for 1.4 percent of the total water flow into Lake Mead, EC presence is considered biologically important," Bandala explains. "Previous work on endocrine disruption in aquatic organisms from the Las Vegas Wash and Lake Mead (i.e., *Cyprinus carpio*) have provided evidence of the link between ECs present in the Las Vegas Wash effluents and the declining health of these aquatic species in the lake" (Patino *et al.*, 2015).

Because of previous reports of endocrine disruption, research has been conducted to identify and quantify ECs in the Las Vegas Wash and Lake Mead (Rosen *et al.*, 2010). The results of these studies have identified urban runoff from roads, driveways, rooftops, yards, and other developed land as one of the main sources of pollutants. Traffic on urban roads, which generates vehicle exhaust and road surface abrasions, is a well-known source of ECs. For example, heavy-duty diesel vehicles have been reported to be major sources of environmental pollution (Goonetilleke *et al.*, 2017). "In some areas, treated wastewater could be a significant supply source for urban water bodies, and the presence of pollutants may suggest its poor viability for reuse," Bandala says. "But successful wastewater reuse depends on finding the appropriate treatment and storage to reduce demand on conventional sources during extended dry periods. We anticipate the novel materials and technology developed during this project will be easily incorporated into conventional water treatment processes and because Nevada is located in an arid region, it can serve as a model for other arid regions of the world."

"We anticipate the novel materials and technology developed during this project will be easily incorporated into conventional water treatment processes and because Nevada is located in an arid region, it can serve as a model for other arid regions of the world."

– Erick Bandala

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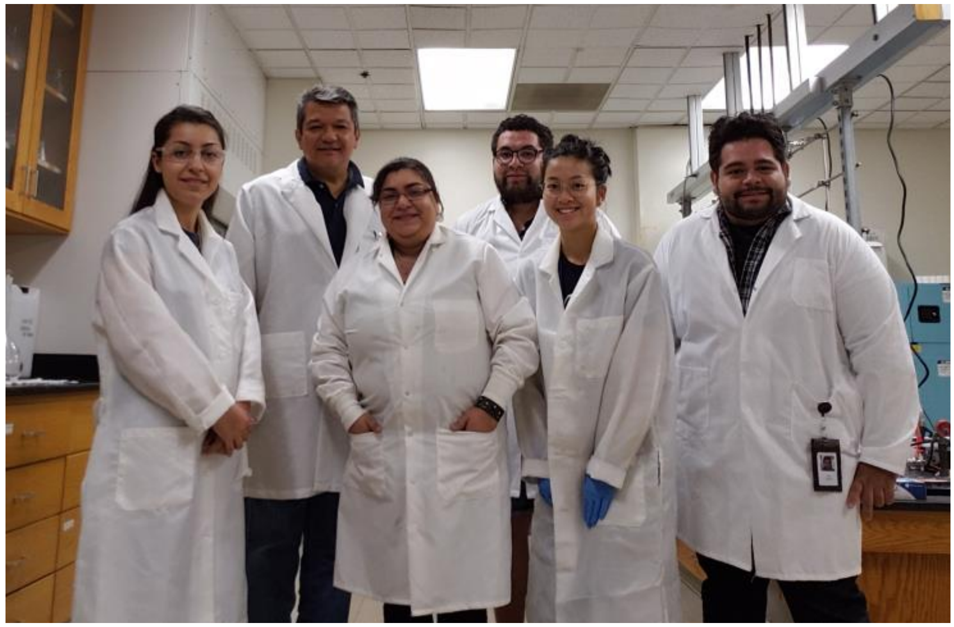
PI Spotlight: Dr. Erick Bandala



From left to right: Soroosh Mortasavian (UNLV PhD student of mechanical engineering), Dr. Erick Bandala, Ahdee Zeidman (UNLV graduate student of hydrology), Alejandro Ortiz (UPEMOR master's student of environmental engineering), Helga Sato (UNLV graduate student of biology), and Juan Guzman (NSC intern).

Dr. Erick Bandala developed an interest in water resources research early in his career. "I come from a developing country [Mexico] where access to safe drinking water is, at minimum, very complicated," Bandala says. "Early in my career, I learned how much of an effect a lack of safe drinking water can have on sustainable development." Bandala's research focuses on water quality, water treatment, and site restoration, with particular emphasis on developing technology to provide safe drinking water and proper sanitation in developing countries. "Billions of people lack access to safe drinking water in Africa, Latin-America, and the Caribbean, but what is most concerning is that it has been estimated that approximately 1.5 million children (5 years old or younger) die yearly because of waterborne diseases related with a lack of safe water access," Bandala adds (Bandala and Raichle, 2013). "As stated in the World Health Organization Millennium Development Goals, access to safe drinking water is a human right. Therefore, I believe that generating efficient, cost-effective, and accessible technology to ensure access to safe water for everyone is not only an interesting scientific and technological challenge, but also a duty of the hydrology community."

"I believe that generating efficient, cost-effective, and accessible technology to ensure access to safe water for everyone is not only an interesting scientific and technological challenge, but also a duty of the hydrology community."

– Erick Bandala

Nevada's unique water demands and limited water resources is what Bandala finds most interesting about conducting water resources research for the NIWR program. "The water situation in Nevada is *sui generis*," Bandala says. "The increasing population growth in the south, the agricultural activities in the north, and the mining industry all contribute to make Nevada a highly interesting place for doing research related with water." These unique demands also present unique challenges for sustainably managing the state's water resources. "As water needs in Nevada continue to increase, water losses need to be reduced and water savings need to be increased, and safe ways to reuse and recycle water need to be found," Bandala says. "However, we also need to be thinking about the quality of our water resources, and not just the quantity, because no matter how much water we have, it will be worthless unless the proper quality, depending on its intended use, can be achieved."

What Bandala likes most about the research he is currently doing is the developments that can be made in hydrologic research and the potential to protect the environment and human health. "Contributing to the restoration of the environment is a

(PI Spotlight continued)

very rewarding activity," Bandala says. "What I find most interesting about this research is that the technology has been proved for other similar applications, which gives us hope that our project may develop new technology. Also, assessing the best reaction conditions, estimating the upscaling parameters, and dealing with any potential problems in developing this technology are the core activities of the project—and they are the fun parts!"

In addition to his current research, Bandala is also interested in research related with limiting the amount of fresh water used by solar power plants; assessing the effects of climate change on water quality and extreme temperatures, which also affect human health; understanding the role of engineered nanomaterials in the food-energy-water nexus; promoting water, sanitation, and hygiene in rural communities; and stormwater treatment and reuse in urban locations. "I would like to find an opportunity to incorporate some of these topics into this project, and my research group is currently looking into the best ways to do that," he adds.

When asked what he would do with six months with no obligations or financial constraints, Bandala is so passionate about his work that he says, "I'd be doing the work I'm currently doing." But if he had the opportunity to go on vacation anywhere in the world, Bandala says, "I would hope to be on a beach, where I can listen to the relaxing sound of the waves and do nothing at all." He also enjoys reading, particularly good science fiction, and when asked if he has a favorite dish to make, he answers, "Chili, because it's easy and it tastes good."

"What I find most interesting about this research is that the technology has been proved for other similar applications, which gives us hope that our project may develop new technology." – Erick Bandala

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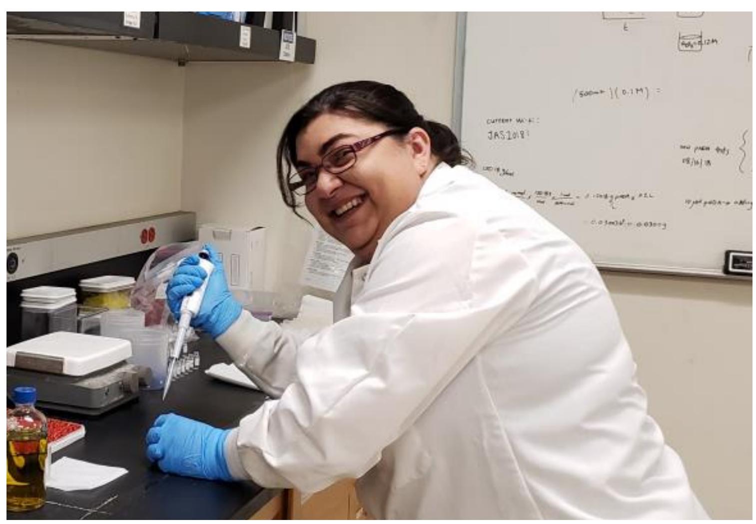
Bandala, E.R., and B. Raichle, 2013. Solar driven advanced oxidation processes for water decontamination and disinfection. In: N. Enteria and A. Akbarzadeh (eds.), *Solar Energy Sciences and Engineering Applications*. CRC Press (ISBN: 9781138000131).

Student Interview: Ahdee Zeidman

We asked graduate research assistant Ahdee Zeidman about her current studies and plans for the future. Here's what she had to say:

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

I am currently pursuing a master's in water resource management at the University of Nevada, Las Vegas (UNLV). I never thought I would end up pursuing any type of hydrologic research because my background is in sustainable agriculture with a focus on plant-soil interactions and, more recently, environmental education with a focus on water management and aquatic invasive species. However, more and more I found myself being drawn to water management, especially wastewater treatment, during my time as an undergrad. The more involved I get with hydrologic research, the more I feel like I made the right choice. Everything I have learned up to this point interconnects



(Student Interview continued)

and it can really help make a change in such a critical way.

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

The project that I am currently working on is "Degradation of Emerging Contaminates in Treated Wastewater using Silica-based Nanomaterials," which is part of the main NWRRI project. The focus of the project is on using novel materials as an effective addition to wastewater treatment processes to reduce contaminants of emerging concern (e.g., pharmaceuticals, endocrine-disrupting contaminants, and antibiotics) in treated wastewater.

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

I hope to learn new research techniques, as well as learn the ins and outs of wastewater treatment that will help me work toward my future goals.

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

I'm looking forward to working on a dynamic project with many different facets, especially the study of antibiotic degradation using bacteria, which is a totally new technique for me because my background has mostly been fieldwork and soil physics lab work.

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

My goal for the next steps in my career is to try and get into the federal sector working for the USDA or the Department of the Interior, which would fulfill a longtime goal of mine. I interned within the National Park Service, and the comradery that I found while working with them and the amount of interagency interactions is something I really enjoyed.

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

My favorite dish to make has to be chili because it was the first dish I learned how to make on my own and I didn't mess up on the first try.

"I'm looking forward to working on a dynamic project with many different facets, especially the study of antibiotic degradation using bacteria, which is a totally new technique for me because my background has mostly been fieldwork and soil physics lab work." – Ahdee Zeidman

7) If you could go on vacation anywhere in the world, where would you want to go, why would you want to go there, and what would you want to do there?

If I could go on vacation anywhere in the world, I would go to Israel to visit family and travel the countryside. ■

Upcoming Events

2018 GSA Annual Meeting
November 4-7, 2018
Indianapolis, IN
community.geosociety.org/gsa2018/home

2018 ASA and CSSA Meeting: Enhancing Productivity in a Changing Climate
November 4-7, 2018
Baltimore, MD
www.acsmeetings.org/

2018 AWRA Annual Conference
November 4-8, 2018
Baltimore, MD
www.awra.org/meetings/Baltimore2018/index.html

NGWA Groundwater Week
December 3-6, 2018
Las Vegas, NV
groundwaterweek.com/

(Continued on the following page)

Events Continued

2018 AGU Fall Meeting
December 10-14, 2018
Washington, D.C.
fallmeeting.agu.org/2018/

2018-2019 SSSA International Soils Meeting: Soils Across Latitudes
January 6-9, 2019
San Diego, CA
www.sacmeetings.org/

2019 NWRA Annual Conference Week Activities
January 28-31, 2019
Reno, NV
www.nvwra.org/2019-ac-week

Chapman Conference on Scientific Challenges Pertaining to Space Weather Forecasting Including Extremes
February 11-15, 2019
Pasadena, CA
connect.agu.org/aguchapmanconference/upcoming-chapmans/space-weather-forecasting/general-information

2019 Nevada Well Drilling Regulations & Forms Class and Water Well Drilling Exam Tutorial
March 6, 2019
Reno, NV
www.nvwra.org/2019-march-well-regulations-workshop

2019 GSA Cordilleran Section Annual Meeting
May 15-17, 2019
Portland, OR
www.geosociety.org/GSA/Events/Section_Meetings/GSA/Sections/cd/2019mtg/home.aspx

Well Design, Construction & Rehab Workshop
May 16, 2019
Reno, NV
www.nvwra.org/2019well-design

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.

Desert Research Institute, the nonprofit research campus of the Nevada System of Higher Education, strives to be the world leader in environmental sciences through the application of knowledge and technologies to improve people's lives throughout Nevada and the world.

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