Although wastewater treatment facilities use oxidation ponds to eliminate organic materials, some phenolic and aromatic compounds are particularly resistant to current treatment processes. If these compounds are released into the environment with treated wastewater, they could affect environmental and human health. “Animal studies show that exposure to these compounds can affect reproduction and development,” says Dr. Henry Sun, the principal investigator of this project. “In humans, long-term exposure can cause a variety of health problems, including irregular breathing and muscle atrophy. This is why the EPS standard for permissible phenols in surface waters is very stringent, less than one parts per billion.”

For this project, the researchers will test a biotechnology that uses bacteria isolated from local soil, Bacillus mojavensis, to create biofilms that can degrade phenolic and aromatic compounds. “Phenols persist in the environment because aromatic rings are very stable,” Sun says. “Even bacteria cannot metabolize them until the rings are opened up and linearized, which can only be done through reaction with hydroxyl radicals. This is why these compounds are traditionally treated with ozone and UV irradiation.” B. mojavensis produces hydrogen peroxide, which generates...
free radicals in combination with dissolved iron that can oxidize amino acids that are aromatic and contain stable rings.

During the first phase of the project, the researchers will raise a biofilm of *B. mojavensis*. The benefit of using a biofilm is that it concentrates the hydrogen peroxide and extracellular hydrolytic enzymes produced by the bacteria, which increases the bacteria’s ability to oxidize harmful compounds. “When bacteria are stressed, they form biofilms,” Sun explains. “To recycle dead cells within these biofilms, the bacteria upregulate their oxidative activity. Our project will use the biofilm’s elevated oxidative activity to degrade aromatic pollution.”

The researchers hypothesize that the biofilm will oxidize the target phenolic compounds and release carbon dioxide. This hypothesis is based on Sun’s previous research on D-amino acids, or right-handed amino acids. “Amino acids come in two forms: left-handed or right-handed. All living organisms synthesize left-handed amino acids,” he says. “D-amino acids are generated in the environment by racemization of left-handed amino acids, and they are toxic. Bacteria possess specific oxidases that catalyze their oxidative degradation, turning a toxic substance into a nutrient source. We believe such oxidative power in biofilms can be used to degrade phenols.” To test their hypothesis, the researchers will assess the biofilm’s ability to degrade compounds with increasing aromaticity, specifically phenol, bisphenol, and Congo Red.

After the researchers test the initial biofilm, they will raise a complex natural biofilm in Las Vegas Wash water and assess its degradation efficiency. One of the things that Sun finds most exciting about this project is its potential to improve municipal and industrial wastewater treatment. “Microorganisms and bacteria in the environment are genetically diverse and there are few things that microorganisms cannot learn to degrade,” Sun says. “And microorganisms are already a big part of the current municipal wastewater treatment. Oxidation ponds are designed to increase the aerobic oxidation of organics by the bacteria present in the ponds.”

Currently, the researchers are testing how to grow a stable biofilm and its capability to degrade phenols. “Ultimately we want to scale it up and process a large amount of polluted water rapidly,” Sun says. “We just

“We have to continually innovate because the existing treatment schemes may not be able to deal with the new synthetic compounds being added to waste streams. As long as synthetic chemists and pharmaceutical companies exist, there will be a need to update our wastewater treatment systems with new biotechnologies.” – Henry Sun
began talking to civil engineers who can help us down the road with incorporating this technique into the existing treatment facilities.” Sun’s long-term research goal is to find ways to use biotechnology to help conserve and manage valuable water resources. “We have to continually innovate because the existing treatment schemes may not be able to deal with the new synthetic compounds being added to waste streams,” Sun says.

“As long as synthetic chemists and pharmaceutical companies exist, there will be a need to update our wastewater treatment systems with new biotechnologies.”

Research into technologies that improve wastewater treatment processes and address emerging contaminants is particularly significant for semiarid regions such as Nevada. The limited water resources in semiarid regions and the increasing necessity of reusing water as these areas become more populated make preserving water quality even more important. “In southern Nevada, for instance, treated municipal wastewater is returned to Lake Mead, where we get our drinking water,” Sun says. “To protect public health and the natural ecosystem, all toxic substances must be removed from wastewater before it is released into the environment.”

Another aspect of the project that Sun finds interesting is the unique properties of the bacteria that he is working with. “Bacteria that grow in the desert have properties that bacteria in other regions do not have,” Sun says. “They are not only extreme hardy, but they also have powerful oxidative metabolisms, which is a characteristic we are specifically trying to utilize in our project.”

“(Project Spotlight continued)
In addition to his interest in microorganisms, Sun’s other research interests include water recycling and reuse in totally enclosed habitats, such as would be used on the international space station—or a human colony on Mars. “The challenges faced by these closed environments are not unlike the challenges that desert communities face,” Sun explains. “I hope that through this project, we can generate insights that could lead to complete water reuse.”

Outside of his research interests, Sun also likes to play pickup basketball. And when asked what one of his favorite books is, he answered: “My favorite book is 1984 by George Orwell because it transcends culture, time, and space. What an English novelist imagined in the 1940s about life in a socialist England is what I lived through 20 years later in communist China. The similarities are uncanny and chilling.”

(PI Spotlight continued)
Student Interview: Yuan Luo

We asked PhD graduate research assistant Yuan Luo 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’m currently studying soil physics in arid areas, which is especially important here in the southwestern United States. My bachelor’s degree is in water resources engineering and since I was a freshmen, I’ve enjoyed the water-related research we did. I also assisted one of my professors with hydrodynamic research for various hydraulic projects. We built models and tested their performance using different extreme conditions. Later on, I worked at a civil engineering company building hydraulic structures. By that time, I learned how soil types make a difference in the way we treat the foundation of hydraulic structures. I began to gain interests in the field of soil physics. Fortunately, I had the opportunity to work with Dr. Markus Berli and he showed me a new world of soil physics. Understanding the soil water dynamics of arid areas can help solve many environmental and economic problems because one-third of the earth’s land is located in arid climates.

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

I’m currently working on the Solar Energy-Water-Environment Nexus project, which includes cooperation from community leaders, industries, federal and state agencies, landowners, and tribal communities. My research is on how solar arrays can change the hydrology of desert environments.

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

I hope to learn how to understand water dynamics in near-surface dry soil—including infiltration, evaporation, and water redistribution—using our finite element model.

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

I’m looking forward to developing a comprehensive and powerful tool to capture and predict water dynamics in arid soil. Once we have this tool, we can not only help with potential environmental issues associated with solar facilities in Nevada, but also apply our research to many other disciplines related to desert environments, such as flooding and erosion, cloud and dust formation, fragile desert ecosystems, and waste disposal.

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

I don’t really have a specific goal for the next steps in my studies, but if possible, I hope that our research on water dynamics in arid soil will be applicable to other arid places around the world.

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

“I’m looking forward to developing a comprehensive and powerful tool to capture and predict water dynamics in arid soil. Once we have this tool, we can not only help with potential environmental issues associated with solar facilities in Nevada, but also apply our research to many other disciplines related to desert environments, such as flooding and erosion, cloud and dust formation, fragile desert ecosystems, and waste disposal.” – Yuan Luo

(Continued on following page)
My favorite book is *The Three-Body Problem* by Cixin Liu. He is the first author from Asia to win the Hugo Award for Best Novel. It’s about an alien invasion, but it’s not a cliché one. It is mind-blowing and brings deeper perspective on what humans should do when the principle of the universe is so dark and simple that the top mission for any creature is to survive. I think every sci-fi lover should read it. Another reason to read it is that the author of the book is an alumnus of my college.

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

My favorite dish is tomato and scrambled eggs. It is very easy to make and is a really good source of protein and vitamins. Also, it is a great dish to serve with white rice or noodles.
Events Continued

Newmont Phoenix Mine Tour
September 17, 2019
Elko, NV
www.nvwra.org/2019-september-newmont-mine-tour

Water Rights in Nevada Class
September 17, 2019
Elko, NV
www.nvwra.org/2019-water-rights-seminar-sept

GSA 2019
September 22-25, 2019
Phoenix, AZ
www.geosociety.org/GSA/Events/Annual_Meeting/GSA/Events/2019info.aspx

2019 NGWA Conference on Fractured Rock and Groundwater
September 23-24, 2019
Burlington, VT

2019 Fall Week of Water Events & Symposium
September 23-26, 2019
Reno, NV
www.nvwra.org/2019fallweekofwater
www.nvwra.org/2019-fall-symposium

SWITCH Tour
September 23, 2019
Reno, NV
www.nvwra.org/2019-sept-switch-tour

Operational Value of the Well
September 26, 2019
Reno, NV

2019 Marlette Lake Water System Tour
September 26, 2019
Carson City, NV

October 14-18, 2019
Polson, MT
connect.agu.org/aguchapmanconference/upcoming-chapmans/winter-limnology

Chapman Conference: The Quest for Sustainability of Heavily Stressed Aquifers at Regional to Global Scales
October 21-24, 2019
Valencia, Spain
connect.agu.org/aguchapmanconference/upcoming-chapmans/aquifers-sustainability

AWRA Annual Water Resources Conference
November 3-7, 2019
Salt Lake City, UT
www.awra.org/Members/Events_and_Networking/Events/ANNUAL_WATER_RESOURCES_CONFERENCE.aspx

Groundwater Week
December 3-5, 2019
Las Vegas, NV
groundwaterweek.com

AGU Fall Meeting 2019
December 9-13, 2019
San Francisco, CA
meetings.agu.org/fall-meeting-2019/

Chapman Conference: Evolution of the Monsoon Biosphere and Mountain Building in Cenozoic Asia
January 5-9, 2020
Washington, D.C.
connect.agu.org/aguchapmanconference/upcoming-chapmans/monsoon-evolution

2020 NWRA Annual Conference Week Activities
February 10-13, 2020
Las Vegas, NV
www.nvwra.org/2020-annual-conference-week

AWRA Geospatial Water Technology Conference: Complex Systems Tribute to David Maidment
March 23-26, 2020
Austin, TX
www.awra.org/Members/Events_and_Networking/Events/Spring_2020_Specialty_Conference.aspx
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.

For more information about the NWRRI, contact:

Amy Russell, Business Manager
702-862-5471
Amy.Russell@dri.edu

Kumud Acharya, Director
702-862-5371
Kumud.Acharya@dri.edu

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Newsletter written and compiled by Nicole Damon.