UA LEADING RURAL WASTEWATER TREATMENT PILOT PROGRAM WITH GRANT FROM COLUMBIA WORLD PROJECTS

By Brock Parker

The initial investment of $710,000 establishes a pilot program that allows researchers to show that rural underserved areas can have healthier and more affordable access to wastewater management systems. With external funding matched by Columbia University, that amount will reach $14 million.

U.S. Rep. Terri Sewell, who represents Alabama's 7th District, participated in a CWP forum on unequal opportunity about the need for better wastewater management. Her presentation helped the initiative's decision to invest in the Black Belt project.

"I am grateful to Columbia World Projects for their investment in my district and in Alabama's rural Black Belt to address the challenges posed by failing wastewater infrastructure," Sewell said in a statement. "This project will build upon the progress my office has made over the years to secure vital federal funding for cost-effective rural sewer and wastewater systems."

U.S. Sens. Richard Shelby and Doug Jones have also been supportive of this project. Representatives from both senators' offices have been present at the meetings helping to launch this initiative.

Alabama's Black Belt, a stretch of 17 counties named for the dark topsoil with dense clay underneath, is home to a population where 40 percent of the residents live below the poverty line. These rural locations don't have access to centralized wastewater treatment like larger cities and towns with public utilities, so by law residents must treat their own wastewater on their property.

This is typically done using a septic system, consisting of a tank and a drainfield where wastewater infiltrates into the ground. However, in the Black Belt, the dense clay doesn't allow the water to drain, so there are often puddles of disease-ridden and pathogen-filled wastewater that are easily accessible to children and pets. Some residences even resort to "straight pipe" systems, which send untreated wastewater directly from the home into nearby woods or other above-ground areas.

Leading UA's efforts on the project is Dr. Mark Elliott from the College of Engineering. Elliott has spent the past few years researching ways to improve access to better sewage systems in lower-income rural areas of the state. The solution Elliott and his colleagues are testing for this project is a decentralized clustered system, which is between a large centralized sewer and expensive individual treatment systems.

"Like an individual on-site system, each home will have a septic tank to handle the solids," said Elliott, an associate professor in the Department of Civil, Construction and Environmental Engineering. "However, instead of the liquids going to a trench where they go into the ground, they're instead collected into a centralized treatment unit that then treats the wastewater."

Collaborating with UA and Columbia University in the Black Belt wastewater project are the University of South Alabama; Auburn University; the University of North Carolina; the University of California, Irvine and a consortium of partners representing government agencies, community-based organizations and other stakeholders.

The initial testing site will be at the Auburn University School of Architecture's Rural Studio in Newbern, Alabama. Once they establish a successful system in that area, they will file permits in order to branch out to other communities in need of these systems.

Elliott said their ultimate goal is to show that these systems work and to convince policymakers to invest more infrastructure money to solve what's been considered an intractable problem all across the country.

"What we're really hoping is we can establish proof of concept of affordability and successful management of these systems in low-density rural areas with many low-income households," Elliott said. "If so, it will hopefully open up federal funds to address wastewater management in Alabama and beyond. The federal government subsidized heavily water and wastewater infrastructure for most of the U.S. population in the 20th century, but many poor, rural communities were left behind and didn't get the development that the rest of the country experienced."

UA-LED STUDY OF SOUTHEASTERN GROUNDWATER ASSISTS WATER MANAGEMENT

By Adam Jones
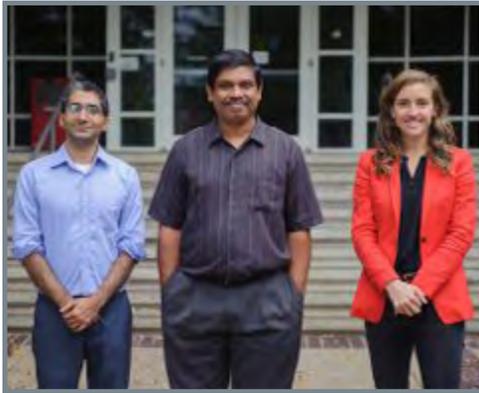
UA researchers on the project from left: Dr. Mukesh Kumar, Dr. Prabhakar Clement and Dr. Leigh Terry,

The University of Alabama is leading a 4-year, $6 million project to conduct groundwater research. The data and modeling tools developed will provide new scientific insights and make useful groundwater predictions for the Southeast.

The information can be used to manage and allocate groundwater resources in critical areas such as drought management, drinking water, ecology, climate models and agriculture.

"Water sustains life," said Dr. Prabhakar Clement, principal investigator on the project and UA professor of civil, construction and environmental engineering. "An adequate amount of freshwater is necessary to preserve human and ecological health, two critical aspects for sustaining a healthy economy. The management of groundwater systems is critical since aquifers store about 100 times more freshwater than lakes and rivers."

UA is partnered with four other universities in the grant from the National Science Foundation. At UA, Clement, also director of the UA Center for Water Quality Research, is joined by his colleagues in civil, construction and environmental

engineering, Dr. Leigh Terry, assistant professor, and Dr. Mukesh Kumar, associate professor, and Dr. Grey Nearing, assistant professor in geological sciences.

"We are thrilled. This is a true team effort, and we have several outstanding partners," Clement said.

Partner institutions include Louisiana State University, the University of Mississippi, Southern University and Tuskegee University.

Along with the research, the grant will support over 20 graduate students, postdoctoral researchers, visiting faculty, summer internship for high school teachers, and several undergraduate interns and lab

> **"Groundwater is an extremely important freshwater source for sustaining the socioeconomic activities of the Southeastern region, but, despite its widespread use, we have little understanding of groundwater to make sound public policy decisions"**
> **-Prabhakar Clement**

assistants. These researchers will get the opportunity to learn technical skills along with exposure and networking with experts and peers in the field.

In the United States, about 38 percent of the population depends on groundwater for drinking water, and in rural areas, groundwater can account for up to 90 percent of drinking water, according to the National Groundwater Association. It also is the primary source of water for more than half of the country's irrigated land.

However, not as much is known about groundwater as surface water. While mapping the availability of water in topsoil, reservoirs and rivers continues to receive attention, mapping of groundwater at fine spatiotemporal resolution over large areas is currently lacking. This causes issues in managing water resources, especially during droughts since groundwater is a strategic reserve for mitigating drought impacts.

The effort supported by this grant will be the first major project to focus on groundwater depletion and management issues in Alabama, Louisiana and Mississippi. The project will harness the power of big hydrological datasets using machine learning tools and process models to develop groundwater recharge and storage maps for three Southeastern states. The team will also develop a first-of-its-kind, regional scale, high-resolution data of aquifer stratigraphy, information crucial for obtaining reliable groundwater predictions.

"Groundwater is an extremely important freshwater source for sustaining the socioeconomic activities of the Southeastern region, but, despite its widespread use, we have little understanding of groundwater to make sound public policy decisions," Clement said.

The results of the project will be shared through a web-accessible data-sharing platform. All the tools and results developed in this project will be open-sourced. The fine resolution groundwater information will be useful for groundwater resource management as well as the planning of agriculture water supply, municipal water supply and rural water supply.

UA PROFESSOR RECEIVES NATIONAL SCIENCE FOUNDATION AWARDS FOR MUSSEL AND WATER RESEARCH

The research, conservation and education of freshwater mussels has led to a 5-year $1.04 million National Science Foundation CAREER award to an ecologist from The University of Alabama.

By Brock Parker

Dr. Carla Atkinson, an associate professor in UA's Department of Biological Sciences, recently received the award, which is one of the most prestigious recognitions of top-performing young scientists. Additionally, her water quality research, along with two other UA colleagues, has earned a 4-year $1.7 million NSF EPSCoR Track 2 grant to study intermittent streams as part of a national project.

More than half of North America's species of freshwater mussels live in Alabama's rivers – 180 to be exact – and they are also one of the most imperiled faunal groups in the world. Atkinson's NSF CAREER award will allow her to continue her efforts.

"The goal of this project is to further examine how they influence ecosystem functions," said Atkinson. "We're going to be looking at a plethora of these species traits, including how much they bury and move, their shell morphology and how much they excrete as far as nutrients like nitrogen and phosphorous."

Freshwater mussels are filter feeders, which means they clean water by filtering particles through their water column and into their gill chambers. At the same time, they're excreting nutrients back into the ecosystem. Many species bury themselves together in sediment substrates, creating a tight-knit community.

"We can think of these areas where they occur in these dense aggregations as hotspots of productivity where they're cleaning up the water, but then also fertilizing the algae and the base of the food web," she said. "That can fuel the rest of the food web, making these river systems more productive and also harboring a higher abundance of other organisms, such as aquatic insects and fish."

Mussels are imperiled because many of these river ecosystems are affected by human interference. They are sensitive to pollutants, and if there is a lot of runoff from agriculture or development, for example, they could also be buried and have their siphons covered up.

Atkinson said one of the most traumatic changes to their environments was the damming of rivers. Many mussels are adapted to live in free-flowing water, and dams create lake habitats upstream. Mussels attach themselves to fish in order to move around, and that movement is limited in reservoirs.

There are also problems downstream of dams. Water temperature can vary depending on where it eventually flows through the dam. If it's released from the bottom, cold water comes rushing through onto the mussels.

"Some species might use temperature cues to know when to reproduce, and if it never reaches that temperature, then they're not going to reproduce," said Atkinson.

Some dams are used for hydropower, which can also affect the mussels.

"When they're generating a lot of electricity, they'll open the gates, causing a lot of high flow to go through. Then when they close the gates, that stops," she said. "You can imagine that it could be quite stressful for an aquatic organism which has been adapted to the conditions in that river for millions of years."

Atkinson said some agencies are now modifying water management and flow through dams to be more beneficial to native aquatic species and will hopefully increase those populations.

Higher biodiversity of mussels can be found in rivers unencumbered by dams, such as the Sipsey and Cahaba rivers. That's where Atkinson spends quite a bit of time with her students, who will also benefit from her NSF CAREER award.

"Not only is it about research, but it's also about education," she said. "This is training the next generation of scientists by bringing everything from undergrads into the lab and into the field, to grad students and a postdoc. That way we kind of have this trajectory of different experiences and get to share our research experiences and questions with one another."

Atkinson is also part of a team of UA biologists that will work on

UA PROFESSOR RECEIVES NATIONAL SCIENCE FOUNDATION AWARDS FOR MUSSEL AND WATER RESEARCH

a national research project to address water quality at the critical connection between streams that flow continuously and those with intermittent flow. She, along with Dr. Jon Benstead, professor of biological sciences, and Dr. Nathaniel Jones, assistant professor of biological sciences, will be part of the project led by the University of Kansas as part of the NSF Established Program to Stimulate Competitive Research, or EPSCoR, grant. UA will receive $1.7 million as its share of the overall $6 million grant between 18 professors and eight institutions across the U.S.

These smaller streams are ubiquitous across the county, and they control the quantity and quality of water delivered downstream to perennially flowing rivers. They make up more than half of the stream miles globally, so it's necessary to fill in the knowledge gaps of how they impact stream health.

"As a group, we collectively feel like they're very important to study from a water quality perspective," Atkinson said. "We want to understand how these streams that flow only a small portion of the year, up to maybe even 70 or 80 percent of the year, are impacting downstream water quality."

The effort is the Aquatic Intermittency effects on Microbiomes in Streams, or AIMS, project. The researchers plan to install new sensors and field sites, train a dozen graduate students and numerous undergraduates in team-science approaches, train 36 new instructors in teaching data science methods and boost workforce development and education.

The AIMS project will address the first obstacle by creating a network of instrumented sites designed to generate "Big Data" to quantify flow intermittency, stream microbiomes and water quality. AIMS will confront the second obstacle by using its network to provide training in collaborative science and interdisciplinary methods to study intermittent streams and by providing workforce training in environmental data tools through a new "On Ramps to Data Science" program, which will focus on data generated by microbiome sequencing, environmental sensors and Geographic Information Systems.

"We're trying to enhance data-science tools across this whole program in which we'll be doing training through The Carpentries foundation," Atkinson said. "That way we can bring some data intensive courses to University of Alabama students, but also work with Alabama A&M in Huntsville to bring some different instructional tools to them."

Researchers from UA's Biological Sciences department in the field to identify characteristics or traits that make some mussel species more susceptible to climate change and habitat disturbance.

The work will also inform sometimes thorny policy and legal debates.

"The streams that are known as intermittently flowing streams are no longer protected under the Clean Water Act, so essentially they have no protections afforded to them," said Atkinson.

Research results could help resolve difficulties defining ecological connections between perennial and intermittent streams that lie at the heart of an ongoing policy debate over legal protection of isolated water bodies, as recently demonstrated by the late 2019 repeal of the 2015 Waters of the U.S. Rule. The researchers said the infrastructure installation planned under the AIMS project is designed to confront these difficulties head-on.

For a more in-depth interview with Dr. Carla Atkinson, please listen to her episode of the Alabama Water Institute Podcast. A video is also available on our YouTube channel.

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Eligibility Criteria:

- A faculty/staff/student appointment at The University of Alabama.
- Research expertise in a water-related field.
- Completion of registration form.

Questions? Please contact Stefanie O'Neill at: soneill2@ua.edu or 205-348-9128.

UA PROFESSORS AWARDED NSF GRANT FOR UNDERWATER ROBOTICS WIRELESS COMMUNICATIONS

Two University of Alabama professors have been selected by the National Science Foundation to lead a $1.5 million effort from its CISE Community Research Infrastructure program.

By Brock Parker

Dr. Aijun Song, assistant professor in UA's Department of Electrical and Computer Engineering, and Dr. Xiaoyan Hong, associate professor in the Department of Computer Science, have been awarded $880,000 by the NSF for their project, "CCRI: mu-Net: Infrastructure to Advance Mobile Underwater Wireless Networking Research." Working with their colleagues from several other universities, they plan to develop a community-shared infrastructure that will enable underwater research robots to exchange information more easily.

The project, called mu-Net, is a low-cost and flexible infrastructure consisting of both software and hardware that will support both laboratory tests and field experiments. Shared infrastructures are not currently available in research communities for coordinated underwater robotic research.

"mu-Net is the first open-source underwater infrastructure of its kind," said Song, the lead principal investigator of the NSF CCCRI project. "Our goal is to make the infrastructure accessible for scientists and academic users."

The mu-Net infrastructure is made up of open-source software that is reconfigurable for simulations and emulations, user services to support shared usage, miniature aquatic robots for lab tests, larger commercially available autonomous surface and underwater vehicles for lake tests. The project will open doors for several areas of research, such
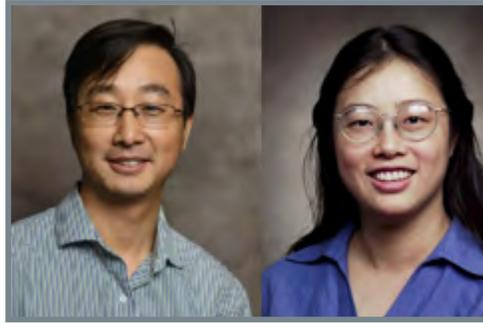
From left, Drs. Aijun Song and Xiaoyan Hong

as cooperative and coordinated marine robotics, underwater mobile communication networks and joint networking and navigation of marine robots. It could also lead to an underwater "Internet of Things," which is a system of internet-connected devices that are able to collect and transfer data over a wireless network without human intervention.

"The mu-Net project will bring significant resources to The University of Alabama for water-related research, especially those involve data collected from water body," Hong said.

Researchers believe mu-Net will increase the ability for greater aquatic exploration for scientific and commercial purposes in areas of marine biology, food sources and economic development. It will expand user communities by creating

a variety of engagement activities such as annual workshops, summer training schools, and girls robotics camps. Additionally, mu-Net is expected to be adopted for various educational and research purposes, such as ocean literacy, workforce training, academic research and industrial technology development.

The project will be funded by NSF for three years. In addition to UA, participating universities include Georgia Tech, City University of New York and Michigan Technological University.

Two autonomous surface and underwater vehicles in Dr. Aijun Song's lab.

UA FOOD SCIENTIST AWARDED AWI GRANT FOR NANOFIBER PRODUCTION EQUIPMENT

By Brock Parker

Dr. Lingyan Kong

The Alabama Water Institute recently awarded an equipment grant to Dr. Lingyan Kong from The University of Alabama's College of Human Environmental Sciences. Kong was awarded $10,900 for an electrospinner, which is a lab scale unit used to produce nanofibers. The AWI funding is half of a cost-sharing grant from CHES, bringing the total to $21,800.

According to the National Institutes of Health, electrospinning is a process that creates nanofibers through an electrically charged jet of polymer solution or melt. This technique is capable of spinning fibers into a variety of shapes and sizes and is applicable to virtually every soluble or fusible polymer.

"Part of my research is aimed at making nanofibers for water-related applications," said Kong, an assistant professor in UA's Department of Human Nutrition and Hospitality Management. "For example, in the most recent grant I obtained with Dr. Feng Yan, we aim to produce nanoparticle-decorated biopolymer nanofibers for water treatment."

The equipment funding, made available through AWI's Equipment Support Program, allowed Kong to upgrade his more simplified electrospinning setup.

"This equipment will be more efficient, versatile and productive," he said. "We want to optimize our nanofiber making process, including raw materials, process parameters and additives, so that we achieve better performance of bio-based nanofibers."

Kong's current project with Yan, an assistant professor in UA's Department of Metallurgical and Materials Engineering, is titled "Photoactive Nanoparticle-Decorated Bio-Nanofibers for Solar

> **"We want to optimize our nanofiber making process, including raw materials, process parameters and additives, so that we achieve better performance of bio-based nanofibers." -Lingyan Kong**

Energy Conversion." It was funded by the USDA and began in June 2020. Thanks to Kong's expertise in food science, the project allows them to incorporate bio-based polymers in the creation of nanofibers instead of synthetic polymers, which can have an adverse impact on the environment.

"Microplastics are a great challenge to the marine ecosystem," said Kong. "For the applications we proposed, such as water desalination and water splitting through solar energy conversion, we don't want to use synthetic polymers because they will eventually be eroded and form tiny pieces, also known as microplastics."

Those microplastics can escape treatment by sewage plants, float in rivers, lakes and oceans, and eventually accumulate in higher level organisms including humans. Kong explained that biopolymers are biodegradable, biocompatible and renewable, making them good candidates to replace synthetic polymers for non-food applications, especially where environmental impact is concerned.

Kong said collaborating on projects like this with researchers in other disciplines is important because scientific breakthroughs are more likely to happen due to the diversity in mindsets and skills.

"I understand AWI membership and research is very diverse and covers many different aspects of water-related issues," he said. "I think I am at the peripheral of that, but I hope my background in biopolymers will be useful for water research and similar to the solutions Yan and I proposed in the grant project."

The electrospinner unit used to produce nanofibers.

UA PROFESSOR AWARDED NSF GRANT FOR SYMBIOTIC ALGAE AND CORAL RESEARCH

The National Science Foundation has awarded Dr. Kenneth Hoadley a $290,214 grant for his research addressing the health of symbiotic algae living among reef corals.

By Brock Parker

Dr. Kenneth Hoadley

Hoadley, an assistant professor in The University of Alabama's Department of Biological Sciences, will use the money for the testing and optimization of a low-cost prototype instrument that will allow researchers and conservation agencies to quickly assess the well-being of the algae, also known as Symbiodiniaceae.

"This project was initially conceived during my Ph.D.," said Hoadley, a senior marine scientist at the Dauphin Island Sea Lab. "I was interested in using open-source hardware and software platforms to build purpose-built instrumentation that would allow me to better characterize algal health and photosynthesis within reef corals."

These instruments, called multispectral fluorometers, are commercially available, but most are expensive and are optimized for non-symbiotic algae. This grant will allow Hoadley to build a more cost-efficient and standardized version meant to determine photophysiology within corals.

A rise in sea surface temperatures and high irradiance can disrupt the symbiotic relationship between algae and their coral hosts, causing them to separate and bleach, leaving them completely white. According to the National Oceanic and Atmospheric Administration, bleaching doesn't necessarily kill corals, but it puts them under more stress and can lead to shorter lifespans. That can lead to the disappearance of reefs, which are vital ecosystems to ocean life.

"Despite our understanding of Symbiodiniaceae genetic diversity and its importance to coral reef health, there is a significant gap in knowledge regarding the functional and physiological variability that exists across species," said Hoadley. "New instruments could help elucidate functional differences and help us understand why certain species are more resilient to climate change than others."

Testing for the new instruments will be done in partnership with Mote Marine Laboratory where multiple coral species are actively grown in laboratory conditions. Those labs help support conservation efforts along the Florida Reef Tract. Hoadley said they will also visit commercial coral aquaculture facilities to test the new platform on additional coral species.

The start date for the grant is March 1, 2021, and it will provide two years of funding for one research technician and supplemental funds for a graduate student. It will also support two NSF Research Experiences for Undergraduates, or REU, students to help with data collection and analysis at field sites in Florida.

Hoadley and his team will also create a display showcasing coral reef research and technology at the DISL to help K-12 STEM outreach and education.

The award is Hoadley's first NSF grant and was made available through the Division of Ocean Sciences-Ocean Technology and Interdisciplinary Coordination Program.scale analytical sciences," Mumper said. "I would like to thank our Congressional and state Legislative delegations for their support and dedication in advancing our research mission and securing critical resources aligned with the Alabama Research Institutes."

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