SIU Research

SOUTHERN ILLINOIS UNIVERSITY CARBONDALE

Removing 'Forever Chemicals'

Eliminating PFAS from Groundwater Using Nanoparticles and Light

PAGE 4

SIU Officially Among Top Research Schools in the U.S.

PAGE 2

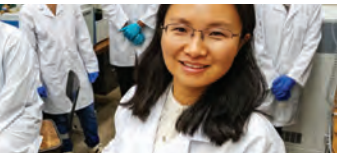
SIU Study Focuses on How to Keep Farmed Largemouth Bass from Eating their Own

PAGE 16

Spring 2025

R1 TOP-TIER RESEARCH UNIVERSITY

Contents



Dear friends of Southern Illinois University Carbondale,

it is my great pleasure to share with you this annual report which highlights some of the outstanding research performed by the SIU Carbondale faculty, staff and students.

We are very proud that our university has officially entered the ranks of the top research universities in the nation: it has been designated "Research 1: Very High Spending and Doctorate Production," in the Carnegie Classifications of Institutions of Higher Education. This prestigious designation by the American Council on Education and the Carnegie Foundation for the Advancement of Teaching confirms that SIU Carbondale is in the same league as less than 5% of the nearly 4,000 classified institutions.

In this issue of our magazine, you will also read about the breadth of SIU Carbondale research: from removing "forever chemicals" from contaminated groundwater, to receiving the prestigious National Foundation CAREER Award, to engineering novel microorganisms to break down plastics. You will read about a $7.2 million joint university-state project to develop a 10,000-square-foot state-of-the-art research and training suite for faculty, students, start-up companies and private firms–and many other projects like our faculty leading a $1.13 million project to integrate AI into 6G technology and studying widemouth bass.

These research projects and awards are only few of the SIU Carbondale accomplishments you will find in our magazine.

And they, in turn, are a small part of SIU Carbondale's overall 2023-24 research performance, when our external grant and contract expenditures reached $76.0 million. Top federal funders of grants were the Department of Health and Human Services, the National Science Foundation, the U.S. Department of Agriculture, and the U.S. Department of Education. Top state funders were the Illinois Department of Economic Opportunity, the Illinois State Board of Education, the Illinois Department of Human Services, and the Illinois Department of Natural Resources.

As reported to the National Science Foundation's Higher Education Research and Development (HERD) survey, R&D expenditures at SIU Carbondale totaled $61.5 million in 2023-24.

I hope that the stories in this magazine offer you a snapshot of SIU Carbondale as it continues to excel in its mission to perform research that serves the state and the nation.

With best Saluki wishes,

Costas Tsatsoulis,
Vice Chancellor for Research and Graduate School Dean

Southern Illinois University CARBONDALE

VOLUME 1, NO. 1
SPRING 2025

SIU Research is published by the
SIU Office of the Vice Chancellor for Research
900 S. Normal Avenue, MC 4344
Woody Hall 350
Carbondale, IL 62901

POSTMASTER
Send address changes to:
SIU Office of the
Vice Chancellor for Research
900 S. Normal Avenue, MC 4344
Woody Hall 350
Carbondale, IL 62901

EDITOR
Kim Rendfeld

ART DIRECTOR
Clint Eilerts (Arthur Agency)

GRAPHIC DESIGNER
Josh Mueller (Arthur Agency)

PHOTOGRAPHY
Russell Bailey
Amihere Benson
Deangelo Handley

CONTRIBUTORS
Tim Crosby
Christi Mathis

Southern Illinois University Carbondale Officially Among Top Research Schools in the U.S.

BY TIM CROSBY

Southern Illinois University Carbondale has officially entered the ranks of the top research universities in the nation: It has been designated Research 1, or R1, in the Carnegie Classifications of Institutions of Higher Education.

The prestigious designation by the American Council on Education and the Carnegie Foundation for the Advancement of Teaching confirms SIU Carbondale is in the same league as elite private and flagship universities across the country. Less than 5% of the nearly 4,000 classified institutions are designated Research 1: Very High Spending and Doctorate Production.

"This is an exciting day for Southern and our campus community, and it is a milestone for all Salukis to celebrate," SIU Carbondale Chancellor Austin Lane said.

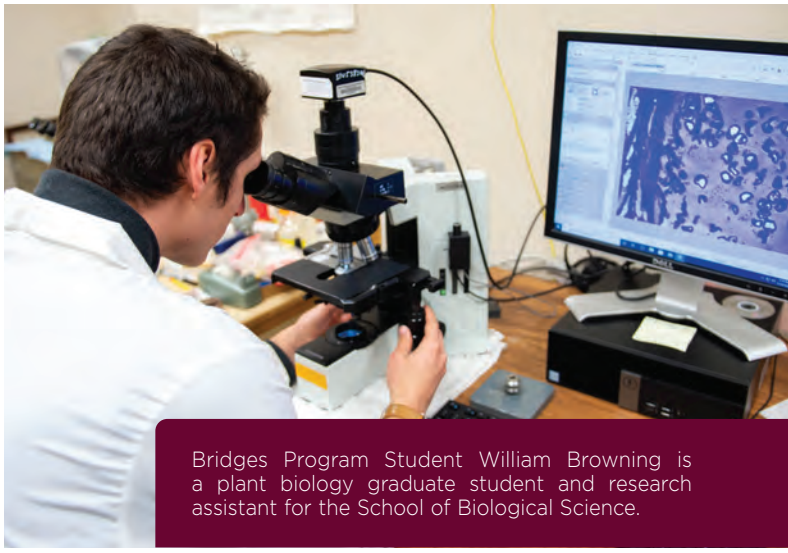
Lane said exploring the R1 designation was an objective in the Imagine 2030 strategic plan, which includes a research and innovation pillar.

"The R1 designation affirms what we already know – SIU Carbondale is among the top research universities in the country," he said. "As the only R1 in rural Illinois and within 100 miles, we are uniquely positioned as a powerhouse for innovation in this region. Our faculty and staff imagined earning this designation, and they worked tirelessly to get us to achieve it. I want to thank them personally for all they've done to make this day possible, and I am especially grateful for our talented, hard-working faculty."

With its new designation under Carnegie's revised criteria, SIU Carbondale is one of just six R1 universities in the state of Illinois, on the same level as Loyola University Chicago, Northwestern, University of Chicago, University of Illinois Urbana-Champaign and U of I Chicago.

Microbiology student Danielle Snyder tends to plants growing in simulated regolith. (Photo by Russell Bailey)

Assistant Professor Lahiru Jayakody investigates how to turn waste plastic into food. (Photo by Russell Bailey)



Bridges Program Student William Browning is a plant biology graduate student and research assistant for the School of Biological Science.

Costas Tsatsoulis, vice chancellor for research, said the new R1 designation highlights the university's status as a comprehensive doctoral research university, which includes the SIU School of Medicine campus in Springfield.

"Our research, scholarship and innovation include disciplines in STEM, in the arts, the humanities, law, medicine, business, education, agriculture, social sciences and more," Tsatsoulis said. "We cover from A to Z, from accounting to zoology, from photography to photosynthesis and from aquaculture to forestry to quantum physics.

"Our elevation to R1 bolsters our efforts toward securing research funding, continuing to recruit high-quality faculty and students, and further supports the vision of Imagine 2030."

HOW THE DESIGNATIONS WORK

Carnegie maintains and releases reports on universities meeting research and doctoral production benchmarks every three years. R1 universities must have at least 70 research doctorates and $50 million in research expenditures. In 2023, for example, SIU Carbondale had 102 research doctorates and $58.3 million in research expenditures.

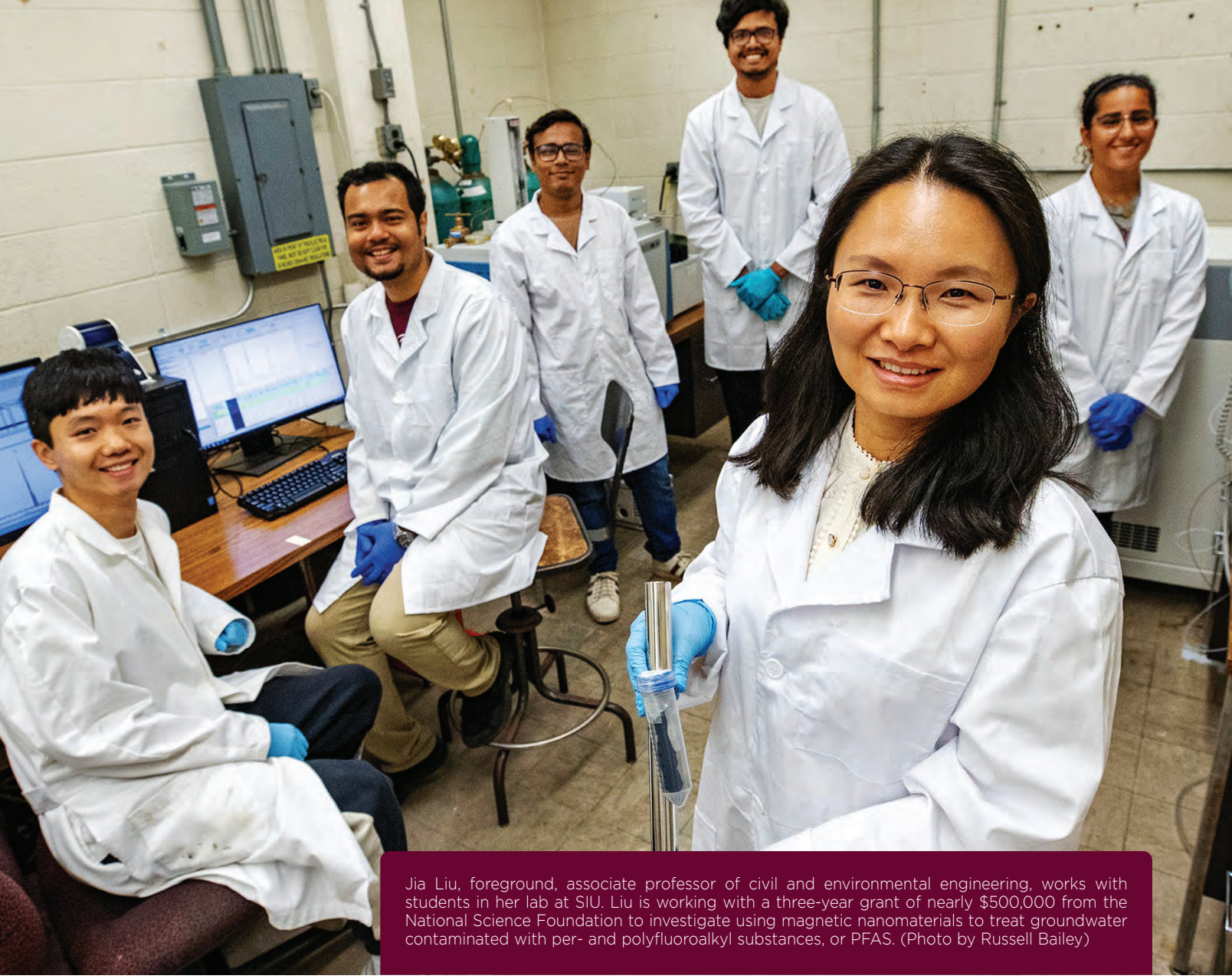
"Becoming R1 enhances our global reputation as a university with a wide variety of research opportunities for graduate and undergraduate students," Tsatsoulis said. "SIU Carbondale has excellent research facilities, well-funded research centers and outstanding faculty guiding graduate students toward master's and doctoral degrees."

RESEARCH OF A 'VERY HIGH' LEVEL

The R1 designation verifies SIU Carbondale faculty conduct research at a very high level, enhancing the classroom experience at both the graduate and undergraduate levels.

Faculty, students and staff on the Carbondale campus and the School of Medicine campus in Springfield have played a pivotal role in the university attaining R1 status, and they will continue to play a key part in maintaining SIU Carbondale's designation, Tsatsoulis said.

"Our faculty will continue to lead SIU Carbondale through their research grants, contracts, partnerships with industry and the state, through collaborations across the nation and world, and through excellence in their disciplines, and training and mentoring of students," Tsatsoulis said.



Jia Liu, foreground, associate professor of civil and environmental engineering, works with students in her lab at SIU. Liu is working with a three-year grant of nearly $500,000 from the National Science Foundation to investigate using magnetic nanomaterials to treat groundwater contaminated with per- and polyfluoroalkyl substances, or PFAS. (Photo by Russell Bailey)

$500K SIU Study Focuses on Removing 'Forever Chemicals' from Water

BY TIM CROSBY

Life itself springs from the ground in the form of water, and a researcher at Southern Illinois University Carbondale is seeking to eliminate PFAS, also known as "forever chemicals," from this life-giving substance by using nanoparticles and light.

Jia Liu, associate professor of civil and environmental engineering, is working with a three-year grant of nearly $500,000 from the National Science Foundation to investigate using magnetic nanomaterials to treat groundwater contaminated with per- and polyfluoroalkyl substances, or PFAS. Liu and her team are exploring the challenges of constructing a pilot-scale treatment unit based on the developing technology and builds on Liu's previous grant-funded work in this area.

AN EMERGING CONCERN

PFAS are commonly used in many products and processes and have made life easier in many ways. They are a key ingredient in such things as firefighting substances to food packaging and Teflon products. They can make fabrics both breathable and waterproof.

With such ubiquitous use, PFAS are commonly found throughout the environment, including in surface water, sediments, air, soil and sludge. But scientists also have noted these substances stick around in the environment long after being used. This, among other factors, gives PFAS the potential to build up in the bodies of living organisms, where they might potentially cause adverse effects.

The EPA of late has taken special note of the issue, issuing national primary drinking water regulations for certain PFAS and announcing health advisories for others when higher levels are detected and continuing to study the issue.

A TRACK RECORD OF SUCCESS

Beginning in 2018, Liu began receiving grants from the U.S. EPA's People, Prosperity and the Planet program to study ways of eliminating PFAS from the environment. Those efforts were focused on effluents released from wastewater treatment plants, which do not remove PFAS.

That research team, which also included faculty members Boyd Goodson, Michael Lydy and Jane Geisler-Lee, as well as SIU students, successfully used iron nanomaterials under ultraviolet light to remove PFAS from the water and demonstrated an innovative point-of-use system that could potentially be deployed at scale in the real world.

"Building on this work, our current NSF-funded project seeks to explore a more efficient treatment method for PFAS in contaminated groundwater," Liu said.

While the focus will remain on removing PFAS, the researchers also will wrestle with removing additional contaminants, such as chlorinated solvents from industrial activities or landfills, that often are mixed in with PFAS. Both PFAS and chlorinated solvents pose significant health risks, and their persistence in the environment makes them particularly challenging to remediate.

"The coexistence of these contaminants further complicates our remediation efforts, and it is driving growing interest in finding effective treatment methods that can address both," Liu said.

"Our focus will be on pilot-scale remediation of PFAS at contaminated sites, with an additional investigation into how the presence of these cocontaminants affects the removal process."

TAKING IT TO THE NEXT LEVEL

As pioneered with the previous EPA grants, Liu and her team will again use a process known as photocatalysis. Photocatalysis uses light to accelerate a chemical reaction. The process uses iron nanoparticles inside a photoreactor to remove PFAS from water samples.

Photocatalysis represents an elegant, low-cost approach to the problem, but in this case, the researchers will pair it with another approach known as dark-light adsorption. In this new, two-phased process, the contaminated groundwater will first enter the reactor containing an iron-carbon nanohybrid material under dark conditions.

As the contaminated water first flows into the reactor in a dark environment, PFAS contaminants are expected to adsorb onto the surface of the material, concentrating them. After this adsorption phase, ultraviolet light will be turned on, and the water flow will be stopped to create a batch reactor.

The two-phased approach will make it easier to treat large volumes of water, Liu said.

"This approach allows us to first concentrate PFAS under dark conditions and then degrade them under light exposure," Liu said. "This dark-light alternating process within the same reactor, using the same nanomaterials, is expected to not only remove PFAS contaminants from the water but also degrade them effectively."

HOPE FOR THE FUTURE

The project, which began in September 2023, is scheduled to end in 2026. If all goes well, the team of Liu, along with at least two doctoral students, one graduate student and two undergraduates, will successfully build a working, pilot-scale reactor of a "bench-top" size holding about 12 gallons. That reactor would then be integrated with other pre- and post-treatment reactors to enhance groundwater treatment for field operations.

"If we're successful, we'll advance the development and deployment of efficient and sustainable technologies for the treatment and remediation of groundwater aquifers contaminated by mixtures of PFAS and chlorinated solvents," Liu said.

SIU officials and honored guests cut the ribbon, dedicating the new BioLaunch lab. (Photo by Amihere Benson)

SIU's State-of-the-Art, $7.2M BioLaunch Boosts Opportunities in Science, the Economy

BY TIM CROSBY

Southern Illinois University Carbondale has opened its $7.2 million BioLaunch lab, a new, 10,000-square-foot space dedicated to cutting-edge life sciences research. It is the newest addition to the Illinois Food, Entrepreneurship, Research, and Manufacturing (iFERM) Hub, a state-of-the-art research and training suite for faculty use, students, start-up companies and private firms.

"Today is an exciting day for Southern Illinois University Carbondale and our region," said Chancellor Austin A. Lane of the new lab's opening. "BioLaunch will advance interdisciplinary science and economic development. It is a perfect example of the research and innovation pillar in our university's Imagine 2030 strategic plan."

Funded in part by a $2.7 million grant from the Illinois Department of Commerce and Economic Opportunity Wet Lab Program, BioLaunch is the newest addition to the Illinois Food, Entrepreneurship, Research, and Manufacturing (iFERM) Hub, a state-of-the-art research and training suite for faculty use, students, start-up companies and private firms in the region. iFERM capitalizes on the university's research and innovation into food, fermentation and biotechnology.

Costas Tsatsoulis, vice chancellor for research at SIU, said BioLaunch will provide top-line resources for faculty and companies.

"BioLaunch and other components of the iFERM Hub will help us solve challenges in food, agriculture, energy and health through research, innovation and education," he said. "And it will provide infrastructure for

the development of Illinois agriculture value-added products to promote and support successful entrepreneurial activities."

BioLaunch contains a biotechnology core, an analytical core, a mass spectrometry core and a business annex, and it is the first of three major construction projects, totaling $13 million, for iFERM, located at the McLafferty Annex on the university's far west side. The other projects include a full-scale production brewery and a value-added agriculture pilot facility.

In addition to BioLaunch, McLafferty Annex houses the Fermentation Science Institute; the Center for Fisheries, Aquaculture, and Aquatic Sciences, and an ultra-fast laser facility.

BioLaunch and other projects are the result of a collaboration with the State of Illinois, SIU Carbondale, the SIU Foundation, SIU's Office of the Vice Chancellor for Research, the SIU Fermentation Science Institute and the SIU Research Park.

The wet labs at BioLaunch offer spaces for cutting-edge research in life sciences and represent a critical component of research and development for companies in biotechnology, pharmaceuticals and medicines, medical devices and diagnostics, energy and more. Wet lab space is customized with ventilation and other infrastructure needed to handle chemicals and materials commonly associated with biotech research.

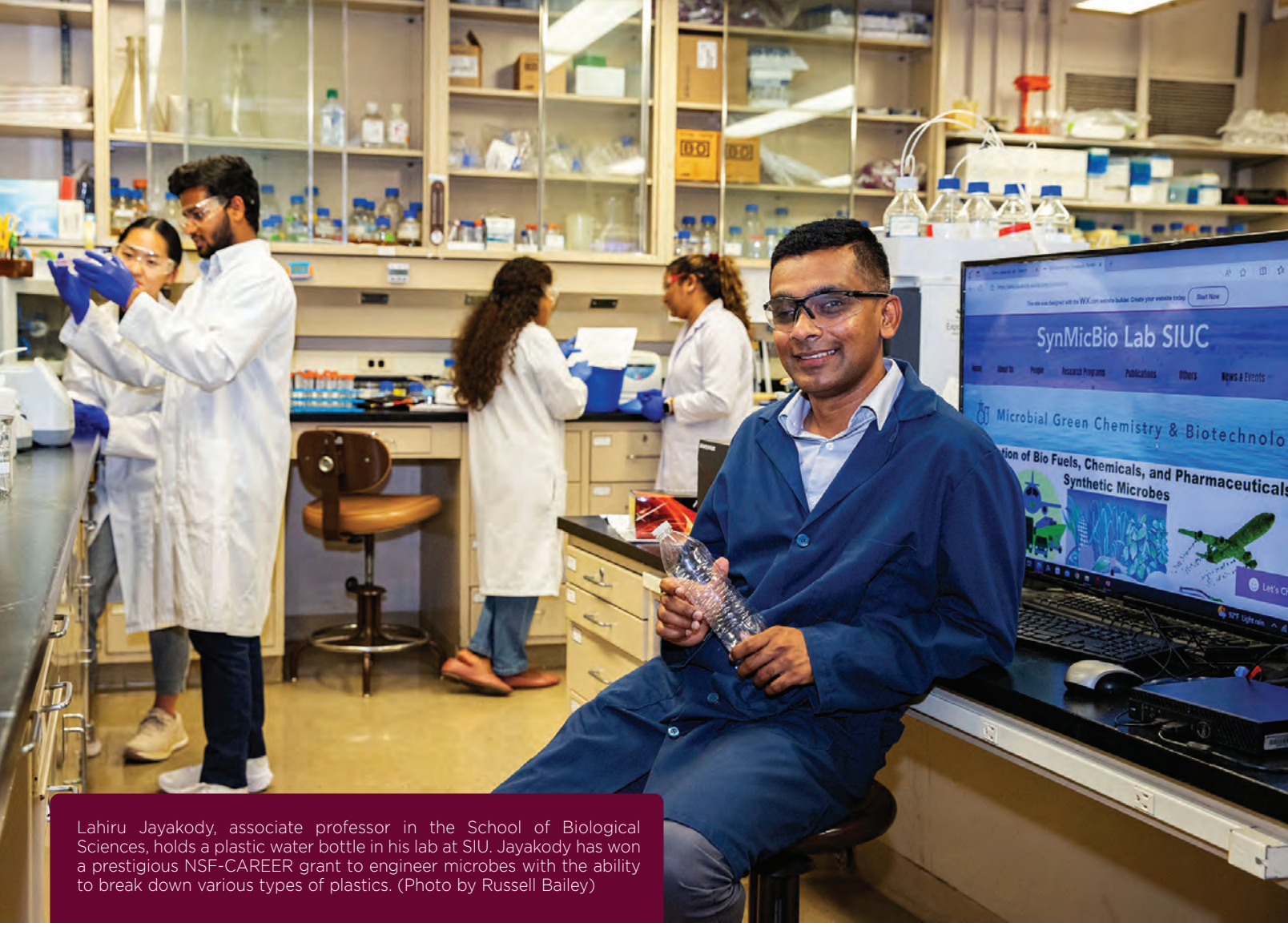
The biotechnology core within BioLaunch covers about 2,500 square feet and has cutting-edge features such as a cold room for experiments, a biosafety laboratory, benches and benchtop scientific instruments and a suite of bioreactors. Open to use by all researchers at the university and regional businesses, much of the lab's mission will include developing, characterizing and prototyping various microbes used in the fermentation processes for beverages, foods and the advanced processing of materials. The biotechnology core can also be used for genomic analysis and genetic engineering.

The analytical core nearby will focus on using high-end instrumentation to deeply analyze materials. As part of the effort, the university has moved much of its mass spectrometry equipment, added new equipment, including a 500-megahertz nuclear magnetic resonance spectrometer, and is providing a centralized location for researchers and regional businesses alike.

The business annex contains flexible meeting areas and training spaces, a catering kitchen and board room. It also includes a shared office space for emerging small businesses using the services of BioLaunch.

Lynn Andersen Lindberg, executive director of the SIU Research Park, said BioLaunch and the iFERM Hub overall will lead to job creation, workforce development and business expansion in the region and in Illinois.

"Whether research or a business enterprise is related to food, energy or something that touches on the periphery of both, life sciences is as the heart of BioLaunch," she said.



Lahiru Jayakody, associate professor in the School of Biological Sciences, holds a plastic water bottle in his lab at SIU. Jayakody has won a prestigious NSF-CAREER grant to engineer microbes with the ability to break down various types of plastics. (Photo by Russell Bailey)

SIU Researcher Wins $624,500 NSF-CAREER Grant to Develop Microbes to Mitigate Plastic Waste

BY TIM CROSBY

Can a microbe be used to eat our way out of the growing problem of plastic waste in our environment? A Southern Illinois University Carbondale researcher thinks it might be possible, and he's using a large federal grant to investigate.

Lahiru Jayakody, associate professor in the School of Biological Sciences and Fermentation Science Institute, is looking at engineering a novel microorganism with the ability to break down various types of plastics into their basic building blocks, or monomers. The process would provide a way to handle waste plastics polluting the environment, while also providing the monomer precursors for other valuable chemicals.

Jayakody has received a prestigious five-year CAREER grant of up to $624,500 from the National Science Foundation to pursue the work at SIU starting Sept. 1. Along with equipment and supplies, the grant also will fund one postdoctoral researcher, two doctoral students, one undergraduate researcher and local high school students.

Also known as the Faculty Early Career Development Program, CAREER grants seek to support early-career faculty who have the potential to serve as academic role models in research and education and to lead advances in the mission of their departments or organizations.

"It is really a dream to receive such a highly competitive award," said Jayakody, thanking his students for providing the vital preliminary data that helped garner the grant.

Goals for the project include developing an efficient microbial process to selectively deconstruct mixed plastic waste and to find ways to funnel the resulting compounds to create high-value chemicals.

A GLOBAL ISSUE

Anywhere between 19 million and 23 million tons of petroleum-derived plastics enter landfills and the oceans each year. The growing problem is having a substantial impact not only on the environment but on human health. Some studies suggest humans ingest up to 40 pounds of plastic during their lifetime, due to its ubiquitous presence in the environment and its use as packaging for food and water.

Jayakody has been on the cutting edge of finding innovative ways to deal with this issue. His research team's other ongoing projects include investigating a way to upcycle waste coffee and tea into microbes to be used to generate a biodegradable alternative to some plastics, as well as μBites (which means "microbites"), which uses specialized yeast to turn waste biomass and plastic into proteins that can be consumed as alternative food sources.

Jayakody hopes to pioneer an innovative, sustainable microbial-based biological system that would convert the carbon in current common petroleum-based plastics – such as polyethylene terephthalate (PET) polyurethane (PU), polycarbonate (PC) – into high-value platform chemicals. Such biochemicals might eventually be used to replace petroleum-based polymers altogether.

"This would remarkably reduce plastic pollution and greenhouse gas emissions," Jayakody said.

WONDER BUG

The key aspect to making this new cycle work is a new bug that will do all the work: Erwinia renovo LJJL01. Created from a related bacterium engineered to efficiently break down PET plastics into their original monomers with secreted plastic-degrading enzymes, the new microbe will selectively break down mixed plastic into its original monomers and convert them into high-value chemicals.

To do this, the researchers will use high-tech genomics, RNA sequencing, proteomics, metabolomics and other techniques aimed at identifying the molecular mechanisms that optimize plastic-degrading enzyme secretion.

"We will develop synthetic biology tools and metabolic engineering approaches to tailor an efficient strain for plastic upcycling," Jayakody said. "The final goal is to develop a microbial strain for consolidated bioprocessing of plastic."

The project will fill the knowledge gap on microbial engineering approaches for polymer deconstruction and the creation of innovative chemicals, Jayakody said.

"We're going to learn more, in-depth knowledge about this novel bacterium and its incredible metabolic capacity, its chemical toxicity tolerance and other factors," he said. "And from that, we'll generate a unique dataset that will help us develop a new host capable of advancing the process."

PREPARING FOR THE FUTURE

Creating such a process would in turn require educating up-and-coming scientists and engineers in this new approach. The project, therefore, comes with a strong educational component.

Jayakody's work will establish advanced synthetic microbiology and biotechnology educational programs at SIU. The efforts are centered on developing the workforce required to combat plastic pollution.

Much of the work will take place in the BioLaunch Core Facility at the McLafferty Annex on the west side of campus. Announced in 2022, the state-of-the-art, 7,500-square-foot facility was one of eight new wet lab spaces funded by the Rebuild Illinois capital program.

"We want to provide rich, synergistic, interdisciplinary research experiences for graduate and undergraduate students, postdoc and industry, including ethnic minorities and first-generation college students, and promote career opportunities," Jayakody said.

He also will create educational innovations for the plastics industry and genetic engineering efforts and reach out to the local community and its younger students to make them aware of the evolving, new technologies in upcycling waste plastic.

"We'll strive to create a deeper awareness of plastic waste's impact on health, the environment and the economy and engage the public to adopt better policies to battle global plastic waste," he said. "Since this is foundational yet transitional research, we're eager to secure additional funding, industrial support and investor backing to further develop the technology."

RISK VS. REWARD

Jayakody said SIU has been extremely supportive of his work, which has helped the project move forward.

"This research involves high-risk, high-reward, hypothesis-driven work that demands dedication to achieve our set goals," he said. "I have great confidence in my research team's and our collaborators' ability to handle the scientific challenges, and I have consistently received excellent support from the SIU administration to smoothly run the projects."

Carl Messick and Lisa Barry of the U.S. Department of Agriculture, work with scenting hound Benny near a Southern Illinois waterway. (Photo provided)

SIU Student Researcher Tracks Invasive Rodent as Part of Study on Semiaquatic Mammals

BY TIM CROSBY

There are four semiaquatic mammals traditionally living in Illinois, but a student researcher at Southern Illinois University Carbondale is using a new technique to keep watch for the presence of a fifth, unwelcome species: nutria, which wreck habitats and spread disease.

Derek Whipkey, a graduate student in zoology, is studying the Southern Illinois distribution of American beaver, muskrat, river otter and American mink, all fur-bearing species that impact the economy. Whipkey also is looking at factors impacting the animals' distribution and the interactions among them, especially between beaver and otter.

While he's at it, Whipkey is also looking into reports of nutria making their way into Southern Illinois. Somewhere between the size of a beaver and a muskrat, nutria reproduce multiple times a year and can destroy vital wetland habitat with intense foraging.

A NEW, UNWANTED NEIGHBOR

Classified as an aquatic rodent, nutria live in burrows alongside water, feeding on plant stems. The Illinois Department of Natural Resources has received reports of nutria in Southern Illinois, prompting researchers to look into the presence of these invasive creatures, which traditionally live in South America but have been introduced into North America, Europe and Asia primarily by fur farmers.

Although nutria are still hunted and trapped in some regions, their destructive burrowing and feeding habits often bring them into conflict with humans, and they are considered an invasive species in the United States. Nutria also can transmit diseases to humans and animals, mainly through water contamination.

LOOKING FOR CLUES

Working with his faculty adviser Guillame Bastille-Rousseau, assistant professor at SIU's Cooperative Wildlife Research Laboratory, and Charlotte Narr, assistant professor of zoology, Whipkey is set up surveillance sites at 67 aquatic areas across Southern Illinois, including Alexander, Pulaski, Massac and Pope counties. At each site, Whipkey looked for visual signs of the mammals' presence; a technique known as a "sign survey," as well as deploying motion-activated cameras.

"A sign survey is a traditional method for determining wildlife presence," Whipkey said. "A typical sign survey consists of an observer walking a transect of some designated length, looking for and recording any physical evidence of the target species. In our case, we had two observers walking a 200-meter transect, looking for signs within 5 meters of the water's edge."

Signs can include animal tracks, distinct foraging signs, scat or a number of other indicators unique to a target species.

"My goal is to determine the distribution of semiaquatic mammals as well as finding the most efficient method at detecting these species," he said. "The sign surveys had the highest detection probability for all native semiaquatic mammal species."

USING A NEW TOOL

In order to specifically confirm the presence of nutria, however, Whipkey also used an old-school method for detecting the mammals – a detection dog – as well as a brand-new, high-tech one known as environmental DNA, or eDNA.

This new, noninvasive method does not directly impact the animals but instead relies on collecting genetic material of target species from the environment, most commonly the local water but also soil and air in more recent applications.

Graduate students Adrienne Stanley and Madison Stokoski used a pump to filter water and collect samples, which Whipkey used to possibly catch a genetic whiff indicating the presence of nutria.

"The idea is that genetic material in the water will be caught in the filters," he said. "We then dry the filters and ship them to collaborators who extract the DNA and determined which species were present or had been present within about a week of the survey samples."

POSITIVE RESULTS

The study, funded by the Illinois Department of Natural Resources via the Federal Aid Restoration Act, wrapped up in December. So far, eDNA samples have detected nutria at two of the 67 sites Whipkey is surveying. In both cases, the new technique was able to "see" nutria when other survey methods did not.

While the two positive detections of nutria are interesting, Whipkey said they may not be cause for alarm just yet.

"I think it alludes to the idea that nutria are dispersing into Southern Illinois but have yet to be established," he said. "There is also the question of if nutria are actually capable of colonizing Southern Illinois. The species is fairly sensitive to cold temperatures and therefore their current range is limited to areas with mild winters. Southern Illinois seems to be right at the border of their range, which may support my previous idea of our detections representing dispersing individuals that are not reproducing."

However, if climate change models are accurate and Illinois becomes warmer, that may change. Whipkey also is in contact with wildlife experts in Maryland, who told him nutria may cope with colder temperatures by losing their tails. Continued monitoring is key.

"eDNA is a promising approach that could be an important tool in the early detection of an invasive species," Whipkey said. "It could allow wildlife managers to take action before the species becomes established."

One of the many participants in SIU's annual 9/11 Saluki Stair Climb at the Banterra Center shows support for veterans. (Photo by Deangelo Handley)

SIU Assists Rural Veterans with Transition to Civilian Life through Training, Research

BY CHRISTI MATHIS

A Southern Illinois University Carbondale faculty member who is passionate about helping veterans is recruiting rural vets for a study about adjusting to civilian life, and they will be rewarded with an SIU artificial intelligence coding certificate and a little cash.

Justin McDaniel, associate professor of public health in the School of Human Sciences, is seeking at least 180 veterans over the next two years to participate in the project funded by a $341,600 National Science Foundation (NSF) grant.

"The transition from military to civilian life is challenging, particularly in terms of retooling for a new career," said McDaniel, who holds joint appointments in the neurology department and the population science and policy department at the SIU School of Medicine. "This transition is often even harder for those who live in rural areas, because access to resources and educational opportunities is more sparce. The focus of this project is helping rural veterans transition from the military into civilian life, college and jobs."

LEARNING, EARNING AND HELPING OTHERS

The project has multiple components, providing veterans with valuable training to boost their careers while also giving McDaniel's team research data to help other veterans.

Any veteran who lives in a rural area is welcome to participate. The Veteran Education, Transition, Empowerment, Research and Advocacy Network (VETERAN) Lab, directed by McDaniel, is providing the participants with free 17-week, asynchronous online training focused on how to work with code-based artificial intelligence. With the MachinE Learning Training for VETerans (MELT-VETT), participants who may have no experience with public health data learn how to use machine

learning, a subdiscipline of AI, to run a basic model. The weekly learning activities take about 30 minutes to finish, and participants will also complete baseline and exit surveys, taking about 20 minutes each.

"These days, AI is basically infiltrating almost every profession," McDaniel said. "A veteran can get a leg up in their career if they are competent in AI and machine learning. Upon completion of the program, veterans will receive a micro-credential certificate from SIU that can be added to their LinkedIn profile or resume."

In addition, each veteran will receive a modest cash incentive and be entered into a random drawing for a larger stipend.

THE RESEARCH ASPECT

McDaniel's SIU partners for the Rural Veteran Personality, Delay Discounting and the Interference Preservation research project include Yvonne Hunter-Johnson, associate professor and academic adviser for the organizational learning, innovation and development program in the School of Education, and Harvey Henson, director of the STEM Education Research Center and associate professor with joint appointments in curriculum and instruction in the School of Education and geology in the School of Earth Systems and Sustainability.

Team members are exploring several areas, including:

- What psychological issues challenge veterans during their learning experience (these may include moral injury, PTSD, personality type, impulsivity and other issues)?
- How can researchers best tailor educational feedback based on the personality type of veterans and the extent of their impulsiveness?
- What effects can veteran peer mentors/tutors have on the educational outcomes for participants? (An additional $32,654 in NSF funding is covering training for a military veteran doctoral student to provide peer-mentoring.)

ONGOING EFFORTS TO BENEFIT VETS

In addition, McDaniel has received three consecutive contracts totaling about $181,790 from the U.S. Department of Veterans Affairs to characterize and evaluate a program whose goal is to rehabilitate service members and veterans with traumatic brain injuries via an innovative two-week assessment and treatment program.

McDaniel established the VETERAN Lab to conduct research to benefit members of the military and veterans and to inform evidence-based policy recommendations. Gifts to support the lab can be made through the SIU Foundation. McDaniel is also the lead author of "Preventing and Treating the Invisible Wounds of War: Combat Trauma, Moral Injury, and Psychological Health (Ethics, National Security, and the Rule of Law)," a book that highlights moral injury research and advocacy efforts.

Gayan Aruma Baduge, associate professor in the School of Electrical, Computer and Biomedical Engineering, is leading an international team of researchers working with a total of $1.13 million in grant money. The three-year project is aimed at investigating AI-assisted integrated sensing and communications for 6G technology. (Photo by Russell Bailey)

SIU Researcher Leads $1.13M Project to Integrate AI into 6G Technology

BY TIM CROSBY

Imagine a world in which a highly intelligent wireless system can monitor the environment and fight pollution, send a fleet of cars to transport several people and help find a missing young child because it can identify anyone anywhere. Sixth generation wireless – or 6G – is on the horizon, and a Southern Illinois University Carbondale researcher is working on the integral aspects that will make it function.

Gayan Aruma Baduge, associate professor in the School of Electrical, Computer and Biomedical Engineering, is leading an international team of researchers working with a total of $1.13 million in grant money. The teams include SIU and Villanova University in the United States and Aalto University of Finland.

SIU's portion of the grant, which comes from the National Science Foundation, totals $336,500. The three-year project is aimed at investigating AI-assisted integrated sensing and communications for 6G technology.

"This is a unique research partnership that bridges the European Union and United States, with a focus on advancing the fields of artificial intelligence and integrated sensing and communications," Baduge said.

In addition to voice and data communication services like those used today, 6G technology is also expected to include sensing functions, such as highly accurate location tracking and mapping, area imaging, and operation of autonomous vehicles, including "platooning," which involves operating several vehicles together as one unit.

Powered and controlled by advancing artificial intelligence, the technology also will be able to perform new functions related to surveillance, including detecting what kind of gestures or activities humans may exhibit, as well as identifying the people making them. Such abilities in the system are aimed at extracting, classifying and predicting typical movements of the human body such as standing, sitting, walking, jumping, smiling or crying, for example.

Baduge's work centers on developing the theoretical foundations of the technology, designing wireless systems that can integrate mobile communications and environment imaging and sensing in future wireless systems. Combining the system would increase efficiency and functionality.

"The 6G wireless systems with integrated sensing and communication functionalities can be useful for environmental monitoring, vehicular networks, remote sensing," Baduge said. "It would also facilitate the creation of smart cities while improving industry, manufacturing and agriculture."

A key to making 6G everything it promises to be involves leveraging the similarities between existing radio sensing and communication systems. Such systems already share – or are beginning to share – frequency spectrums, hardware architecture and information processing pipelines.

Baduge hopes to design a structure that more formally combines the two systems into a single hardware platform using a unified waveform and transmission strategy controlled by AI. Such a system would be much more capable of processing signals from various sensors while also handling common cellphone and data transmission.

EVOLUTION OF THE SYSTEMS

Historically, wireless radio systems for cellular communications and radar sensing were designed and operated independently. The systems used different waveforms, non-overlapping radio frequency bands, and separate hardware platforms.

The current state-of-the-art 5G wireless communication systems have been designed and optimized primarily for mobile cellular communications. The demand for higher data rates and the number of connected wireless devices, however, is increasing, and satisfying this demand has prompted engineers to use large antenna arrays operating at higher frequencies where radar also lives.

In short, it's getting crowded.

"The electromagnetic spectrum or radio frequency band used for communication and sensing purposes is an extremely scarce and expensive resource," Baduge said. "Integrating communication and sensing tasks into the same hardware platform can greatly improve efficiency."

Such a design can also be cost effective as expensive radio frequency equipment can be reused for communication and sensing purposes, he said.

CHALLENGES AHEAD

Integrating two systems designed for different things is extremely challenging, Baduge said, as data communication and radar sensing tasks have mutually competing design objectives.

"Because of that, we're proposing to use a range of tools from communications and information theory, estimation and detection, and data-driven artificial intelligence to overcome the design challenges," he said.

Baduge hopes the research will help integrate radio sensing functionality into 6G technology, including cellular communication systems, wireless local area networks and industrial internet-of-things networks ("smart" homes and appliances, etc.), while keeping costs low and conserving frequency spectrum and computational capacity.

SIU research assistant Asyeh Sohrabifar, left, and doctoral student Alexander "Koaw" Zaczek run tests on samples at a lab on the SIU campus as part of the largemouth bass study. (Photo by Russell Bailey)

$324K SIU Study Focuses on How to Keep Farmed Largemouth Bass from Eating Their Own

BY TIM CROSBY

The largemouth bass is a popular sportfish among anglers, who know that familiar "thump." But researchers at Southern Illinois University Carbondale are looking to find better ways to farm it to the table for humans by keeping the infamously cannibalistic species decidedly off its own menu.

Using a two-year, $324,000 grant from the U.S. Department of Agriculture, SIU researchers are working with Purdue University and local industry partner Big House Fish Farm on improving intensive aquaculture methods for largemouth bass and getting a more productive and predictable yield. The study concluded last fall.

In addition to providing recreation, largemouth bass are also one of the most popular table fares, especially in live Asian markets. Largemouth bass have been farmed for nearly a century, although the target market typically is anglers fishing small lakes and impoundments for fishing.

In Southern Illinois, the market is growing, generating at least $3 million a year for local fish farmers with room for more, said Jim Garvey, director of the Center for Fisheries, Aquaculture and Aquatic Sciences at SIU and a co-leader of the study along with Habibollah Fakhraei, assistant professor of environmental engineering. The acceptance of largemouth bass as a food fish in live markets is relatively new, and raising them in high densities to maximize production in small ponds has presented challenges.

"Largemouth bass are top predators in lakes and are not really adapted to living at high densities," Garvey said. "In the wild, they eat live prey

and often eat each other. It's not unusual for a pond containing a bunch of little bass to produce one or two surviving big bass that have eaten their brothers and sisters."

The research, therefore, is aimed at determining ways to increase survival by reducing cannibalism in largemouth bass while encouraging them to eat formulated feeds.

A TEAM EFFORT

Along with Garvey, SIU researcher Hannah Holmquist, research assistant Asyeh Sohrabifar, post-doctoral student Giovanni Molinari, and doctoral student Alexander "Koaw" Zaczek are working on the project, which takes place in nine ponds near SIU's Touch of Nature Outdoor Education Center south of Carbondale.

Zaczek said the team is using three of the ponds to supply water to three 600-gallon tanks holding largemouth bass. Researchers also partitioned three other ponds to keep the fish separated, while three other ponds hold control group fish. The team is studying how the various holding methods impact the fishes' survival and growth.

Fencing and netting prevent hungry local predators such as otter, great blue heron and great egret from enjoying the buffet, which totaled more than 11,000 fish at the project's outset. Strict protocols govern the researcher team's day-to-day interaction with the specimens and include feeding, cleaning, aeration, waste management, equipment maintenance and other factors, Zaczek said.

Close quarters being the order of the day, the team takes a particular interest in nitrogen cycles of each enclosure, watching for signs of trouble with the waste generated by the fish overwhelming the environment.

The team collects samples daily and weekly to run lab tests and monitor nutrient data and other factors, Zaczek said.

"We're looking to see, particularly in the split-ponds, if the ammonia that is generated by the fish waste is processed via the nitrogen cycle and more conducive to fish health compared to the control ponds," he said. "Basically, the hope is that the ammonia released by the fish is broken down into nitrite and then nitrate in the non-fish-containing portion of the ponds so that the returned water to the fish of the pond contains minimal to no ammonia."

Doctoral student Alexander "Koaw" Zaczek works on one of three 600-gallon tanks holding largemouth bass at a research fishery south of Carbondale. SIU is working with partners using a $324,000 grant from the U.S. Department of Agriculture to improve intensive aquaculture methods for the fish. (Photo by Russell Bailey)

CUTTING DOWN ON CANNIBALISM?

Encouraging fish to eat more evenly across the population might prove easier in denser populations, Zaczek said.

"We're trying to get all the fish to take to the feed early," he said. "In a big pond, where the fish are spread out, it becomes more difficult to ensure even feeding, and it's harder to get fish to take to the feed early. The fish that do take to the feed early get a head start, grow big and are more likely to eat their cohorts."

With the fish living in such conditions, cannibalism can certainly take a bite out of the bottom line. Discouraging this behavior in largemouth bass is a challenge, Zaczek said.

"Well, that's something easier said than done," he said. "The hope is the confined space and higher fish density will cause the fish to take to the feed better and eat more similarly, which also would encourage similar growth rates. They are less likely to eat each other if they are the same size."

A GROWING MARKET

With largemouth bass becoming a more popular culinary item, Zaczek said, the team's research could help open important revenue paths for fish farmers. If either the tank-side or split-pond method prove to be more efficient, producers' efforts might result in more fish surviving at more predictable sizes.

Success also might lead to other fish farmers experimenting with such methods on their own properties using other common species found in aquaculture such as catfishes.

"Buyers are happier if fish are of similar size, and sellers are happier when they are capable of delivering more product," he said. "As in most industries, efficiency is always the goal in aquaculture."

Chris Stantis, assistant professor in the Department of Anthropology, helped lead a recent survey and analysis of tap water from 30 cities across the U.S. to compare the variability of oxygen-stable isotopes. The work will help forensic investigators in identification cases. (Photo by Russell Bailey)

SIU Researcher Analyzes Water Isotopes, Refining a Method to Solving Mysteries

BY TIM CROSBY

While the sleuths on popular forensic crime shows make solving a case with science look easier than it actually is, a researcher at Southern Illinois University Carbondale is refining those methods using chemical analysis of local tap waters.

Chris Stantis, assistant professor in the Department of Anthropology, helped lead a recent survey and analysis of tap water from 30 cities across the U.S. The resulting paper, which compares the variability of oxygen-stable isotopes in the various samples, recently was published in the journal PLOS One.

Because the body's oxygen isotopes signify the water the person drinks when forming tissues, those telltale signs have long been to study migration patterns in archeological studies and increasingly with success in forensic identification investigations. But researchers wanted to examine how much variation exists in such isotopic values in any given place, which could significantly impact the accuracy of such tests.

Analyzing more than 4,000 samples and bringing her expertise in statistical analysis to bear, Stantis examined how variable oxygen-stable isotope values were in tap water samples from diverse locations. Nailing down those variations could in turn help investigators identify the body of a missing person by indicating where that person grew up.

A TELL-TALE SIGNATURE

Three stable isotopes occur naturally in all waters. Of those three, two are abundant and easily measured using mass spectrometry methods.

Scientists for years have used these oxygen isotopes, along with two hydrogen ones that also occur in water, to study basic hydrological cycles and other phenomena, including groundwater recharge, the origin of precipitation and runoff dynamics.

The isotopes in water, however, also provide important clues about where people and animals originate and live. Forensic investigators more recently have used these "tags" to help identify missing persons, as well as solve crimes.

While many researchers have looked at the average and mean values of isotopes found in hair and other tissue, Stantis' work aims to take this approach a few steps further.

"We knew there was a lot of complexity underlying this method that remained to be unexplored," she said. "As we dug deeper, we saw huge variability from city to city."

That issue was potentially troubling, Stantis said.

"If there's huge variability in a certain city regarding tap water oxygen stable isotope values, we're not sure we can confidently say that someone comes from that city based on the values found in their hair," she said. "Two people from the same city could have really different values."

IMPORTANT DIFFERENCES

The researchers found that forensic investigators need to be aware of the variations, as several factors can result in multiple isotope values within the same city.

In Atlanta, for example, tap water mostly originates from one river system. The city's treatment centers and reservoirs, however, alter the isotope values in water in different ways, creating variability.

"In Portland, there isn't much variation, so we can reach conclusions with high confidence," Stantis said. "But in places such as San Francisco and Atlanta, there is high variability, while Los Angeles is really complicated, due to its increasingly complex water-sourcing system.

"So, trying to use this method in those cities might be much more difficult, and investigators should consider those factors."

MAJOR UNDERTAKING

The project has roots stretching back to 2013, when some of the first samples were originally collected for other studies. The research team eventually amassed 4,068 samples across dozens of cities, with Stantis starting her analysis in 2022 while at the University of Utah before coming to SIU.

"At first, we wanted to know what tap water data was even out there," she said. "But as this data came together and questions formed, I took over the data cleaning and analysis, both of which proved to be enormous tasks."

On top of the various isotope factors, the researchers also took into account potential climatic, environmental and socioeconomic variables that might impact the findings. Along with her expertise in statistical analysis and coding, Stantis also brought the perspective of an anthropologist to the effort.

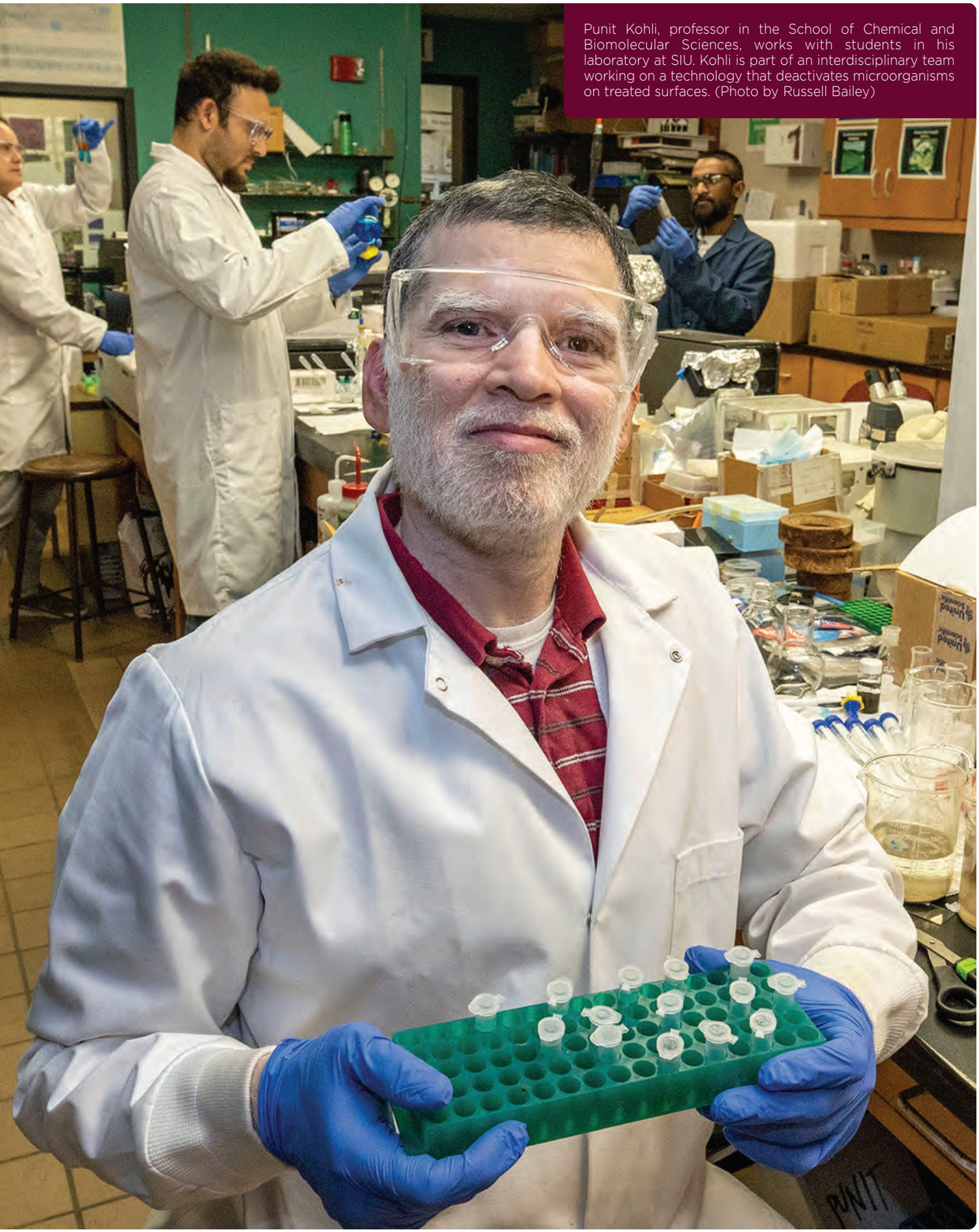
"As an anthropologist, I also tend to think about all of the different factors that affect human environments," she said. "I look at the cultural-economic, of course, but also physical factors like elevation and available water. Pulling together tons of different datasets from the U.S. Geological Survey, the U.S. Census, and ecological and hydrological papers meant shifting gears a lot of times for how different researchers view and analyze the world."

Stantis said bringing order and analysis to the chaotic variability was a significant challenge.

"It was possibly the biggest headache I've ever encountered as a researcher," she said, with the custom computer analysis requiring her to write what ended up as almost 2,000 lines of code, which, in turn, took many days' worth of computer-chewing to produce results.

The resulting insights will pay dividends, Stantis said, and point to the large amount of work still to be done.

"There's still a lot of underlying causes of variability to explore across the country," she said. "We can also now see just how much data are missing from big cities like Chicago and New York City, which were so underrepresented in terms of tap water samples that we couldn't even examine these places where millions of people live."



Punit Kohli, professor in the School of Chemical and Biomolecular Sciences, works with students in his laboratory at SIU. Kohli is part of an interdisciplinary team working on a technology that deactivates microorganisms on treated surfaces. (Photo by Russell Bailey)

SIU Researchers Investigate Technology to Kill Supergerms at the Nano Level

BY TIM CROSBY

Researchers at Southern Illinois University Carbondale are studying how to zap antibiotic-resistant bugs using electricity on the nano scale, which could lead to fewer infection-related deaths in hospitals.

Punit Kohli, professor in the School of Chemical and Biomolecular Sciences, along with researchers from the departments of chemistry, microbiology, physiology and the SIU School of Medicine, recently published a paper in the journal Science Advances outlining their work. The technology, known as "electrically polarized nanoscale metallic" or "ENM," involves applying an electrical potential to nanoscale metallic coatings that polarizes the coatings and generates chemicals called reactive oxygenated and chlorinated species. Such substances can deactivate a wide range of harmful microorganisms.

The U.S. Patent and Trademark Office has issued a provisional patent on the technology, Kohli said.

WIDE APPLICATIONS

Any surface prone to biological contamination is a target for the technology, Kohli said. So along with potential benefits for the health care setting, the technology might also be applied to a wide range of uses, including in homes, restaurants, public places such as schools, railway stations and airports, and industry.

"It could be incorporated on wearable masks, clothing, doorknobs, hospital furniture – like on handles and bed frames," Kohli said. "It might even be put to use in heating and air conditioning applications."

Kohli said ENM devices are quick and easy to fabricate and rely on external, low-powered batteries that operate in the milliwatt range.

"Because of the decreasing supply of new antibiotics, recent outbreaks of infectious diseases and the emergence of resistance of microorganisms to almost all available antibiotics, it is imperative to develop new effective strategies for deactivating a broad spectrum of microorganisms and viruses," Kohli said. "Conventional alkaline batteries or solar cells can power ENM devices for many hours without any observable decrease in performance."

The technology relies on the electrochemical production of certain types of ions that convert oxygen to hydrogen peroxide. That, in turn, forms reactive chemical species including hydroxyl radicals and hypochlorous acid that are highly damaging to germs, contributing to antimicrobial properties.

"It represents an unconventional but innovative tool for deactivating a broad spectrum of microorganisms," Kohli said.

The technology can be used by covering household or industrial items with a copper-silver coating before attaching a battery to it, which then generates reactive oxygenated and chlorinated species.

The technology can deactivate a wide range of microorganisms – bacteria, fungi, viruses or archaea – in as little as 10 minutes, Kohli said. Such bugs tested in the study include lentivirus, a group of model retrovirus that can cause chronic and deadly diseases, as well as Candida albicans and Aspergillus fumigatus, two fungi that can cause serious health problems or death in immunocompromised patients.

SIU Research

SOUTHERN ILLINOIS UNIVERSITY CARBONDALE

siu.edu/research