tx H_2O

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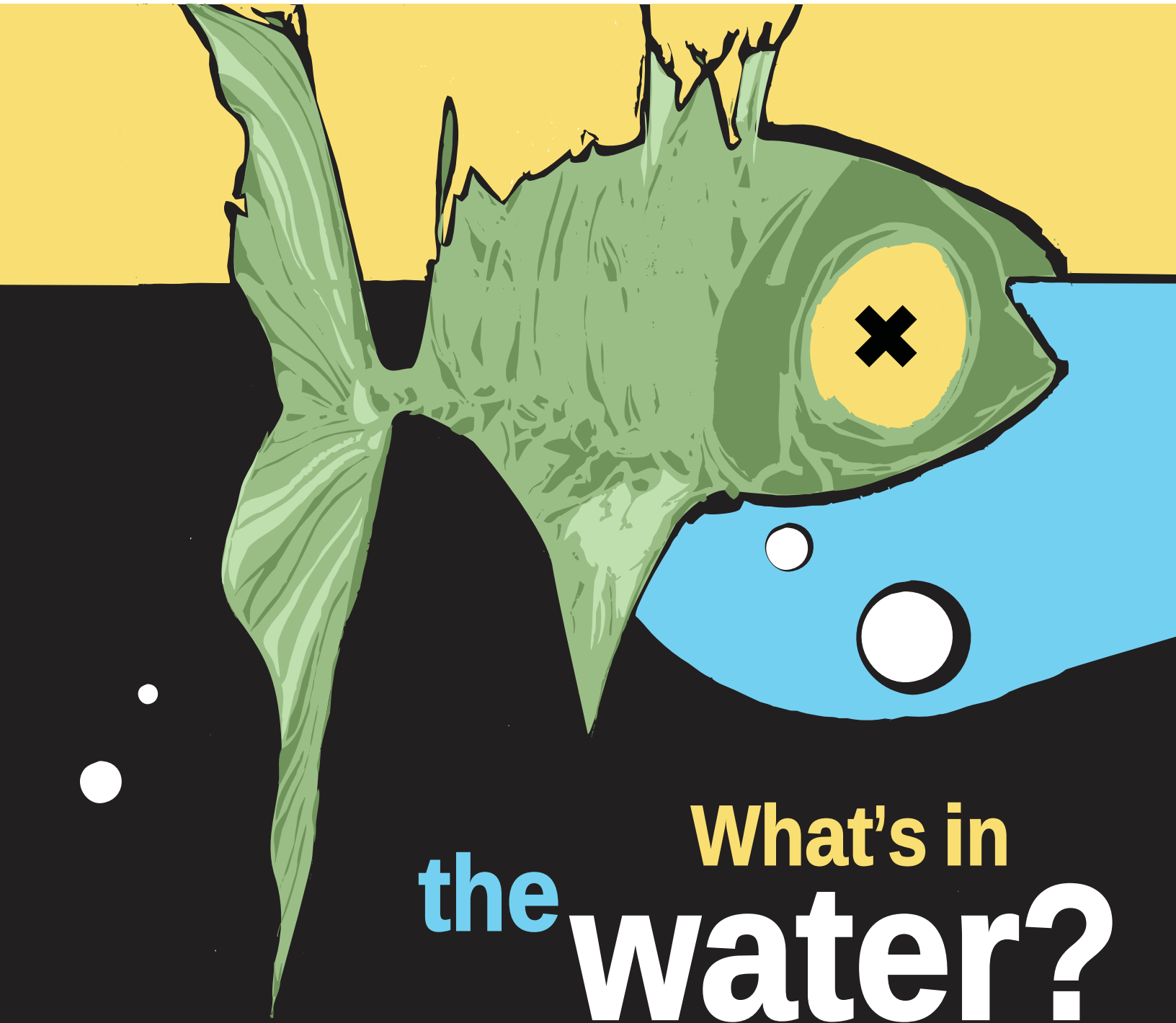

What's in the water?

Texas AgriLife Research
Texas AgriLife Extension Service
Texas A&M University College of Agriculture and Life Sciences

Working to make every drop count

The devastating earthquake in Haiti at the first of the year brought front and center the critical need for fresh, clean, and easily accessible water. But having clean water for humans and animals is essential every day, everywhere. Thankfully, researchers and water managers across Texas are working to ensure that we have just that. We spotlight a few of these researchers in this issue.

The lead story examines the efforts of two research groups—one from Texas A&M University, the other from Baylor University—who are expanding research and technologies on pharmaceuticals and personal care products (PPCPs) found in water and treated wastewater. The Baylor group, which includes Dr. Bryan Brooks and Dr. Kevin Chambliss, is improving scientists' abilities to detect and assess PPCPs in our creeks and rivers, while the Texas A&M group, lead by Dr. Kung-Hu "Bella" Chu, is developing innovative techniques to remove these contaminants from water. While sensationalized a bit in the national news media, this issue nevertheless is an important one worth solving.

Many scientists are examining another aspect of clean water: waters contaminated with bacteria, particularly *E. coli*, which is used as an indicator of possible fecal contamination in fresh water. Lakes, rivers, and streams with fecal contamination may contain pathogens that can cause illnesses in humans. Since bacteria is the No. 1 pollutant of Texas water, discovering more about *E. coli* in water—its sources and how it grows and travels in the environment—is essential to solving this pollution problem. Efforts of scientists will strengthen the state's efforts in cleaning up bacteria-contaminated waters.

Join me in reading about the remarkable ongoing work to make every drop count.

B. L. Harris

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On the cover:
What's in the water?
Scientists study pharmaceuticals, bacteria, and arsenic in water.

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Texas Water Resources Institute
make every drop count

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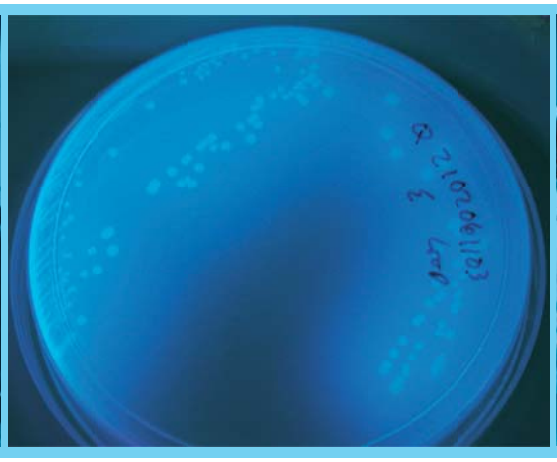

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Dr. Chu testing chemicals.
Photo by Leslie Jordan.
Illustration by Mary-Margaret Shread.

Story by Leslie Jordan

This is your stream.

This is your stream on drugs.

Scientists' expanding research and technologies show that traces of pharmaceuticals in water may threaten aquatic health

All over Texas, humans and animals are using pharmaceuticals: psychiatrists prescribe anti-depressants, veterinarians give farm animals hormones and antibiotics, and patients recovered from surgery flush their expired prescription pain-killers. In each case, traces of these drugs and other pharmachemical compounds can make their way through wastewater treatment facilities and eventually into natural water ways that supply drinking water for humans, livestock, and wildlife, as well as habitats for aquatic species.

As scientists and engineers learn more about this problem, work to detect more contaminants, and develop solutions for keeping water safe, should consumers be worried about effects these substances could have on public health? According to the current body of research, the answer is *no*. Should they be concerned about the impact on the fish, turtles, and aquatic life in those waterbodies? *Maybe so.*

From obscurity to controversy

After a decade of researching pharmaceuticals and personal care products (PPCPs) in water and treated wastewater, Dr. Bryan Brooks, professor of environmental science and biomedical studies at Baylor University, has seen the interest in the subject grow exponentially. Brooks recalls earlier days when he and colleague Dr. Kevin Chambliss, a Baylor chemistry professor, were among the few researchers studying this topic—compared ⇨

to thousands of papers and projects focusing on PPCPs today.

One reason for this increased attention is that researchers' ability to detect and measure PPCPs in water has grown. Because scientists are continually learning how to identify more and more substances at lower and lower levels, increasing numbers of reports have resulted in a growing public awareness of PPCPs in water.

In 2008, the Associated Press released an extensive report on pharmaceuticals in drinking water that included statistics on levels of these drugs in municipal water supplies throughout the country. The report brought this emerging water issue to the attention of the public and congressional legislators.

According to Brooks, although the prospect of leftover pharmaceuticals in your water glass may sound troublesome, the facts show that when chemical compounds from pharmaceuticals are found in water supplies, they generally exist in miniscule amounts—on the scale of low or sub-parts per trillion.

"If you were to look at parts per trillion, or 50 nanograms per liter, of a pharmaceutical, that's like 50 people being surrounded in a field by a trillion of their closest friends—so not that many—and that's a higher number than what is detected in drinking water," Brooks said.

"The science is developing rapidly," he said. "We need to now step back, think about lessons learned in managing water quality and substances in the environment, and then ask the most relevant questions, so that we are managing *real* risks and not just those that we think *may* be a problem."

Drugs in Texas waters

In 2006, Brooks and Chambliss studied fish in Pecan Creek in Denton, and found residues of three human medications not previously identified in fish tissue. These three new compounds were from an over-the-counter antihistamine, a drug for high blood pressure, and a treatment for epilepsy and bipolar disorder. Researchers also found an antidepressant that had been detected in a previous study. Like many waterways in Texas, Pecan Creek receives treated effluent from a wastewater treatment plant.

"... that's like 50 people being surrounded in a field by a trillion of their closest friends ..."

"These results demonstrated the increasing need to consider bioaccumulation of emerging contaminants in the environment," Chambliss said. "This research proved that fish are being exposed to multiple compounds in our waterways."

Chambliss and doctoral student Alejandro Ramirez developed a method of using

liquid chromatography-tandem mass spectrometry that enabled them to, for the first time, simultaneously screen the fish for several different types of drugs. Previous PPCP studies could only identify individual medications or classes of medications, but the Baylor team's new method tested for up to 25 different drugs in several therapeutic categories.

The researchers concluded that while the results showed the potential dangers for fish and other aquatic life, the risk to human public health was minimal but should be monitored.

"The pharmaceutical levels that are detected in drinking water supplies and in edible fish species' tissue are far below the normal daily dosage someone would take of that medicine. So yes, we need to study the issue, but right now the highest relative risk is not to people," Brooks said. "By looking at therapeutic thresholds for drugs, we see that these risks are much lower than others we experience in life, such as driving to work. But there are risks for the organisms *living* in these streams, experiencing exposure to these substances—which in fact in some cases has shown adverse effects in aquatic organisms."

By combining risk assessment and toxicology, Brooks uses existing pharmacology and toxicology information about how drugs affect humans to more efficiently predict their potential effects on wildlife.

"I'm working to see how we can use existing toxicology information on pharmaceuticals and comparative biology data to identify which types of compounds are most risky to wildlife," he said. "We don't have hundreds of millions of dollars to spare, so why reinvent the wheel? If we can use existing information, based on pharmacology in humans, we have shown that you can actually use that information to predict potential compounds of concern for wildlife. I think it's a prudent approach."

The threat to aquatic life

The dangers that PPCPs pose for aquatic life merit additional research because when fish live in streams containing PPCPs, they are exposed to a veritable buffet of chemical compounds, which were designed for specific purposes and doses. These compounds were not designed for an organism's entire life or for usage in combination with other compounds, Brooks said.

"Most medications are not intended to be used for the whole life-cycle of an organism. They are meant to be used for days, weeks, perhaps months, and sometimes longer," he said.

Brooks and Chambliss recently proved that fish throughout the country are exposed to multiple PPCPs. In 2006, the researchers were contracted to conduct an U.S. Environmental Protection Agency (EPA) pilot study because of their innovative methodologies for detecting PPCPs in fish tissue. The study, the first designed to look for the occurrence of PPCPs in fish from U.S. waterways, specifically focused on effluent-dominated rivers.

The sampling locations included discharge areas of wastewater treatment plants in Chicago, Dallas, Orlando, Fla., Phoenix, and West Chester, Pa., near Philadelphia. Isolated from human sources of contamination, the Gila River Wilderness Area in New Mexico was the study's reference site.

The researchers tested fish fillets and liver tissue for 24 different human medications, and tested fish fillets for 12 chemicals found in personal care products. The results revealed that the residues of seven pharmaceuticals and two personal care products were in fish at all five sampling locations. Multiple compounds were often found in the same fish. Gemfibrozil, a medication used to treat high cholesterol and triglyceride levels, was found in livers of wild fish for the first time. No pharmaceutical compounds or personal care product chemicals were detected in any fish collected at the reference stream in New Mexico.

"While this study found the residue of several pharmaceuticals and personal care products in fish tissue, it also demonstrated for the first time that fish from several different locations across the country are exposed to multiple PPCPs in effluent-dominated waterways," Brooks said. ⇨

Because of Brooks and Chambliss's findings, the EPA expanded its investigation of PPCPs in fish under its National Rivers and Streams Assessment. This project completed fish collection in 2009 and will release a final report in 2011.

Engineering beneficial bacteria

Environmental engineers also are looking at the problems PPCPs pose to drinking water, and are developing innovative techniques to remove the contaminants.

Dr. Kung-Hu "Bella" Chu, assistant professor of environmental engineering in the Zachry Department of Civil Engineering at Texas A&M University, has been studying organic compounds in water and wastewater since 2002. She has successfully identified and isolated bacteria to biodegrade estrogenic compounds frequently found in treated wastewater.

Environmental estrogens in wastewater are a result of synthetic estrogens in pharmaceuticals such as birth control and hormone therapies, as well as natural estrogens excreted by humans and animals—both male and female. Estrogenic compounds enter into the environment via effluent because wastewater treatment facilities are not designed to remove them. As with non-estrogenic PPCPs, the dangers estrogen residues pose to fish and wildlife are more widely accepted than potential threats to human health.

In 2006, Chu and her postdoctoral researcher, Dr. Chang-Ping Yu, and doctoral student Hyungkeun Roh discovered a bacteria strain called strain KC8 that efficiently degraded estrogens in wastewater.

Roh then worked to further characterize the strain, which included testing how various environmental factors affected its estrogen degradation ability.

"The good news is that in the real world, this strain can grow fast because it can use the various organics readily available in the wastewater," Chu said. "This strain can use estrogen to grow, too—it's kind of their food, so that they can reproduce. But other microorganisms can also degrade estrogen, just differently.

"One group of important wastewater microorganisms, ammonia-oxidizing bacteria, cannot *grow* on estrogens, but rather they can degrade estrogens just for fun—it's like candy for them!"

Chu and her research team are continuing to study these various organisms, including the different ways they degrade estrogens and the best environmental conditions for the degradation.

"For example, strain KC8 grows really fast in an organic-rich environment, but ammonia-oxidizing bacteria grow really slowly and take a longer time, probably double, in that environment," Chu said. "So we need to ask, what conditions and which microorganism might play a significant role in degrading these estrogens?"

From pristine streams to hormonal rivers

Another concern that Chu wants to address is the many other trace organics with estrogenic potential found in wastewater. Individually, these substances are present at relatively low concentrations, but together they might trigger unwanted estrogenic responses.

To investigate this, Chu and her team used a Yeast Screening Assay, which can look for the estrogenic potential of a specific compound or a mixture of chemicals. The assay produces a red color to indicate the presence of estrogenic compounds in the tested samples.

"So it's going to tell you if the compounds—both known and unknown compounds in the water—would induce any biological response, rather than tell you the concentration of an individual compound measured by chemical analysis," Chu said. "This assay is complementary to chemical analysis since it helps with deciding if a biological response will be triggered or not."

The assay was used in a study Chu conducted in Tennessee's Great Smokey Mountains National Park, where her team took water samples along a river that flows through the park.

"We used this pristine area, with the high elevation water," Chu said. "But right after you

get out of the park gate, probably 10-15 miles down, the area is very developed."

Due to tourism, the population around the river fluctuates, and several wastewater treatment facilities are needed in the community. The small river is clean as it flows through the park, but outside of the park, the treated wastewater from the plants discharges into the river. The researchers took samples at several different points—at the border of the park, along the river, near the wastewater treatments plants, and then downstream of the plants.

"In this short study, we first demonstrated the impact—that yes, treated wastewater is contributing estrogenic compounds into the receiving water body," Chu said. "And then we also wanted to know, how long would it take for these concerning compounds to be naturally attenuated in the river water before it is used as a drinking water source?"

According to Chu, her team found that the estrogenic responses in the river water decreased as the river flowed away from the effluent outfalls, but elevated estrogenic responses were still observed in the river about a mile and a half away from the discharge points. Chu said that this suggested the river may not be able to remove some chemicals naturally or fast enough.

"Continuous discharge of these compounds into the receiving waters, like effluent containing estrogen, can serve as a long-term pollution source in the river," she said. "Despite the capacity of natural purification, these chemicals will remain in the river to potentially cause harm to aquatic life and require advanced treatment processes to remove these compounds. From a sustainability point of view, we need to find a cost-effective treatment approach to remove these chemicals from wastewater to minimize the release of these compounds into the environment."

Looking ahead

As Americans continue consuming pharmaceuticals, scientists keep researching PPCPs in water, and as wastewater treatment technologies advance, the science and the public's response to these issues are sure to evolve.

"Water is something that we must have, clearly, and all great civilizations have flourished when there were plentiful supplies of high-quality water," Brooks said. "So our situation is no different from lessons that we have learned throughout history. Responsible water management is trying to understand emerging issues, and make responsible decisions for the environment, our drinking water, and our fisheries."

**Some information from Baylor University News.*

As scientists continue to examine the pharmaceutical problem, state and federal agencies are developing innovative policy and monitoring solutions.

To flush or not to flush

The Texas Commission on Environmental Quality (TCEQ) is looking at better standardizing how pharmaceutical compounds get into the environment in the first place. Texas Senate Bill 1757, which became effective in June 2009, commissioned TCEQ to conduct a study of methods for disposing of unused pharmaceuticals so that they do not enter a wastewater system. By January 2011, TCEQ is required to submit to the legislature a report on the best methods for disposal.

Identifying emerging contaminants

Every five years, the U.S. EPA releases a Contaminant Candidate List (CCL). The CCL 3 list was completed in 2009. The list identifies emerging contaminants and currently includes several PPCPs. According to EPA, it considered the best available data and information on health effects and occurrence to evaluate thousands of unregulated contaminants. The resulting list includes pesticides, disinfection byproducts, chemicals used in commerce, waterborne pathogens, pharmaceuticals, and biological toxins. EPA will evaluate all the contaminants on the CCL 3 to determine which have sufficient information to allow EPA to make a regulatory determination, and which contaminants need to be further researched to determine regulatory actions. To learn more, see *http://www.epa.gov/safewater/ccl/ccl3.html.*

Story by Leslie Jordan

TEEX Tackles Toxins

TEEX develops ECLOX protocols to detect toxins in drinking water.

Thanks to the Texas Engineering Extension Service (TEEX), utilities personnel across Texas can monitor water safety and quality using a highly effective machine—ECLOX—that was once shelved and forgotten because no one knew how to use it correctly.

In a joint effort by the Texas Commission on Environmental Quality (TCEQ) and TEEX, scientists have now enabled cities to use the ECLOX to detect a variety of toxins that could accidentally or intentionally contaminate a water supply.

After 9/11, many public water systems acquired an ECLOX field analyzer to measure drinking water contaminants. But there was a big problem, says TEEX Water and Wastewater Laboratory Associate Training Specialist Keith McLeroy: The equipment came with minimal instructions and no protocols for establishing baseline data for comparing the ECLOX readings.

TCEQ turned to the TEEX Water and Wastewater Program to establish baseline data for 24 public water systems in Texas, and to develop a protocol for measuring possible contaminants.

"We were able to establish, basically from scratch, all quality assurance and quality control protocols for running the ECLOX process on drinking water," said McLeroy of TEEX's Infrastructure Training and Safety Institute. "After many years of looking at every research paper with the word 'ECLOX' in it, we were the first to actually achieve this (developing the protocols) with drinking water—no one else had done that."

After completing the joint project with TCEQ in which TEEX developed the specific ECLOX protocols, TEEX is now known for its expertise in ECLOX baseline data development, protocols, and training. McLeroy conducted a customized, one-day ECLOX training workshop for the city of Fort Worth, after it acquired nine ECLOX units in 2008.

The ECLOX unit was originally designed by Dr. Gary Thorpe of the University of Birmingham, U.K., to measure contaminants in the effluent discharged by factories.

"In a nutshell, ECLOX stands for Enhanced Chemiluminescence Oxidation Reduction," McLeroy said. "It's basically a chemiluminescence process,

TEEX Training Specialist Keith McLeroy works with the ECLOX luminometer.
Original photo by Martial Voltier, TEEX
Photo manipulation Mary-Margaret Shread

which is two chemicals coming together to make a light. It's like those glow sticks that when you snap and shake them, they shine light, except this is a biochemical luminescence, similar to how a firefly combines two enzymes and that's what makes it light up."

When testing water samples, the luminometer records the light output. If the light is bright, the chemiluminescence chemical reaction is occurring properly, McLeroy said. However, if a toxin, or some other substance that inhibits the chemicals coming together, is in the water, the light will dim or shut off.

"The ECLOX is an instrument, an analyzer—I liken it to a smoke detector," McLeroy said. "It's not going to tell you exactly what the toxin is in the water, only that something is wrong."

As TEEX and TCEQ are believed to be the only agencies developing drinking water protocols for the ECLOX, their reputation is growing.

"We've discovered that the ECLOX makes a great drinking water monitoring tool when used correctly," said McLeroy, who was assisted on the projects by Jeff Bowman and Marc Adams of TEEX's Environmental Training Program. ⇨

"After years of work, Texas is now ECLOX central—there's no other state with as much background data on drinking water. Other places have many ECLOX machines, but don't know how to use them well yet," McLeroy said. "So our goal is to get this technology and easy-to-understand training out to anyone around the globe who has an ECLOX machine."

In the next two years, TEEX and TCEQ plan to develop ECLOX protocols for 12 more cities in Texas—helping ensure safe drinking water throughout the state.

"This work is important to Texas," McLeroy said. "Because we have worked with TCEQ to develop ECLOX background data that is accessible and understood by ECLOX-using personnel, after the completion of this year's cities' protocols, that will be 36 cities that have the tools to maintain secure drinking water."

*Some information from a TEEX news release

Keith McLeroy holds the ECLOX, a device for detecting toxins in water.
Photo by Martial Voltier, TEEX.

Story by Kathy Wythe

Beating Bacteria

Scientists work to understand and track bacteria in water

A big production is underway in Texas—not a theatrical production but a scientific one, investigating bacterial pollution in fresh waters.

Bacteria is the No. 1 pollutant of Texas water. Recreation in 274 waterbodies, a majority of which are freshwater streams, rivers, and lakes, is impaired because of bacteria contamination, according to the state's 2008 impaired water list. As a result, much of the ongoing scientific investigation has focused on freshwater recreation.

To determine if fresh water is impaired for contact recreational activities such as swimming and wading, Texas water managers and scientists primarily use *E. coli* bacteria as an indicator of possible fecal contamination. Water with fecal contamination may contain pathogens—not only bacteria but viruses and parasites as well. These pathogens can cause illnesses in swimmers and anyone else who swallows the water, according to U.S. Environmental Protection Agency (EPA) studies.

"The concern is that there are elevated numbers of *E. coli* in many of the streams in Texas," said Dr. Terry Gentry, assistant professor of soil and aquatic microbiology in Texas A&M University's Department of Soil and Crop Sciences, "and this (large number) indicates that there may potentially be pathogens in the water that can cause disease."

Bacteria are so prevalent in the water because they are found in fecal wastes of all warm-blooded animals, said Dr. Larry Hauck, lead scientist of Tarleton State University's Texas Institute for Applied Environmental Research (TIAER). Hauck is involved in several bacterial prevention pollution projects.

"Anything from a diaper thrown out in the parking lot at a mall to birds and livestock at water sources can contribute bacteria to the environment," he said.

This fecal contamination can find its way into the state's streams, rivers, and lakes through runoff from the surrounding land, inadequate treatment of wastewater, and failing septic systems.

Bacteria Task Force Recommendations

Acknowledging the enormity of the bacteria problem within the state, in September 2006, TCEQ and the Texas State Soil and Water Conservation Board (TSSWCB) established a joint Task Force on Bacteria Total Maximum Daily Loads (TMDLs) to make recommendations to strengthen the agencies' efforts in cleaning up bacteria-contaminated waters.

Dr. Allan Jones, formerly of the Texas Water Resources Institute (TWRI) and now of the Texas AgriLife Research and Extension Urban Solutions Center in Dallas, was chair of the task force. Other members were Dr. George Di Giovanni of Texas AgriLife Research Center at El Paso; Hauck of TIAER; Dr. Joanna Mott of Texas A&M University – Corpus Christi; Dr. Hanadi Rifai of the University of Houston; Dr. Raghavan Srinivasan of Texas A&M University's Spatial Science Laboratory; and Dr. George Ward of The University of Texas at Austin. More than 50 other professionals contributed to the task force's report. ⇨

In its 2007 report, the task force made recommendations for implementing bacteria TMDLs and implementation plans (I-Plans) as well as suggestions for research needed to strengthen the scientific tools available for TMDL and I-Plan development.

According to TCEQ, a TMDL is like a budget for pollution. It is a calculation of the maximum amount of a pollutant, such as bacteria, that a water body can receive from all sources and still meet water quality standards. An I-Plan puts the TMDL into action by outlining the steps necessary to reduce pollutant loads through regulatory and voluntary activities.

The task force recommended that the state agencies follow a three-tier approach to implementing bacteria TMDLs. (See box for recommendations and descriptions of tiers on page 16.)

"Basically, the task force recommended simple, less time-consuming, and less costly processes for the first tier, with increasingly complex methods used for more complicated TMDLs," Jones said.

"The three-tiered approach to developing bacteria TMDLs and I-Plans incorporated adaptive management, and phased implementation to the extent allowable by EPA," he said. "The objectives of Tiers 1 and 2 are to ensure that each TMDL is developed using a scientifically credible, cost-effective process with strong stakeholder involvement."

According to Ron Stein, TMDL team leader at TCEQ, his agency is following most of the task force recommendations for its current and future TMDLs and I-Plans. "Based on work we (TCEQ) have done across the state, it is apparent that the best approach for dealing with contact recreation impairments for bacteria is essentially following the Tier 1 recommendations from the task force report," he said. "This means to use the simplest method you can to determine the TMDL."

TCEQ currently has 13 TMDL projects for bacteria that are addressing 64 of the impaired water body segments; all are using the Tier 1 process, he said.

Hauck and his team at TIAER are working with TCEQ to develop TMDLs in several watersheds, including the Upper Trinity River, Carters and Burton creeks in Brazos County, and Cottonwood Branch and Grapevine Creek in Tarrant and Dallas counties.

Projects: applying the science to the streams

As TCEQ and others are following the task force's recommendations for developing TMDLs and I-Plans, other scientists are refining the scientific tools as suggested in the task force report.

One project focusing on the scientific tools as well as the recommendations of the task force is the *Fate and Transport of E. coli in Rural Texas Landscapes and Streams*. This project is an assessment demonstration project funded by TSSWCB through a Clean Water Act §319(h) nonpoint source grant from the EPA and managed by TWRI. Dr. R. Karthikeyan, assistant professor, and Dr. Saqib Mukhtar, associate professor and Texas AgriLife Extension Service specialist in Texas A&M's Department of Biological and Agricultural Engineering; Dr. Roel Lopez, associate director of Texas A&M's Institute of Renewable Natural Resources; Srinivasan, director of Texas A&M's Spatial Sciences Laboratory; and Dr. Daren Harmel, agricultural engineer for USDA's Agricultural Research Service in Temple, are working together on the project.

One component of the project entails the scientists conducting a sanitary survey of a demonstration watershed to identify the specific animals that are contributing *E. coli*. Israel Parker, Lopez's graduate student, is trapping wildlife frequenting the study area. The wildlife fecal samples are then taken to the lab where the *E. coli* is extracted and counted.

"What we are finding is that *E. coli* counts from feces of armadillos, raccoons, and opossums are significantly higher compared to the *E. coli* counts from feces of cattle, and that median *E. coli* concentrations varied with age and gender," Mukhtar said. ⇨

Story continued on page 15.

"Anything from a diaper thrown out in the parking lot at a mall to birds and livestock at water sources can contribute bacteria to the environment."

Story by Kathy Wythe

Proposed water quality standards move Texas closer to cleaner waters

As Texas concentrates on cleaning up its water through Total Maximum Daily Loads (TMDLs), TMDL Implementation Plans (I-Plans), and watershed protection plans (WPPs), many water quality experts in Texas are realizing that applying a single standard of primary contact recreation to hundreds of different surface water bodies may not be realistic or beneficial.

While public interest is high in having an ambitious standard as possible, Jim Davenport, technical specialist for the monitoring and assessment section at the Texas Commission on Environmental Quality (TCEQ), said a standard that is too ambitious "becomes problematic" as the list of impaired waters grows.

"It becomes important to tailor our recreation use standards appropriately," he said. "For a water body that doesn't have full primary contact recreation such as swimming, it is important to set our standards to meet its actual use."

With that in mind, TCEQ's Surface Water Quality Standards Advisory Work Group has been working with stakeholders on expanding its water quality standards, including those standards for recreational use. TCEQ has proposed expanding the categories for contact recreation use from two categories—contact recreation and non-contact recreation—to four, adding two more levels: secondary contact 1 and 2 (see definitions on page 19).

The agency is also proposing different numerical criteria for *E. coli* that will be applicable in fresh water based on these assigned recreational uses. Currently the geometric mean criterion for *E. coli* is 126 colonies per 100 milliliters for contact recreation. Under the proposed revised standards, the geometric mean for primary contact recreation category would increase to 206 colonies per 100 milliliters, 630 colonies per 100 milliliters for secondary contact 1, and 1,030 colonies per 100 milliliters for secondary contact 2.

For salt water, *Enterococci* bacteria are used as indicator bacteria for aquatic recreation. The geometric mean for primary contact is proposed to remain at 35 colonies per 100 milliliters while secondary contact 1 is proposed as a new recreational use category with a geometric mean criterion of 175 colonies per 100 milliliters, Davenport said.

By having standards that more accurately reflect actual use, Davenport said the agency can focus its resources on water bodies that should have primary contact recreation use designation but do not meet it. "Because we are seriously attacking water quality problems, we have to make sure we target effectively," he said. "Our goal is to make sure we have reasonable standards so when we do a TMDL, we have an appropriate target to go for."

At its January 2010 meeting the commission agreed that the complete standards should be proposed to the public and set a March public hearing on the standards and the procedures to implement the standards. The target date for adoption of the standards by TCEQ is July, with an effective date of August 2010.

Dovetailed with the changes in standards is the use of recreational use attainability analyses or RUAAs, which characterize the impaired water body and then are used to determine which recreational use category is most appropriate for a particular water body.

Davenport said TCEQ has used UAAs for other standards but the agency is just beginning to use UAAs for recreation. Along with TCEQ's water quality standards group and TMDL program, the Texas State Soil and Water Conservation Board is using RUAAs for some of its projects.

During RUAAs, Davenport said, agency staff, university researchers, or private con-

it's worth th

sultants conduct one to three surveys on the water body. They determine if there is any recreation activity on the water and/or public access to the water and measure the flow and depth of the water.

The surveyors also look at historical records and interview people who know the area.

"You can only get so much information with surveys," he said. "Observations from local people are important."

Dr. Larry Hauck of Tarleton State University's Texas Institute of Applied Environmental Research and his staff are conducting RUAAs in the Dallas/Fort Worth area and in the Atascosa River watershed.

"The premise is that through site visits, looking at historical records, and talking to local people, you can reconstruct what recreational activities have happened in the past and what is occurring in the present at these various stream systems you are studying," Hauck said. "We are actually gathering data that will indicate what the true level of recreational use occurring, as determined from studies."

water quality standards

Water quality standards are the foundation for managing surface water quality. A standard consists of two parts:

- a use, or the purposes for which surface water will be used
- the criteria or the indicators used to determine if the use is met

Davenport said the two agencies have more than 120 RUAAs being conducted. Depending on the results of the RUAAs and standards revisions, water bodies could be put into one of the four proposed categories of contact recreation, and, depending on the associated bacteria counts, some of the water bodies may no longer be listed on the state's impaired water body list.

The proposed expanded contact recreation use and water quality standards, along with the RUAAs, will provide a better starting point for developing TMDLs, TMDL I-Plans, and WPPs, paving the way for improved water quality in Texas.

e work

"Prior to this study, we did not have any data comparing feces of cattle versus wildlife to determine what kind of *E. coli* loads we had," he said, adding that such findings have not been published previously in the literature.

The scientists are also identifying the different types of land uses throughout the watershed, which helps determine what animals may be on the land. For example, Karthikeyan said, if they know the watershed has cattle ranches, they can estimate the number of cattle on the land and calculate the potential amount of bacteria from the cattle wastes.

Information obtained during the sanitary survey provides input data for the modeling tool SELECT—Spatially Explicit Load Enrichment Calculation Tool. This model was developed and applied by Karthikeyan's graduate students Aarin Teague, Kendra Reibschleager, and Kyna McKee to analyze the land use and animal and human sources in the watershed to determine the potential bacteria sources and their contributions. SELECT then helps the researchers develop a pie chart with the different percentage contributions from each potential source.

"We wanted to see what sources are really contributing, and what percent each source is really contributing to the creek," Karthikeyan said. ⇨

In the past, when load or pollutant reductions were calculated for the TMDL, the same amount of reduction was applied to all sources throughout the watershed, Karthikeyan said. Instead of making every contributor reduce its load the same amount, with SELECT and the development of the pie chart, the contributor is given the load reduction based on what it is actually contributing.

These researchers also are interested in how *E. coli* is transported into the water, how long it lives, and how it grows outside in the environment, and the environmental factors that influence these processes. Biological and Agricultural Engineering graduate students Reema Padia and Meghan Gallagher are looking at the different conditions that trigger the growth, survival, and regrowth of *E. coli* bacteria and characterizing optimal growth conditions for different *E. coli* isolates from different sources.

Mukhtar said the growth and survival of *E. coli* from animal feces were tested in soil with 25 percent moisture content (nearly dry or aerobic conditions), 57 percent moisture content, and 83 percent moisture content (nearly saturated or anaerobic conditions). "Our results show that *E. coli* from both cattle and wildlife had greater growth at 25 percent soil moisture content rather than the expected higher moisture environment of 75 percent or more," he said. "This finding verified the facultative behavior (growth and survival under both aerobic and anaerobic conditions) of *E. coli* contributing to accelerated growth levels at a cooler temperature (20 C) and under nearly aerobic conditions."

The scientists are also looking *E. coli* being re-suspended or dispersed again in streams, suspected as a significant source of *E. coli*. Karthikeyan said streams with high flows always spike in *E. coli* concentrations, and the team is trying to determine if the spike is from *E. coli* in runoff or from *E. coli* in the creek sediments that are re-suspended.

"An indicator organism of fecal contamination should not live and reproduce in the environment for an extended period of time after it leaves the gut of an animal," he said. "If *E. coli* does, it may not be a good indicator."

Recommendations of Bacterial TMDL Task Force

The Task Force recommended a three-tier approach to implementing bacteria TMDLs and I-Plans:

Tier 1 is a one-year process that includes the following steps:

1) Form representative stakeholder group
2) Develop comprehensive GIS of the watershed
3) Survey potential bacterial sources
4) Calculate load duration curves from existing monitoring data
5) Analyze data collected by agency personnel and stakeholders

After reviewing information from Tier 1, the group may choose to complete and submit a draft TMDL for agency approval, request an evaluation of the designated use of the water body (a use attainability analysis), or proceed to Tier 2.

Tier 2 is a one- to two-year effort with the following steps:

1) Collect targeted monitoring data to fill gaps in previously collected data
2) Conduct qualitative library-independent BST and limited library-dependent BST analysis to determine whether humans and/or a few major classes of animals are sources
3) Develop simple spatially explicit or mass balance models of bacteria in the watershed
4) Analyze data

After analysis of Tier 1 and Tier 2 data, the group may chose to complete and submit the draft TMDL (or I-Plan if a TMDL was developed after Tier 1), request an evaluation of the designated use (an use attainability analysis), or initiate a "phased TMDL" and proceed with Tier 3 analysis.

When finished, the project's results will help decrease the uncertainties in estimating the *E. coli* load from various sources and help simulate the fate and transport processes of *E. coli* in watersheds and streams, the researchers said.

Other TWRI-managed projects using the task force recommendations include the *Modeling Support* and *Bacterial Source Tracking for Big Cypress Creek, Development of a Watershed Protection Plan for Attoyac Bayou, Bacteria Assessment and Modeling Support for Buck Creek Watershed Protection Plan Development*, and *Little Brazos River Bacteria Assessment* projects. TSSWCB funds these projects with either federal Clean Water Act §319(h) grants or state general revenue appropriated by the Legislature.

Bacterial Source Tracking

The task force also recommended ongoing research into bacterial source tracking (BST). BST uses genetic fingerprinting techniques similar to forensics or paternity testing to identify bacterial strains that are host-specific, Gentry said.

"The technique generates unique fingerprints of *E. coli* from each potential source," he said, "so a fingerprint of *E. coli* from a cow is going to look different than that from a hog."

The task force recommended BST for the second and third tier of TMDL development and in I-Plans. Library-independent methods were suggested if more definitive data are required for TMDL or I-Plan development.

For several years, task force member Di Giovanni, professor and Faculty Fellow in environmental microbiology, has led the development of BST research in Texas in his laboratory at the Texas AgriLife Research and Extension Center at El Paso. (See related story on page 20.) Di Giovanni and Gentry are expanding the statewide library, developed through Di Giovanni's previous work, incorporating *E. coli* isolates from different animals and different geographical locations.

To develop the Texas Known Source Library or library-dependent BST, Di Giovanni explained, they collect samples from known fecal sources, such as wildlife, pets, domestic animals, livestock, and wastewater samples that are of human origin.

"We then isolate *E. coli* from those samples and type them with our typing or fingerprinting techniques," he said. "And we create a library of *E. coli* from these known source samples. Then we get a water sample and we isolate the *E. coli* that are from unknown origins. We match these fingerprints (of *E. coli*) up with an isolate in our library and that identifies the source."

Library-independent BST uses similar molecular techniques to detect a different group of bacteria, *Bacteroidales*, ⇨

Tier 3 is a two- to three-year process that includes:

1) Continue strong stakeholder involvement

2) Implement more extensive targeted monitoring

3) Conduct quantitative library-dependent BST analysis

4) Develop a detailed hydrologic/water quality model for the watershed

5) Analyze data

Tier 3 should be implemented only when this level of detailed analysis is needed for I-Plan development or for TMDL development for particularly complex watersheds for which consensus cannot be reached after Tier 2.

TCEQ/TSSWCB Joint Meeting Actions

At their June 29, 2007, meeting, the Commissioners and Board Members adopted the principles and general process of the task force recommendations and directed staff from both agencies to:

- Develop a joint agency bacteria TMDL guidance document
- Establish a multi-agency, statewide bacteria workgroup to continue examining the scientific research and development needs identified in task force report
- Resume TMDL efforts in areas where activities were suspended pending the outcome of the task force

The agencies also supported ongoing water quality standards revision process.

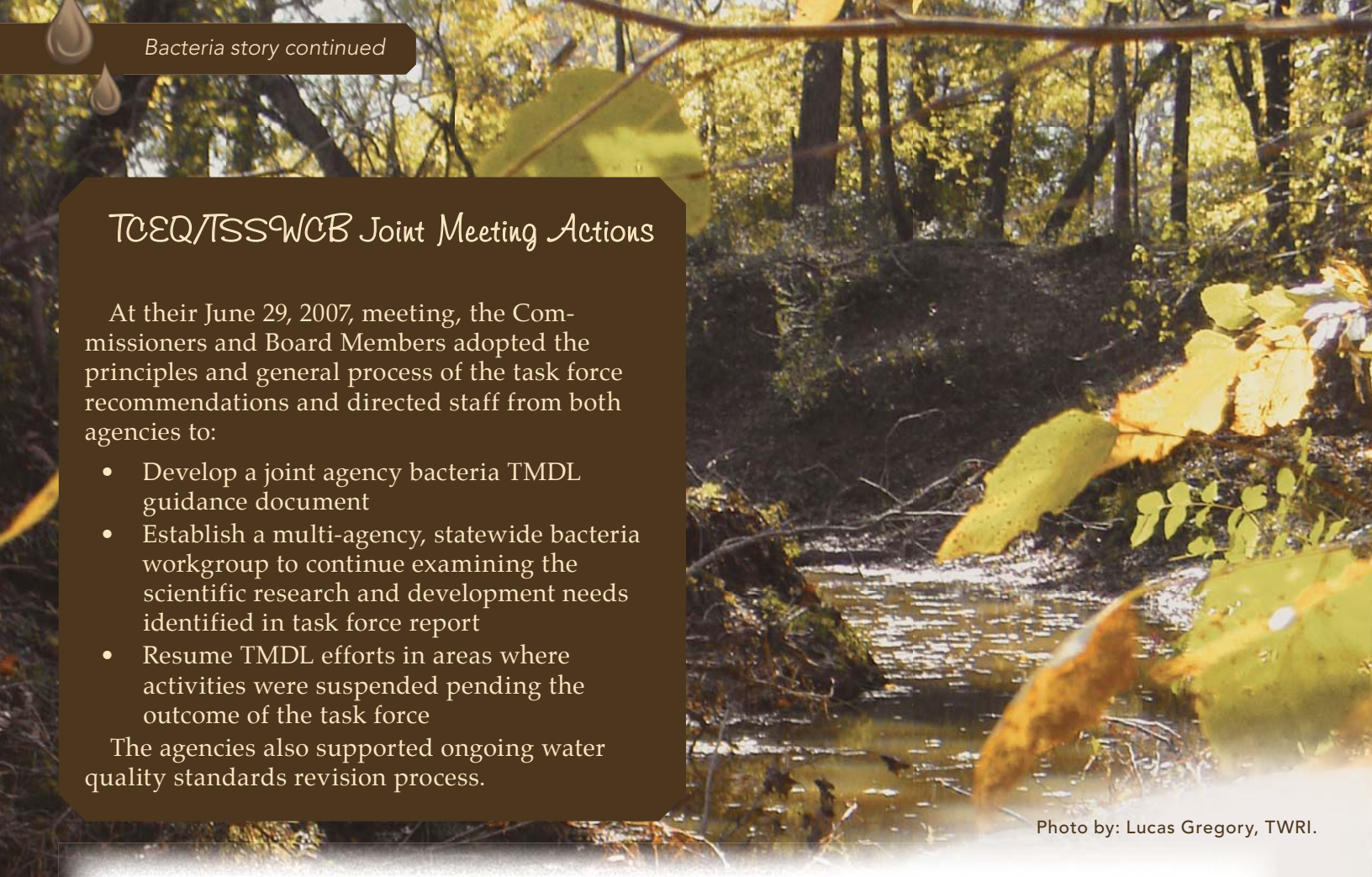


Photo by: Lucas Gregory, TWRI.

from certain animal populations in the water samples. *Bacteroidales* are more abundant in feces than *E. coli* and, because they are less tolerant of oxygen, are less likely to multiply in the environment, Gentry said. The DNA is extracted from water samples and tested for genetic markers that are already developed for *Bacteroidales* associated with humans, ruminants (such as cattle, deer, and sheep), horses, and hogs in addition to new genetic markers for other sources as they are developed.

The disadvantage of using *Bacteroidales*, Di Giovanni said, is currently no genetic markers have been established for most wildlife, which researchers are finding to be significant contributors to the bacteria pollution. "It doesn't encompass all the potential sources we're interested in, and that's the serious weakness of it," he said.

With a grant from TSSWCB, funded with state general revenue appropriations, Gentry equipped a BST lab equivalent to the El Paso lab. Through different projects throughout the state, both labs are collaborating to expand and verify the Texas Known Source Library.

For example, Gentry said, his lab, along with Di Giovanni's, is testing the library with *E. coli* isolates from different geographic regions in Texas to determine if the existing library is sufficiently representative or if additional *E. coli* isolates need to be added to the library.

"As part of several projects in multiple watersheds, we are pulling approximately 100 *E. coli* isolates over time from each watershed and comparing them to the statewide known-source library," Gentry said. "We are also collecting approximately 250 water samples from each of the watersheds and screening those for *Bacteroidales*."

Gentry said he is using the combined approach (library-dependent and library-independent) on several projects, including the *Modeling Support and Bacterial Source Tracking for Big Cypress Creek Bacteria Assessment* and the Attoyac Bayou and Little Brazos River projects.

Complicated waters

With results from these projects showing that wildlife is a major contributor in many rural watersheds, the solutions may be different from expected.

"People often automatically think that high *E. coli* counts in water indicate contamination from humans, grazing livestock, or concentrated animal feeding operations," Gentry said. "While these can be major sources, as more data is coming in, we are seeing a large wildlife contribution (in the watersheds he is investigating). If you determine that a substantial portion of the bacterial contamination is coming from human-associated sources such as malfunctioning septic systems or livestock, you can repair or improve the septic system or implement best management practices to reduce or eliminate the contamination. However, it is less clear what to do about the wildlife contributions to water quality impairments."

Wildlife expert Lopez said there are options to address possible wildlife contamination. "Good range management can deal with any potential contributions from free-ranging wildlife," he said.

For Karthikeyan, the key is verifying the models. Although there "will always be uncertainty and variability" in determining the source of bacterial pollution, by developing more exacting analysis techniques, he said, they can more confidently convey to stakeholders the potential sources.

"Describing fate and transport of *E. coli* in a watershed is really a complex process, but we are doing the best we can," said Karthikeyan, who is working with TSSWCB to use SELECT in over a half dozen watersheds across the state.

"We are providing solutions based on science not just stats and graphs. We are getting the best science possible."

Even without all the answers, Stein of TCEQ said the new way of developing TMDLs and I-Plans with more people involved is "instrumental and vital" to improving water quality around the state.

"There is vast amount of effort across the state to put in place activities that will improve water quality," Stein said. "The state is working quite diligently to get people engaged in improving water quality in their watersheds."

Involvement from local residents is important, Stein said, because "if you can get people in the watershed engaged in thinking how they can improve water quality, you are getting the best plan possible. You are getting the people living in the watershed who know the watershed and know what is going on to develop the plan, and they are best equipped to do that."

For more information about TWRI's bacteria-related projects, visit *http://twri.tamu.edu.* Links to TCEQ's and TSSWCB's water quality information can also be found on the TWRI Web site.

Draft Definitions (2010 TSWQS Revision)

- ***Primary contact recreation:*** Activities presumed to involve a significant risk of ingestion of water (e.g., wading by children, swimming, water skiing, diving, tubing, surfing, and whitewater kayaking, canoeing, and rafting).
- ***Secondary contact recreation 1:*** Activities that commonly occur but have limited body contact incidental to shoreline activity (e.g. fishing and boating). These activities are presumed to pose a less significant risk of water ingestion than primary contact recreation but more than secondary contact recreation 2.
- ***Secondary contact recreation 2:*** Activities with limited body contact incidental to shoreline activity (e.g. fishing and boating) that are presumed to pose a less significant risk of water ingestion than secondary contact recreation 1. These activities occur less frequently than secondary contact recreation 1 due to physical characteristics of the water body or limited public access.
- ***Noncontact recreation:*** Activities that do not involve a significant risk of water ingestion and where primary and secondary contact recreation should not occur because of unsafe conditions, such as ship and barge traffic. Activities would include those with limited body contact incidental to shoreline activity, such as birding, hiking, and biking.

The proposed standards and additional summary information are available at: http://www.tceq.state.tx.us/permitting/water_quality/stakeholders/2010standards.html.

Story by Courtney Swyden

The Baron of Bugs

Keeping waterborne pathogens at bay

While a student at The University of Arizona, Dr. George Di Giovanni planned to attend medical school. But a slight shift in his college career led him to the occasional title of the "baron of bugs" today.

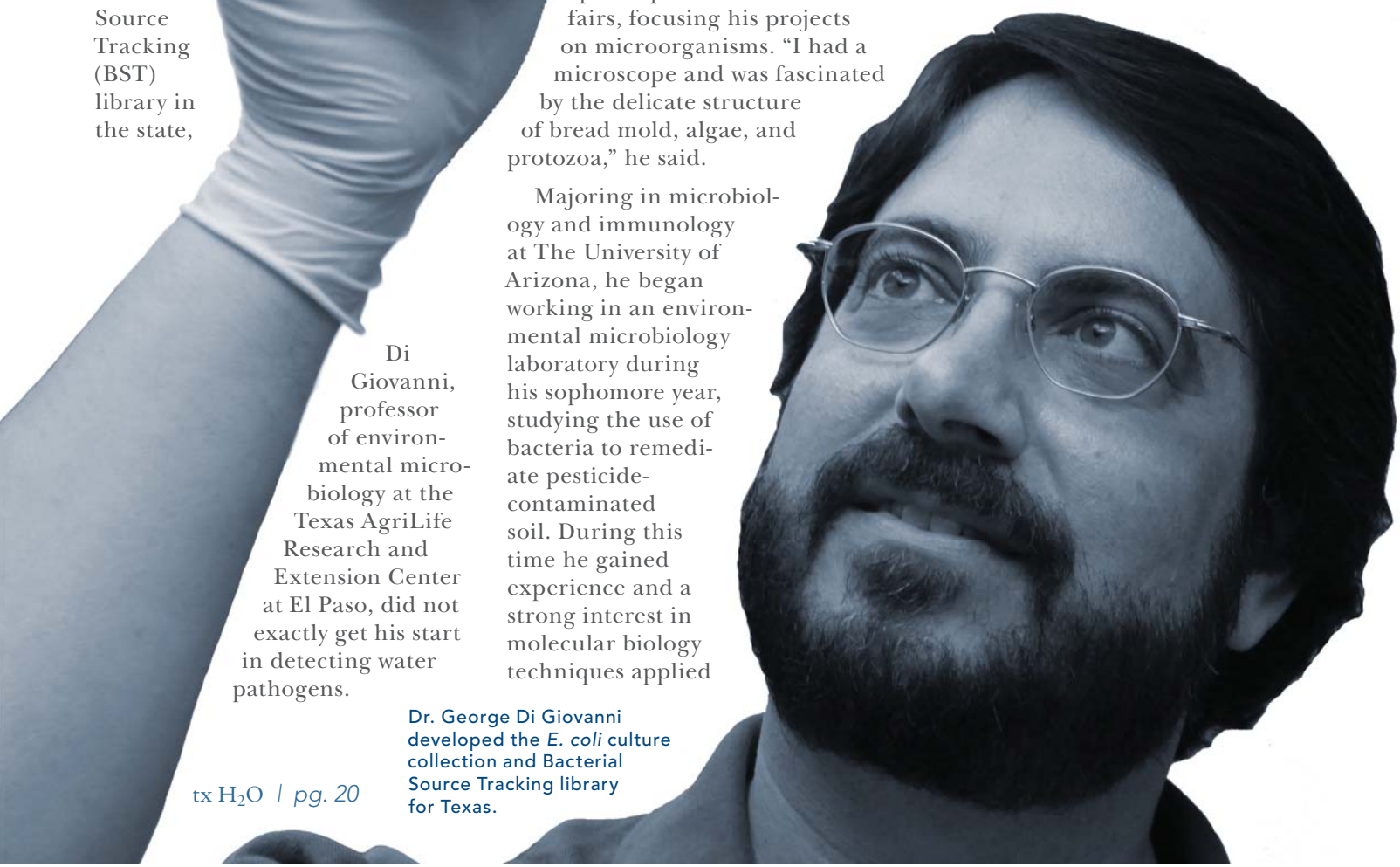
As the primary developer of the most comprehensive *E. coli* culture collection and Bacterial Source Tracking (BST) library in the state, Di Giovanni, professor of environmental microbiology at the Texas AgriLife Research and Extension Center at El Paso, did not exactly get his start in detecting water pathogens.

"I consider myself an environmental microbiologist, and there are a lot of sub-disciplines in that area," said Di Giovanni, whose interest in detecting and characterizing microorganisms in the environment eventually shifted from soil to water. "The whole overriding theme was the analysis of organisms from environmental settings, and that's always been an interest to me."

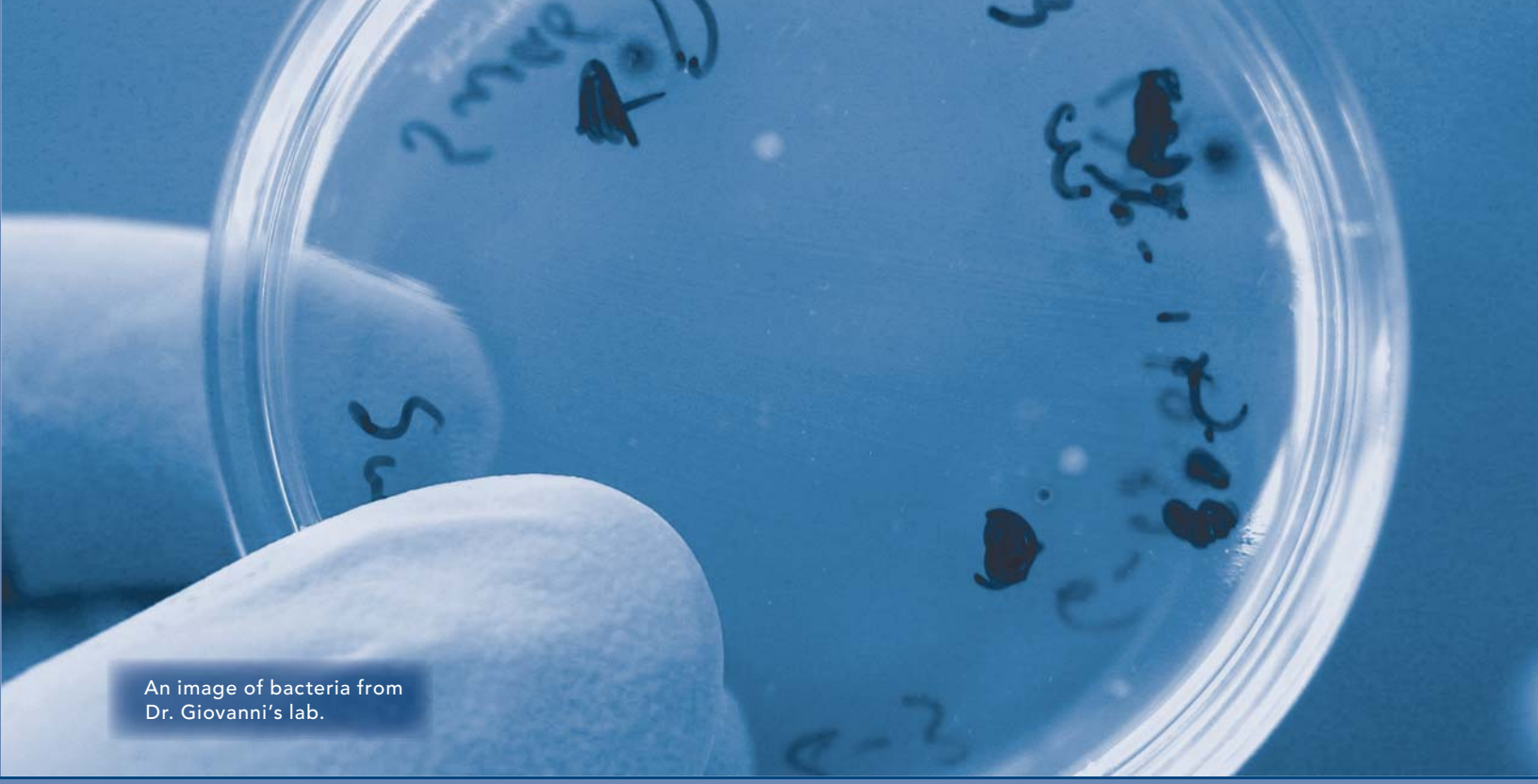
As a child, Di Giovanni participated in science fairs, focusing his projects on microorganisms. "I had a microscope and was fascinated by the delicate structure of bread mold, algae, and protozoa," he said.

Majoring in microbiology and immunology at The University of Arizona, he began working in an environmental microbiology laboratory during his sophomore year, studying the use of bacteria to remediate pesticide-contaminated soil. During this time he gained experience and a strong interest in molecular biology techniques applied to soil microorganisms and environmental samples.

His doctoral research at The University of Arizona focused on gene transfer and bioremediation of pesticide-contaminated soil, where he applied both culture and molecular-based analyses to microorganisms in the environment. His postdoctoral position with the U.S. Environmental Protection Agency took him to Oregon, where he worked as a National Research Council associate and continued research in environmental microbiology.



Dr. George Di Giovanni developed the *E. coli* culture collection and Bacterial Source Tracking library for Texas.



An image of bacteria from Dr. Giovanni's lab.

"At that point, things shifted a little bit, and I was actually looking at biotechnology risk assessment of transgenic plants," he said. Di Giovanni became interested in microorganisms in the root zone of these transgenic, or genetically engineered, plants and their impact on microbial communities.

"At the end of my post doctorate, I decided to continue with molecular environmental microbiology research, but shifted from the detection and characterization of soil microorganisms to the detection of waterborne pathogens," he said.

The expertise gained while working with soil-based environmental samples was transferrable to the water environment, and in 1997 he became an environmental scientist for the American Water Works Service Company in Belleville, Ill. At the largest privately owned water and wastewater utility company in the United States, Di Giovanni's work focused on waterborne pathogens.

"The key thing there was detection and characterization of organisms in the environment, except instead of working with soil now I was working with water," he said. "Since it was a drinking water company, the focus was detecting pathogens in source water used for drinking water production, as well as finished drinking water itself."

Though he believed great advancements in basic and applied waterborne pathogen research were being made, he foresaw limited research opportunities at the water company. At this time, Di Giovanni said, the water industry and regulatory communities were beginning to take a serious interest in molecular methods for waterborne pathogens.

"With the exciting research opportunities on the horizon, I felt an academic environment would be a better fit for my interests," Di Giovanni said. In 2001, he joined Texas AgriLife Research where he continued in this line of research. His focus has been on the detection of waterborne pathogens—specifically *Cryptosporidium* and *Giardia*—and source tracking to identify and control human and animal sources of surface water pollution.

In 2003 Di Giovanni and his team of researchers began the first BST studies in the state with support from the Texas State Soil and Water Conservation Board and the Texas Commission on Environmental Quality (TCEQ) in the Lake Waco and Lake Belton watersheds. Their BST research focused on *E. coli*, and the team developed a comprehensive *E. coli*-based library.

"The thing about bacterial source tracking and the way it is applied here in Texas and in many other states is that we are not specifically looking at pathogens," Di Giovanni said. "What we are looking at are indicators of fecal pollution because that fecal pollution can contain pathogenic organisms."

The library was developed by isolating and sampling known fecal sources, including wildlife, domestic animals, livestock, and wastewater samples of human origin. Di Giovanni's team isolated *E. coli* bacteria from the samples and typed them using DNA fingerprinting methods to create a library of *E. coli*.

The team then isolated *E. coli* from water samples and compared them with the known source sample library to obtain source ⇨

identifications. The libraries from the Lake Waco watershed and the Lake Belton watershed were combined for cross-validation to match the correct sources and for use in future studies.

"At that point we had the basis of the state library because those two projects were fairly large," Di Giovanni said. The library has been refined, and continuing cross-validations will allow for further improvements. Cross-validations take his team to various watersheds to obtain *E. coli* from known source samples and to attempt identification of those isolates using the current library. Currently the library includes 1,173 *E. coli* isolates from 1,045 different fecal source samples selected from more than 5,000 *E. coli* isolates.

"To test the identification accuracy of the library, we treat the *E. coli* library isolates as unknowns, and then test them against the remaining library and look at the rates of correct identification. The accuracy is okay at this point (87 percent), but we could do better," Di Giovanni said.

This intensive library will save researchers time and money while performing studies in smaller watersheds. The library will assist in identifying water isolates from other watersheds. Di Giovanni said that *E. coli* collected from other watersheds will be incorporated into the continually developing state library.

Di Giovanni and his team received the 2007 Texas Environmental Excellence Award, the state's highest environmental honor, presented by TCEQ, for their extensive BST research and development of the statewide library. The library was recognized as saving millions of dollars on future pollution source tracking projects as well as supporting the development of effective pollution control strategies to ensure safe drinking water.

Currently, Di Giovanni's lab is leading an international project on *Cryptosporidium* with funding from the Water Research Foundation in hopes to transfer this technology to water testing labs. The collaboration includes laboratories in Scotland, England, Wales, Australia, Canada, South Africa, and the United States.

"We are getting the water industry prepared to move into the 21st century," Di Giovanni said. "Unfortunately it is pretty scary; they have been behind a long time."

The United States requires testing of *Cryptosporidium* from drinking water sources, and the current project involves meeting these mandates by using microscopy-based testing. However when a test sample is recovered and viewed under a microscope, *Cryptosporidium* can be identified but the particular species or genotype cannot be identified.

Di Giovanni's lab and cooperators are solving this problem by taking the microscope slides and removing the oocyst—the stage of *Cryptosporidium* found in water—and using molecular techniques to identify the species and genotype. This allows for a more accurate human-health risk assessment and identification of potential sources impacting a watershed. For example, Di Giovanni explained, if all of the *Cryptosporidium* found in a particular source water were animal-associated and not pathogenic to humans, it would contain very little risk to humans.

"It is currently an exciting time in waterborne pathogen research since the water industry and regulatory communities are beginning to embrace and adopt molecular methods," Di Giovanni said. "It is very gratifying to contribute to this revolution in water quality testing and the protection of public health."

Dr. Karina Barrella, post-doctoral research associate at the Texas AgriLife Research and Extension Center at El Paso, works on the E. coli library.

Story by Kathy Wythe

texas stream team

Ambassadors for Texas water

Roger Miranda of Texas Commission on Environmental Quality volunteers as a certified trainer for Texas Stream Team. Photo by Robert Sams, Texas Stream Team

An African proverb says it takes a village to raise a child. However, the Texas Stream Team would say it takes a group of citizens to monitor Texas waters.

The Texas Stream Team, formerly Texas Watch, is based at Texas State University and is affiliated with the university's River Systems Institute. The team is a network of agencies and trained volunteers working together to monitor water quality and educate residents about the natural resources in the state, according to Jason Pinchback, the team's program director. Established in 1991, the team is administered through a cooperative partnership with Texas State, the Texas Commission on Environmental Quality (TCEQ) and the Environmental Protection Agency (EPA).

The more than 2,000 volunteers are trained to collect water samples according to a water quality plan approved by TCEQ and EPA. The monitors make field observations and analyze the samples for dissolved oxygen, pH, specific conductance, Secchi depth transparency, temperature, and *E. coli* to assess the quality of aquatic life and contact recreation conditions of the water.

Training for the volunteers begins with classroom instruction followed by field work at a nearby water body to practice what they learned in the classroom, Pinchback said. They are then tested to make sure their water sample values are accurate and they follow correct procedures. After this phase, the volunteers are certified water quality monitors.

Because of the intense interest in bacterial pollution across the state, the team recently added another part to the training: teaching the monitors how to collect, process, and analyze water samples for *E. coli* contamination, Pinchback said.

Although TCEQ does not use the information collected by the volunteer monitors in its official water quality monitoring program, the monitors' information supplements the official data and helps those involved in water quality assessment identify water

Wimberley students learn about the unique significance of Jacob's Well. Photo by Greg Dannheim

quality problems and make decisions, he said.

Professional staff from TCEQ and other partners monitor the water quality of only about 15 percent to 25 percent of the surface water in Texas, and of those, samples might be collected only two to four times a year. With 191,000 miles of streams and 11,240 reservoirs large enough to be named, that "leaves a large niche for citizen monitors," Pinchback said.

"The power of citizen monitors is the number of sites they get to and the amount of data collected at individual sites," he said. "Around 2,000 monitors sample just under 400 sites, collecting 3,500 samples per year."

In addition to training volunteer water monitors, the team conducts watershed outreach and education, focusing on changing attitudes and perceptions about nonpoint source pollution, Pinchback said.

"We really push the nonpoint source message about how each one of us impacts watersheds," he said. "The outreach and education activities help people understand how their daily activities at home or throughout their daily lives could be affecting the watershed functions."

Through these various activities, Pinchback said the team hopes to "change attitudes and perceptions that result in positive behavior changes, which, in turn, helps reduce pollution loading."

Once a year for the past 10 years, the stream team has visited fourth graders in Wimberley, giving them creekside hands-on activities where students conduct water quality tests, sample for macroinvertebrates, learn about the creek's historical significance, and participate with watershed model demonstrations.

"These outreach activities also create ambassadors so people talk to friends and family about what they have learned," he said.

The stream team also engages citizens in water resources management projects, Pinchback said. He cited an ⇨

texas stream team

Dr. Julie Westerlund, associate professor of biology at Texas State University, assists in training volunteer monitors. Photo by Texas Stream Team

incident near Rockport several years ago when citizens concerned about a potential water quality problem asked for the team's help.

"We served as a communications conduit (between the different stakeholders) as well as helped come up with a study design and sampling plan for local people interested in monitoring the water," he said.

With a full-time staff of four, the team seeks out partner organizations to increase its capability to reach more people with its message. The city of Denton, Houston-Galveston Area Council of Governments, and the Colorado River Watch network are among the stream team's more than 60 partners.

"Partners provide continuity in the local area," Pinchback said, adding they sometimes supply equipment and training and monitoring support. "Each partner has a different role depending on what their capacity is and what their mission is."

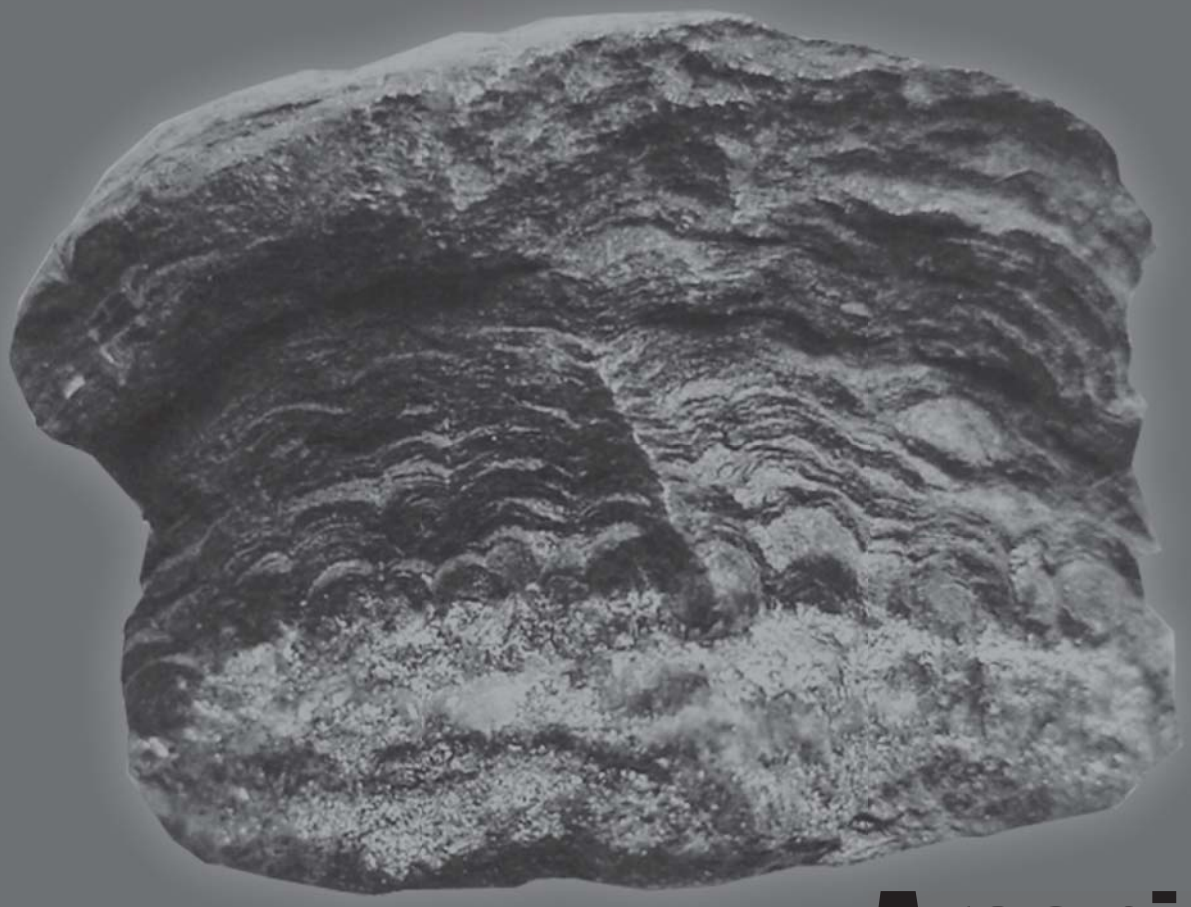
David Hunter, watershed protection manager for the city of Denton, said the city has been involved with the stream team since 2007 when his entire staff was trained as monitors and trainers. Working with professors and students at Texas Woman's University, the city staff has since trained more than 100 monitors.

"The benefits are immense," Hunter said. "Our volunteer monitors have completed hours of work performing water quality analysis. On just water quality sampling and analysis, they have done about $1,500 worth of work in the time that they have been monitoring for us, but, more importantly, we have an additional set of eyes and expertise."

Hunter said the city also uses the stream team to extend its public education efforts on water quality. "Most people don't know what a watershed is or don't know what watershed they are in," he said. "This should be the exception not the rule. The Texas Stream Team is changing that."

For more information about the Texas Stream Team, visit its Web site at *http://txstreamteam.rivers.txstate.edu/*.

Story by Kathy Wythe



Arsenic in your water?

Economists study perceptions of risks from drinking water high in arsenic

In several "hot spots" across the United States people may be drinking water with high levels of naturally occurring arsenic without understanding the associated risks, according to agricultural economists.

"Many households in arsenic 'hot spots' are in fact being exposed to harmful doses of arsenic," said Dr. Douglass Shaw, professor of agricultural economics at Texas A&M University. He recently investigated the perceptions of and exposure to arsenic in private and public drinking water through an Environmental Protection Agency (EPA) grant.

"Some people didn't realize that they had an arsenic problem, but most did," Shaw said. "We concluded that some households therefore ignore the risks, or they did not fully understand that they were being exposed."

For example, Shaw said, some people reported not drinking water from their tap, but making coffee or juice or cooking with tap water. This indicates they did not fully understanding their arsenic exposure.

Earlier research has found that people who drink water containing arsenic levels of 50 parts per billion for 15 to 20 years have about a 1 in 100 risk of dying from lung or bladder cancer, and smokers have twice that risk. In 2001, EPA lowered the arsenic maximum contaminant level (MCL) for drinking water to 10 parts per billion, based on studies that suggested cancer risks decrease at lower levels. Drinking water suppliers had to comply with the new standard by 2006.

For his research, Shaw collaborated with Dr. Paul Jakus of Utah State University, Dr. Mary Riddel of the University of Nevada, Las Vegas, Dr. Mark Walker of the University of Nevada, Reno, and former Texas A&M doctorate students, To N. Nguyen and Yongxia Cai.

The group conducted telephone surveys and distributed an educational booklet about arsenic and its risks in drinking water; the research was carried out in Fernley, Nev.; Appleton, Wis.; Oklahoma City, Okla.; and Albuquerque, N.M. In the surveys and booklet, the group explained the human health risks and explained how these risks vary among individuals. Researchers then asked participants to estimate their own risk levels.

"Once we had these estimates, we explored whether the risks are tied to behaviors that might reduce the risks, at least eventually, if not immediately," Shaw said. "We also wanted to see whether people felt uncertain about the risks they face. The specific behaviors we explored are called 'averting behaviors,' which include buying and drinking bottled water instead of tap water, and/or treating their water for the presence of arsenic in it."

The research found that although some of the participants were uncertain of the health risks they face, smokers understood that they are at higher risk for lung and bladder cancer from arsenic than non-smokers are. This difference may be because of heightened awareness about these kinds of cancer as they relate to smoking, Shaw said.

The research also showed that most adults understood that children face a higher risk than adults do, mostly because small children are less able to handle the levels of toxicity in their bodies and may be exposed for longer periods.

They also compared risk perceptions of arsenic to the consumption of bottled water, and found that general water quality and taste is the primary factor in the decision to buy bottled water.

"But as their perceived mortality risks from arsenic in their drinking water rise, expenditures for bottled water significantly increase," Shaw said. "In other words, the first trigger to get people buying bottled water has to do with overall water quality, but people who spend a lot more on it than others are paying attention to the arsenic risks in the manner that we would expect."

To view journal articles from this study, visit Shaw's Web site at *http://agecon2.tamu.edu/people/faculty/shaw-douglass/papers.htm.*

Arsenic in Texas groundwater

Arsenic is a naturally occurring element in rocks, soils, and the waters in contact with them, and its contamination of groundwater is largely the result of minerals dissolving from weathered rocks and soils. Groundwater arsenic contamination is widespread in Texas, especially in South Texas and the Panhandle.

In a 2000 study, the U.S. Geological Survey (USGS) mapped potentially high-risk areas for naturally occurring arsenic in groundwater and identified South Texas as one of the highest concentrations in the United States.

According to a 2006 study by the Bureau of Economic Geology (BEG), a research unit of the University of Texas at Austin, about 6 percent of water wells in Texas exceed the maximum contaminant level (MCL) for drinking water to 10 parts per billion. Contamination is focused in the southern High Plains (32 percent of wells exceed the MCL) and the southwestern Gulf Coast (29 percent of wells exceed the MCL).

For more information, visit USGS's Web site at *http://water.usgs.gov/nawqa/trace/arsenic/* and BEG's report at *http://www.beg.utexas.edu/staffinfo/pdf/Scanlon_As_r2005.pdf.*

TWRI welcomes new faces

Julie Svetlik has recently joined the Texas Water Resources Institute (TWRI) as a project specialist. She also holds a joint appointment with the Institute of Renewable Natural Resources and Texas AgriLife Research Office of Corporate Relations. Before joining the institute, Svetlik served as natural resource economist for the West Virginia Water Research Institute. She holds a bachelor's degree in wildlife and fisheries sciences from Texas A&M University and a master's degree in agriculture and resource economics from West Virginia University. She is currently a doctoral candidate in resource management and sustainable development from West Virginia.

Allen Berthold was recently named a TWRI project manager. Berthold leads several projects involving planning, developing, and implementing water-related research and education. He currently manages a number of projects on bacteria issues in rural Texas waterbodies. Berthold joined the institute as a student technician in January 2009. He earned his bachelor's degree in agricultural leadership and development from Texas A&M and will soon complete his master's in water management and hydrologic science from the university.

Amanda Engledow was recently selected as a project manager for TWRI. She currently manages projects that focus on implementation of the locally developed Arroyo Colorado Watershed Protection Plan as well as the assessment of water quality impairments in rural Texas waterbodies. Engledow earned a bachelor of science degree in bioenvironmental science and a doctorate in plant pathology, both from Texas A&M.

Texas Groundwater Protection Committee celebrates 20 years

Dr. B.L. Harris of Texas Water Resources Institute talks with Mark Vickery, Texas Commission on Environmental Quality executive director, and Bill Mullican, private consultant, during the Texas Groundwater Protection Committee's meeting celebrating its 20th anniversary. The committee, created by the Texas Legislature and composed of nine state agencies and one statewide association with groundwater-related responsibilities, identifies areas where new or existing groundwater programs could be enhanced and improves coordination among agencies involved in groundwater activities.

The TGPC Web site (*http://www.tgpc.state.tx.us/*) functions as a clearinghouse of groundwater information with links and publications on a number of topics including pesticides, water wells, septic systems, groundwater contamination and pollution prevention, water conservation, classroom applications, oil, gas, and mining issues, and Frequently Asked Questions.

Texas AgriLife Extension Service

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Annual RGBI Conference scheduled jointly with TSUS

The Rio Grande Basin Initiatives Annual Conference is set for May 17-20 in Alpine, Texas. This year's conference not only includes the Texas and New Mexico project participants, but it is being held jointly with the Texas State University System, including Sul Ross State University, Texas State University-San Marcos, Lamar University, and Sam Houston State University. Sul Ross is hosting this meeting on campus. The conference agenda allows times for both the RGBI and TSUS Rio Grande research participants to discuss their current projects. In addition to the conference presentations, a riparian workshop is scheduled for Monday morning and a field tour for Thursday afternoon. For more information, please visit the conference Web site at *http://riogrande-conference.tamu.edu*. Additional details will be posted as they become available.