FIRST-WORLD PROBLEM?

In rural Alabama, UA engineering students are tackling a wastewater-treatment crisis health experts are shocked to find in a developed nation.

BY OLIVIA MCMURREY

Most of Dr. Mark Elliott's PhD and post-doctoral work focused on drinking-water and sanitation challenges in developing countries. When colleagues told him he would see situations similar to those he encountered in Cambodia playing out in the American South, where he moved in 2013 to take a position at The University of Alabama, he was skeptical.

Elliott's first research project in the state took him to the Black Belt, a string of 17 rural and economically depressed counties named after their topsoil, to gather data on water quality in private wells.

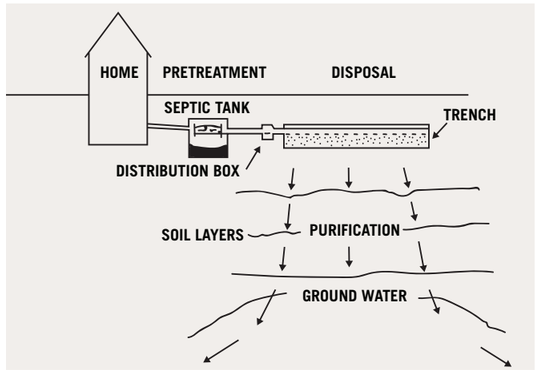
"At the first trailer we pulled up to, I literally had déjà vu when I opened the van door," says Elliott, an assistant professor in the department of civil, construction and environmental engineering. "It was 95 degrees and humid, and it smelled like sewage everywhere. I looked around to the side, and you could see this white pipe coming out of the trailer into a pool of raw sewage behind a fence. I started to come around to the fact that people were telling me the truth."

Others have taken note of the problem and its human-health consequences recently as well.

"I haven't seen this" in the developed world, Philip Alston, a United Nations official sent to investigate poverty and human-rights abuses in America, told an AL.com reporter in December of 2017, while touring communities in Butler and Lowndes counties where disposing of household wastewater in open pits is common.

Residents of the Black Belt, located about an hour's drive from the UA campus, become sick with E. coli infections and tropical diseases and parasites such as hookworm that were once thought to have been eradicated in the United States.

Elliott has diverted his research focus to rural Alabama, and he and his students are attempting to uncover the extent of the problem – how much raw wastewater is flowing into the region's water system, where this is occurring and how human health is affected – and figure out solutions. Since 2014, they have been conducting research projects funded by the U.S. Environmental Protection Agency, The University of Alabama's Center for Freshwater Studies and Center for Community-Based Partnerships and the U.S. Geological Survey (through the Alabama Water Resources Research Institute).



This illustration shows how a traditional septic system should work. In more than half of Alabama's Black Belt, clay soil prevents these systems from functioning properly.



Graduate students Parnab Das [right] and Aaron Blackwell collect water from Big Prairie Creek outside Newbern, Ala., looking for traces of wastewater from nearby homes.

Why it's happening

In most parts of the United States, homes are connected either to sewer systems that take wastewater to treatment plants or to septic systems that filter out contaminants before they reach groundwater. In much of the Black Belt, however, sewer systems do not exist because the area is too rural, and traditional septic tanks usually fail.

The clay soil of the Black Belt holds in water rather than letting it drain through – something that must happen for a standard septic system to work as intended. Researchers estimate more than half of Alabama's Black Belt contains soil that prevents septic systems from functioning properly. When wastewater can't filter down, it goes up, Elliott says, surfacing in yards or inside homes.

Elliott expected to find many residences with failing septic systems – and he did encounter that – but he discovered even more homes with no wastewater systems at all. Due to the area's poverty, many residents have difficulty paying $3,000 for a regular septic system, and the $12,000 to $15,000 required for a system that will work with the area's soil is out of the question. "A lot of people decided that instead of investing in a system that was going to fail, they just wouldn't have the system," Elliott says.

In these instances, a "straight pipe" – exposed plastic piping – takes wastewater from the home to another part of the property. If there is a wooded area behind the house, the pipe typically leads there. If the residence is surrounded by other homes, the pipe usually goes to a low point on the property or a dug-out trench or pit. Eventually, the untreated wastewater drains into streams, rivers and lakes.

According to a survey Elliott conducted of Wilcox County, approximately 60 percent of homes use straight pipes. He estimates more than 500,000 gallons of raw sewage could be entering the county's rivers and streams each day.

After a drought ended in 2016, Elliott's team found a 1,000-fold increase in E. coli bacteria in a creek near the small town of Newbern in Hale County. The findings indicate rainwater runoff transported sewage into the stream.

Health effects

The scope of health consequences related to poor sanitation in the Black Belt is largely unknown, but Elliott says preliminary evidence is disturbing.

A study conducted by Baylor College of Medicine in Houston, Texas, in conjunction with the Alabama Center for Rural Enterprise and published in The American Journal of Tropical Medicine and Hygiene in November of 2017 found 34 percent of people living in Lowndes County tested positive for genetic traces of hookworm, which is spread through human feces.

The parasite's larvae enter the body through the skin –



A straight pipe leads to a pool of raw sewage behind a home in Alabama's Black Belt.

most often the soles of a person's feet – then travel to the small intestine, where the worms attach and draw blood, leading to anemia, weight loss, lethargy and mental impairment, particularly in children.

Waterborne illnesses resulting from bacterial, viral and protozoan pathogens and health problems caused by chemical agents, including pharmaceuticals, in wastewater are likely common as well, Elliott says. The lack of health-care facilities and resources in the Black Belt – Wilcox County, for instance, has only one family physician – means root causes of many ailments are never pinpointed. "A lot of these things, like hookworm, were thought to be eliminated 100 years ago, so it's not like people are looking for them," Elliott says. And if a waterborne illness has no known agent, health-care providers are not required to report it to the state and federal organizations that monitor such illnesses. "There could be all manner of diseases, but unless they know what the agent is, it's unlikely to be reported," Elliott says.

People in the Black Belt can be exposed to untreated wastewater in numerous ways, including: walking barefoot in yards where wastewater is present; coming in contact with flies that have been exposed to wastewater; handling objects such as toys that have contacted wastewater; touching indoor-outdoor pets and items they have contacted, such as flooring (Dogs often sit in pooled wastewater to cool down in summer.); drinking tap water that passed through cracked utility pipes infiltrated by sewage; drinking well water (Modern wells are sealed so they can't be contaminated with surface water, but that's not the case with older wells that aren't maintained.); and participating in recreational water activities at places such as William Dannelly Lake in Wilcox County and Perry Lake in Perry County.

"We saw a child's toy ball floating in a puddle at the end of a straight pipe in a yard," says Parnab Das, a doctoral student from Kolkata, India, who is studying civil and environmental engineering and conducting research in the Black Belt. "That's one indication humans are coming in contact with this water."

Das sees research into wastewater-treatment issues in the Black Belt unfolding in three phases: 1) assessing the problem; 2) determining health impacts and relating them to phase-one data; and 3) developing and implementing solutions.

"At this moment, we are trying to assess how bad the problem is," Das says.

Student contributions

At least 20 UA students have been involved in researching sanitation problems in the Black Belt or writing research-funding proposals. Students have collected and analyzed approximately 400 water samples. [See the sidebar for a summary of past and current research projects.]

Students have earned academic credit through CE 521 Environmental Engineering Microbiology and CE 591, an independent study. Elliott also plans to integrate Black Belt research into CE 420 Environmental Measurements and CE 498 Undergraduate Research Experience.

In Fall 2017, Jamison Humburg, a senior from Rock Hill, S.C., majoring in environment engineering, helped write a research proposal as part of his CE 521 course, in which students learn about water microbes that are dangerous for human health and how to apply that knowledge to civil and environmental engineering. He also carried out research a previous class proposed that was funded by the EPA.

"It was really cool because I got to see both sides of it: writing a proposal and carrying out the work," Humburg says. "As an undergraduate student, usually you do one or the other. It was neat to see the fruit of that labor being realized."

Students develop a deep understanding of the research process, Elliott says, from formulating the idea to reviewing the literature, finding knowledge gaps and writing a proposal that's well suited for the specific call. "Then they find out that once you get funding, you actually have to do what you said you were going to do," he says.

Humburg travelled to Hale County five times during or after rain, spending eight to nine hours each trip collecting water samples from parts of creeks up- and down-stream from homes with straight pipes. In Spring 2018, Das, who was enrolled in CE 591, took dry-weather samples as part of the same study. By comparing the two data sets, researchers will be able to determine if, where and how much human waste is seeping into the watershed.

Das presented findings from a similar study at an EPA conference in Washington, D.C., in April of 2017. The number of E. coli bacteria increased from 1 per milliliter before a drought to more than 1,000 per milliliter afterward.

Members of the Fall 2017 CE 521 class entered two research proposals in EPA's P3 (People, Prosperity and the Planet) competition. The one Humburg worked on proposes building a heat-map model to determine which areas have higher potential for human-waste contamination. "We hope it could be used throughout the Black Belt and in areas of Mississippi and Louisiana," Humburg says.

Elliott says many students tell him they want to work on water and sanitation problems in developing countries. "Giving them the opportunity to work on projects like this right in our backyard will hopefully change their perspective about the challenges of water and sanitation among some of the poorest populations in the United States," he says.

Humburg says he was surprised human-waste runoff is a problem in the United States. "We take clean water for granted," he says. "Even as a younger student in environmental engineering, I didn't know what all went into creating the infrastructure that provides clean water and proper disposal of wastewater."

Finding this challenge in one of the world's wealthiest nations was perhaps more unexpected for Das. "This experience has helped me as a researcher and as a social thinker as well," he says. "As a global citizen, if I do clean-water-related research, I have to include all countries because a problem might be in developed countries as well."

Research goals and possible solutions

Elliott says the work his team has begun is a long-term initiative he suspects will last at least 20 years.

"We're hoping our research projects produce results that draw attention to this problem and the scope of the problem so we can get some money to implement solutions," he says.

He plans to approach federal and state agencies, the U.S. Department of Agriculture, rural-development organizations and foundations for funding to implement solutions, the top three of which are:

1. **Extending networked sewer systems** – A few Black Belt towns have sewer systems, but some concentrations of homes just outside city limits are not included. They could be added to existing systems.
2. **Creating smaller sewer systems in rural areas away from towns** – These are called clustered or decentralized systems, and they can consist of 20 to a few hundred homes.
3. **Using better independent systems in areas where the other two solutions are not possible** – Because systems that work in the Black Belt are expensive, a grant program would be necessary to help residents afford them, or low-cost systems would need to be invented.

The second EPA P3 proposal from the Fall 2017 CE 521 class attempts to achieve the latter goal. The system engineering students are designing in collaboration with geology and biology students would enhance degradation of organic matter, reduce clogging and prevent wastewater from backing up inside homes.

"People have been talking about this issue," Elliott says. "There's a lot of momentum going right now, and we're hoping we can take advantage of that and start addressing this problem instead of just talking about it."

For more information about UA-led efforts to improve wastewater treatment in the Black Belt, contact Dr. Mark Elliott at melliott@eng.ua.edu or 205-348-5469.



Dr. Mark Elliott, left, talks with PhD student Parnab Das as he works with water samples in the lab.

Past and current research projects

The University of Alabama is leading research into the wastewater-treatment crisis in Alabama's Black Belt region. Efforts have centered around a primary, U.S. EPA-funded project that began in 2014 and provides funding through early 2019. A former UA student, Phillip Grammar, co-wrote the research proposal. Other, smaller projects supplement work on the main project, says Dr. Mark Elliott, who heads the research team and is an assistant professor in UA's civil, construction and environmental engineering department.

Past and current projects include:

- The original research project, funded by the U.S. EPA Gulf of Mexico Program – This project involves water-quality testing, community outreach and training and funding to inspect 300-400 septic systems.
- Water-quality sampling in Hale County, supported by the UA Center for Freshwater Studies and the EPA – Researchers tested water quality in streams in areas where many homes use straight pipes.
- A door-to-door survey of residents in Hale and Wilcox counties, funded by the U.S. Geological Survey – The surveyor asked residents where their wastewater goes and did site inspections that involved documenting straight pipes and where they carry waste, and looking for signs of failing septic systems.
- Water-quality sampling in Hale and Perry counties, backed by the EPA and generated through a student-written proposal – This project looks at the impact of straight pipes on streams. Elliott's Fall 2015 CE 521 Environmental Engineering Microbiology class wrote the project proposal as part of the EPA's P3 (People, Prosperity and the Planet) competition for college students.
- Building a model to predict how common straight pipes are in a given area, funded by the UA Center for Community-Based Partnerships – Researchers are combining site-inspection data, the knowledge of health-department inspectors and septic-system installers and information about soil types and property values to create a model that will forecast where straight pipes are likely to exist. Scientists could use the model in other parts of the rural South.