Clean H20

Water is a limited resource, yet all life depends on it for survival. The world's population tripled in size during the 20th century and the use of the world's renewable water resources increased six-fold. During the next 50 years, the population is expected to increase by another 40-50 percent. An increase in industrialization and urbanization, will result in an increased demand for water and an increase in the amount of wastewater produced. The world's water supply cannot keep up with this increasing demand, so humans must continue to use water efficiently and wisely. One way to extend our water supply is to recover or reclaim previously used water.

BY MÓNICA MUÑOZ + KIPPRA D. HOPPER

GRADUATE STUDENT JOE GRIECO HELPED TO ENGINEER A BIOLOGICAL REACTOR.

PHOTOS: ARTIE LIMMER

Faced with the

FACT THAT WASTEWATER RECOVERY METHODS will become an increasingly important response to water shortage, researchers at Texas Tech University's Water Resources Center are investigating the efficacy of water recovery systems in producing water that is safe for human consumption. Headed by Civil Engineering faculty members Audra N. Morse, Ph.D., assistant professor, and Andrew Jackson, Ph.D., associate professor, the Water Recovery Group has evaluated the performance of a replica of NASA's Advanced Life Support Integrated Water Recovery System. This system is designed for use during space exploration missions, but the information regarding how well contaminants are removed from wastewater in this system will prove indispensable for terrestrial water treatment systems.

"The information we are obtaining in the NASA project also can be used on Earth. NASA needs to be cost effective; they don't have unlimited space. In fact, everything is limited—power, space, volume, mass—so they strive for efficiency. We worry about how we can make water recovery cost effective — in space and on earth," Morse explains.

The Water Recovery Group, which includes several graduate and undergraduate students, replicated the biological and physio/chemical treatment train developed at the Johnson Space Center. The system operates as a pseudo closed-loop system and produces potable water. The process successfully reduces organic carbon, converts oxidized nitrogen to reduced forms, and removes substantial amounts of nitrates through denitrification. The system also has proven to be efficient as it reduces mass loading on the post-processing system.

Morse, her colleagues Jackson and Darryl James, associate professor of mechanical engineering, as well as her graduate students have designed a special biological reactor to make the device space-compatible. The researchers are studying fluid flow on Earth for use in non-gravity space. "We had to figure out a way to have fluid move through the bacteria bed that cleans the water," Morse says. "We use centrifugal force, the same force in tornadoes, to overcome the effects of gravity. NASA, which has funded the project through 2009, wants proof that this reactor system will work in microgravity."

The researchers found an unusual element to their biological reactor as they discovered they could use soft-air BBs in the reactor to clean wastewater with various bacteria. "The density of the material is similar to water. With this density, we can overcome gravity and show on Earth that the reactor works in microgravity," Morse explains. "The first step in the research is the design of the reactor. The proof-of-concept is making the reactor work in microgravity. We then quantify the fluid flow operation with the next step to treat the water. We cannot have air bubbles accumulate in the elbows and connections because in space, the bubbles eventually will stop the flow. We also have to verify that we can clean water to NASA's specifications."

The Texas Tech biological reactor is unique in that bacteria grow on the beads, which are continuously moving. In other biological reactors, the bacteria grow on a static medium, Morse says. The researchers are determining whether the collision of these particles will help or be detrimental to the bacteria growth. "We need to make sure that the natural processes are working. We are working on the habitat for a variety of bacteria," Morse says.

THE PROCESS SUCCESSFULLY REDUCES ORGANIC CARBON, CONVERTS OXIDIZED NITROGEN TO REDUCED FORMS, AND REMOVES SUBSTANTIAL AMOUNTS OF NITRATES THROUGH DENITRIFICATION. THE SYSTEM ALSO HAS PROVEN TO BE EFFICIENT AS IT REDUCES MASS LOADING ON THE POST-PROCESSING SYSTEM.


The graduate student who designed the current model of the biological reactor is Joe Grieco, in mechanical engineering. He is videotaping the particles inside the reactor from various angles to see if researchers need to redesign the reactor. Grieco tracks the particles frame by frame, and then weighs them to ensure the plastic of the BBs is not damaged as it hits the other BBs.

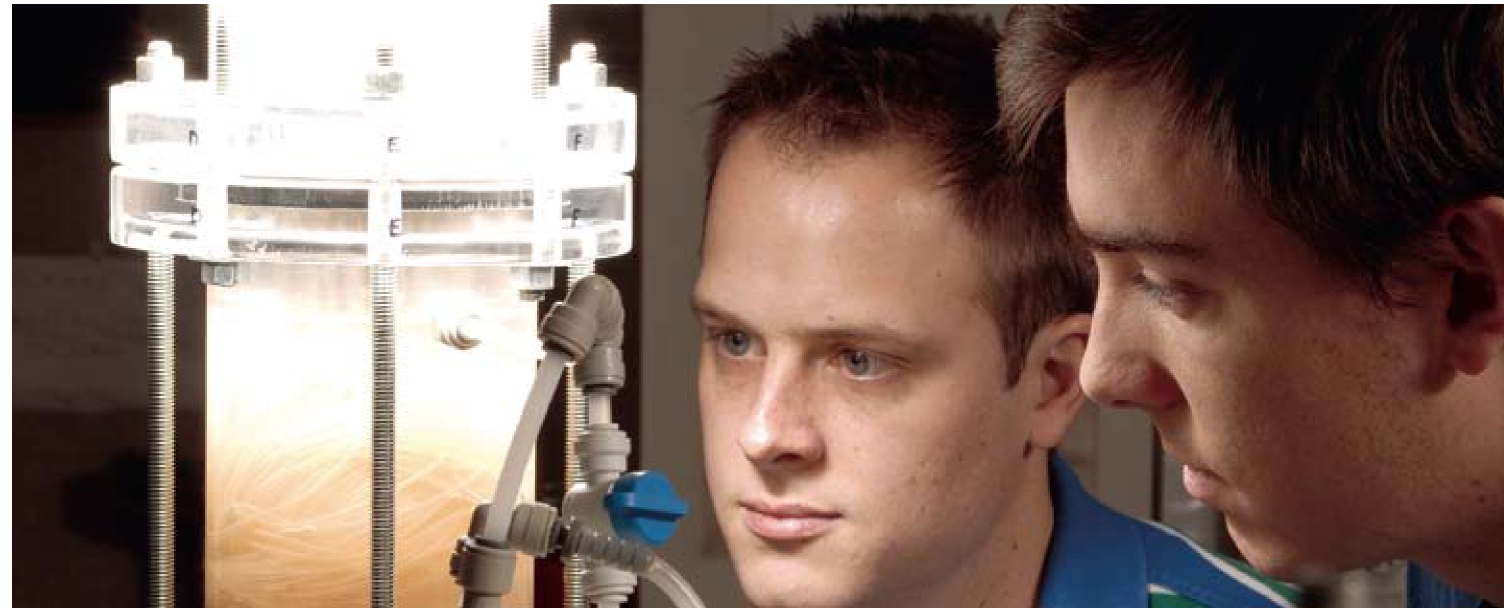
"We tend to look at biological reactors, which is the first part of the treatment. A lot of power is required for chemical treatment, but if we treat it biologically first, which is very low energy and low intensive, then it saves supplies and energy down stream. It is efficient," Jackson says. "Our reactors are not going to be used on Earth because we have terrestrial systems that work great, but there are implications from our research for the treatment of wastewater back to drinking water on Earth. What we find out about these closed-loop systems and how they operate in the very concentrated waste streams in space will be of use. The reactors are specialized, but the implications are very broad."

One of the group's more prominent projects involves investigating the fate of pharmaceuticals, such as amoxicillin, estrogens, ciprofloxacin, and over-the-counter medicines, during the water treatment process. Their studies with amoxicillin have shown decreased levels of the antibiotic in water throughout the biological components of the system, while the post-processing units of the system removed the pharmaceutical. This indicates that amoxicillin would not accumulate in a water reclamation system such as this. Studies with estrogens showed that they could be detected in the biological components of the system and in the product water, indicating that the post-processing system is unable to completely remove estrogens. Future work will reveal the fate of ciprofloxacin and over-the-counter medicines.

- RESEARCHER AUDRA N. MORSE IS PART OF THE WATER RECOVERY GROUP.
- FACING PAGE: STUDENTS JASON CRAWLEY AND NICK LANDES
- (LEFT TO RIGHT) SCAN THE VIEW INSIDE THE REACTOR.

The results of the lab studies with pharmaceuticals will prove to be highly applicable in real-world settings. For instance, the research with amoxicillin will help inform concerns of antibiotic resistance. "We know that bacteria develop resistance to low doses of an antibiotic, and concentrations in water may be low enough to cause a microbe to develop resistance. If one becomes infected with a pathogen that has resistance, a cure may be difficult to find. The presence of low doses of antibiotics in water basically makes it a vehicle for transferring resistance," Morse cautions.

Lubbock officials are looking at ways to reuse some of its wastewater in order to reduce the increasing demand on potable water. Lubbock's particular interest in what happens to pharmaceuticals and personal care products that are introduced into local water sources calls for Morse's expertise. "City officials are looking at ways to use treated wastewater for irrigation of parks and highways. They also are interested in discharging wastewater into the lake systems in the future. They can wait about 60 days, and then they can pull the water back in to use it as a drinking water supply source," Morse explains. "They have been employing groundwater for 70 years, and we don't really know how well antibiotics, personal care products and pharmaceuticals have degraded over this time. It is possible that the groundwater may have become a reservoir for these compounds. They want to know what is coming out of their wastewater plant and what is going into the natural system. I am in the process of working with them, so that we can do some analyses."



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The project is a component of the Environmental Protection Agency (EPA) larger project funded for the Center for Water Law and Policy. Morse has been granted $192,000 to carry out this study, and she will be collaborating with Todd Anderson at the Institute of Environmental and Human Health. Many remaining questions regarding, first, the cost-efficiency of water recovery systems, and, second, the compounds that can be adequately removed during wastewater treatment need to be addressed. As these questions gain answers, researchers are hopeful that people will be more receptive to the idea of water reclamation.

"Most people are very opposed because they imagine a direct water reclamation process," Morse says. "If water reclamation is performed in a direct fashion, it is called toilet to tap, and the phrase is enough to make people cringe. However, most people don't realize that we already recycle wastewater. The water we use most of the time is recycled; it is just not recycled through a direct process, such as creating a pipeline from the wastewater plant to the water treatment plant and then drinking it. A process that direct will be years out because currently a strong stigma is associated with water reclamation."

In an effort to reduce some of that stigma, researchers stress the positive aspects of water reclamation. Both Morse and Jackson emphasize the effectiveness of existing wastewater treatment systems. "In some cases, and this is really true, we typically will treat our wastewater to better quality than what stream water is just because we cannot control all that goes into the stream. We have regulations in place to try to control run-off into the streams, but we are not always successful. Most people find the idea of recycled wastewater horrifying, but it is not," Morse assures.

Also, people are asked to keep in mind that indirect methods for reclaiming water exist in which the water that has been treated can be returned to lake systems or groundwater sources. This water can remain there for a number of years before being pumped out for consumption. Morse goes a step further to remind us that water reclamation represents what may one day be an inevitable reality, and she suggests that people need to change the way they think about it. "People think that water is a god-given right and that they should have it. We need a paradigm shift in our thinking of how we need to preserve and carefully use our water sources. We have to be open-minded so that we can provide for the future and make sure these resources are available," she urges.