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How Gray Does Your Garden Grow?

By Lyn Corum

A first-of-its-kind study being carried out by the Texas A&M El Paso Research Center is measuring the effects of graywater irrigation on vegetable and cotton crop yields as compared with irrigation using brackish water.

Graywater reuse for landscape irrigation is increasing in popularity, according to the Water Environment Research Foundation (WERF). But what about crops? In what may be a first, a study being carried out by the Texas A&M El Paso Research Center is demonstrating that vegetable and cotton crop yields are larger when irrigated with graywater in comparison with brackish, salty water. However, the study is not examining the health effects of irrigating food crops with graywater.

The main driver for graywater irrigation, of course, is water conservation. Woody Irving, a planner in the El Paso Field Division of the US Bureau of Reclamation, which provided part of the funding for the El Paso Research Center study, says the area is experiencing a drought and all surface water has been affected. Water comes to the southwest Texas area via the Rio Grande River. Its headwaters are in Colorado, where the snowmelt for the last 10 years has been reduced. Meanwhile, cities are growing all along the river, Irving explained.

Graywater is typically defined as wastewater that originates from clothes washers, bathtubs, showers, and sinks but does not include wastewater from kitchen sinks, dishwashers, and toilets. It may contain grease, food particles, hair, detergents, pharmaceuti-

cals, and personal-care pollutants. Most are biodegradable, but some may be sodium-based, which can result in graywater degrading the soil structure and potentially harming landscapes in arid environments.

According to a 1999 study by the Soap and Detergent Association, about 7% of US households were reusing graywater. WERF reports that states in the West and southwest, including California, Arizona, Idaho, Nevada, New Mexico, South Dakota, Utah, Texas, and Washington, have developed comprehensive guidelines or regulations for graywater reuse.

The potential threat to human health and long-term impact on plants, soil chemistry, and microbiology are the major areas of concern with the use of graywater. However, research in these areas is limited. A 2006 study by WERF reviewed the state of knowledge of the long-term impacts of using graywater for landscape irrigation and identified areas where research is needed.

Currently, graywater irrigation is limited to landscaping because it contains levels of fecal coliform that exceed allowable criteria set by regulatory agencies for wastewater and natural water discharge where it may come into body contact. WERF states that there is controversy regarding whether the organism counts are an accurate indicator of the actual health threat.

The Texas Graywater Study

With the goal of conserving shrinking fresh water supplies, researchers at the Texas A&M El Paso Research Center designed two experiments to determine the effects of graywater irrigation on crop production and its impact on soil conditions. Specifically, the experiments, now in their third year, will provide recommendations for appropriate application rates for graywater in arid regions to improve water conservation in a manner that will not harm plants or degrade soils susceptible to salt accumulation.

The US Southwest is facing water shortages for both agriculture and urban uses, says Zhuping Sheng, a researcher at Texas A&M's El Paso Agricultural Research and Extension Center. In Texas, people are using brackish groundwater that is high in salinity to preserve potable water. The total dissolved solids in brackish water is 2,000 milligrams per liter, while freshwater total dissolved solids measures 700 to 800 milligrams per liter, Sheng explains. The quality of the brackish water is so poor it has to be blended with fresh water, he says. As a result there is great interest in using graywater for agriculture and landscape uses.

Sheng and his colleague, Nancy Assadian, received $20,000 in 2004 from the US Bureau of Reclamation to study the potential benefits and safety of using graywater to irrigate vegetable crops. Another $21,000 came from Cotton Inc., a Texas state support committee, to study the use of graywater and salty groundwater to irrigate cotton crops. The US Department of Agriculture, through its cooperative state research, education, and extension service, the Rio Grande Basin Initiative, provided additional funds for both projects.

Sheng and Assadian chose the Rogelio Sanchez State Jail as the site for the field test because they already had a relationship with it. No, they had not spent time there—jail crews assist in and are trained in maintenance projects and maintain the research plots at the El Paso Research Center.

All photos Texas A & M University

Young cotton plants growing at Rogelio Sanchez State Jail.

Vegetables and Cotton Grown

The six vegetable plots and four cotton plots at the jail are located on a desert mesa of shallow, loamy sand underlain by caliche, hardened calcium carbonate formed in sediments within the bedrock. The area receives less than 10 inches of rain during the growing season.

Two ongoing field tests, one for vegetables and another for cotton, are in their third year, so results are preliminary. Vegetables were selected because there are major health concerns about whether pathogens such as *E. coli* could be transmitted through graywater irrigation. Cotton was chosen because it is a major crop in Texas and is produced by a number of the state's correctional facilities. Sheng says a species resistant to the boll weevil

Young tomato plants growing at Rogelio Sanchez State Jail.

was selected.

Each of the six vegetable plots was 24 feet by 21 feet. Three received graywater irrigation, and three received brackish water. Each plot was planted with three rows of one vegetable: tomatoes, long green chilies, or bell peppers. This resulted in two plots of tomatoes, two of green chilies and two of bell peppers.

The four cotton plots were 21 feet by 27 feet, two of which were irrigated with graywater and two with brackish water. Half of the plot was conditioned with mulch, while the other half remained unconditioned.

The soil was amended with mulch to determine if it improves the use of either or both types of irrigation waters. Soil amendment was not applied to the vegetable plots because of the potential for introducing diseases. Sheng says the team conducted soil column tests in the first year to assess the impact of soil conditioning on water movement in the soil. The results show that soil conditioning with mulch does change permeability and helped retain water in the soil.

Vegetable seedlings were purchased from a local nursery and transplanted to the plots in early May of each year. The tomatoes, chilies, and bell peppers were chosen because they are very susceptible to salinity. According to Assadian, "If we could grow high-maintenance veggies with poor water, we knew we could grow almost any crop ...We also wanted to verify that pathogen contamination may be little to none under a hot and dry desert environment in spite of potential waterborne pathogens," says Assadian. Cotton seeds were planted the first two years.

Before planting, two moisture sensors in each plot were placed 5 and 8 inches below the soil surface and connected to aboveground data loggers. Once the vegetables and cotton were planted and irrigation had begun on a schedule of every two to three days, soil moisture was measured at time intervals from one minute to 15 minutes, along with salinity and the presence of *E. coli*. Data were downloaded every other week. Just one sample of *E. coli* was found in one of the tomato plots irrigated by graywater.

Water Had To Be Transported

Wastewater at the prison comes from showers, kitchens, and laundry, comprising 68% of the facility's total domestic wastewater. In this study, only laundry water was used. Eleven loads are washed each day at the prison, using 3,500 gallons of water. A continuous pipe system going directly from the subsurface laundry trap inside the prison to the plots could not be constructed for security reasons. Instead, water is pumped to a storage reservoir and then transferred to the stationary 250-gallon-capacity water tank for transport. Access to the prison facility did create some difficulties at the beginning of the project when transportation of the graywater was set up.

The brackish water was also transported to the field from a private well in a 250-gallon stationary water tank. At the beginning of the third year, the owner of the private well did not continue the contract with the prison. Fresh water was then used for irrigation, making the third year of the study a base case, and data from the previous two years will be compared to it once the growing season has concluded.

Water was delivered to the plots via a 2-inch diameter PVC pipe using gravitational flow from the stationary water tank. That pipe was connected to a perforated PVC pipe laid perpendicular to the rows in each plot, so that water was distributed uniformly to each furrow.

The irrigation schedule was determined by total irrigation demand and irrigation rate. Sheng says it was not necessary to irrigate every day. He adds that irrigation mimicked local practices. At the beginning of each test year, the researchers applied large quantities of fresh water to flush out the salts. If they didn't, the salts would build up and affect crop production.

Also, during the first year, the scientists studied the amount of leaching taking place. They were concerned about the amount of brackish water leaking into the freshwater ground table. Irrigation water at the site infiltrates downward and tends to be retained by the caliche layer at a depth of 3 feet. Groundwater at this location lies about 300 feet below the surface. Sheng said there is no immediate concern that the irrigation water might contaminate the groundwater.

However, in other areas where the groundwater is shallow, the potential does exist for graywater

irrigation to contaminate groundwater and should be evaluated carefully, Sheng says.

The Preliminary Results

In general, in the initial harvests, graywater increased vegetable yields and the number of vegetables harvested from selected plants relative to those receiving brackish water. Salinity was higher in the soil irrigated with brackish water than it was in that irrigated with graywater, leading to the conclusion that less salinity improves crop growth, says Sheng.

Furthermore, Sheng concludes, soil conditioning with mulch does affect cotton production. Its impacts on soil salinity varied depending on interaction of mulch and irrigation water. Second-year results were still positive for graywater use, but production differed. The results were also affected by rainfall events during the year.

Vegetable Production

The graywater produced no detrimental effect on vegetable plant growth, and it did not create early transplant stress, according to Sheng. During initial harvests, it increased vegetable yields 14% or more and increased the quantity of vegetables by 20% relative to those receiving the brackish irrigation water. For beef tomatoes, graywater irrigation produced larger-size fruits than did brackish-water irrigation. However, the opposite was true for cherry tomatoes. In this case the brackish-water irrigation produced larger-size fruits.

Assadian reported that long green chilies and bell peppers were more salt sensitive than tomatoes and had lower yields than tomatoes. Salts decreased long green chili pods to the size of jalapeno peppers. Bell pepper mortality was highest, suggesting more sensitivity to environmental change and salinity than tomatoes or long green chilies.

During the first year, about 30% of all plants were infected with curly leaf virus within a month of transplanting. The infection, caused by leafhoppers driven in from the fringe of the desert by a cool, moist winter and spring, increased and affected overall plot production. Insecticide was applied, according to Assadian, but did not control transmission. In spite of the infection, all vegetables grew well in all the plots.

Mature cotton plants growing at Rogelio Sanchez State Jail.

Cotton Production

Mulch conditioning had a major impact on cotton growth and production. Without it, graywater-irrigated cotton grew 5 inches higher than cotton irrigated with brackish water. When mulch was added, cotton grew at almost the same rate regardless of irrigation supply, since it reduced the impact of salinity of the brackish water.

However, there was a difference in the amount of lint or cotton fiber produced. The cotton irrigated with graywater and given mulch produced 70% more cotton fiber. Cotton grown in mulched soil and irrigated with brackish water produced 1.5 times more cotton fiber than that grown without mulch.

For the third-year test, the researchers took notice of the need to apply the soil conditioner properly to aid germination. Sheng says growers need to be aware of how much and when the soil conditioner is applied. He says it wasn't mixed properly in the initial application and may need to be applied two or three weeks earlier and the soil irrigated before planting. This last observation has not been tested yet, Sheng says.

Lessons Learned

Sheng has concluded that graywater is a good alternative source of water for irrigating vegetables, cotton, and other crops. Brackish water can be used for irrigation, but its impacts on the salinity and sodicity of soil as well as its impacts on crop production should be assessed carefully.

Applicability of both is specific to site, soil texture, quality of the water source, hydrological conditions, and crop types. Therefore, says Sheng, each application should be evaluated before large-scale implementation.

Current regulations prohibit direct use of graywater irrigation on vegetable crops that are being grown for human consumption, and the vegetables grown at the Rogelio Sanchez State Jail were not eaten, Sheng reports. It is likely that much more research will need to be done to prove whether or not graywater is safe to irrigate vegetables intended for the dinner table. The major concern is whether the vegetables harbor viruses that may have been introduced through the graywater,

Mature tomato plants growing at Rogelio Sanchez State Jail.

but this was not part of the study, he says. The study was limited to assessing the impacts of graywater and brackish water on vegetable and cotton crop growth.

In spite of the limits of the study, Sheng says the jail administration is very interested in the results and would like to prove to state regulators that it is safe to eat the fresh vegetables. (This may prove difficult in light of discovering *E. coli* in one tomato sample during the first growing season.)

In addition to the need for water conservation, the jail is short on land, has not grown its own vegetables, and, with limited financial resources, serves only canned vegetables in its cafeteria. However, Sheng points out, the jail could use fresh water or brackish water to grow vegetables on what land it has.

What's in the Future?

Sheng says that additional work is being planned at the El Paso Research Center, pending funding. Graywater is a great alternative source of water for crop irrigation and landscaping, especially in small or remote rural communities, he says.

Graywater is a good alternative for landscaping in urban areas as well, Sheng argues. Not only will the practice conserve water; it will also reduce load on the municipal wastewater collection and treatment systems. But given the increasing need for water conservation, especially in the western and southwestern portions of the US, studies on health issues surrounding the use of graywater irrigation will become critical.

It should be noted only laundry water was reused in this study. Graywater often includes shower water, and as WERF pointed out in its 2006 study, it contains a multitude of chemicals due to the wide array of products that are disposed of in household drains. As household activities change, brands or types of personal hygiene products and cleaning products will change. What is not known is how the combination of chemicals affects irrigated areas in terms of plant health, soil microbiology, and soil chemistry.

Will these constituents accumulate in the soil in sufficient quantities to harm plants or perhaps be transported below the root zone to the groundwater during the rainy season? WERF notes that a number of graywater systems have been operating for some years with no obvious detriment to vegetation, but the scientific documentation is lacking. It also could find no published studies examining the changes in soil chemistry as a result of irrigating with graywater. Furthermore, the long-term effects of graywater irrigation on plant health have not been studied.

The WERF report (03-CTS-18CO) can be found at www.werf.org. **we**

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