Title: Effect of Treatment on Harvested Rainwater Quality

Focus Categories: Conservation, water quality, water supply

Keywords: rainwater harvesting, roofing materials, treatment, water quality, drinking water

Duration: 03/01/2011-02/28/2012

Federal Funds Requested: $5,000

Non-Federal Funds Pledged: $10,000.00 (See the letter pledging matching funds.)

Principal Investigator: Sarah Keithley, M.S. Student, Department of Civil, Architectural, and Environmental Engineering, The University of Texas at Austin, 1 University Station C1786, Austin, TX, 78712.

Co-Principal Investigator: Mary Jo Kirisits, Assistant Professor, Department of Civil, Architectural, and Environmental Engineering, The University of Texas at Austin, 1 University Station C1786, Austin, TX 78712. E-mail: kirisits@mail.utexas.edu. Phone: 512.232.7120

Congressional District: 21st District

Abstract:

Rainwater harvesting, which is the capture of rainwater from a roof catchment, has many environmental benefits. For instance, it is a local water resource, so electricity is not consumed to pump it across long distances; it also reduces stormwater run-off. While harvested rainwater is a valuable resource that can be treated for indoor domestic use (potable and non-potable), there is a surprising lack of data regarding the quality of harvested rainwater before and after treatment. The objective of the proposed project is to quantify the physical, chemical, and biological quality of rainwater harvested from pilot-scale roofs (asphalt fiberglass shingle, Galvalume®, concrete tile, cool, and green) and a full-scale roof (Galvalume®) before and after common treatment processes (i.e., cartridge filtration and ultraviolet [UV] light or chlorine disinfection). Thus, this research will allow us to determine if the common processes employed to treat rainwater will produce water that meets potable and non-potable standards. The proposed project also will include an outreach component in which middle-school students will participate in hands-on exercises to examine the quality of harvested rainwater before and after treatment.

Statement of Critical Regional Water Problems:

Water scarcity due to diminishing per capita resources and excessive stormwater run-off due to high-volume rain events are common problems encountered in Texas. For example, it is predicted that groundwater resources will be exhausted by 2050 in Texas if historical groundwater extraction patterns continue (Loáiciga et al., 2000). Rainwater harvesting is one way to address these problems. In parts of Texas with insufficient or inaccessible groundwater, rainwater harvesting represents a way to capitalize on a local water resource. As an added benefit, the capture and storage of rainwater decreases the volume of stormwater run-off and thereby decreases the loading of non-point source pollution to receiving waters.

Although harvested rainwater is a valuable resource, it can contain a variety of pollutants including nitrate, metals (e.g., aluminum, lead, and zinc), organic compounds (e.g., polycyclic aromatic hydrocarbons and natural organic matter), and microorganisms (e.g., fecal coliform, *Salmonella* spp., *Escherichia coli, Cryptosporidium,* and *Giardia*) (Chang and Crowley, 1993; Polkowska et al., 2000; Simmons et al., 2001; Lye, 2002; Basheer et al., 2003; Ahmed et al., 2008; Mendez et al., 2010). The quality of harvested rainwater is affected by a variety of factors including roofing material (Mendez et al., 2010), length of time between rain events (Yaziz et al., 1989), and season (Jones and Harrison, 2004).

While residential rainwater harvesting systems in Texas are not required to meet United States Environmental Protection Agency (USEPA) drinking water standards (i.e., potable use) or water reuse standards (i.e., non-potable use), it would be wise to meet them from the standpoint of human health protection. We are finishing a project funded by the Texas Water Development Board, which shows that the rainwater harvested from a variety of roofing materials (asphalt fiberglass shingle, Galvalume®, Kynar®-coated Galvalume®, concrete tile, cool, and green) does not meet several drinking water standards (e.g., turbidity, fecal coliform, total coliform, aluminum, and iron) even after the first-flush water is discarded; furthermore, it shows that the quality of harvested rainwater varies depending on the type of roofing material. In summary, untreated harvested rainwater can contain pollutants that exceed drinking water and water reuse guidelines, thereby posing a risk to human health.

Nature, Scope, and Objectives of the Research:

The objectives of the proposed research are to examine the effect of common treatment processes (e.g., filtration and disinfection) on the quality of harvested rainwater and to compare the quality of treated, harvested rainwater to USEPA drinking water standards and water reuse guidelines.

Pilot-scale. Rainwater will be collected from our existing pilot-scale roof site (Fig. 1) at the Lady Bird Johnson Wildflower Center in Austin, TX. Five pilot-scale roofing materials (asphalt fiberglass shingle, Galvalume®, concrete tile, green, and cool) will be examined. Each roof has a first-flush device, which diverts ten gallons per 1,000 ft^2 of collection area, followed by a polypropylene storage tank. After a minimum 1-in rain event, the water from the storage tank will be split and treated in parallel. One train will consist of 5-µm membrane filtration and UV disinfection, and the other train will consist of 5-µm membrane filtration and chlorine disinfection; given the ease of obtaining and dispensing chlorine, rainwater harvested for non-potable AND potable uses is often disinfected with chlorine (Dennis Lye, personal communication, 2010). Nine water quality parameters of the untreated and treated rainwaters will be analyzed: pH, conductivity, turbidity, total coliform, fecal coliform, nitrate, nitrite, DOC, and metals. Our laboratory is equipped with a filtration apparatus and UV disinfection chamber for conducting these experiments. Four rain events will be captured for the pilot-scale roofs in this one-year project, targeting one rain event per season.

Figure 1. Pilot-scale roofs. (A) asphalt fiberglass shingle, Galvalume®, concrete tile; (B) green; (C) cool.

Full-scale. The quality of rainwater harvested from a full-scale installation also will be analyzed before and after treatment. This will allow us to examine treatment efficacy for larger volumes of water than are possible from the pilot-scale roofs. A full-scale collection-storage-treatment system at the private residence of Joe Wheeler (Austin, TX) will be sampled. This system collects rain from a galvanized metal roof; the rain goes through a pre-filter and is stored in a 5,000-gallon polypropylene cistern until it is treated (25-µm cartridge filter, 5-µm cartridge filter, and UV disinfection). In a preliminary sampling of this system, the turbidity of the treated water was observed to be higher than the USEPA drinking water guideline of 1 nephelometric turbidity unit (NTU). The system will be sampled at least once per season during the project (i.e., 4 events) and before and after at least one routine system maintenance event (e.g., changing the UV bulb, or changing the cartridge filters). The same water quality parameters that will be monitored for the pilot-scale roofs will be monitored for the full-scale roof.

Outreach. This project also will include an outreach component. Specifically, we will team with the 7th grade science teacher (Rachel Fierro) at the Ann M. Richards School for Young Women Leaders; this public middle-school (Austin, TX) focuses primarily on training economically disadvantaged girls in science, technology, engineering, and mathematics. We will deploy our treatment units on the rainwater captured by their existing harvesting system, so that the students can analyze water quality before and after treatment. This outreach will have two benefits: (1) the girls will work with a female graduate student and a female professor on an engineering project and (2) it will educate members of the Texas community about rainwater harvesting.

Results Expected from this Research:

As domestic use of harvested rainwater becomes more common, the quality of that water before and after common treatment processes should be better understood so that public health might be protected. Two important results are expected from this project: (1) this research will show if common treatment processes (e.g., filtration and disinfection) applied to rainwater harvested from five different roofing materials are sufficient to yield quality in line with USEPA drinking water standards and water-reuse guidelines; (2) this project will expose a group of middle-school girls to the concept of treating harvested rainwater to meet use-appropriate standards. Given the lack of data in the literature on the quality of treated, harvested rainwater, we expect our data set to be very valuable in the field of rainwater harvesting.

References

Ahmed, W., et al. 2008. *Appl Environ Microbiol.* 74(17):5490.

Basheer, C., et al. 2003. *J Chromatog A.* 1016:11.

Chang, M. and C.M. Crowley. 1993. *Water Res Bull.* 29(5):777.

Jones, A.M. and R.M. Harrison. 2004. *Sci Total Environ.* 326:151.

Loáiciga, H., et al. 2000. *J Hydrol*. 227(1-4): 173.

Lye, D.J. 2002. *J Am Water Res Assoc.* 38(5):1301.

Lye, Dennis. 2010. Personal communication (November 5, 2010)

Mendez, C.B., et al. 2010. Effect of Roof Material on Water Quality for Rainwater Harvesting Systems. Texas Water Development Board (Austin, TX).

Polkowska, Z., et al. 2000. *Atmos Environ.* (34):1233.

Simmons, G., et al. 2001. *Water Res.* 35(6):1518.

Yaziz, M., et al. 1989. *Water Res*. 23(6):761.