Title of Proposal Trihalomethane Formation Potential in Rainwater Harvested from Different Roofing Materials

Focus Categories: Treatment, water quality, water supply

Keywords: Rainwater quality, rainwater harvesting, roof runoff, sustainable water supply

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Abstract: Rainwater harvesting systems are one way to address the worldwide increase in water demand. Although rainwater harvesting systems may be simple and inexpensive to construct, various sources of contamination can negatively affect water quality. Currently, we are sampling five pilot-scale roofs (asphalt fiberglass shingle, Galvalume® metal, concrete tile, cool, and green) at the Lady Bird Johnson Wildflower Center in Austin, Texas to examine the effect of roofing material on harvested rainwater quality. Preliminary data show that harvested rainwater contains 2-37 mg/L dissolved organic carbon (DOC). If the harvested rainwater is for indoor use, it must be disinfected. If it is disinfected with chlorine, the presence of DOC can lead to the formation of harmful disinfection by-products such as trihalomethanes (THMs). The main purpose of the proposed work is to examine the trihalomethane formation potential (THMFP) of rainwater harvested from the pilot-scale roofs constructed of five different roofing materials.

Statement of Critical Regional Water Problems: The construction of rainwater harvesting systems is being encouraged globally as a means of protecting human health and conserving water. To minimize waterborne diseases in developing countries, for example, the United Nations supports the International Decade for Action (2005-2015) to design and implement rainwater harvesting systems worldwide. Moreover, water conservation in the United States has resulted in the construction of 100,000 residential rainwater harvesting systems, with 400 full-scale rainwater harvesting systems built in Central Texas and 6,000 rain barrels installed in the City of Austin (Texas Water Development Board, 2005).

Since water demand is expected to increase with population growth, the need for alternate water sources, like rainwater harvesting systems, will become more important. For example, it was reported that the population of Texas will double between 2000 and 2050 (Texas Water Development Board, 2002). As a result, to meet the increase in water demand, the potability of harvested rainwater needs to be assessed. Since there are no current treatment requirements for potable rainwater harvesting systems (Texas Commission on Environmental Quality, 2007), it is essential to examine best practices to minimize human exposure to chemical or microbial contaminants from harvested rainwater. In the proposed research, we will look for the production of harmful THMs in harvested rainwater disinfected with chlorine; if excessive THMs are formed, alternate disinfection strategies (i.e., ultraviolet light) or DOC removal might be warranted.

Nature, Scope, and Objectives of the Research: Total coliform, fecal coliform, *Salmonella* spp., *Campylobacter, Escherichia coli, Cryptosporidium*, and *Giardia* have been detected in harvested rainwater storage tanks (Ahmed et al., 2008; Texas Commission on Environmental Quality, 2007; Lye, 2002; Simmons et al., 2001; Gould, 1999; Crabtree et al., 1996; Lye, 1987). Thus, it is recommended to disinfect harvested rainwater prior to indoor use. **To our knowledge, no one has examined the formation of harmful disinfection by-products such as trihalomethanes (THMs) in harvested rainwater that has been disinfected with chlorine, and that is the goal of the proposed work.** THMs include chloroform ($CHCl_3$), bromodichloromethane ($CHBrCl_2$), dibromochloromethane ($CHBr_2Cl$), and bromoform ($CHBr_3$), and all four THMs have been classified by the United States Environmental Protection Agency (EPA) as possible or probable human carcinogens.

We have constructed three pilot-scale roofs (asphalt fiberglass shingle, Galvalume® metal, and concrete tile) and have access to two additional pilot-scale roofs (cool and green[1]); all are located at the Lady Bird Johnson Wildflower Center, which is 15 miles from the University of Texas at Austin campus. Figure 1a shows the pilot-scale roofs. Figure 1b shows the sampling device, which collects three sequential samples ("first flush", first tank, and second tank). Once the capacity of the tanks is met during a rain event, any additional rain exits the system through an overflow spout. An ambient rain sampler (18-inch-diameter polyethylene funnel attached to a 10-L polypropylene tank) is in place to capture ambient rain without roof exposure.

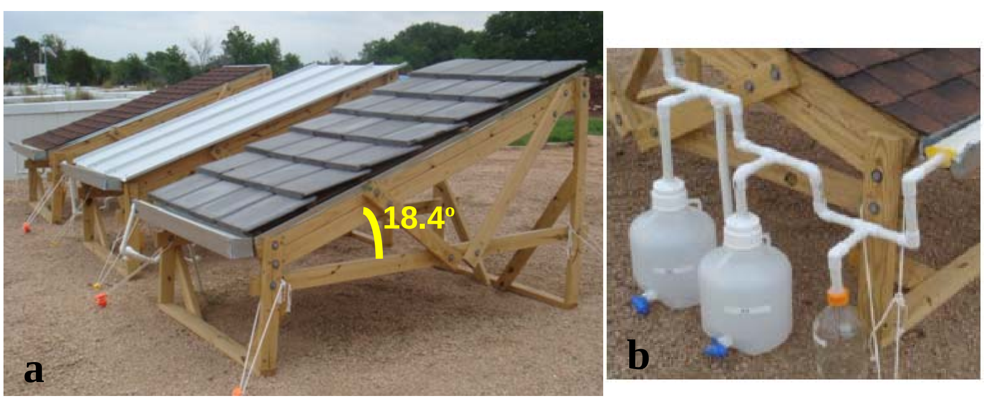

Figure 1. (a) The pilot-scale roofs. From right to left: concrete tile, Galvalume® metal, and asphalt fiberglass shingle. Green and cool roofs are in the background. (b) Harvested rainwater sampler.

With a small budget from the Texas Water Development Board, we have harvested rainwater from the five roofs for three rain events and have evaluated a number of water quality parameters including pH, conductivity, turbidity, total suspended solids, fecal and total coliform, nitrate,

[1] The green roof contains a substrate, drainage layer, and membrane root barrier as described previously by Simmons et al. (2008) for a Type E green roof. The cool roof consists of a white, acrylic-surfaced, 2-ply atactic polypropylene (APP) modified bituminous membrane (Simmons et al., 2008).

nitrite, DOC, selected synthetic organic compounds, and metals. We do not have funding to look at disinfection by-product formation in that project; thus, the funds requested from TWRI would allow us to complement our current data set.

THMs and other disinfection by-products are formed by reactions between the disinfectant and organic carbon in the water. Our current data show that DOC concentrations in harvested rainwater vary by roofing material. Figure 2 shows DOC data from one rain event. The green roof consistently yielded the highest DOC concentrations in the second tank, while the metal and cool roofs consistently yielded the lowest DOC concentrations in the second tank. Our complete data set shows that DOC concentrations in the rainwater harvested after the first flush ranged from 2 to 37 mg/L. Given the DOC concentrations in the harvested rainwater, it is possible that total THMs will exceed EPA drinking water guidelines (80 μg/L); although these regulations do not apply to residential rainwater harvesting systems, exceeding these regulations is a risk to human health.

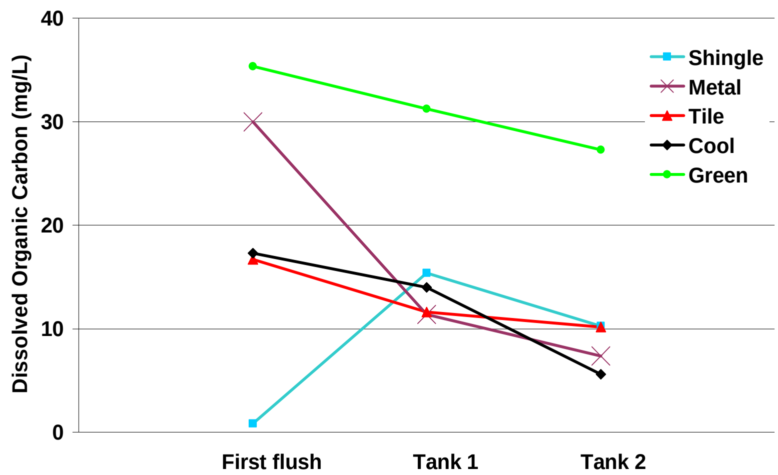

Figure 2. DOC concentrations in rainwater harvested from the pilot-scale roofs.

The main objective of the proposed research is to examine the THMFP of rainwater harvested from the five pilot-scale roofs. Rainwater will be harvested from the pilot-scale roofs in three rain events, and THMFP will be conducted according to *Standard Methods for the Examination of Water and and Wastewater* (Method 5710). The concentrations of chloroform, bromodichloromethane, dibromochloromethane, and bromoform will be measured according to USEPA Method 551.1 with a Hewlett Packard 5890A gas chromatograph, liquid autosampler, and J&W DB-5 column; we have the equipment and expertise for these analyses in our Environmental and Water Resources Engineering Program at the University of Texas at Austin.

Results Expected from this Project: With an increase in water demand, rainwater harvesting systems represent an important alternative source for drinking water. The results of this project will allow us to improve our understanding of post-disinfection harvested rainwater quality from five different roofing materials; the results will demonstrate if some roofing materials are superior to others in terms of minimizing THMFP. The results will show if alternate disinfection strategies (i.e., ultraviolet light) or DOC removal might be warranted if the harvested rainwater is to be used for potable purposes.

References

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