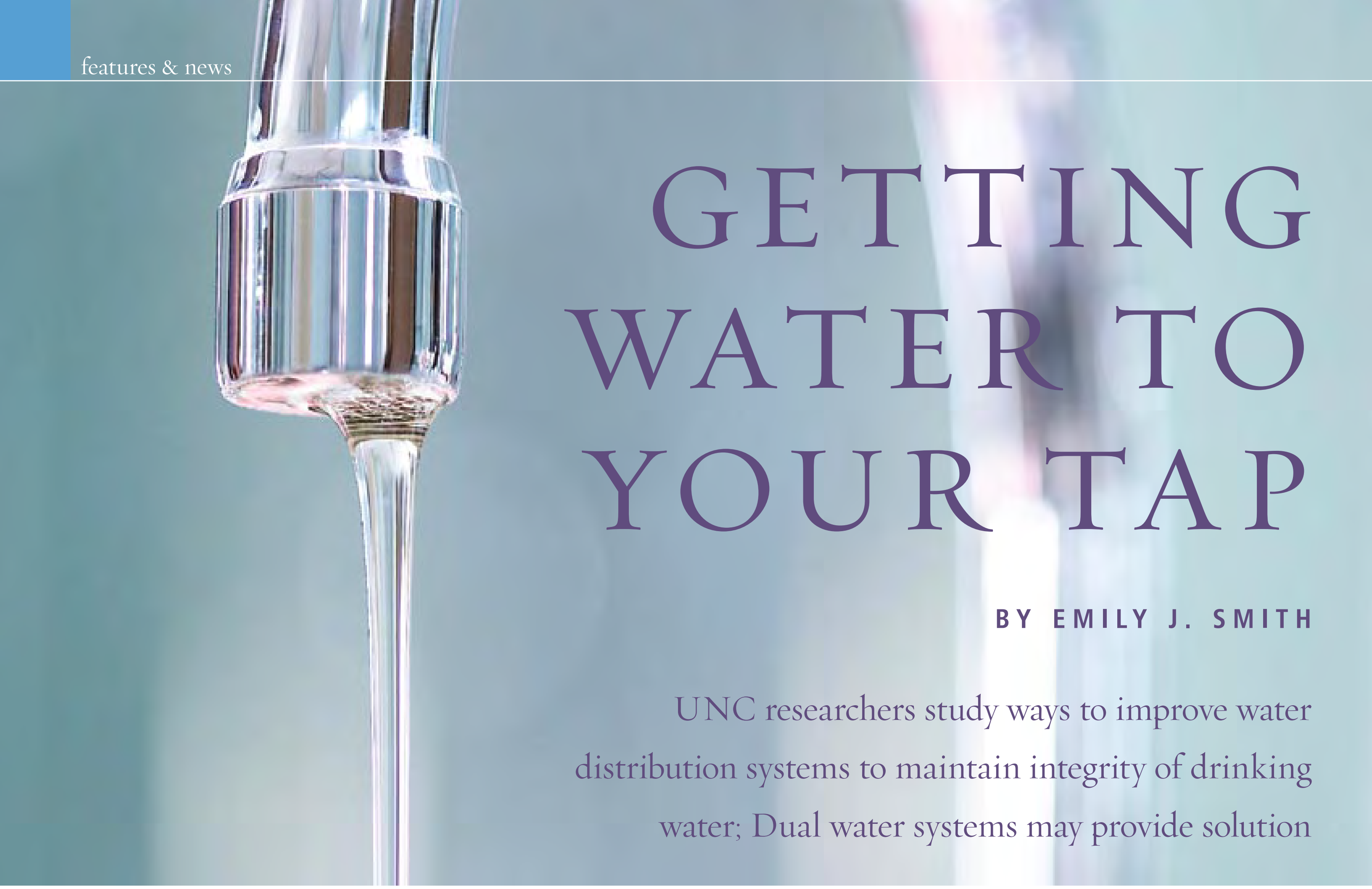

GETTING WATER TO YOUR TAP

BY EMILY J. SMITH

UNC researchers study ways to improve water distribution systems to maintain integrity of drinking water; Dual water systems may provide solution

Many efforts are made by water treatment facilities across the United States to purify water meant for drinking. But when water leaves treatment plants, do the pipes that carry it maintain its integrity? How long does it take for water to travel from the treatment plant to homes and businesses, and how pure is the H_2O that comes out of the tap? These are questions that Dr. Francis DiGiano, professor of environmental sciences and engineering at Carolina's School of Public Health, has spent his career answering.

"Our research has shown that water quality can deteriorate within drinking water distribution systems. Although epidemiological evidence is still scant, poor quality water can expose water customers unnecessarily to health risks such as bacterial infection," says DiGiano.

The most well-documented water quality problems in distribution systems are loss of disinfecting power and subsequent re-growth of bacteria, notes DiGiano, who has worked with North Carolina water municipalities in Raleigh, Durham, Cary, Greenville and Carthage, among others, to study the issue. His research involves determining the "residence time" of water in a distribution system (the length of time it takes water to travel through the distribution system) and also measuring chlorine levels in the water. Chlorine has been used by water municipalities to disinfect drinking water since the early 1900s. Its introduction dramatically reduced the incidence of waterborne disease in this country and is considered one of the great public health successes of this century. Research has shown, however, that when chlorine levels in the water distribution system decline, bacteria can grow.

Many utilities, including some in North Carolina, have switched from "free chlorine" to "combined chlorine" for water disinfection to prevent formation of disinfection byproducts (see p. 34). While combined chlorine is supposed to last longer in the distribution system than free chlorine, DiGiano has measured considerable loss in some parts of distribution systems he has investigated. This means that we may be exposed to bacteria in the water we drink.

"The cause-and-effect relationship between bacterial re-growth and specific

TIP: Hot water pipes are likely to have more corrosion. To avoid contaminants that may be in drinking water, let the water run for several minutes on the first draw in the morning. Never drink from the hot water faucet or use this water for cooking.

water quality parameters has not been well established because many interdependent variables are involved. Clearly, the loss of disinfectant, which is closely linked with long residence time, is a very important factor," DiGiano says "Additionally, pipe materials, temperature, length of time the water stays in the distribution system, use of storage tanks, presence of biodegradable organic matter in the water, type of disinfectant used, and the inactivation rate of disinfectant all are important."

The aging water distribution infrastructure in the United States also plays a role in the re-growth of bacteria in pipes. More than 20 percent of pipes in the United States are over 40 years old. It's much higher in cities with populations of 100,000 or more, where more than 40 percent of pipes are older than 40 years. In fact, 6 to 10 percent of the pipes in cities are more than 80 years old, DiGiano says.

Made of cast iron, older pipes are prone to corrosion. Over time, these older pipes can develop layers of encrusted corrosion inside them that slow or block water flow and provide crevices where bacteria can hide. Equally important, corrosion-induced reactions cause both free chlorine and combined chlorine to disappear, a finding that DiGiano observed both in the laboratory and in several North Carolina distribution systems he has studied. This was the subject of a paper he published with the American Water Works Association in 2005 along with graduate student, Weidong Zhang, that won the association's annual best paper award. The paper is available online at *www.awwa.org*.

In the United States, pipes installed today are made either of cement-lined ductile iron or polyvinyl chloride (PVC). Corrosion is less likely with cement linings and completely eliminated with PVC. However, PVC pipes are not used in the large diameters needed by many cities. They are also subject to chemical intrusion and may be more apt to break, increasing the chances for bacterial contamination to the system, DiGiano says.

UNC School of Public Health research has shown that water quality can deteriorate within drinking water distribution systems. Poor quality water has the potential to expose water customers unnecessarily to health risks such as bacterial infection.

Regardless of pipe material, prolonged time in the pipes causes water quality deterioration. Long water pipelines, caused by suburban sprawl, increases the time water is in the pipes, decreases chlorine residuals in water distribution systems and increases the likelihood of bacterial growth.

"In Greenville, South Carolina, for example, water has to travel 40 miles to get to homes across the city from where it's treated," DiGiano says.

One solution to this problem might be to build "booster" treatment plants in U.S. cities where water has to travel long distances, he says.

Dual water systems

Since cast iron pipe replacement programs are underway in many U.S. cities, another option is to replace corroded pipes with "dual water systems." One set of pipes carries reclaimed wastewater treated for non-potable (non-drinking) uses, like toilet-flushing, irrigation and fighting fires; another smaller set of pipes carries drinking water. Even more feasible is use of dual water systems in new communities.

Dual water systems could result in higher-quality drinking water, notes Dr. Daniel Okun, Kenan Distinguished University Professor Emeritus of environmental engineering at UNC, who developed the distribution design.

The key idea in reducing pipe diameters in drinking water systems is to shift the fire protection function from potable water to the reclaimed water supply. "Water distribution systems in U.S. cities have been designed to meet fire code, so the diameter of pipes is much greater than it has to be to provide homes and businesses with what they need for daily use," Okun says. "Since fires don't happen all the time, water spends a long time getting from where it's treated to where it's consumed, and the longer it spends in the pipe, the more time it has for reactions to occur that degrade the quality." ■

PHOTO BY RAMONA DUBOSE

Elliott DuBose, age 6 (above), takes a slurp from a drinking fountain after a football game.

Cast-iron pipes (like the one to the left) are prone to corrosion over time. Layers of encrusted corrosion inside pipes can slow or block water flow and provide crevices where bacteria can hide. UNC researchers are working with North Carolina water municipalities to study this issue.