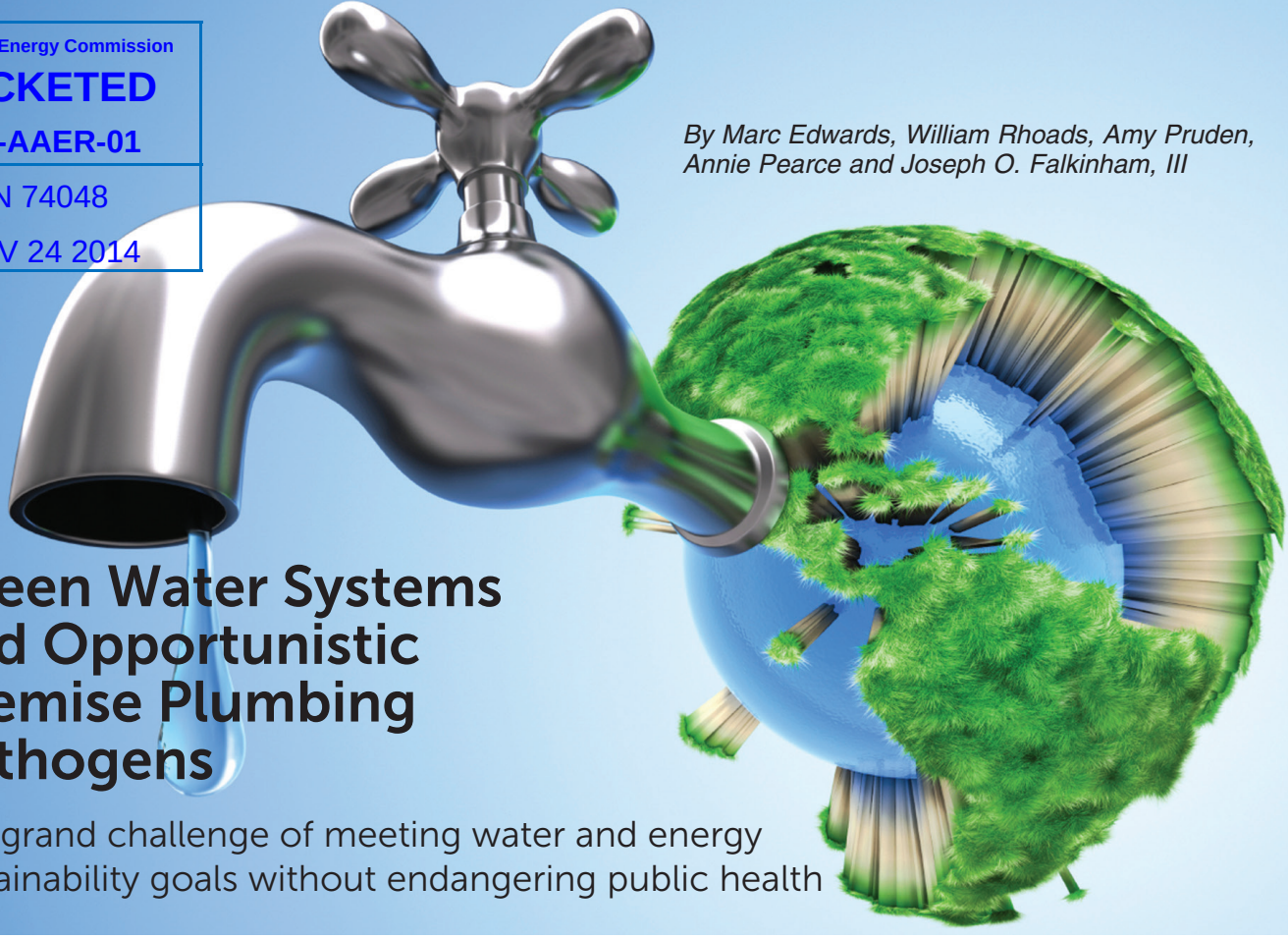
By Marc Edwards, William Rhoads, Amy Pruden, Annie Pearce and Joseph O. Falkinham, III



Green Water Systems and Opportunistic Premise Plumbing Pathogens

The grand challenge of meeting water and energy sustainability goals without endangering public health

The goal of creating building water systems that are more sustainable has been embraced by green building and Leadership in Energy and Environmental Design (LEED) advocates, as well as consumers. Current versions of LEED require water conservation measures in all certified buildings, and the number of projects pursuing LEED certification continues to grow both in the U.S. and worldwide.[1]

By 2015, McGraw Hill Construction estimates that approximately 40 to 48 percent of all new non-residential construction projects (by value) in the U.S. will be green.[2] Green water systems generally incorporate water conserving low flow fixtures, but now also often include innovations such as on-site water collection and treatment, rainwater cisterns, and water reuse. Building water systems are also at the heart of the energy-water sustainability nexus, as they consume about 3.3 to 5.5 percent of total U.S. energy demand, and account for 14 to 20 percent of total residential energy consumption.[3] Recent federal and state tax credits for efficient or green hot water systems have encouraged consumers to install water heat recovery systems, and/or solar, heat pump, or tankless gas heaters in millions of U.S. homes.

These changes are likely to have significant impact on the trajectory of waterborne disease in the U.S., which is now primarily attributable to Opportunistic Premise Plumbing Pathogens (OPPPs).[4] OPPPs are "bad bugs" that grow in the unique water environment that is created by materials, design and operation of a typical building plumbing system. OPPPs do not cause sickness in consumers when drinking or cooking with water. Instead, consumers become ill from breathing tiny airborne water droplets containing these microbes when showering, washing hands, or engaging in other water use activities. Other OPPPs can cause infections through water contact with open wounds or from unusual exposures, such as rinsing contact lenses or using household water to rinse sinuses.[4]

There are many OPPPs of concern, and new ones are likely to be discovered in the years ahead. The most infamous is Legionella, which was discovered in the 1970s and causes Legionnaires' Disease (a severe and deadly pneumonia) or Pontiac fever (a less dangerous flu-like illness) in its victims. Legionella is now the primary source of potable waterborne disease outbreaks and deaths in the U.S., according to tracking by the U.S. Centers for Disease Control. Other high profile OPPPs associated with plumbing systems include Mycobacteria, which causes severe lung disease; P. Aeruginosa, which causes skin infections that can sometimes be fatal; and Naegleria fowleri, which is a brain-eating amoeba recently tied to a few deaths via tap water exposures.

Illnesses associated with OPPPs affect tens of thousands of Americans each year and cause thousands of deaths. As detection and forensics have improved in recent years, it has become apparent that at least some of these potentially harmful microbes are present at some level in almost every home plumbing system. For example, a 2014 survey by the U.S. Environmental Protection Agency (EPA) found genetic evidence of Legionella in nearly half of the cold tap waters sampled.[5] Because of improved ability to detect OPPPs, as well as increased numbers of elderly and other groups at risk for OPPPs disease in the U.S. (it is estimated that 25 percent of citizens in the U.S. will be over 60 years by 2025), incidence of OPPP disease appears to be growing rapidly in certain regions. The annual cost of hospitalization for Medicare patients due to Legionnaires' disease and pulmonary NTM infection is estimated at over $250 million.[6]

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It is anticipated that water and energy conserving plumbing systems will impact the types and numbers of OPPPs microbes present in building plumbing systems, and the resulting likelihood of consumer exposure and disease.[7] For example, numerous research studies conducted during the past 10 years have found that metered hands-free hot water faucets dispense much higher levels of P. Aeruginosa or Legionella than do conventional faucets.[8-12] Thus, despite efforts to reduce water waste and improve hygiene by automating water faucet operation, we may be creating even larger problems for reasons that are as yet unidentified.

Our first-of-its-kind effort focused on sampling cutting-edge green, net zero water, and net zero energy buildings, has revealed disconcertingly high levels of microbes (and OPPPs) in potable water systems.[13-15] We hypothesize that this is partly because water is held in pipes longer in green buildings due to low water use, giving microbes more time to grow.

Some innovations, such as solar water heaters and rain-water cisterns, also often require large volumes of stored water to meet sustainability goals, thereby increasing water holding time and microbial risk. Attempts to conserve energy through reducing water heater temperatures can also create conditions more amenable to pathogen growth in hot and cold water systems. For all of these reasons, a leading practitioner noted at an ACEEE Hot Water Forum that LEED potable water systems might also stand for "Legionella Enabled Engineering Design."[16]

The present situation with green building plumbing design and pathogen growth is reminiscent of the last century, when laws were first passed to require indoor plumbing, resulting in an era of improved sanitation that ultimately wiped out many traditional waterborne diseases such as cholera and typhoid. However, the disconnect between the expertise of the plumbing industry on the one hand and consumer health on the other, resulted in legal requirements to use lead pipe when making service connections in many cities through as late as 1986. As chronicled by Werner Troesken in "The Great Lead Water Pipe Disaster," the resulting high incidence of lead poisoning and growing fetal and infant death rates, represent one of the greatest environmental disasters in U.S. history.[17] Its legacy extends to the present day with millions of lead pipes still in U.S cities and a modern day lead-in-drinking-water crisis in Washington, D.C. from 2000-2004.[18] Throughout, consumers and their doctors were largely left to fend for themselves, re-discovering lead pipe dangers through personal tragedy, and solutions to the lead pipe problem are very expensive and have not been effectively championed by public health agencies.

The present day disconnect between massive green plumbing investments on one hand, and understanding of OPPPs on the other, is therefore very worrisome. As one simple example, no laboratory research has ever been conducted to verify the previously cited body of field observations made over the last 13 years, indicating that metered hands-free faucets sometimes harbor more opportunistic pathogens than conventional plumbing. Similarly, research determining exactly why such devices are sometimes problematic, which could lead to design strategies to avoid future problems, has also not been conducted. A noble donation was made to start such work, but by the time a laboratory was identified to conduct the research the funding promises could no longer be honored.[19] But the possible health threat remains and may even be growing.

Clearly, a new research funding mechanism is needed to protect the public, commensurate with the large public health threat posed by OPPPs and society's massive strategic investment in green plumbing infrastructure. That effort should take into account the likelihood that it is not possible to control all microbes in building plumbing water systems; rather, probiotic approaches should be considered that examine control of OPPPs through creation of healthy microbial communities.[20] Unless a proactive approach is initiated to identify research priorities at this opportune time, reactive remedies

will be imposed after repeated tragedies, to the detriment of consumers, plumbing industry stakeholders, and the environment. We owe it to future generations to realize the promise of sustainable buildings without endangering public health. ■

Marc Edwards *is the Charles Lunsford Professor of Civil Engineering at Virginia Tech. In 2004, Time Magazine dubbed Edwards "The Plumbing Professor" and listed him amongst the 4 most important "Innovators" in water from around the world. Amy Pruden is a Professor of Civil Engineering and Principle Investigator on several OPPPs research projects, and William Rhoads is researching green plumbing systems as a graduate student co-advised by Edwards/Pruden. Annie Pearce is an Associate Professor specializing in sustainable buildings research at the Myers-Lawson School of Construction, and Professor Joseph Falkinham has decades of experience in OPPPs research in the Department of Biological Sciences. All authors are with Virginia Tech.* *The National Science Foundation (CBET Award #1336650) and the Alfred P. Sloan Foundation Microbiology of the Built Environment program provided funding for this work.*

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