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Editorial

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Recognizing Drinking Water Pipes as Community Health Hazards

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ABSTRACT: On this Earth Day, let us begin to recognize that aging water infrastructure, particularly lead pipes, solder, and faucets, represents a community health hazard of enduring significance. Causes of the crisis in Flint, Michigan, are discussed, but such scenarios could take place in thousands of similar communities. Recommendations are offered to the public as taxpayers, the U.S. Environmental Protection Agency, and to chemical educators and water engineers. Old water infrastructure needs maintenance, repair, and replacement, and funds should be established now to accomplish the task.

KEYWORDS: *General Public, Environmental Chemistry, Toxicology, Water/Water Chemistry*

April marks the 46th anniversary of the first Earth Day, celebrated on April 22, 1970. This "environmental movement" was forged from serious events including the Cuyahoga River catching fire (multiple times), chronic choking-smog in Los Angeles, a heavily polluted Lake Erie, and perilous pesticide exposures documented by Rachel Carson's seminal book, *Silent Spring*. We came also to recognize the threat of hazardous chemicals at infamous sites (Love Canal, Times Beach, and the Hudson River PCBs), which triggered major legislation such as the Clean Water Act (1972), the Toxic Substances Control Act (1976), and the Safe Drinking Water Act of 1974. Now we live with a legacy of toxic chemicals known to the public only by initials: PCBs, TCE, and DDT, and many new and emerging ones. These are remnants of a more careless time, when industries did not realize the mess they were making and the long-term clean ups that would be required to remedy the situation. Right? Perhaps, but few people recognize another type of risk that they live with every day—our outmoded distribution systems as a legacy for drinking water contamination.

Recent events in Flint, Michigan, have brought to the forefront the threat of lead contamination from drinking water pipes. A city of 100,000 people has been exposed to lead and other agents in their drinking water supplies, endangering the health of children. Lead is a neuro-behavioral toxin that can seriously affect development in children and the health of adults.

But what exactly caused the problem in Flint? In one respect, a poor economy in a rust-belt region started the crisis. Flint faced a financial emergency and became governed with tight fiscal management controls from the state. To save money, decision-makers switched from the relatively expensive Detroit water supply, emanating from the pristine outflow of Lake Huron and the Detroit River, to the higher chloride content of the Flint River. This more corrosive source-water could have been chemically stabilized at the Flint drinking water treatment plant, but the problem was not recognized.

From that point, the aging water infrastructure of Flint, Michigan, becomes the focus of the story. Flint is little different from thousands of urban communities. Most of the eastern half of the United States has water distribution systems with an average pipe age of more than 50 years.[1] In fact, some networks have subsystems more than 100 years old. Fifty years ago, the threat of lead contamination was not fully appreciated and the materials of choice for service lines (small pipes that run from the water main to the home) were often lead pipes. In addition, the "premise plumbing" inside old houses often contains lead pipes, pipe joints with lead solder, and brass faucet fixtures containing lead. From all these sources, it is possible to generate soluble lead in drinking water, particularly when the water flowing through lead pipes becomes corrosive. Furthermore, pipe deposits can break free, allowing small particles of lead to make their way into drinking water.

Many mistakes were made in Flint. Soon after the source water was switched to the Flint River, complaints arose as to red, yellow, or brown smelly water coming from taps (iron rust deposits from pipes). That should have been a clue that treated Flint River water was chemically destabilizing the pipe deposits formed over decades (Figure 1). Tubercles build up in aging pipes over time as a result of chemical precipitation of calcium carbonate and other scale minerals or corrosion products from

Figure 1. Pipe scale from a ductile iron water main in Iowa. Note the iron-containing nodules that have formed on the inside of the pipe, which could dissolve or break away in the presence of corrosive water. Photo credit: Richard L. Valentine; used with permission.

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iron pipes. When these pipe deposits are chemically destabilized, they can break loose and contaminate drinking water with particles that also effectively scavenge lead from lead pipes. Thus, it is likely that the lead found in the blood of Flint residents[2] came partly from small particles containing lead that were solubilized under low-pH conditions of the human gut.

What have we learned from the crisis as chemical educators and water engineers? First, we must take very seriously our business of providing safe drinking water to the public. It's a huge responsibility. We don't teach the human dimensions enough! We don't teach that water managers must be continuously cognizant of—not only the quality of water leaving the water treatment plant—but also the legacy of old pipe networks that can become disturbed by any changes we make in the chemistry of the water. In Washington, DC, it was changing the residual disinfectant from chlorine to chloramine.[3] In Flint, Michigan, it was changing to corrosive source water. We must consider how any change to the water chemistry (the stability or redox state) affects an aging pipe infrastructure.[1] Lead pipes are a hazardous legacy, much like the waste sites of old.

For the U.S. Environmental Protection Agency, the lesson to be learned is that the Safe Drinking Water Act and the rules for compliance sampling need tweaking. Primary responsibility is to produce high-quality drinking water not only at the exit from the water treatment plant, but also at the customers' taps. More frequent sampling at the tap for filtered and unfiltered samples, at "dead-ends" in the system, and at longer residence times, will tell a more comprehensive story. A national fund to replace aging water infrastructure is sorely needed—this includes the service lines to the house and the premise plumbing that is owned by the homeowner. Special funds will be needed for economically disadvantaged people to address the problems of old housing stock.

For the public as taxpayers, we must realize that the lack of infrastructure maintenance, repair, and replacement has its consequences. We have been warned by the American Society of Civil Engineers[4] and the American Water Works Association[5] that our infrastructure is crumbling and needs replacement soon. Perhaps this Earth Day is an opportunity for action.

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Notes

Views expressed in this editorial are those of the author and not necessarily the views of the ACS.

Dr. Jerald L. Schnoor, Ph.D., P.E., holds the Allen S. Henry Chair in Engineering and serves as a Professor of both Civil and Environmental Engineering and Occupational and Environmental Health, while also serving as Co-Director, Center for Global and Regional Environmental Research, all at The University of Iowa, Iowa City, Iowa, USA. Schnoor is a registered professional engineer and a member of the National Academy of Engineering (elected in 1999) for his pioneering work using mathematical models in science policy decisions for environmental protection. In addition, Schnoor serves as a Core Director of the Iowa Superfund Research Program and leads the W. M. Keck Phytotechnology Laboratory, which specializes in using plants to help clean and protect the environment, while reducing chemical exposures to humans.

Serving as Editor-in-Chief of *Environmental Science and Technology* 2002−2014, Schnoor guided the leading journal in both environmental science and environmental engineering. His editorial writings on environmental protection have been widely accessed by the international community. Dr. Schnoor has published (as author, coauthor, or editor) seven books and 200 research articles in archival journals. He chaired the Board of Scientific Counselors for the U.S. Environmental Protection Agency, Office of Research and Development 2000−2004 and was a councilor on the National Advisory Environmental Health Sciences Council to the National Institute of Environmental Health Science. Recently, he served as Chair of the National Research Council Committee on Science for Environmental Protection in the 21st Century.

Schnoor's publications cover a wide range of topics, including water sustainability, water quality modeling, phytoremediation, and climate change. Schnoor won the 2010 Clarke Prize from the National Water Research Institute for his work on water sustainability. In 2013, he was honored as an Einstein Professor by the Chinese Academy of Sciences and has lectured widely on water and climate change. A major honor from his peers came in 2015 when Jerry received the Perry L. McCarty AEESP Founders Award for excellence in environmental engineering education, research, and practice from the Association of Environmental Engineering and Science Professors. Together with several colleagues, Jerry published a recent Perspective in *Science* on water infrastructure and safe drinking water, "How do you like your tap water?"

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