

# Real-World STEM: Global Access to Clean Water

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#### **Great Engineering Achievements**



#### Air Conditioning and Refrigeration

Beyond providing convenience, these innovations extend the shelf life of food and medicines, protect electronics, and play an important role in health care delivery.

# CHAPTER 2

### **PROBLEMS:** Pollution, Waste, and Drought

"Numerous [water] systems across the country have tested with high lead levels over and over again, which raises concerns about what may be going on [with people's health] in those communities."

—Alison Young, investigative journalist

Quoted in Adam Wernick, "An Investigation Has Found Lead in 2,000 Water Systems," PRI, April 9, 2016. www.pri.org.

**C** lean water is one of the most precious resources on Earth. But this precious resource is under constant attack. On a single day in October 2016, news stories described Iowa drinking water contaminated by agricultural chemicals, Wisconsin drinking water containing toxic industrial chemicals, and Missouri drinking water fouled with dangerous levels of bacteria from sewage. And problems exist in nearly every city and state. According to a 2016 study by the advocacy organization Environmental Working Group, the cancer-causing chemical chromium-6 is present in municipal water systems across America. Chromium-6, which is used in a variety of industrial processes, can be found in dangerous levels in drinking water consumed by 218 million Americans—two-thirds of the population.

#### Pollution from Many Sources

Chromium-6 is released into the environment through leaky storage tanks, poor handling procedures, and inadequate waste disposal practices. It is among hundreds of toxic chemicals found in water supplies. Like chromium-6, many of these toxins are known as nonpoint source pollution—they enter the environment from numerous sources rather than a single source like a factory. Nonpoint source pollution includes motor oil, gasoline, antifreeze, and other automotive chemicals. Other sources of nonpoint source pollution include fertilizers, herbicides, and pesticides from farms and chemicals that leak from mining and oil-drilling operations. All of these pollutants seep into aquifers and wash into rivers, lakes, and streams when it rains or snows. Since nonpoint source pollution comes from such a broad range of sources, control measures to keep the toxins out of drinking water are extremely difficult and expensive to implement.

The problem of toxic chemicals in the water supply is not confined to any one nation. In China many freshwater sources are heavily polluted with agricultural and industrial chemicals. China's Environmental Ministry reported in 2015 that 60 percent of the country's aquifers—and one-third of its surface waters—are unfit for drinking or bathing.

Millions of people who live in rural areas without access to bottled water have little choice but to use the tainted water to drink, cook, clean, and water crops. And this is cause for concern. According to a Chinese environmental scientist known only as Qiu J, 190 million people in China become ill and 60,000 die from diseases caused by water pollution every year. Many victims of Chinese water pollution live in places known as cancer villages, where people suffer unnaturally high rates of cancer due to factory waste that is dumped into local water supplies.

#### Leaching Lead in Flint

Chromium-6 is a heavy metal, a substance with an atomic weight five times that of water. Other heavy metals include gold, arsenic, mercury, and silver. These substances occur naturally in the environment, and small amounts of some heavy metals, such as chromium, copper, selenium, and zinc, are essential to the metabolism of the human body. However, at high concentrations heavy metals are poisonous; exposure to heavy metals can damage the nerves, lungs, kidneys, liver, bones, and glands.

Lead is a heavy metal that is particularly harmful to the developing brains of young children. According to the World Health Organization, lead toxicity can cause irreversible learning disabilities, behavioral problems, and loss of intellectual abilities as measured by intelligence quotient, or IQ, tests. Lead exposure can also re-



sult in high blood pressure, heart and kidney disease, and reproductive problems in women. Perhaps the most troublesome aspect of lead exposure is that the metal is delivered to water taps through tainted pipes throughout the country. This issue made headlines in 2015 when people in Flint, Michigan, began showing signs of lead poisoning.

As in many Midwestern cities, most of Flint's water pipes were laid in the early 1900s and had not been upgraded since that time. It was common during that era for most water pipes to be made from two types of material: lead and cast iron. Lead is a relatively soft material that made the pipes easy to cut and shape when they were installed in individual homes. Flint's lead and cast iron water pipes worked well for decades. This is because the Detroit Water and Sewage Department (DWSD), which supplied the city's water from Lake Huron and the Detroit River, added a chemical called orthophosphate to the water. Orthophosphate prevents corrosion in pipes by forming a protective film that stops lead and rust from leaching into the water.

#### WORDS IN CONTEXT

#### orthophosphate

a chemical that prevents corrosion in pipes so that lead and rust do not leach into drinking water Flint is a majority black city where 40 percent of the residents live in poverty and government administrators often struggle with budget shortfalls. In 2014 Flint officials decided to switch to a new water source after the DWSD increased its rates. City officials started up the local water treatment plant, which had been idle for decades, and began drawing water from the Flint River on April 25, 2014. That day Flint's

mayor, Dayne Walling, issued a press release: "It's regular, good, pure drinking water, and it's right in our backyard."<sup>10</sup>

#### Losing IQ Points

Despite Walling's assurance, many of Flint's one hundred thousand residents immediately noticed the new water was bad. As Flint resident Melissa Mays stated, "After the water switch, I ran the kitchen tap and it came out just yellow, just disgusting yellow."<sup>11</sup> Mays and her neighbors could see there was a problem, but few of them knew the reason. It was later discovered that the Flint water department did not add orthophosphate. This made Flint tap water much more acidic and caused the protective coating that had been forming in the pipes for decades to dissolve. As investigative reporter Alison Young explains, the Flint water "basically stripped the insides of pipes and sent torrents of particles and lead into people's homes."<sup>12</sup> These particles colored the water a murky yellowish brown while newly released bacteria made it foamy and gave it a rotten-egg smell.

Flint residents complained for months, but city and state environmental officials denied there was any problem. Even when tests revealed high lead levels in the drinking water, officials downplayed the hazards. As a nurse employed by the state told a young mother who was worried about the high levels of lead in her child's blood, "[He'll only lose] a few IQ points. . . . It is not the end of the world."<sup>13</sup>

The seriousness of the problem was highlighted in early 2015 when a research team from Virginia Tech traveled to Flint to thoroughly test the tap water. Lead is measured in parts per billion (ppb), and EPA regulations state that water with more than 15 ppb of lead is unsafe. The Virginia Tech researchers were startled by what they found at the home of LeeAnne Walters: her tap water contained 397 ppb of lead. Walters was the mother of four, and her children suffered from numerous maladies caused by the contaminated water flowing from her taps. Her three-year-old twins suffered from painful burning rashes, and one of the twins had stopped growing. Her fourteen-year-old was stricken with abdominal cramps so severe that she required several trips to the emergency room. Walters also had problems; at one point her

#### **Chromium-6: An Unregulated Chemical**

The EPA has known about the health hazards of chromium-6 for decades. The chemical made headlines in the late 1990s when environmental activist Erin Brockovich revealed that the utility company Pacific Gas & Electric (PG&E) had been leaking the chemical into the groundwater supply of Hinkley, California, for thirty years. Many of the town's six hundred residents were afflicted by stomach cancer, liver damage, and reproductive problems.

Brockovich's battle with PG&E was brought to the public's attention in the 2000 movie *Erin Brockovich* starring Julia Roberts. However, the EPA never set regulations to prevent chromium-6 from leaching into drinking water supplies. In 2016 Brockovich made note of this problem:

More than 20 years ago, we learned that this dangerous chemical poisoned the tap water of California communities. . . . But in that time the EPA hasn't set drinking water standards for . . . chromium-6. This is an abject failure by the EPA, including members of Congress charged with overseeing the agency, and every American should be outraged by this inaction.

Quoted in Pam Wright, "'Erin Brockovich' Chemical Taints Tap Water of 218 Million Americans, Study Finds," Weather Channel, September 22, 2016. https://weather.com.

eyelashes fell out. All of these problems were later blamed on the long-term effects of lead poisoning.

In October 2015 Flint switched back to the Detroit water supply, but it was too late. Corrosion in the pipes continued to taint the water supply. In January 2016 President Barack Obama declared a state of emergency in Flint. This allowed the Federal Emergency Management Agency to provide Flint residents with bottled water, water filters for their homes, test kits, and other equipment. Five Michigan government officials resigned or were fired over the mishandling of the crisis; three faced criminal charges for covering up the problem. Studies conducted in late 2016 showed that around twelve thousand Flint children were exposed to high levels of lead and would face serious health problems. Several lawsuits were filed against the state and city, and Michigan is now spending more than \$165 million to replace the city's water pipes. Ironically, the switch to Flint River water was done to save the city \$5 million a year.

#### The Challenge of Water Inequality

The issue of lead in water pipes extends far beyond the problems in Flint. Thousands of cities installed lead water pipes until the substance was banned from water systems in 1986. As a result, forty-one states have unsafe levels of lead in their water supply, according to a 2016 EPA report. Elevated levels of lead were also found in numerous city water supplies, including those in San Francisco, Philadelphia, Seattle, and Washington, DC. The EPA said that water being supplied to at least seven thousand schools has more than 15 ppb of lead.

On March 22, 2016, Obama pledged to improve drinking water quality in the United States. March 22 is acknowledged by the UN as World Water Day, when people can show they care about water quality and supply. According to a White House press release on World Water Day,

Water challenges are facing communities and regions across the United States, impacting millions of lives and costing billions of dollars in damages. These challenges are particularly problematic in predominantly poor, minority, or rural communities, where water inequality can go

# SOURCE NOTES

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#### **CHAPTER 2**

#### **PROBLEMS: Pollution, Waste, and Drought**

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## FIND OUT MORE

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Bill Nye, *Unstoppable: Harnessing Science to Change the World*. New York: St. Martin's Griffin, 2016.

David Sedlak, *Water 4.0.* New Haven, CT: Yale University Press, 2014.

#### Websites

**Circle of Blue** (www.circleofblue.org). In 2000, journalists and scientists founded this website to provide information about the world water crisis and its relationship to food, energy, and health.

**Environmental Working Group** (www.ewg.org). This organization focuses on environmental research concerning toxic chemicals and human health, farming practices and agricultural chemicals, and the sustainable use of water and other natural resources. Its website encourages student and consumer participation in environmental actions.

**Natural Resources Defense Council** (www.nrdc.org). Hosted by one of the world's leading environmental organizations, this site provides science-based information about threats to the air, freshwater, and oceans, along with details concerning global warming, factory farming, fracking, and other ecological issues.

**Trans Africa Pipeline** (http://transafricapipeline.org). Hosted by a Canadian nonprofit organization working to build a massive



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