IS IT SAFE TO DRINK THE WATER?

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If you board a ferry in bustling Hong Kong, cross to Lantau Island, and get on a local bus, the forests of cranes atop new buildings soon give way to forested hills, too steep for the construction boom to reach. An hour's ride up the spines of the mountain range brings you to Po Lin Monastery. Towering above the temple buildings sits Tian Tan Buddha, a bronze statue of Buddha sitting cross legged. The statue is massive; in fact, it is the largest seated bronze statue of Buddha in the world.[1] Lantau Island is hot and humid, even in the hills, and you get thirsty climbing the many ceremonial steps up to the statue. At the bottom of the steps, amidst the monastery buildings, sits a public fountain. Chained to the fountain is a bamboo ladle, thoughtfully provided for the thirsty visitor. And there is a small line of tourists waiting to drink from it.

Such communal drinking cups are common in many parts of Asia today. They used to be widespread in the United States, as well. A century ago, though, this practice started to change due to safety concerns. In 1908, for example, *Technical World Magazine* featured an article by a Lafayette College biology professor with the ominous title, "Death in School Drinking Cups." Newspapers and public health boards took up the cause as well, with dire warnings and grim illustrations of this dangerous practice. The Minnesota State Board of Health made its view clear in its gruesome public education sheet reproduced below. In 1909, Kansas became the first state to ban communal cups in public places and others soon followed. Indeed, the success of the paper "Dixie Cup" was largely due to the new

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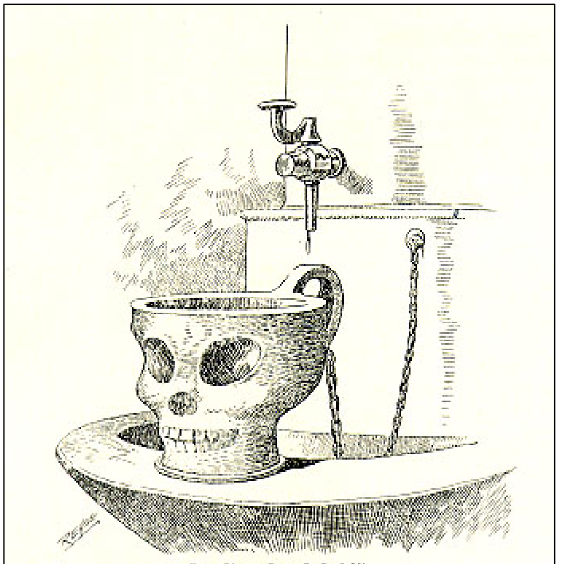
1. Hong Kong Atlas, Tian Tan Buddha, http://www.hkatlas.com/hk/sightseeing/new-territories/tian-tan-buddha (last visited Dec. 15, 2008).

demand for cheap, disposable drinking cups for use at public fountains.[2]



From *Pioneer Press*, St. Paul, Minn.
Educational Sheet distributed by Minnesota State Board of Health.

At the turn of the twentieth century, shared water cups in American public places came to be regarded not only as unsafe, but illegal. Yet shared cups remain commonplace in many parts of the world today. There were no Western tourists waiting in line at the Tian Tan Buddha fountain that day. But there was surely a line. For most of the visitors, it obviously seemed safe to drink the water. From the perspective of this American visitor, though, one could not help ask, "Why are they drinking water from a cup that has been used by others? Don't they know that's unsafe?"

Travel books to distant places have long held warnings not to drink the water. Martin Lister warned seventeenth century visitors to Paris to avoid drinking the water because it caused "looseness, and sometimes dysenteries."[3] Euphemistic phrases for travelers' upset stomachs today range from "Montezuma's Revenge" to "Delhi Belly," but the problem is very real. The Centers for Disease Control estimate that up to fifty percent of international travelers suffer from

2. Dixie Cup Company History, http://ww2.lafayette.edu/~library/special/dixie/company.html (last visited Dec. 15, 2008).

3. A. Lynn Martin, *The Baptism of Wine*, 3 GASTRONOMICA—J. FOOD & CULTURE 21, 22 (2003).

diarrhea every year.[4] While locals may have developed immunity to many of the pathogens that afflict visitors,[5] they, too, have legitimate concerns over their drinking water.

Throughout history, societies have been predicated on ready access to sources of drinking water, whether in the cisterns of Masada high above the Dead Sea, the graceful aqueducts carrying water into Rome, or the sacred aboriginal water holes in Australia's outback. But access is not enough. The water has to be safe to drink. And this presupposes a deceptively simple question—*how do we know what "safe" water is?*

In twenty-first century America, the answer seems simple—government experts and scientists tell us. We take for granted that our tap water is subject to exacting chemical and biological analyses. The name of the relevant federal law says it all—The Safe Drinking Water Act. This law requires the Environmental Protection Agency (EPA) to set maximum contaminant levels for copper, lead, and more than eighty other compounds.[6] Our water is regularly tested by local officials and, if the standards are violated, we expect to find out and have something done about it. It is not as if the water we drink from the tap is pure, distilled H_2O, of course. There are plenty of minerals and bacteria in the municipal water we drink, but it is considered safe enough to drink.[7]

This seems a commonsense, perhaps obvious, approach. Yet, in historical terms, the very idea of the need to conduct detailed chemical and biological analyses, much less even caring about drinking water's invisible contents, is still stunningly novel. The germ

4. Ctrs. for Disease Control and Prevention, Travelers' Diarrhea, General Information (Nov. 21, 2006), http://www.cdc.gov/ncidod/dbmd/diseaseinfo/travelersdiarrhea_g.htm.

5. *See, e.g.,* H.L. Dupont et al., *Diarrhea of Travelers to Mexico: Relative Susceptibility of United States and Latin American Students Attending a Mexican University*, 105 AM. J. EPIDEMIOLOGY 37 (1977), *available at* http://www.ncbi.nlm.nih.gov/pubmed/831463 (finding that resistance to agents responsible for diarrhea in Latin America develops among visiting students after prolonged exposure).

6. Safe Drinking Water Act of 1974, 42 U.S.C. § 300g-1 (2000) (requiring the EPA to specify contaminants which, in the judgment of the Administrator, "may have any adverse effect on the health of persons"); ENVTL. PROT. AGENCY, NATIONAL PRIMARY DRINKING WATER STANDARDS (2003), *available at* http://www.epa.gov/safewater/consumer/pdf/mcl.pdf.

7. ELIZABETH ROYTE, BOTTLEMANIA 100–01 (2008). Royte describes a humorous challenge posed by the presence of copepods, microscopic crustaceans, in New York City's drinking water. These are harmless, but they are there. "After excruciating debate, Talmudic scholars decided that observant Jews—forbidden by the Torah to consume creeping creatures without fins or scales—need not filter out copepods. But if they chose to filter anyway, doing so on the Sabbath would not violate the prohibition against work." *Id.*

theory of disease has only existed for about 150 years, a recent development compared to the history of human settlement. And even this approach has shortcomings. Legitimate questions are still being asked about our drinking water. Are the standards stringent enough? Does the infrastructure delivering our water meet these standards? How can we be sure that we are even regulating the right substances?[8]

This article explores how societies throughout history have responded to the timeless challenge—"Is it safe to drink the water?" Our technical understanding of water safety is more sophisticated than ever before, but a society's understanding and regulation of drinking water have never been purely technical matters. While the Safe Drinking Water Act may look dramatically different than the laws and norms relied on by other societies and in other times, they share far more similarities than differences. The fundamental problem, as we shall see, is that no source of water can ever be completely risk free, either today or two hundred years from now.

Given that, how should popular perceptions of safety interact with purely technical considerations in the standard-setting process? The conception of safety evolves over time and across cultures, informed by a society's understanding of disease, its technological capability, aversion to risk, wealth, and other factors. Norms and values shape our management of safe drinking water just as surely as do chemical assays. Because of the universality of this challenge, because safety is an eternally moving target, one can take valuable lessons from the historical record. The following sections will explore *how* societies have changed their conceptions of safe drinking water through time, shifting their behavior, governance, and laws as a result, and what this means for us today.

I. DRINKING WATER SAFETY TODAY

Water is one of the few essential requirements for life. Regardless of the god you worship or the color of your skin, if you go without water for three days in an arid environment, your life is in danger. Without water, plants wilt, shrivel, and die. Even viruses, which may not even be alive, go dormant and "turn off" without

8. A 2005 report by the advocacy organization, the Environmental Working Group, concluded that "tap water in forty-two states was contaminated with 141 chemicals for [which] the government had failed to set safety standards." *Id.* at 125. What the Environmental Working Group fails to address is whether standards actually need to be set for these chemicals, i.e., whether they truly pose a threat to health.

water.[9] Nor is the importance of water limited to our planet. The likely presence of water on Mars has been cited as evidence for life on the Red Planet since the nineteenth century, when excited astronomers drew careful maps of Martian canals.[10]

Drinking water can harm us if we drink too little, drink too much, or drink the wrong water. The danger of drinking too little was made starkly clear in the 1906 account of Pablo Valencia, who wandered for eight days in the Sonoran Desert outside Tucson. When found by the rescue party, he was described by his rescuer in gripping detail.

> Pablo was stark naked; his formerly full-muscled legs and arms were shrunken and scrawny; his ribs ridged out like those of a [starving] horse; his habitually plethoric abdomen was drawn in almost against his vertebral column; his lips had disappeared as if amputated, leaving low edges of blackened tissue; his teeth and gums projected like those of a skinned animal, but the flesh was black and dry as a hank of jerky; his nose was withered and shrunken to half its length, the nostril-lining showing black; his eyes were set in a winkless stare, with surrounding skin so contracted as to expose the conjunctiva, itself black as the gums; . . . his joints and bones stood out like those of a wasted sickling, though the skin clung to them in a way suggesting shrunken rawhide used in repairing a broken wheel.[11]

Ironically, drinking too much water can also be harmful. As Paracelsus famously described, the dose determines the poison.[12] Consider the tragic promotion run by the Sacramento radio station, KDND.[13] As part of its "Morning Rave" program, the disc jockeys

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9. *See generally* Luis P. Villarreal, *Are Viruses Alive?*, 291 SCI. AM. 100 (2004) (noting that viruses can turn off biological activities).

10. *See generally* NASA, *Approaching Mars*, June 18, 2003, http://science.nasa.gov/headlines/y2003/18jun_approachingmars.htm (noting amateur astronomers' excitement at viewing Mars' south polar cap, made of frozen water and carbon dioxide). A NASA publication, NASA, *The Case of the Missing Mars Water*, Jan. 5, 2001, http://science.nasa.gov/headlines/y2001/ast05jan_1.htm, explains:

> The reason for the intense interest in Martian water is simple: Without water, there can be no life as we know it. If it has been 3.5 billion years since liquid water was present on Mars, the chance of finding life there is remote. But if water is present on Mars now, however well hidden, life may be holding on in some protected niche.

11. W. J. McGee, *Desert Thirst as Disease*, 13 INTERSTATE MED. J. 279, 283 (1906) (further noting that Valencia survived his ordeal and went on to seek his fortune in the desert mountains as a miner).

12. W. NORMAN ALDRIDGE, MECHANISMS AND CONCEPTS IN TOXICOLOGY 137 (1996) ("What is it that is not poison? All things are poisons and none that are not. Only the dose decides that a thing is not poisonous.").

13. Cbs5.com, *Radio Station Fires 10 After Deadly Contest*, Jan. 16, 2007, http://cbs5.com/watercooler/water.contest.water.2.278829.html.

were talking up the latest racy on-air contest—"Hold Your Wee for a Wii." The idea was simple enough—the person who drank the most water without urinating would win a Nintendo Wii video game console. Twenty-eight year old Jennifer Lea Strange was ready to go. She told the woman beside her that she really wanted to win the game for her two kids. After the first few rounds of drinking eight-ounce bottles of Crystal Geyser water, Jennifer was going strong, watching as one bloated contestant after another dropped out. After close to two gallons of water, though, Jennifer just could not take another sip. She finished a frustrating second. Once in the car, she felt more than frustration. She called her boss, saying she had a terrible headache and was heading home. She was found there several hours later. The cause of death was determined to be "water intoxication."[14]

Apart from the extremes of drinking too little water or too much, why is drinking water unsafe? The simple answer is that fresh water is just not very clean. Water is a great solvent, but many things in nature that are water soluble are not good for us (arsenic quickly comes to mind). Teeming numbers of microorganisms live in water, as well. In fact, natural selection has ensured that many of these microorganisms can *only* live in water.

> These bacteria, algae, fungi, and viruses—often as many as 100 million *per milliliter*—can live in water that is hot or cold, clear or muddy, rapidly flowing or stagnant. They can live in desert pools where water temperature exceeds 140° F, or on frozen tundras where temperatures dip below -50° F. We like to think that water drawn from unpolluted rivers, streams, and lakes is naturally pure and fit for human consumption. Sometimes it is, but this is not common. Water, by its very nature, is often very dirty.[15]

And this is water from natural surroundings. Once water in wells, rivers, or lakes comes into contact with the garbage, animal, and human waste we inevitably produce in towns and cities, things only get worse.

To appreciate the breadth of the drinking water problem at the global scale, one must consciously step outside our daily experience. In developed countries, with rare exception, we do not even think about drinking water. It is plentiful, safe, and easily available. Nor

14. The technical term is hyponatremia, and marathon runners need to be careful about a similar danger of drinking too much water during a race. *See, e.g.*, TheBostonChannel.com, *Doctors: Marathoner Died from Too Much Water*, Aug. 13, 2002, http://www.thebostonchannel.com/newscenter5/1610699/detail.html.

15. FRANCIS H. CHAPELLE, WELLSPRINGS: A NATURAL HISTORY OF BOTTLED SPRING WATERS 10 (2005).

do we often consider the quality or quantity of drinking water. We simply turn the tap or open a bottle of water. Most of us do not know the source of our water, and do not particularly care to know. Water supply is seen as a government or corporate responsibility.

For most of human history, however, safe drinking water has been the exception, not the norm. Indeed, unsafe drinking water remains the norm in much of the world. Neither water quality nor quantity can be assumed. Over one billion people, almost exclusively in the global South, do not have access to even a basic water supply.[16] Well over two billion people lack adequate sanitation.[17] As a result, approximately half of the developing world's inhabitants suffer from illnesses caused by contaminated water supplies.[18] Though an inexact figure, researchers estimate that diarrheal diseases are responsible for the death of one child every eighteen seconds.[19]

Because water supply infrastructure is not provided in the poorest urban areas, or in many rural areas, obtaining water is regarded as an individual or domestic responsibility. In contrast to the ease of turning on a faucet, lack of infrastructure means a high labor input as someone from the household (generally a woman or a girl) must collect each day's water, whether from a communal pond or well, tanker, or kiosk. Less than half of the population in Africa lives within a fifteen-minute walk of a safe drinking water source.[20] The daily average for water gathering in 1997 across East Africa was an hour and a half, triple the time spent three decades earlier.[21]

Where communal or free water sources are too far away or clearly contaminated, the poor purchase their water from street vendors or tanker trucks.[22] These prices are always higher than the

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16. Peter Gleick, *The Millennium Development Goals for Water: Crucial Objectives, Inadequate Commitments*, *in* THE WORLD'S WATER 2004–2005: THE BIENNIAL REPORT ON FRESHWATER RESOURCES 2 (Peter Gleick ed., 2005).

17. *Id.*

18. WATERPARTNERS INT'L, WATER FACTS 1 (n.d.), *available at* http://water.org/FileUploads/H2OCrisisFactSheet08.pdf.

19. *See* ROBERT D. MORRIS, THE BLUE DEATH: DISEASE, DISASTER, AND THE WATER WE DRINK 264 (2007).

20. *See* John Thompson et al., *Waiting at the Tap: Changes in Urban Water Use in East Africa Over Three Decades*, 12 ENV'T & URBANIZATION 37, 48 (2000) (examining the largest study of water gathering in East Africa, which found that women spent on average 17.5 hours per week gathering water in Senegal and 15.3 hours weekly in Mozambique).

21. *Id.*

22. *Id.* at 46 (noting that forty percent of those surveyed in the East African study used water vendors); s*ee also* Karen Bakker, *Archipelagos and Networks: Urbanization and Water Privatization in the South*, 169 GEOGRAPHICAL J. 328, 333 (2003) (noting the differences in

price of water from municipal supply systems, often twelve to twenty times as much, with the tragic irony of the poorest in society paying the most for their water.[23] The resulting social and economic impacts are immense. While climate change has taken hold of the media as the greatest threat facing humanity, many environment ministers would disagree. To them, unsafe drinking water is clearly the single greatest threat facing their citizens, particularly children.[24]

With a significant proportion of women's time and family income dedicated to gathering safe domestic water, opportunities for economically productive activities such as education or other employment are squeezed out. It is no exaggeration to say that introduction of piped water can transform the social and economic fabric of a community. Yet the trend is worsening. From 1950–1985, the percentage of the world's urban population doubled.[25] The United Nations (UN) estimates that over half of all people on earth now live in urban, rather than rural, settings.[26] As a result of growing urbanization, the number of clean communal water sources is decreasing as water and sanitation provision come under increasing pressure.[27] Indeed, social scientists have introduced the term *water deprivation*—"the inability reliably to obtain water of adequate quantity and quality to sustain health and livelihood"—as a basic index of poverty.[28]

In recognition of these pressing issues, the governments of the world committed one of the eight Millennium Development Goals to drinking water. By 2015, the UN has pledged to "reduce by half the proportion of people without sustainable access to safe drinking

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water access between the elite and the poor in the developing world).

23. *See* Fiona Harvey, *A Costly Thirst*, FIN. TIMES (London), Apr. 3, 2008, at 9, *available at* http://www.ft.com/cms/s/0/3c12a800-0197-11dd-a323-000077b07658.html?nclick_check=1.

24. Personal Communication with William Reilly, former EPA Administrator (Sept. 21, 2005).

25. Bakker, *supra* note 22, at 334.

26. Org. for Econ. Co-operation & Dev. [OECD], *Global Trends in Urban Water Supply and Waste Water Financing and Management: Changing Roles for the Public and Private Sectors*, at 7, OECD Doc. CCNM/ENV(2000)36/FINAL (Nov. 17, 2000), *available at* http://www.olis.oecd.org/olis/2000doc.nsf/LinkTo/NT00002C72/$FILE/00086209.PDF.

27. Even those with access to piped water cannot count on adequate service. *E.g.*, *Private Passions*, ECONOMIST, July 19, 2003, at 8. Consider, for example, the state of water supply in Delhi, India: "There are few water meters, and those that are installed soon break down . . . . Large parts of the city, especially the slums, get water for only a few minutes a day. Illegal tapping into groundwater is widespread, so the water table is falling fast." *Id.*

28. Ben Crow, *Water: Gender and Material Inequalities in the Global South* 3 (Ctr. for Global, Int'l, & Reg'l Studies, Univ. of Cal., Santa Cruz, Working Paper No. 2001-5, 2001), *available at* http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1000&context=cgirs.

water."[29] Given the poor state of water provision in much of the world and the limits on debt-burdened governments to fund significant infrastructure, this remains a daunting goal.

By contrast, drinking water in the United States is much safer. There are roughly 170,000 public drinking water systems regulated by the EPA and local authorities.[30] Given the size of the system, outbreaks of waterborne diseases are relatively infrequent. Even here, though, safe water is not guaranteed.[31] The single greatest outbreak of waterborne illness in U.S. history occurred just fifteen years ago, in 1993, when the city of Milwaukee was terrorized by a little-known parasite in the drinking water, *Cryptospiridium parvum*. For two weeks, the city's Howard Avenue treatment plant provided contaminated water. Over 400,000 people, roughly one-quarter of the city's population, became ill and sixty-nine people died.[32] While Milwaukee was a large, single incident, over 400,000 illnesses and seventy-three deaths from drinking water were reported from 1991–2002.[33]

Asking whether it is safe to drink the water remains an important question, both in the United States and abroad.

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29. U.N. DEP'T OF ECON. & SOC. AFFAIRS, THE MILLENNIUM DEVELOPMENT GOALS REPORT at 40, U.N. Sales No. E.08.I.18 (2008), *available at* http://www.un.org/millenniumgoals/pdf/The%20Millennium%20Development%20Goals%20Report%202008.pdf. This is also illustrated by the United Nations' choice of symbolic anniversaries. March 22 every year is dedicated to World Water Day. G.A. Res. 47/193, ¶ 1, U.N. Doc. A/RES/47/193 (Feb. 22, 1993); *see also* World Water Day, http://worldwaterday.org/page/135 (last visited Dec. 15, 2008). The year 2003 was proclaimed the International Year of Freshwater. G.A. Res. 55/196, ¶ 1, U.N. Doc. A/RES/55/196 (Feb. 1, 2001). And the decade from 2005–2015 has been declared the International Decade for Action on Water for Life. As former UN Secretary General Kofi Annan has stated, "[w]e shall not finally defeat AIDS, tuberculosis, malaria, or any of the other infectious diseases that plague the developing world until we have also won the battle for safe drinking water, sanitation and basic health care." MORRIS, *supra* note 19, at 263–64 (quoting Kofi Annan).

30. Envtl. Prot. Agency, Public Drinking Water Systems: Facts and Figures, http://www.epa.gov/OGWDW/pws/factoids.html (last visited Dec. 15, 2008).

31. *See* ROYTE, *supra* note 7, at 221; *see also infra* note 33 and accompanying text.

32. Phaedra S. Corso et al., *Cost of Illness in the 1993 Waterborne* Cryptosporidium *Outbreak, Milwaukee, Wisconsin*, 9 EMERGING INFECTIOUS DISEASES 426, 426, 430 (2003).

33. Michael F. Craun et al., *Waterborne Outbreaks Reported in the United States*, 4 J. WATER & HEALTH 19, 23, 27 (2006) (noting that the most frequent pathogens have been *Giardia* and *Cryptospiridium*, both of which survive in cold water and are resistant to common water treatment practices).

II. THE TIMELESS CHALLENGES OF PROVIDING SAFE WATER

The basic challenge of providing safe water has remained the same for as long as we have had human settlements, and it can be broken into four separate tasks.

- Source identification—how do we find and store safe drinking water?
- Source protection—what do we need to do around the source to keep the water safe?
- Treatment—what can we do to the water to make it safe for drinking?
- Distribution—how do we get water from the source to the point of consumption, and keep it clean during the journey?

While easy to state, each of these tasks presents its own set of technical, policy, and legal challenges.

A. Source Identification

Everyone needs to know how to find a reliable source of drinking water. For some of us, this involves no more than going to the sink or pulling a bottle of water from the refrigerator. For early explorers of unknown lands and mariners in uncharted seas, however, the fate of Pablo Valencia in the Sonoran Desert was a very real threat. They all faced the same terrible fear of running out of water before chancing upon a new source. This is no less true for nomadic peoples in arid lands. The Old Testament is filled with references to springs and wells, their importance clearly evident from the fact that each was given a special name.[34] Indeed, it may be the earliest example of critical intellectual property. Knowledge of water sources has always been vital to a group's survival.

As Elizabeth Royte has described, "From the beginning of human time, access to sufficient clean water was the sine qua non for establishment of a settlement. Lack of good water cramped expansion, and the search for new sources drew civilization's map."[35] Archaeological excavations from the Neolithic time onward have found a striking correspondence between settlements and reliable sources of drinking water nearby, whether wells, springs, streams, or lakes.[36] Storage of drinking water was often necessary to urban

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34. C.E.N. Bromehead, *The Early History of Water Supply*, 99 GEOGRAPHICAL J. 142, 142 (1942).

35. ROYTE, *supra* note 7, at 21.

36. *See, e.g.*, Bromhead, *supra* note 34; *see also* Andrew Sherratt, *Water, Soil and*

planning, as well. Thus, one can find examples of sophisticated water management in virtually every archaeological excavation of ancient civilizations—from Mesa Verde in the American Southwest and the Maya Lowlands; to an excavation at Jawa, in northeastern Jordan, dating from the fourth millennium B.C.; to the Romans' towering aqueducts that remain standing today.[37]

The need to identify safe sources of water is as crucial for mobile settlements as permanent ones, and nowhere has this been more true than during times of war. As the Roman general, Vegetius, observed, "[A]n army must not use bad or marshy water: for the drinking of bad water is like poison and causes plagues among those who drink it."[38] Napoleon was only half right when he said that an army marches on its stomach.[39] It also needs to slake its thirst. Consider that in the Napoleonic wars, disease killed eight times more soldiers than battle injuries.[40] In the American Civil War, diarrhea and dysentery claimed more lives than the battlefield.[41] And during the pivotal battle of El Alamein during World War II, as many as fifty percent of the German and Italian troops suffered from water-borne diseases. The German general commanding the North African theater, Erwin Rommel, is said to have claimed that his defeat was due to dysentery, not Field Marshall Montgomery's Eighth Army.[42]

Nor was water dangerous solely in army camps. In many cultures, the most effective strategy to avoid unsafe drinking water has been to avoid water altogether. In the fifteenth century, for example, Sir John Fortescue observed that the English "drink no

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Seasonality in Early Cereal Cultivation, 11 WORLD ARCHAEOLOGY 313, 314 (1980); Robert Miller, *Water Use in Syria and Palestine from the Neolithic to the Bronze Age*, 11 WORLD ARCHAEOLOGY 331, 333 (1980).

37. *See generally* David Kennedy, *Water Supply and Use in the Southern Hauran, Jordan*, 22 J. FIELD ARCHAEOLOGY 275 (1995); Vernon L. Scarborough & Gary G. Gallopin, *A Water Storage Adaptation in the Maya Lowlands*, 251 SCIENCE 658 (1991); Richard Wilshusen et al., *Prehistoric Reservoirs and Water Basins in the Mesa Verde Region: Intensification of Water Collection Strategies During the Great Pueblo Period*, 62 AM. ANTIQUITY 664 (1997).

38. JOSHUA I. BARZILAY ET AL., THE WATER WE DRINK: WATER QUALITY AND ITS EFFECTS ON HEALTH 10 (1999) (quoting Vegetius).

39. JOHN BARTLETT, BARTLETT'S FAMILIAR QUOTATIONS 505 (Emily Morison Beck ed., 14th ed., Little, Brown & Co. 1968) (1855).

40. G. C. Cook, *Influence of Diarrhoeal Disease on Military and Naval Campaigns*, 94 J. ROYAL SOC'Y MED. 95, 95 (2001).

41. eHistory.com, Civil War Medicine: An Overview of Medicine, http://ehistory.osu.edu/uscw/features/medicine/cwsurgeon/introduction.cfm (last visited Dec. 15, 2008).

42. Cook, *supra* note 40, at 97.

water unless it be . . . for devotion."[43] As Andrea Cast explains, in the Middle Ages, "[p]hysicians warned people who were weak, old, phlegmatic, or melancholic to avoid drinking water . . . . Water was the medical antithesis of wine. What wine cured, water caused to decay."[44] The sixteenth century English doctor, William Bullein, warned, "to drinke colde water is euyll" and causes melancholy.[45] His contemporary, Andrew Boorde, claimed that "water is not holsome soole by it self; for an Englysshe man . . . [because] water is colde, slowe, and slack of dygestyon."[46] Presumably, water interfered with digestion by cooling the stomach and its furnace-like operation.

Historian Francis Chappelle describes this well in explaining the Pilgrims' aversion to drinking the readily available water in New England. To the Pilgrims, he explained,

> [D]rinking water—any water—was a sign of desperation, an admission of abject poverty, a last resort. Like all Europeans of the seventeenth century, the Pilgrims disliked, distrusted, and despised drinking water. Only truly poor people, who had absolutely no choice, drank water . . . . [T]here is one thing all Europeans agreed on: drinking water was bad—very bad—for your health.[47]

If not water, then what did people drink? The answer in ancient times was alcohol. The drink of choice in Egypt was beer, and in ancient Greece was wine.[48] Water was routinely added to beer (called "small beer") and wine in the Middle Ages.[49] This lowered the alcohol content but would have purified the water, as well.[50] The alcohol in these drinks retarded and even killed microbes. While India Pale Ale may now be all the rage in microbreweries, the addition of hops was originally intended to preserve ale through slowing bacterial growth.[51] It may not be surprising, then, that one of the very first buildings constructed in Plimoth Plantation was a brewhouse.[52]

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43. CHAPELLE, *supra* note 15, at 102.

44. Andrea Cast, Women Drinking in Early Modern England 2 (2001) (unpublished Ph.D. dissertation, University of Adelaide) (on file with author) (quoting BULLEIN, THE GOUERNEMENT OF HEALTHE f. Ciii (1558)).

45. *Id.* at 1.

46. *Id.* at 1–2 (quoting BOORDE, DYETARY OF HELTH (1542)).

47. CHAPELLE, *supra* note 15, at 102.

48. *See generally* TOM STANDAGE, A HISTORY OF THE WORLD IN SIX GLASSES 104 (2005) (discussing the evolution of alcoholic beverages in relation to the slave trade).

49. *See* CHAPELLE, *supra* note 15, at 103.

50. *Id.*

51. *Id.*

52. *Id.* at 105.

i. Rules and Norms

When alcohol was not available or affordable, how did those searching for drinking water know the source was safe? Long before recognizing the role, or even the existence, of microorganisms, people have understood that they need to be careful about what they drink. Over time, different groups' collective experience of identifying safe water developed into norms, ancient versions of a safe drinking water act, for identifying safe water. Importantly, however, these norms focused primarily on the *source* of the water because that is what they could observe. Hippocrates, for example, wrote that water from rock springs was "bad since it is hard, heating in its effect, difficult to pass, and causes constipation. The best water comes from high ground and hills covered with earth."[53] Perhaps the greatest water engineers of all, the Romans, designed their aqueducts to segregate drinking water from other uses.[54] Europeans recognized, as well, that certain water sources should be avoided. Thomas Bullein warned, for example, that "standing waters and water running neare unto cities and townes, or marish ground, wodes, & fennes be euer ful of corruption, because there is so much filthe in them of carions & rotten dunge, &*c*."[55]

Nor are such norms purely historical. A recent study of villages in Yorubaland, a region in southwestern Nigeria, examined norms to determine safe water in traditional African communities today. Just as the Romans and Europeans developed rules to identify safe water,

> [the Yoruba] believe that when water comes from the mountains it has a sacred origin and, therefore, it has many qualities that other streams lack. . . . Because a rock represents a mountain, also any water springing under a rock of these streams is believed to be safe. Similarly, rainwater is always regarded as safe because it comes directly from heaven. . . . The local people give movements of flowing water a strong emphasis. They say that it is easy to *see* if the water is clean and good for human consumption. Flowing water is regarded safe, as the movements will take dirt away. . . . Therefore, stagnant water is not considered as safe as flowing water. . . . People emphasize visual evidence, especially the movement of water, in perceiving safe water. "Seeing is believing," and what you can see, that is, if water seems clean, proves its safety.[56]

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53. *Airs, Waters, Places*, *in* HIPPOCRATIC WRITINGS 148, 153 (Geoffrey Ernest Richard Lloyd ed., J. Chadwick & W. N. Mann trans., Penguin Classics 1983) (1952).

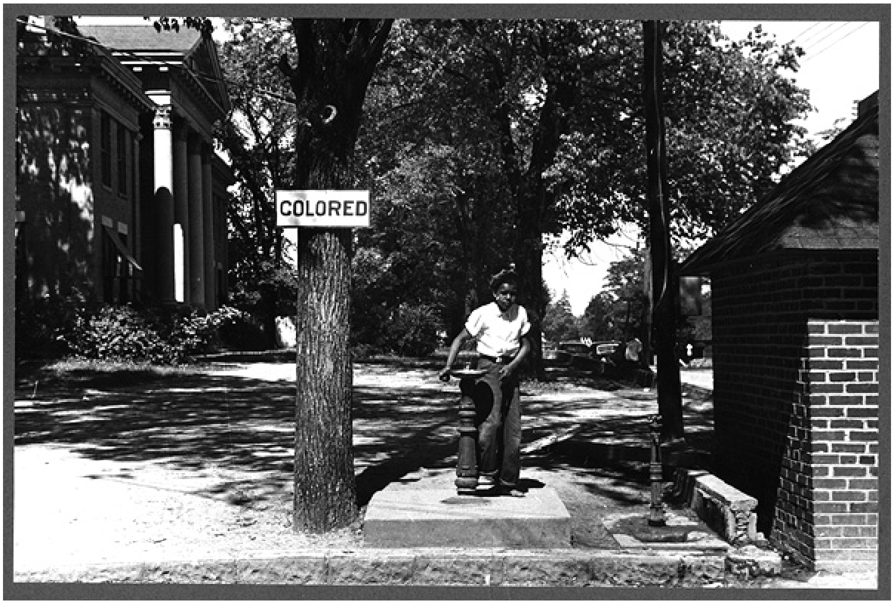
54. *See* HARRY B. EVANS, WATER DISTRIBUTION IN ANCIENT ROME 136–37, 140 (1994).

55. Cast, *supra* note 44, at 2 (quoting BULLEIN, THE GOUERNEMENT OF HEALTHE f. Ciii (1558)).

56. Eva-Marita Rinne, *'Seeing is Believing': Perceptions of Safe Water in Rural Yoruba*, *in*

In fact, all societies have such rules and practices, though they may look very different. In a number of cultures, for example, drinking water is as much a spiritual as a physical resource—water can transmit both physical and metaphysical contaminants. As a result, there are specific rules to prevent spiritual pollution of drinking water. Traditional Hindi in India, for example, maintain a complex social hierarchy.[57] Reinforcing this order, upper and lower castes actually draw their water from distinct sources.[58] If sources were shared, there would be a risk of the lower caste transmitting their social pollution.[59]

While we in the United States may scoff at, or have trouble comprehending, this practice, it should look familiar. Less than fifty years ago, in fact, this was commonplace in many parts of the South. As the photo below illustrates, drinking fountains were segregated by law, with one for "Whites" and one for "Colored."[60] Was the anxiety whites felt over drinking from a fountain that had been used by blacks all that different from the Hindi concern of higher castes drinking from the same sources as lower castes?



A HISTORY OF WATER 269, 277, 281 (2006).

57. *See* NANDITA SINGH, *WATER MANAGEMENT TRADITIONS IN RURAL INDIA: VALUING THE UNVALUED* (2004)*, available at* http://www.sasnet.lu.se/EASASpapers/21NanditaSingh.pdf.

58. *Id.*

59. *Id.*

60. *See* John Vachon, *A Drinking Fountain on the County Courthouse Lawn* (photograph 1938), *available at* http://www.loc.gov/rr/print/list/085_disc.html.

Rules for purifying water are common among religions, as well. Zoroastrianism, for example, regards drinking water, or pouring it away, in the dark as a sin.[61] Ernest Crawley relates that in Islam,

> Muhammad forbade drinking water in a standing posture. Three breaths are to be taken before a draught, for the reason that thus the stomach is cooled, thirst is quenched, and health and vigour imparted. Drinking from the mouth of a leather bag was forbidden. "He who drinks out of a silver cup drinks of hell-fire." The faithful may not drink out of green vessels, large gourds, or vessels covered with pitch, the last being used for wine.[62]

The Safe Drinking Water Act[63] seems light years from these sorts of norms. In simple terms, the law requires the EPA to assess physical, chemical, or biological contaminants in drinking water and their adverse health effects.[64] Based on the risk posed by each contaminant and its likelihood to occur in public drinking water systems, EPA then decides which contaminants to regulate.[65] It sets maximum contaminant level goals (MCLGs) for each of these—the highest concentration of the contaminant in water that is still safe to drink.[66] For many contaminants, such as microbes and carcinogens, this number is zero.[67] It may not be practical to eliminate these contaminants, though, so EPA also sets a maximum contaminant level (MCL).[68] This is the practical standard, and it is as close to the MCLG as possible, given technology and cost limitations.[69]

According to this plan, if the analysis of a drinking water sample's contents does not exceed the MCLs, then drinking water from our tap is safe. EPA is supposed to periodically re-evaluate the

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61. ERNEST CRAWLEY, DRESS, DRINKS AND DRUMS 194 (1931).

62. *Id.* at 199.

63. Safe Drinking Water Act of 1974, 42 U.S.C. §§ 300f to 300j-26 (2000).

64. *See id.* § 300g-1.

65. *Id.*; *see also* Envtl. Prot. Agency, Understanding the Safe Drinking Water Act (June 2004), http://www.epa.gov/OGWDW/sdwa/30th/factsheets/understand.html.

66. *See* 42 U.S.C. § 300g-1(b)(4)(A) ("Each maximum contaminant level goal . . . shall be set at the level at which no known or anticipated adverse effects on the health of persons occur and which allows an adequate margin of safety.").

67. *See* Envtl. Prot. Agency, Drinking Water Contaminants, http://www.epa.gov/safewater/contaminants/index.html (last visited Dec. 15, 2008).

68. *See* 42 U.S.C. § 300g-1(b)(4)(B) (stating that the maximum contaminant level shall be set at a level "which is as close to the maximum contaminant level goal as is feasible").

69. This simple description leaves out the required balancing of an adequate margin of safety with economic and technological feasibility. *See id*. § 300g-1(b)(4)(D) (defining feasible to include technological feasibility); *id.* § 300g-1(b)(6) (allowing the Administrator to utilize cost benefit analysis to set maximum contaminant levels at a level "that maximizes health risk reduction benefits at a cost that is justified by the benefits").

stringency of the standards, revising them in light of new data and considering new contaminant candidates to add.[70] Some of the current candidates, for example, include the microbe *Helicobacter pylori* and the chemical 1,2,4-trimethylbenzene.[71]

This hyper-technical approach could not seem more distant from checking whether water emerges from under a rock or whether the person who used the well before you was an Untouchable. Yet, these sets of rules all seek the very same end—safe drinking water—and they all make sense to their societies. Such norms are essential and they are effective, to a point. Indeed if such rules have endured over long periods of time, almost by definition they have to work; otherwise, the society that followed them would be incapacitated by water-borne diseases. The Yoruba preference for flowing water makes some sense in a modern light. It avoids the higher microbial activity in warmer, stagnant water. A preference for clear water makes sense, too. It should avoid the high numbers of bacteria often found in turbid water. Assessing how *well* such rules work, though, is a complicated matter.

ii. Conceptions of Disease

If water from a particular source is regarded as unsafe, locals have clearly made the connection between drinking the water and some bad result—such as spiritual impurity, blindness, or stomach cramps. But there must also be a causal mechanism lurking beneath this judgment. Today, one might say that "people get typhoid because they drink water with *typhoid bacteria*, of course." But before the microscope revealed an entirely new world beyond our eyes, for most of human history, physicians have grappled with the problem of people getting sick without any physical contact at all with ill people. With our modern understanding of disease, we may look patronizingly on earlier practices of locating latrines next to wells or of blood letting, but before the era of the germ theory these seemed entirely reasonable in their respective societies. In fact, cultural understandings of what causes disease, whether physical or spiritual, underpin the rules for drinking water.

At the time of the Greeks and Romans, for example, physicians believed that the health of the body depended upon the balance of

70. *Id.* § 300g-1(b)(1).

71. Envtl. Prot. Agency, Drinking Water Contaminant Candidate List and Regulatory Determinations, http://www.epa.gov/safewater/ccl/ccl2.html#microbial (last visited Dec. 15, 2008).

four humors—black bile, yellow bile, phlegm, and blood.[72] The task of the physician was to diagnose the illness and deduce the surplus or deficit of each humor causing the ailment. He could then nurse the patient back to proper balance and health. Thus, the common practices of bleeding a person, or emetics, were intended to remove surplus humors. Each humor was linked to specific physical qualities. Blood was warm and moist, while black bile was cold and dry. Hence Bullein's admonition that drinking cold water was "euyll." Its chill risked slowing the flow of humors and could cause melancholy.[73] Indeed the name of the disease, "cholera," comes from the term for yellow bile, "choler."[74]

This conception was eventually supplanted by the miasmatic theory of disease. This theory held that diseases were caused by breathing contaminated air. The general concept was that an airborne mist containing poisonous "miasma" served as the agent of disease and could often be identified by its foul odor.[75] Hence the name for malaria, which means "bad air."[76] This theory explained how people could quickly infect one another without physical contact, as well as the awful stench surrounding diseased flesh. Although an inaccurate explanation, the miasma theory was effective. Its immediate policy implication—improved cleanliness—no doubt reduced the spread of pathogens.

A moment's reflection makes clear the consequences of the miasmatic theory of disease for how people thought about drinking water. If the most threatening diseases—epidemics such as bubonic plague, cholera, or typhoid—were airborne, then drinking water was unlikely to be a serious cause of concern. This is not to say, of course, that people were ignorant of the link between drinking water and disease. People obviously could get sick from drinking certain types of water, but not the most feared epidemics.[77] The drinking water was safe enough, just not risk-free, to use modern parlance.

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72. *See, e.g.*, LOGAN CLENDENING, SOURCE BOOK OF MEDICAL HISTORY 39 (1942).

73. Cast, *supra* note 44, at 1 (quoting BULLEIN, THE GOUERNEMENT OF HEALTHE f. Ciii (1558)).

74. *See* MORRIS, *supra* note 19, at 13. A nineteenth century medical text described cholera as "occasioned by a putrid acrimony of the bile." *Id.*

75. NANCY TOMES, THE GOSPEL OF GERMS: MEN, WOMEN, AND THE MICROBE IN AMERICAN LIFE 3 (1998).

76. MORRIS, *supra* note 19, at 33.

77. *Id.* at 32 (explaining the distinction in medical theory at the time between contagious diseases, which moved slowly, and epidemic diseases, which moved and killed quickly).

iii. Arsenic in Bangladesh

Conceptions of drinking water safety turn not only on assumptions over how diseases are transmitted, but also on evaluations of relative costs and risks. Nowhere is this more clear than the sad crisis playing out in Bangladesh.[78] One of the most densely populated and poorest countries in the world, Bangladesh sits in the delta of the Ganges and Brahmaputra rivers. Access to fresh water is not a problem; indeed, the country often suffers from seasonal flooding. Unfortunately, these rivers are heavily polluted as they move downstream and become unfit for drinking.[79] Traditionally, Bangladeshis have relied on surface waters from ponds and shallow wells for their domestic water use.[80] Pollution from inadequate (often non-existent) sewage systems, however, has made high death rates from cholera and diarrhea commonplace, particularly among the young. Seeking to remedy this public health problem, the World Bank and the United Nations International Children's and Educational Fund (UNICEF) agreed to fund a nationwide program.[81] The ambitious goal was to shift domestic sources from surface water to the country's plentiful and clean groundwater.[82] Literally millions of tubewells—shallow pipes operated by steel hand pumps—were eventually sunk.[83]

This seemed a poster child for what development aid should be all about, providing simple, inexpensive, and effective technology to overcome a terrible public health challenge. Success was quickly and confidently declared.

> A tubewell became a prized possession: it lessened the burden on women, who no longer had to trek long distances with their pots and pails; it reduced the dependence on better-off neighbors; and most important, it provided pathogen-free water to drink. By the early 1990s 95 percent of Bangladesh's population had access to "safe" water, virtually all of it through the country's more than 10

78. *See* Allan H. Smith et al., *Contamination of Drinking-Water by Arsenic in Bangladesh: A Public Health Emergency*, 78 BULLETIN OF THE WORLD HEALTH ORG. 1093, 1093 (2000); A. Mushtaque & R. Chowdhury, *Arsenic Crisis in Bangladesh*, SCI. AM. MAG., Aug. 2004, at 86, 90.

79. *See* Mushtaque & Chowdhury, *supra* note 78, at 89 (noting that arsenic levels are highest where the Ganga and Brahmaputra rivers washed soil down from the Himalayas to the Bay of Bengal).

80. *Id.* at 90.

81. *E.g.*, Smith et al., *supra* note 78, at 1093; Mushtaque & Chowdhury, *supra* note 78, at 87.

82. Mushtaque & Chowdhury, *supra* note 78, at 87.

83. *Id.*

million tubewells—a rare success story in the otherwise impoverished nation.[84]

While the aid groups were congratulating themselves, however, tests of the groundwater revealed a tragedy unfolding. Many of the plentiful freshwater aquifers were located in soils containing arsenic. It had not occurred to any of the engineers to test for arsenic when the wells had been drilled, but it was surely there.[85] Laid down in geologic strata over millions of years, the undetected arsenic dissolved into the groundwater, and was now pumped up for drinking and domestic use. The largest public drinking water initiative in the history of Bangladesh had monstrously transformed. It was now the worst case of mass poisoning in the world. No one knows just how many people are at risk of arsenic poisoning, but the number is clearly in the tens of millions.[86]

Acute arsenic poisoning can kill within a few hours. Much more common, however, and unlike most waterborne diseases, arsenic poisoning can remain in hiding for up to ten years after drinking the water. The initial symptoms include black spots on the upper body, bronchitis, and loss of sensation. In serious cases, this gives way to swollen legs, cracking palms and soles, and renal malfunction. If the victim survives the likely threats of gangrene and kidney failure, cancer follows.[87]

Is the water safe to drink? Bangladeshis cannot answer that question. To them, the more relevant decision is *which* water source is *less unsafe* to drink. As one researcher described, "[I]t took about 20 years to move everyone from surface water to ground water . . . and then in the 90s [we are] suddenly telling people the groundwater can kill you . . . ."[88] A number of field projects have tested wells,

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84. *Id.*

85. *See id.* The British Geological Survey provided engineering services for the project. It was sued in the United Kingdom in 2003 for its failure to test for arsenic prior to the wells' construction. Sutradhar v. Natural Env't Research Council [2003] EWHC 1046 (QB). The case was dismissed by the court of appeals, [2004] EWCA Civ. 175, and affirmed by the House of Lords, [2006] UKHL 33.

86. Mushtaque & Chowdhury, *supra* note 78, at 88 ("Today around 30 percent of Bangladesh's tubewells are known to yield more than 50 micrograms of arsenic per liter of water, with 5 to 10 percent providing more than six times this amount. The Bangladesh government specifies more than 50 micrograms per liter as being dangerous. . . . The World Health Organization's upper limit, which is also the recently revised standard of the U.S. Environmental Protection Agency, is 10 micrograms.").

87. *Id.*

88. Email from Alex Pfaff, Professor, Sanford Institute for Public Policy, Duke University, to author (Sept. 26, 2007, 8:03 PM EST) (on file with author).

painting those with high arsenic levels red and those with low levels green, and this has had some effect.[89] But most wells remain untested and many people continue to draw their water from red wells.[90] While some have suggested that people be encouraged to go back to surface water,[91] this poses real problems as well. After all, the harm from microbial diseases is why they switched to groundwater in the first place.[92]

In deciding which water is safer to drink, villagers are surely undertaking some sort of personal risk assessment. On the one side are the ease and modernity of using tubewell water, which they are now being told may be dangerous to drink. On the other is surface water, which they know can lead to cholera and diarrhea, though perhaps not if certain treatment procedures are used. Waterborne diseases in surface water strike quickly, making the connection between disease and water easy to draw. Arsenic is a slow killer, unseen until it strikes years later.

Balancing the trade-offs in this risk-risk dilemma is complex, and most certainly not a purely technical question. Time spent going to a more distant green tubewell rather than a closer red tubewell can impose its own costs. And which water you drink can also be a status statement. As one field worker has described, "In conversations with villagers, we realized that although they want arsenic-free water, they do not want to feel that they are going back in time to methods they once discarded. Tubewells had fitted nicely with their forward-looking aspirations."[93]

Sometimes the devil you know in surface waters is worse than the one you do not know in groundwater. In areas of the country racked with poverty and a low life expectancy, how should people balance uncertain short and long-term health threats against the convenience, self-worth, and time saved of nearby tubewell water? The situation remains tragic precisely because there are no easy solutions.

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89. Mushtaque & Chowdhury, *supra* note 78, at 90.

90. *See* Smith et al., *supra* note 78, at 1100.

91. *E.g.*, Mushtaque & Chowdhury, *supra* note 78, at 90.

92. Moreover, many of the traditional ponds used as water sources have since been polluted or converted into aquaculture. *See id.*

93. *See id.*

B. Source Protection

Once one has identified a reliable and safe source for drinking water, it is essential to protect the source from harms, both seen and unseen. Most obviously, and particularly in arid regions, one must protect against physical appropriation. Where water is scarce, clear property regimes emerge with effective sanctions.[94] Despite the widespread norm of a right of thirst, outsiders still need to ask permission to drink from a well in southern Zimbabwe or a spring in central Australia.[95]

After the attacks of 9/11, protecting drinking water sources against terrorist threats has taken on a new level of importance.[96] But sometimes a source cannot be meaningfully protected. Groundwater sources, for example, are difficult to protect if the local hydrology is not understood or if the underground aquifer lies under an area too large to control.[97] In other cases, the water consumers may be downstream of pollution sources over which they have no control. In the 1906 Supreme Court case *Missouri v. Illinois*, for example, the city of St. Louis sought to halt Chicago's discharge of sewage into the Illinois River. Chicago's filth, the Court was told, had poisoned St. Louis' drinking water.[98] Despite claims of increased typhoid cases, the Court was not persuaded and refused to enjoin the discharge.[99]

The most common approach for source protection has been through norms restricting activities that may cause pollution. Biblical text from Deuteronomy, for example, required that waste be disposed of well away from areas of human habitation.[100] The Babylonian Talmud similarly forbade throwing waste into wells.[101] Nor could tanneries, slaughterhouses, cemeteries, or furnaces operate within

94. *See generally* James Salzman, *Thirst: A Short History of Drinking Water*, 18 YALE J.L. & HUMAN. 94, 99 (Supp. 2006).

95. *Id.* at 101–03.

96. *See, e.g.*, U.S. GEN. ACCOUNTING OFFICE, GAO-04-29, DRINKING WATER: EXPERTS' VIEWS ON HOW FUTURE FEDERAL FUNDING CAN BEST BE SPENT TO IMPROVE SECURITY 2 (Oct. 2003), *available at* http://www.gao.gov/new.items/d0429.pdf.

97. In the classic movie by Louis Malle, *Manon of the Spring*, for example, the central story involves Manon finding the underground source of the village's water and blocking it. MANON OF THE SPRING (MGM World Films 1987). The villagers panic over the loss of water and blame their complicity in crimes against Manon's father years earlier. *Id.*

98. Missouri v. Illinois, 200 U.S. 496, 517 (1906).

99. *Id.* at 526. It did not help that St. Louis was discharging its sewage into the river, as well. *Id.*

100. *Deuteronomy* 23:12–13.

101. BARZILAY ET AL., *supra* note 38, at 9.

twenty-five meters of a well.[102] Some of the earliest environmental laws and policies in England concerned source protection. Building owners were required to keep their street frontages clean.[103] People were paid to collect "night soil" and other waste from streets and cesspits.[104] Dung was collected, transported in boats to the middle of the Thames, and dumped where the current ran strongest.[105]

Half a world away, Australian aboriginal groups have had clear source protection norms as well. Defecating and starting a fire near a waterhole were vitally serious offenses, giving those responsible for the water the right to punish these transgressions by death.[106] Among the Yoruba in Africa, the head of the community, known as the *baale,* establishes rules for source protection:

> [B]athing, or washing clothes at the place, or even near the place where drinking water is normally fetched [is prohibited]. Also, small children or people with any disease are not allowed to go to the streams, or to walk in the water. People are also asked to remove their shoes before going to fetch water to avoid contamination of water . . . . "If one is caught washing clothes near the drinking water source, he will be reported to the King and given an appropriate punishment."[107]

In addition to regulating behavior, societies have relied on engineering approaches to source protection. One can find examples in the Bible of low-tech approaches. The Book of Genesis describes the shepherdess Rachel, who kept her well covered with a rock to keep the water clean.[108] As with all things hydrological, though, for impressive technology one inevitably looks to Rome. The Romans realized that flushing wastes out of the city was just as important as bringing clean water into the city. While the aqueducts are justly renowned, equally impressive was the Cloaca Maxima, Rome's sewer

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102. *Id.*

103. *See* London: The greatest city, Medieval London, http://www.channel4.com/history/microsites/H/history/i-m/london2.html (last visited Dec. 15, 2008).

104. Museum of London, What Was Life Like in Medieval London?, http://www.museumoflondon.org.uk/English/Learning/Learningonline/features/viking/viking_4.htm (last visited Dec. 15, 2008).

105. London: The greatest city, *supra* note 103.

106. *See* Deborah Rose, *Fresh Water Rights and Biophilia: Indigenous Australian Perspectives*, DIALOGUE, Mar. 2004, at 35, 37.

107. Rinne, *supra* note 56, at 280–81 ("Anyone breaking the common rules of, for example, bad behaviour at the water source is prone to punishment. These punishments are based on traditional leadership systems and customary law of the Yoruba.").

108. BARZILAY ET AL., *supra* note 38, at 8.

system.[109] Constructed in the sixth century, B.C., the connected pipes and ditches drained the filth of the city's public toilets, bath houses, buildings, and streets into the Tiber, which carried it safely away downstream.[110]

With the fall of the Roman Empire, however, the engineering approach to source protection in Europe largely fell away. There were still examples in the Middle Ages of built works to bring in water. Thus, the Great Conduit of London was built in the thirteenth century between London and the springs at Tybourne. Water was transported to cisterns in the city, and the water apparently was sold by leasing official tankards to people for drawing water.[111] One can find impressive technology in some monasteries as well. Indeed, the cities of Southampton and Bristol contracted with their local monasteries to use their water systems.[112] But almost nothing was built to address sanitation, in part perhaps because there was no money to be made, and in part because the connection had not yet been made between sanitation and source protection. For the most part, filth flowed out windows, down the streets, and into the same streams, rivers, and lakes where the city's inhabitants drew their water. As a result, cities quite literally stank to high heaven.

This state of affairs only became worse as cities grew in population through the Middle Ages and well into the nineteenth century. As late as 1854, journalist George Goodwin graphically described London as a "cesspool city . . . . The entire excrementation of the Metropolis . . . shall sooner or later be mingled in the stream of the river, there to be rolled backward and forward around the population."[113] The Thames grew so polluted in the 1850s that "Parliament had to adjourn from time to time because of the overpowering stench."[114] The curtains in the chambers "were soaked

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109. *See* ROBERT S. KANDEL, WATER FROM HEAVEN 199 (2003).

110. While Rome's waterworks receive the greatest attention, it is worth noting that other great civilizations also had impressive public sanitation works. For example, "Mohenjo-Daro, metropolis of the Indus valley civilization that flourished 4,000 years ago, boasted both public and private wells providing clean water, and a system of vaulted culverts for removal of sewage." *Id.*

111. *See* London: The greatest city, *supra* note 103; Florilegium Urbanum, Physical Fabric, The Great Conduit (Aug. 27, 2004), http://www.trytel.com/~tristan/towns/florilegium/community/cmfabr24.html; Roger D. Hanson, *Water-Related Infrastructure in Medieval London*, http://www.waterhistory.org/histories/london/london.pdf (last visited Dec. 15, 2008).

112. Florilegium Urbanum, *supra* note 111.

113. PETER H. GLEICK, THE WORLD'S WATER 2006–2007 at 129 (2006) (quoting George Goodwin).

114. VERONICA STRANG, THE MEANING OF WATER 30 (2004) (citation omitted).

in chloride of lime to suppress the 'noxious stench.'"[115] Indeed, one historian has claimed that "[t]he Dark Ages for water were the nineteenth century, when increasing industrialization, urbanization, inadequate hygiene, and inadequate knowledge made drinking water dangerous."[116]

By the end of the nineteenth century, however, London's drinking water and sanitation had improved dramatically, and this was the case in many other European and North American cities as well. The cause for this sea change was two-fold—the development of the germ theory of disease and "The Great Sanitation Awakening." These came together in the classic story of John Snow and the Broad Street Pump.

Starting on August 30, 1854, an outbreak of cholera in the Soho area of London resulted in over 500 deaths. There was nothing remarkable about this. Cholera and typhoid outbreaks in urban areas were common in the nineteenth century. An outbreak in New York City had killed 3500 people in 1832, and typhoid had killed over 50,000 Britons a year earlier.[117] As described above, common wisdom held that these diseases spread in miasmic air. John Snow, though, suspected otherwise. A self-made man, Snow had become an influential London physician, personally chosen to administer chloroform to Queen Victoria during the birth of her son, Prince Leopold.[118]

Snow had been fascinated by cholera epidemics for much of his career, and the miasmatic explanation struck him as inadequate. If cholera passed through the air, how to explain the fact that some members of a family would become ill while others did not, all living under the same roof and breathing the same air? Snow suspected that cholera "poisons" passed through water, but did not know how to demonstrate this.

The Soho deaths caught his attention and he took advantage of the available data. In 1836, Parliament had passed the Registration

115. *See* U.K. Parliament, Archives, Parliament and the Thames, http://www.parliament.uk/parliamentary_publications_and_archives/parliamentary_archives/archives___parliament_and_the_thames.cfm (last visited Dec. 15, 2008).

116. Martin, *supra* note 3.

117. Michael C. Finnegan, *New York City's Watershed Agreement: A Lesson in Sharing Responsibility*, 14 PACE ENVTL. L. REV. 577, 590 (1997); STRANG, *supra* note 114, at 30.

118. MORRIS, *supra* note 19, at 55. Snow was meticulous in his personal affairs and soon after arriving in London, he built a still for his drinking water. *Id.* at 36. It may well be that purifying his water saved him from more than one cholera epidemic in London. *Id.*

Act, for the first time requiring personal records to be kept of the recently deceased, including the cause of death. Snow grew increasingly encouraged as he checked the records and found that every cholera victim had lived within a quarter-mile of the popular Broad Street Pump, a fifteen-foot deep well known for its clear drinking water. Snow's theory, though, faced a major obstacle. A widow, Susannah Eley, had died of cholera during the outbreak but lived in Hampstead, nowhere near Soho; and another woman had died in Islington, even farther away. If cholera had been transmitted through drinking water at the Broad Street Pump, how had it infected these women so many miles away?

Unwilling to discard his theory, Snow visited the widow's son to see if there might be some unknown connection with the Broad Street Pump. Snow learned that while the widow had not visited Soho prior to her death, she had previously lived in the area. She so enjoyed drinking the water from the Broad Street Pump that she regularly sent her servant to fill water bottles. Indeed, she had done so days before her death. The son of the recently-deceased widow went on to sadly relate that he had also recently lost his cousin. Had the cousin visited his mother?, Snow enquired. Oh yes, the son replied. In fact she had drunk the same Soho bottled water as his mother before returning to her home in Islington and dying the next day.

Armed with this information, Snow persuaded the Soho Parish leaders to remove the pump handle at Broad Street and the outbreak stopped soon after.[119] This marked both the first time a government had sought to stop the outbreak of a waterborne disease and the birth of the modern field of epidemiology, which even today boasts a pump handle as its symbol.[120]

While rightly celebrated as real-life medical sleuthing that puts *CSI* and its innumerable television spin-off shows to shame, Snow's detective work proved particularly persuasive to the Soho Parish leaders because it coincided with scientific and municipal developments playing out at the same time. The hold of the miasmatic theory of disease was slowly loosening its grip through the nineteenth century, thanks to developments in the field of microbiology by Louis Pasteur, Robert Koch, Joseph Lister, and

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119. This story is related in CHAPELLE, *supra* note 15, at 81–82. There is a longstanding debate over whether closing the well ended the outbreak, or whether it would have declined on its own. MORRIS, *supra* note 19, at 86.

120. MORRIS, *supra* note 19, at 86. The symbol of the International Society of Epidemiology is a pump handle. CHAPELLE, *supra* note 15, at 82.

others. While Antony von Leeuwenhoek had seen and described microorganisms to the British Royal Society in the late 1600s, no connection had been made at the time between disease and these newest additions to the living world. Indeed, there was strong opposition to Snow's explanation for the spread of cholera. The London Medical Gazette, a leading journal of the day, dismissed his arguments as "an entire failure of proof that the occurrence of any one case could be clearly and unambiguously assigned to the use of the water . . . . Foul effluvia from the state of the drains [i.e., an airborne miasma from the sewers] afford a more satisfactory explanation of the diffusion of the disease."[121]

The germ theory of disease began to take hold in the 1800s and was premised on two theories. First, specific diseases are caused by specific microorganisms that live in air and water. Microorganisms and other life are not created by spontaneous generation. Second, the same germs reproduce from bearers of the same disease.[122] Snow's findings supported this theory, as did the later finding that the mother of an infant suffering from cholera had disposed of the child's soiled diaper in a cesspit directly adjacent to the Broad Street Pump just days before the cholera outbreak.[123] While the germ theory of disease remained controversial throughout the 1800s, its stature as a legitimate theory was crucial in shifting popular attitudes toward waterborne diseases.

The Soho Parish leaders were also well aware of the raging debate over public sanitation. Championed by Edwin Chadwick, the Victorian crusade for improving the sanitary conditions of the urban poor centered around the idea that disease could be prevented. Trained as a lawyer, Chadwick was relentless, leading John Stuart Mill to recognize him as the most effective politician of his time.[124] Chadwick accepted the miasmatic theory of disease but opposed common wisdom by arguing that greater attention to drainage, clean drinking water, and removal of waste would greatly improve the well-being of the city's poor. Working through the Poor Law Commission, in 1842 he powerfully set out his agenda in the 457-page *Report of the*

121. MORRIS, *supra* note 19, at 41–42. Karl Marx, who lived in the neighborhood, wrote to Friedrich Engels that the likely cause was nearby sewers that had been "driven through the pits where those who died of the plague in 1668 . . . were buried." *Id.* at 89–90.

122. TOMES, *supra* note 75, at 33.

123. CHAPELLE, *supra* note 15, at 83.

124. MORRIS, *supra* note 19, at 44.

Sanitary Condition of the Labouring Population of Great Britain.[125] In denouncing the state of affairs, his prose reads powerfully even today. Indeed, it was so incendiary that his fellow committee members refused to place their names on the report, leaving Chadwick as the sole author.[126] His main conclusion included the following:

- That the various forms of epidemic, endemic, and other disease caused, or aggravated, or propagated chiefly amongst the labouring classes by atmospheric impurities produced by decomposing animal and vegetable substances, by damp and filth, and close and overcrowded dwellings prevail amongst the population in every part of the kingdom, whether dwelling in separate houses, in rural villages, in small towns, in the larger towns—as they have been found to prevail in the lowest districts of the metropolis.
- That such disease, wherever its attacks are frequent, is always found in connexion with the physical circumstances above specified, and that where those circumstances are removed by drainage, proper cleansing, better ventilation, and other means of diminishing atmospheric impurity, the frequency and intensity of such disease is abated; and where the removal of the noxious agencies appears to be complete, such disease almost entirely disappears . . . .
- That the formation of all habits of cleanliness is obstructed by defective supplies of water . . . .
- That the population so exposed is less susceptible of moral influences, and the effects of education are more transient than with a healthy population.
- That these adverse circumstances tend to produce an adult population short-lived, improvident, reckless, and intemperate, and with habitual avidity for sensual gratifications . . . .
- That the existing law for the protection of the public health and the constitutional machinery for reclaiming its execution, such as the Courts Leet, have fallen into desuetude, and are in the state indicated by the prevalence of the evils they were intended to prevent.[127]

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125. EDWIN CHADWICK, REPORT ON THE SANITARY CONDITION OF THE LABOURING POPULATION OF GREAT BRITAIN (M.W. Flinn ed., Edinburgh Univ. Press 1965) (1842).

126. *Id.*; MORRIS, *supra* note 19, at 50.

127. CHADWICK, *supra* note 125.

The report was a sensation, its 10,000 copies far exceeding previous government publications.[128] While seemingly out of place in a report on sanitation, the direct connections Chadwick drew between sanitation and moral health are a significant part of the story. Chadwick's and others' calls for improved sanitation were reinforced by moral crusaders, evangelicals who sought to remedy society's evils by physical as well as spiritual cleansing.[129] The notion that "cleanliness is next to Godliness" took root during this era, and made the religious community a powerful ally for sanitation reform. It is no coincidence that the Quakers founded the Metropolitan Free Drinking Fountain Association—a philanthropic society that built free public fountains and watering troughs throughout the city.[130] Chadwick and Charles Kingsley, another great reformer, often described sanitary reform as the "Will of God."[131]

The ranks of "Sanitarians" swelled with the great and the good, including such luminaries of the age as Charles Dickens, Benjamin Disraeli, and Florence Nightingale.[132] Their efforts, and those of their religious and morality allies, led to pioneering legislation such as the Sanitary Acts, Water Acts, and Public Health Acts, all of which laid the legal foundation for improved source protection. In a matter of decades, centuries-old habits were formally challenged and rejected.[133]

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128. MORRIS, *supra* note 19, at 50.

129. Julia Twigg, The Vegetarian Movement in England, 1847–1981: A Study of the Structure of its Ideology (1981) (unpublished Ph.D. dissertation, London School of Economics, University of London), http://www.ivu.org/history/thesis/medicine.html ("Many of the sanitarians had evangelical religious backgrounds and they attacked the 'atheistical materialism' of the new medicine that undermined personal responsibility and the link between suffering and sin. Simple cleanliness and personal moral purity instead, were seen as the true way. Some of the psychological charge in the Victorian concern with cleanliness and its wider moral meanings is evident in opposition to vaccination, which was regarded as unclean, a form of poisoning that violated the purity of the subject's body." (citation omitted)).

130. Howard Malchow, *Free Water: The Public Drinking Fountain Movement and Victorian London*, 4 LONDON J. 181, 184–88 (1978). The motivation was two-fold, in part a public service for those too poor to purchase drinking water, and in large part a strategy of the temperance movement. *Id.* Many of the fountains were strategically located next to popular pubs, tempting thirsty souls with free, safe, and wholesome water rather than the purchase of sinful beer or spirits. *Id.*

131. STRANG, *supra* note 114.

132. *Id.* at 50.

133. In 1874, for example, the Rivers Pollution Commission Report advised against drinking water from the Thames River. THOMAS J. BELL, HISTORY OF THE WATER SUPPLY OF THE WORLD 21 (1882). The Commission noted the pollution created by "bathing, washing of sheep and cattle, and dirty linen and putrid carcasses of animals float[ing] upon its surface . . . . [T]here is no hope of this disgusting state of the river being so far remedied as to preclude the presence of animal and other offensive matters, even in the filtered Thames water as delivered in the

The great wealth flowing from the four corners of the British Empire provided the means for major infrastructure projects. A firm believer in the miasmatic theory of disease, Chadwick contended that "[a]ll smell is disease."[134] The answer to the wastes creating the poisonous miasmas was, ironically, water flowing through sewers, which would wash away the sewage and, with it, the source of the city's ills. This was a novel idea, long forgotten since Roman times. Prior to Chadwick's time, sewers had been designed to drain rain from the streets; indeed, the term "sewage" did not even exist until 1849.[135]

Both improved sanitation and the provision of readily available safe drinking water gradually became explicit government priorities, and the results proved impressive. In 1852, the average age of death in the English town of Dudley had been a shocking seventeen years old.[136] Twenty years after putting in sewers, life expectancy had almost doubled.[137] Similarly, from 1850–1900, life expectancy in French cities improved from thirty-two to forty-five years old.[138] Medical advances clearly contributed to this increased longevity, but the Great Sanitation Awakening seems an apt title for such striking results.

The examples above have largely focused on London, but one could tell similar stories for Chicago, Philadelphia, or other cities.[139] New York's strategy focused on a massive engineering project to pipe water from the pristine Catskills-Delaware watershed, over 120 miles northwest of the City, to a series of local reservoirs.[140] Chicago's efforts at source protection were even more heroic. In 1860, the city of Chicago hired Ellis Sylvester Chesbrough, who was fresh from

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metropolis." *Id.* (quoting the Rivers Pollution Commission's report).

134. MORRIS, *supra* note 19, at 46.

135. *Id.* at 48–49. John Snow and Edwin Chadwick, who agreed on most issues, strongly differed over the outflow of the sewers, which Chadwick directed into the Thames and, unknowingly, polluted the drinking water for many Londoners. *Id.* at 51–52.

136. This was likely due in no small part to the fact that "human excrement [was] in all back streets, courts and other eligible places." MARQ DE VILLIERS, WATER: THE FATE OF OUR MOST PRECIOUS RESOURCE 104–05 (2000) (citation omitted).

137. *Id.*

138. *Id.*

139. *See, e.g.*, AM. PUB. WORKS ASS'N, HISTORY OF PUBLIC WORKS IN THE UNITED STATES, 1776–1976 399 (Ellis Armstrong ed., 1976).

140. In order to ensure water quality, New York City was even granted zoning authority by the state legislature over towns in the watershed. GRETCHEN C. DAILY & KATHERINE ELLISON, THE NEW ECONOMY OF NATURE: THE QUEST TO MAKE CONSERVATION PROFITABLE 67–69 (2002).

designing the water system for Boston.[141] Chesbrough realized, as had Chadwick, that the key to source protection and clean water was removal of wastes.[142] The problem, though, was that Chicago sat in a low swamp, and building a sewer under the city streets would not provide enough elevation for the waste to flow out of town. His solution was as novel as it was ambitious. Needing higher elevation for the waste to flow through the sewers, he laid the sewers on *top* of the streets, covered them, and then built new streets *above* the sewers, raising the buildings in the process, or turning their second stories into ground floors.[143] The source for Chicago's water supply was extended six hundred feet into Lake Michigan and then piped into the city.[144]

Impressive as these engineering feats were, it is important to ask why the same Awakening did not occur in other parts of the world at the same time, particularly in colonial cities. This may seem an odd question. After all, the stringent water pollution laws and massive infrastructure in the developed world today stands in glaring contrast to the primitive source protection in much of the developing world. While it has become politically incorrect to use the adjectives "First World" and "Third World," they have real meaning when discussing drinking water and source protection today.

What is odd, though, is that this sanitary divide is a recent distinction. When George Goodwin decried London as a "cesspool city" in the 1850s, he could very well have been saying the same thing for one of the jewels in England's colonial crown, Madras in India.[145] The stark contrast between London and Madras today, where less than a third of the Indian city's population has adequate sanitation, is deceptive. If you had visited both cities 150 years ago, the similarities would have been more striking than the differences. "[M]ost urban citizens—rich and poor—lived amidst excrement and sewage."[146]

In retrospect, there was a significant fork in the road roughly 150 years ago, with cities in the global North rapidly improving sanitation

141. This story is recounted in MORRIS, *supra* note 19, at 137–38.

142. *See id.* (discussing Chesbrough's plan, as in the spirit of Chadwick and the sanitarians, to design a sewer).

143. *Id.*

144. *Id.*

145. There, a British soldier described at the time "[t]he large mass of people, living under the most primitive and unsanitary surroundings afforded an almost unbounded field for the spread of every kind of epidemic disease." GLEICK, *supra* note 113, at 129.

146. *Id.*

and drinking water quality, while those in the global South lagged behind. Indeed, the French term, *cordon sanitaire*, is used today to describe a barrier that prevents a disease or other unwanted conditions from spreading. Its original meaning, however, referred to the "quarantine line" in colonial cities that quite literally demarcated separate sanitation systems—one for the Europeans and one for the natives.[147] Marshalling public and private investment for sanitation is a massive undertaking, so daunting that no city was able to create a comparable sewer system to Rome's for almost two millennia. The decision not to invest in sophisticated sanitation infrastructure in their colonies at the same time as the Awakening back in the imperial home countries was partly a result of fiscal priorities, partly a result of discrimination. Looking back, though, one thing is clear. Applying separate sanitation standards to the governing and the governed in the Age of Empire had far-reaching consequences for the human miseries from waterborne diseases that continue today.

With the emergence of the germ theory, understanding of the importance of improved sanitation, and acceptance that sanitation infrastructure was first and foremost a government responsibility, by the turn of the twentieth century, source protection had improved dramatically in Europe and North America. This is not to say, however, that drinking water diseases were a thing of the past. Far from it. Typhoid fever still claimed thousands of victims every year, including the famed aviation brother, Wilbur Wright, who died in 1912.[148] Indeed, it was just such concerns over drinking water that spurred the trips of wealthy Europeans to spas and the first boom in bottled water sales.[149] Ensuring source protection was a limited solution, however. To take the next big step in ensuring the safety of drinking water, municipalities turned to an approach that had always been part of the drinking water story—treatment.

C. Water Treatment

The Old Testament's Book of Kings recounts the story of the Prophet Elisha, the son of Elijah. Soon after the death of his father, Elisha traveled to Jericho. There, he was met by the men of the city, who sought his aid.

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147. *Id.* at 129–30.

148. CHAPELLE, *supra* note 15, at 181.

149. *Id.* at 105.

> The men of the city said to Elisha, "Look, our lord, this town is well situated, as you can see, but the water is bad and the land is unproductive."
>
> "Bring me a new bowl," he said, "and put salt in it." So they brought it to him.
>
> Then he went out to the spring and threw the salt into it, saying, "This is what the Lord says: 'I have healed this water. Never again will it cause death or make the land unproductive.'" And the water has remained wholesome to this day, according to the word Elisha had spoken.[150]

While the methods surely varied, treatment of water was commonplace in the ancient world. Sanskrit writings from approximately 2000 B.C. recommend water purification methods.[151] Pictures of water treatment devices have even been found in the tombs of the Egyptian pharaohs Amenophis II and Rameses II.[152]

In his classic tome written sixty years ago, *The Quest for Pure Water*, M.N. Baker exhaustively sets forth in over 500 pages "The History of Water Purification From the Earliest Records to the Twentieth Century."[153] While not a riveting page-turner, the range of treatment technologies is truly impressive, from siphons in ancient Egypt and cloth straining in Persia to techniques of aeration, distillation, flocculation, coagulation, and William Walcott's hopeful patent in 1675 for "making . . . sea water fresh."[154] Interestingly, the most obvious purification method to us—boiling water—was not commonplace. While there are references to boiling water in the Middle Ages, the common practice was light boiling, which would have been only partly effective in purifying the water.[155] Of course, if there were no conception of living germs in water, much less the health threat they might pose, then boiling water would seem a waste of time.

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150. 2 *Kings* 2:19–22 (New International).

151. Kathy Jesperson, *Search for Clean Water Continues*, ON TAP (Nat'l Drinking Water Clearinghouse, Morgantown, W.V.), Summer 1996, at 6, *available at* http://www.nesc.wvu.edu/ndwc/pdf/OT/OTs96.pdf ("[I]mpure water should be purified by being boiled over a fire, or being heated in the sun, or by dipping a heated iron into it, or it may be purified by filtration through sand and coarse gravel and then allowed to cool." (quoting the Sus'ruta Samhita Sanskrit writings)).

152. *Id.*

153. M.N. BAKER, THE QUEST FOR PURE WATER (1948).

154. *Id.* at 358.

155. Cast, *supra* note 44, at 2. It seems likely that boiling water for the popular drinks of tea and coffee also helped kill microorganisms in the water. *See id.*

At the same time as the Great Sanitation Awakening and the construction of municipal sewage systems, cities started building large-scale treatment works. The most common technology was slow sand filtration, purifying water by passing it through sand.[156] In 1703, the French Academy of Sciences had considered a plan that would have provided sand filters for every household, but the first municipal plant was not built until a century later in Paisley, Scotland.[157] By 1827, Glasgow, Scotland was piping filtered water to its Glaswegian consumers. Even such a simple technology, however, proved controversial and uptake proved slow.

In the late 1890s, for example, Pittsburgh considered whether to pass its water supply through a sand filtration system. This was strongly opposed by Edward Bigelow, director of the city's Public Works Department, who contended that "the city's water did not cause typhoid and warned that impugning its quality would discourage investment in the city."[158] Nor was he alone in his concern about bad press. Philadelphia's city council raised identical concerns over hurting the city's image.[159]

The most significant development in drinking water treatment occurred at the turn of the twentieth century, with the realization that adding low concentrations of chlorine to water would kill most of the microorganisms. Prior to that time, no municipalities had ever added chemicals to their drinking water supplies. The technical challenge lay in delivery, how best to mix reactive chlorine into large amounts of water. The town of Middlekerke, Belgium installed the first chlorine disinfection system in 1902. Jersey City took the lead in the United States, providing the first chlorination of drinking water for an entire city. In September 1913, the very first chlorine water treatment plant in America was built at Philadelphia's Belmont Filters.[160]

Easy to apply, inexpensive, and persistent in the water, chlorination gradually took hold. The adoption of chlorinated water was accelerated by the Department of the Treasury, which appointed a Commission in 1913 to establish the nation's first drinking water

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156. *See* DEP'T OF ENG'G, MERCER UNIV., HISTORY OF DRINKING WATER SYSTEMS (2005), *available at* http://egrweb.mercer.edu/eve406/eve406rom/documents/History-Water.pdf; BAKER, *supra* note 153, at 19, 118.

157. DEP'T OF ENG'G, MERCER UNIV., *supra* note 156, at 2.

158. Joel A. Tarr & T.F. Josie, *Critical Decisions in Pittsburgh Water and Wastewater Treatment*, *in* A HISTORY OF WATER 314, 322–23 (Terje Tvedt et al. eds., 2006).

159. *Id.* at 323.

160. CHAPELLE, *supra* note 15, at 3.

standards.[161] While these standards were binding only on common carriers involved in interstate commerce (particularly trains), they had a widespread and immediate impact. Since water was taken on at local depots along the rail lines, this indirectly forced those communities—indeed, all communities providing water to common carriers—to chlorinate their water as well.[162] By 1941, eighty-five percent of the country's over five thousand water treatment systems chlorinated their drinking water.[163]

The widespread adoption of chlorinated drinking water had two immediate impacts. The first was in the marketplace, where the bottled water sector collapsed.[164] We think of bottled water as a recent market entry, but it was big business at the turn of the twentieth century, as well. With Philadelphia and other cities' provision of chlorinated public water, however, the prime reason for buying bottled water in the first place—safety—was no longer relevant. And the chic branding that bottled water might have enjoyed was swamped by the appeal of chlorinated water. More than just a novelty, chlorinated water meant that water for an entire city could be made safe because of human ingenuity. In an age of technological optimism, municipal chlorination was a heady achievement. It was trendy, "modern" water, perhaps viewed in the same way as some Bangladeshis initially viewed groundwater from their new tubewells.

The second impact was on public health. The age-old scourges of waterborne disease—typhoid and cholera—had finally been neutered. Both pathogens, deadly and easily spread by water, were acutely vulnerable to low levels of chlorine. Typhoid epidemics were still killing thousands of Americans in the 1920s, but by the 1950s, even individual cases of typhoid had become rare.[165] It has been claimed that chlorination of drinking water saved more lives than any other technological advance in the history of public health.[166]

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161. Patrick Gurian & Joel A. Tarr, *The First Federal Drinking Water Quality Standards and Their Evolution: A History from 1914 to 1974, in* IMPROVING REGULATION: CASES IN ENVIRONMENT, HEALTH, AND SAFETY 43, 53 (Paul S. Fischbeck & R. Scott Farrow eds., 2001).

162. "In practice, an entire city's supply had to conform to the standards if any portion of it was used in interstate commerce." *Id.* at 62.

163. *See* CHAPELLE, *supra* note 15, at 15.

164. *Id.*

165. *See id.* at 182 (noting that although the introduction of chlorination in the 1920s decreased "the frequency and severity of these typhoid epidemics," they still occurred).

166. *Id.*

In retrospect, chlorinating drinking water supplies seems an obvious decision. At the time, however, it was highly controversial. Despite high incidences of waterborne disease, drinking water was still generally regarded as safe. Adding a chemical to water to make it safer had never been done before on a large scale and it seemed to many, to use a term with particular resonance in the bottled water market today, unnatural. A pro-chlorine writer in 1918 summarized the many complaints against chlorination:

> The nature of the complaints against chlorinated water is very diversified and includes imparting foreign tastes and odours, causing colic, killing fish and birds, the extraction of abnormal amounts of tannin from tea, the destruction of plants and flowers, the corrosion of water pipes, and that horses and other animals refuse to drink it.[167]

In fact, the Jersey City government had refused to pay its innovative water supplier, the East Jersey City Water Company, for the treatment plant providing chlorination. The City argued that the water needed to be free from upstream sewage and therefore filtered. The company responded that its obligation was to provide safe drinking water, which chlorinated water assured. The judge eventually sided with progress and chlorination, concluding that "[t]he device for removing dangerous germs, now in operation, is effective and capable of rendering the water delivered to Jersey City pure and wholesome for the purposes for which it was intended."[168] The *New York Times* article reporting the decision proved remarkably prophetic, predicting, "So successful has been this experiment . . . that any municipal water plant, no matter how large, can be made as pure as mountain spring water."[169]

The debate over chlorination continues today. A class of compounds known as trihalomethanes can be produced as a by-product of chlorination in the presence of water containing organic materials such as humic acids. Trihalomethanes, most notably chloroform, are carcinogens. While there is uncertainty over the data, they suggest a connection between chlorinated water and bladder, colon, and rectal cancer.[170] Such controversies over

167. JOSEPH RACE, CHLORINATION OF WATER 63 (1918).

168. Jersey City v. Jersey City Water Supply Co., 82 A. 732, 733 (N.J.); *see also* RACE, *supra* note 167, at 12.

169. MORRIS, *supra* note 19, at 161.

170. John D. Graham & Jonathan Baert Wiener, *Confronting Risk Tradeoffs*, *in* RISK VERSUS RISK: TRADEOFFS IN PROTECTING HEALTH AND THE ENVIRONMENT 15 (John D. Graham and Jonathan Baert Wiener eds., 1995); MORRIS, *supra* note 19, at 168–77.

chlorination pose risk versus risk dilemmas—microbial disease vs. cancer; morbidity vs. mortality; younger vs. older victims; and well understood threat vs. significant uncertainty.[171] Such concerns over involuntary risk—the government adding chemicals to public drinking water—played out yet again mid-century in the controversy over fluoridation of public water supplies.[172]

III. WHY DO WE THINK IT IS SAFE TO DRINK THE WATER?

This article began with the observation that, although we do not give a second thought when filling a glass from a nearby faucet, "for most of human history, safe drinking water has been the exception, not the norm." And this seems obvious. The high levels of cholera, typhoid, dysentery, and other waterborne diseases that were commonplace in times past have thankfully become rare, if not nonexistent, in developed countries today. Consider that in 1900, an American had a one in twenty chance of dying from a gastrointestinal infection before the age of seventy. In 1940, this had been reduced to a 1 in 3333 chance; and in 1990 to a 1 in 2,000,000 chance.[173] This is a staggering achievement.

No surprise, then, that from the vantage of twenty-first century America, we view the quality of drinking water in the past and in much of the developing world as unsafe, and for good reason. It goes without saying that if we got into a time machine and exited in 1854 at the well on Broad Street, we would be wise enough not to drink that water. If the history we have traversed in this article means anything, though, it is that the assumption in the preceding paragraph—that safe drinking water has generally been the exception rather than the norm—is wrong.

While *we* may look with horror on the water drunk in days gone by, people at the time did not. People generally regard their water as safe. The widow in Hampstead liked the Broad Street Pump water so much she sent her servant specially down to bottle it for her. It is only later, when we look back through the lens of modern

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171. Susan W. Putnam & Jonathan Baert Wiener, *Seeking Safe Drinking Water*, *in* RISK VERSUS RISK: TRADEOFFS IN PROTECTING HEALTH AND THE ENVIRONMENT 124–25 (John D. Graham and Jonathan Baert Wiener eds., 1995).

172. *See, e.g.*, F.B. EXNER & G.L. WALDBOTT, THE AMERICAN FLUORIDATION EXPERIMENT (James Rorty ed., 1961); DONALD R. MCNEIL, THE FIGHT FOR FLUORIDATION (1957).

173. MORRIS, *supra* note 19, at 162.

microbiology and public health, that the water seems unsafe and the laws inadequate.

The interesting question, then, becomes how such transitions occur, why formerly safe water becomes regarded as unsafe and norms adapt. Think back to the example of the communal cup at Tian Tan Buddha. Why did attitudes toward shared drinking water cups change so rapidly in America in the early 1900s, indeed forcing a change in laws, yet this practice persists in parts of Asia today? Why was chlorination welcomed in some communities in the early 1900s, yet strongly opposed in others? Why do some Bangladeshis continue to draw water from red-painted tubewells and others do not? Why do most Yoruba drink from the river and not treat their water? In these cases and others, common understandings of safe drinking water are in flux; norms are contested.

What explains these transitional periods and their influence on rules? The answer is multi-faceted. A large part of the story clearly turns on changing conceptions of disease. Imagine there was no time machine and you really were a Londoner living in Soho 150 years ago. If you, an educated person, *knew* that diseases such as cholera and typhoid were spread through airborne miasmas, then getting your water from a covered well would be prudent. Through this perspective, the cesspit located next to the well would, in fact, be very convenient. You can dump your garbage and collect your day's water at the same place. How thoughtful of the municipality.

Put another way, what has changed over time has not been the demand for safe drinking water. That has always been a constant in every society. What have changed are our conceptions of safety and what makes drinking water unsafe. The miasmatic theory of disease taught us to avoid water that smelled, but gave no reason to be concerned about pollution near the water source. John Snow's insights into the transmission of cholera and the subsequent rise of the germ theory alerted us to the dangers posed by unseen killers, and the need for filtration and chlorination to ensure safe water. New insights into waterborne diseases trigger changes in behavior; eventually norms adapt to these changes (often involving new technologies) and mandate them.

Part of the answer turns on the stickiness of social norms. As we discussed earlier, people in Yorubaland identify their drinking water sources from a set of rules, the most important of which is that the water should come from a clear, flowing stream. While one can understand that this norm could be very practical—for example, reducing the microbial problems associated with standing water—it posed a riddle for Eva-Marita Rinne.[174]

People have been told that drinking from flowing water can cause disease. They have been told of the benefits from point-of-use strategies—using chemicals, filtration, and boiling water to disinfect. Some use these treatment practices, but not many. Their norms have not changed. Why do they continue drinking unsafe water?

Rinne does not really know. She suggests that poverty plays a role, since not everyone can afford the treatment options. She suggests passivity, since people do not "regard themselves capable of solving environmental health problems, but rather they rely on the local governments."[175] She finally suggests a catch-all explanation of tradition, concluding that rules for drinking water sources result from "common experience of past generations, the visual evidence of how safe water looks, and of everyday life practices of ensuring safe water."[176] The basic explanation of why they drink unsafe water is, quite simply, that on balance, they think the water is safe enough.

And part of the answer turns on the relative nature of safety. It is understandable that the miserable Pablo Valencia, parched and wandering in the Sonoran Desert, might happily drink out of a fetid pool of water to slake his thirst. In that case, to paraphrase Adam Smith, water clearly would be far more valuable than diamonds, even unclean water.[177] For Valencia, such water would have been safe enough, even though you or I would probably not even use it to wash our car. Drinking water, even if teeming with microbes, is always a safer option than death from dehydration.

In Yorubaland, Bangladesh, and many parts of the world today, the determination of whether the water is "safe enough" is not as straightforward as for Pablo Valencia. Determining safety turns on a complicated balance of threats to health, opportunity cost of collecting cleaner water (time spent gathering water versus time spent for other important needs such as earning money or collecting

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174. *See* Rinne, *supra* note 56, at 278.

175. *Id.* at 282.

176. *Id.* at 278. The beliefs are consistent. The Yoruba are suspicious of treated water. Rinne argues that community members feel they know their sources are safe, but they can never be sure about treated water coming from the water tanks or pipes. *Id.*

177. *See, e.g.*, Michael V. White, *Doctoring Adam Smith: The Fable of the Diamonds and Water Paradox*, 34 HIST. POL. ECON. 659 (2002) (discussing the paradox of water's high value in use and relatively low value in trade, to the high value of exchange given to diamonds despite their lack of practical use).

firewood), and social pressures. What should a villager in Bangladesh do with a red-painted well nearby and a green well over an hour's walk distant? Which option should the law favor—drinking from surface water with the known risk of waterborne disease, drinking from the green well but losing several hours each day to gather the water, or drinking from the nearby modern well and the possibility of arsenic poisoning sometime in the future?[178]

This fundamental challenge is equally true in the developed world as well. We assume we know what safe water is. Part of our view is technocratic. As expressed in the Safe Drinking Water Act or standards set by the World Health Organization, our focus is on biophysical assays of water, maximum contaminant levels, and economic and technical feasibility of treatment. The norms of water safety are determined for us by scientists in lab coats somewhere. Yet this veneer of knowledge can mask significant uncertainty. Recall the furor over arsenic standards in drinking water at the start of the Bush Administration in 2000. The issue was whether to tighten current standards from fifty parts per billion to ten parts per billion. The standard would impose significant costs, particularly on small communities. One might assume this was still worth it, given the dangers from arsenic.[179] The problem, though, was that the calculated benefits were highly uncertain—ranging from 5 to 112 lives saved and from $10 million to $1.2 billion.[180] Or consider the uncertain carcinogenic effects of chlorination. Or take the example of endocrine disruptors. These compounds mimic hormones and, at least in laboratory tests, interfere with the endocrine system and

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178. These are not merely academic observations. Some of the most promising research today in global public health focuses on why people will or will not take precautions, such as choosing to drink water from one source and not another. In some cases, it appears driven by the cost of having to walk farther for safer water, in others by the social shame of needing to ask neighbors for access to their well. *See, e.g.*, Nava Ashraf et al., *Can Higher Prices Stimulate Product Use? Evidence from a Field Experiment in Zambia* (Nat'l Bureau of Econ. Research, Working Paper No. 13247, 2007), *available at* http://www.nber.org/papers/w13247.pdf (examining which factors encourage point of use strategies for water treatment, and whether it is more effective to give away chlorine treatments that purify water for free or to charge, and whether charging more for the chlorine increase the likelihood it will be used at home).

179. Consider the comments of Representative David Bonior, who knows a good story when he sees one: "Americans disagree about a lot of things, but drinking arsenic isn't one of them. . . . When you turn on the kitchen sink, you ought to be able to drink what comes out, without worrying about being poisoned." Cass R. Sunstein, *The Arithmetic of Arsenic*, 90 GEO. L.J. 2255, 2255 (2002) (quoting Rep. David Bonior).

180. *Id.* at 2258. "Today, the maximum contaminant level for arsenic is ten parts per billion, and more than fifty-six million Americans drink water that exceeds this level." ROYTE, *supra* note 7, at 121.

sexual development.[181] Chemically stable and difficult to remove with conventional drinking water treatment methods, the data concerning endocrine disruptors' presence in our drinking water and likely impact on the population are highly disputed.[182] One could tell a similar story about compounds from pharmaceuticals and personal care products in our drinking water.[183] Do these new, synthetic compounds pose serious threats to our drinking water, to our safety? Our current understanding does not provide cause for alarm, hence they are largely unregulated.[184] But some people are concerned and this number may well grow.[185]

Ironically, part of our conception of safe drinking water is anti-scientific. As noted earlier, bottled water sales have been booming. Popular ads for bottled water are all about the natural, pure essence

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181. American Water Works Association, Endocrine Disruptors, http://www.awwa.org/Resources/topicspecific.cfm?ItemNumber=3647&navItemNumber=1580 (last visited Dec. 15, 2008); Our Stolen Future: Changes in the Rate of Sexual Development, http://www.ourstolenfuture.org/NewScience/reproduction/Puberty/puberty.htm (last visited Dec. 15, 2008) ("[E]xposure to estrogen mimics reduces the age of puberty in females, while exposure to compounds that interfere with androgens (like testosterone) delays puberty in males.").

182. J.H. Kim, *Removal of Endocrine Disruptors Using Homogeneous Metal Catalyst Combined with Nanofiltration Membrane*, 51 WATER SCI. & TECH. 381 (2005); *see also* Our Stolen Future: What's the controversy?, http://www.ourstolenfuture.org/Basics/controv.htm (last visited Dec. 15, 2008) (noting that the "controversy about endocrine disruptors has centered almost exclusively on the question of human health implications").

183. *See, e.g.*, Julie Gerberding, Pharmaceuticals and Personal Care Products (PPCPs) in Drinking Water, http://www.drinktap.org/consumerdnn/Home/WaterInformation/WaterQuality/PharmaceuticalsPPCPs/tabid/73/Default.aspx (last visited Dec. 15, 2008); Abby C. Collier, *Pharmaceutical Contaminants in Potable Water: Potential Concerns for Pregnant Women and Children*, 4 ECOHEALTH 164, 170 (2007); Lisa J. Schulman, *A Human Health Risk Assessment of Pharmaceuticals in the Aquatic Environment*, 8 HUM. & ECOLOGICAL RISK ASSESSMENT 657, 657 (2002).

184. As the EPA reports, "Studies have shown that pharmaceuticals are present in some of our nation's waterbodies. Further research suggests that there may be some ecological harm when certain drugs are present. To date, no evidence has been found of human health effects from PPCPs in the environment." Envtl. Prot. Agency, Frequent Questions: Pharmaceuticals and Personal Care Products (PPCPs), http://epa.gov/ppcp/faq.html#iftherearei ndeed (last visited Dec. 15, 2008).

185. In the late 1990s, the United States Geological Survey analyzed American waterways for the presence of drugs in the water. ROYTE, *supra* note 7, at 127–29. "In 2002, the agency announced it had found traces of eighty-two different contaminants, including natural and synthetic hormones, antibiotics, antihypertensives, painkillers, and anti-depressants. The researchers also found caffeine, nicotine, and the residue of personal-care products such as shampoo, sunscreen, and insecticide. The stuff was just about everywhere: in rural and urban areas, in wells, surface water, and groundwater . . . . Wastewater treatment plants aren't designed to remove hormones, to say nothing of antidepressants, painkillers, and the plasticizers found in shampoo and other types of plastic bottles." *Id.* It should be noted that these compounds exist in very low concentrations, and their mere presence says little about whether they pose a risk we should care about.

of the clear liquid. Aquafina, Pepsi's successful bottled water brand, could not make this clearer. The product's slogan, spelled out in big letters on the label, reads, "*Purity Guaranteed.*"[186] But the regulatory standards for bottled water are less demanding than those for tap water. In pure biophysical terms, bottled water may often be less safe than tap water (leaving aside the many times it simply *is* tap water), yet eager consumers keep buying the product.[187] Or consider the opposition to water reclamation projects that treat sewage to provide drinking water. The final result is as safe as anything coming out of the tap, but has been staunchly opposed from San Diego to Tampa.[188] There is something of the profane in drinking one's own waste.

IV. CONCLUSION

There is no question that our ability to understand the risks posed by drinking water has dramatically improved over the centuries. Measuring traces of contaminants in parts per trillion is now commonplace. We also have a far deeper understanding of the toxicology of drinking water contaminants. In some cases, however, risk assessments, toxicology, and cost benefit analyses of drinking water contaminants are indeterminate. They provide answers, but with significant error bars. In the face of such uncertainty, should EPA rely on public perceptions of safety when these, too, can seem fallible or irrational? We know far more than John Snow ever did about what makes water unsafe but must still, on occasion, grapple with imprecision when forced to make decisions.

Our views are shaped by a continuous co-evolution of norms and knowledge. Over time, as we learn more about the nature of waterborne diseases and the trade-offs of choosing particular water sources over others, our norms for identifying, protecting, and treating drinking water change as well. But this takes time and can lead us down false paths. There are particular historical junctures when the very identity of safe water becomes contested. It is at these moments that we find John Snow at the Broad Street Pump, chlorination of municipal water, banning communal cups at drinking

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186. Nor is it clear what purity even means in the context of drinking water. Federal regulations permit the presence of bacteria in five percent of samples from public water sources. *See id.* at 100. It may be safe enough, but does this make it pure?

187. *See* NATURAL RES. DEF. COUNCIL, BOTTLED WATER: PURE DRINK OR PURE HYPE? (1999), *available at* http://www.nrdc.org/water/drinking/bw/bwinx.asp.

188. Sadie F. Dingfelder, *From Toilet to Tap*, MONITOR ON PSYCHOL., Sept. 2004, at 26, *available at* http://www.apa.org/monitor/sep04/toilet.html.

fountains, the tragedy over arsenic-contaminated wells in Bangladesh, and endocrine disruptors today. At these moments, concepts as basic as the causes of disease and the norms over provision of water become unstable and eventually untenable, replaced by new norms, laws, and policies. And then, assured once again that our water is safe, success is declared and concerns over drinking water fade, until the next challenges arise, whether in a cryptosporidium outbreak in a major city or in scientific research suggesting a new, unexpected class of harmful substances in our water. The basic question, "Is it safe to drink the water?" will no doubt be as relevant centuries from now as it is today.