Securing Our Water Supply: Protecting a Vulnerable Resource

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Contents

Preface

Until September 11, 2001, the challenge of detecting intentional contamination of our water systems wasn't given much thought. For the past 17 years, as an employee of Hach Company, the world's largest manufacturer of analytical solutions for the drinking and wastewater industries, I have been involved with research directed at finding solutions to the problem of maintaining the quality of our nation's and the world's water supplies. My main role at Hach has been the development of analytical methods. In the past, most of these methods have focused on detecting and quantifying accidental and environmental pollutants in water and wastewater. For example, I developed the simple and inexpensive field test used by the Bangladesh Arsenic Mitigation Water Supply Project to test over five million wells in that country for naturally occurring arsenic contamination.

The tragic events in New York, Washington, and Pennsylvania rapidly and dramatically changed the picture for everyone in the water industry and made us aware of our vulnerability to deliberate contamination. At Hach, being experts in the water quality industry, we quickly recognized the vulnerability of our water supply systems to intentional contamination, and in January 2002, we began a program to develop strategies to combat this mode of attack. By April 2003, we formed a separate business unit, Hach Homeland Security Technologies, to specifically address these problems. I was named chief scientist of this group and have spent the past several years studying the terrorist threat to water and approaches to ameliorate it. The purpose of this volume is to share with you some of the insights I have gained into security issues as they relate to the water industry and hence, to better prepare for such an attack. As the proverb says, "Forewarned is forearmed."

I hope you find this book useful and informative.

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1

The Psychology of Terrorism: Why Target Water?

While we must remain determined to defeat terrorism, it isn't only terrorism we are fighting. It's the beliefs that motivate terrorists. A new ideology of hatred and intolerance has arisen to challenge America and liberal democracy.

—John Kerry

Introduction

The events of September 11, 2001, dramatically and irrevocably changed our worldview. The picture that many of us had of an America safe and secure from foreign attack was shattered on that morning. We realized, like never before, that we are vulnerable. As the days following the attack progressed, we came to understand the extent and the scope to which we were open to devastating terrorist assaults were not limited to kamikaze jetliners crashing into buildings. As an open society, the critical infrastructure we need for our culture and way of life to endure was not hardened. Our power grid, cyberspace, the transportation network, communications systems, public health, the food supply, and the water supply (the focus of this book) were open to assaults that could rapidly cripple the nation. The country quickly mobilized to address these issues.

Since then, we have made great strides in securing certain weak points, but much work remains to be done. Today we find ourselves in the midst of what President Bush has termed "The War on Terror." Our troops fight this war on the battlefields of Afghanistan and Iraq and in myriad other places around the globe. Those of us at home do our part by trying to decrease our vulnerability to future attacks and regain some vestige of the sense of security that we lost on 9/11.

Terrorism as Theater: Does Water Qualify?

Pisacane's theory of propaganda by deed began the long-standing courtship of media attention by the perpetrators of terrorist acts. Terrorists have always sought to maximize the exposure of their deeds. That is why many historical acts were orchestrated to achieve the largest audience possible—for example, the Assassins' choice of the optimum venue to publicize their attacks, committing their murders at shrines on holy days. The rise of the mass media has allowed terrorists to play to a truly worldwide audience. The importance of an audience to the terrorist agenda was put into perspective when Abbe Hoffman made the statement that all terrorist attacks are at least partly theater.[21]

A terrorist attack is intended to serve more than the single purpose of simply scaring the attacked individuals. It is meant to have meaning for the victim's peer group as well so that not just the victim, but also all those whom the victims are representative of are subjected to the terror of the deed and are plunged into a state of fear. It is also meant to have meaning to observers who are actually or potentially sympathetic with the terrorists' cause, thus helping in the recruitment of new terrorists. The result must be easily communicated to and understood by both groups. Therefore, most attacks are chosen because they are easily interpreted by the intended audience. The visual media is the most universal for conveying a message to a wide audience. This leads to the choice of tactics and targets that are easily conveyed in video and still pictures. A crashed airliner, a burning building, or explosions do not require explanation in multiple languages to be understood by an international audience. For example, the current insurgency in Iraq has been careful to make detailed video recordings of brutal and graphic terrorist acts such as the beheading of captives. These recordings then appear in videos that are used as training and recruiting tools.[22]

Many people hold that it is just for this reason that water is not a likely terrorist target. The argument is that an attack on water supplies does not fill the bill as an example of good theater. It lacks the dramatic special effects of a fiery airplane crash or the human drama of a hostage crisis. Their argument further states that the only way to enhance the theatrical effect of an attack on water supplies is to orchestrate it in such a way as to have it coincide with another type of attack. For example, pipelines could be blown up to disrupt the water supply or be contaminated to the extent that the system's operators are forced to shut it down. In close coordination with the denial of service attack on the water system, mass bombings or arson could be carried out in the area affected by the loss of water. The lack of water combined with the more conventional bombing or arson attacks would prevent the timely dousing of the flames and add to the general destruction. The idea is that this would generate more terror than a contaminant attack on water supplies initiated with the sole goal of causing mass casualties.[23]

hundreds of recipes for the manufacture of toxic or irritating gases and smokes for use in warfare. One account describes an arsenic-based toxic gas called "soul-hunting fog."[2]

600 BC. *Claviceps purpurea* is a fungus that grows on grasses such as rye. It replaces the grain seed heads with a purplish fungal growth. This fungus contains mycotoxins and is commonly known as rye ergot. The toxins contain alkaloids, which are similar in nature to lysergic acid diethylamide (LSD).[3] The ancient Assyrians placed these infected seed heads in their enemies' wells. Ergot can be very toxic and can produce hallucinogenic symptoms similar to LSD. Large doses of ergot poison can cause delusions, paranoia, uncontrollable twitching, seizures, and cardiovascular problems leading to gangrene and potentially death.[4]

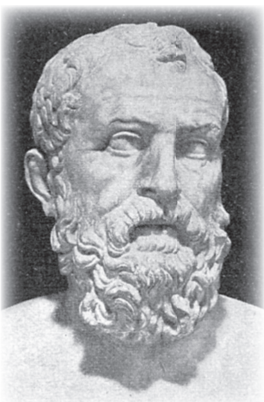

Fig. 2–1. Solon of Athens used the poisoning of water to great advantage during the siege of Cirra.

590 BC. Solon of Athens was said to have used poison during the siege of Cirra, the port city of Delphi in ancient Greece (fig. 2–1). A dispute arose as to the ownership of some land that had been set aside for the god Apollo's temple. Solon was called on to settle the matter and promptly laid siege to the city. Sieges being generally long and drawn-out affairs, Solon decided to speed matters up by placing a dam across the Plesitus River, which was the city's main water supply. The inhabitants, not being ready to submit, relied on a few wells and rainwater to tide them over. Even with these alternate sources, water was in short supply in the city. This is when Solon had his big idea. He is purported to have used a purgative extracted from the roots of the hellebore (commonly known as skunk cabbage) to poison the water behind his makeshift dam. He then broke the dam and allowed the contaminated water to flow into the city. The inhabitants, thinking the siege was coming to an end, gratefully drank their fill of the fresh flowing water. The result of drinking the contaminated water was extreme diarrhea, rendering the defenders of the city unable to resist (sitting down on the job, as it were) when Solon mounted a fresh attack, ending with the city's fall.[3,4]

300 BC. Numerous examples exist of the use of dead animals for the contamination of wells and other water sources in Persian, Greek, and Roman records from this period.[5]

128 BC. The Roman jurists of this time had a saying, *Armis bella non venenis geri,* which translates as "War is fought with weapons, not with poisons." This prescription was not enough to prevent their generals from poisoning wells when it was expedient. Aristonicus was a rebel who had a dispute with the Romans over the control of territory in Asia Minor. His forces were quickly defeated; however, they were not completely destroyed, and Rome was faced with the prospect of a long guerrilla war. To prevent this, they poisoned the local wells that the rebels needed for water supplies. This resulted in a quick Roman victory and the return of Roman rule to the area.[6]

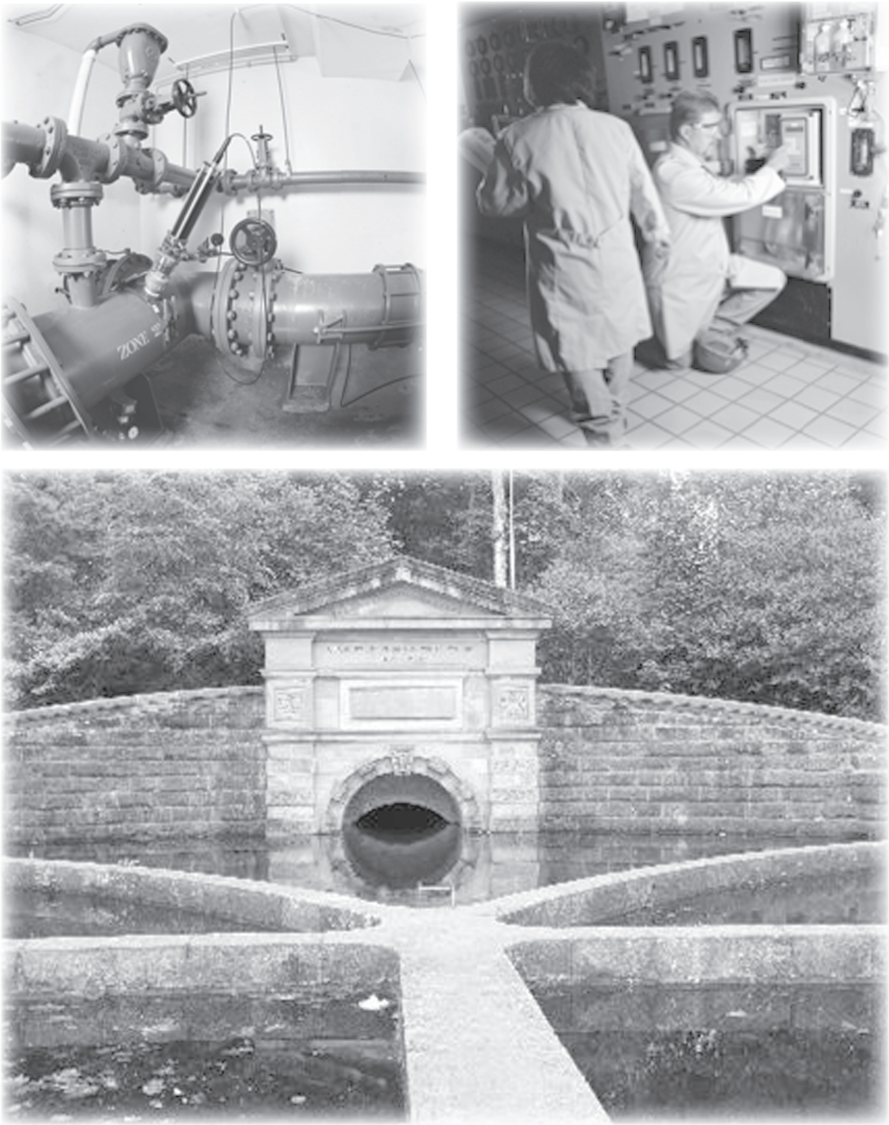

Fig. 4–1. Much of the drinking water infrastructure is aging and in poor or marginal condition, while other parts of the water supply network are state of the art and have been furbished with modern equipment.

It took a concerted allied operation to successfully develop a program capable of bursting large dams. Such an operation undertaken by terrorists is unlikely. It would, however, be possible for terrorists to develop a mobile bomb based on a large tanker truck, filled with explosives, that could be driven across a large dam with a roadway on top of it. The driver could then crash the truck into the water alongside the dam. The truck could be rigged to act as a depth charge that would explode along the underwater surface of the dam, thus creating the shock wave needed to burst the dam.

This scenario could be easily prevented by restricting traffic along the tops of the largest and most vulnerable dams. Government officials are aware of this threat, and they are taking it seriously, as evidenced by the following headline from the *New York Daily News* of September 2, 2004: "Bomb study convinces exec to close road atop NY dam." The article details how the county executive, Andrew Spano, was persuaded to leave the road across Kensico Dam, in Westchester County, closed to traffic. Spano said that West Lake Road, which he had planned to reopen on September 4, would remain closed permanently, in the interest of public safety. He had originally planed to reopen the road, but the study changed his mind. New York City, which owns the Kensico Reservoir, behind the dam, had undertaken a bomb blast study to evaluate the dam's vulnerabilities. Christopher Ward, New York City's environment commissioner, was opposed to reopening the road and commissioned the study. According to Ward, if the dam were lost or damaged, "about 250,000 residents could face catastrophic flooding and New York City could lose most of its drinking water."[7]

Untreated water transport

In many cases, the facilities for treating water and the areas where it is needed are quite some distance from the source. It is necessary to transport the water from the source to the treatment plant—by means of aqueducts, pipes, canals, and ditches. These transport conduits can be anywhere from a few hundred yards to hundreds of miles in length. In many instances, they pass through remote areas where little or no physical security exists. Like source waters, they present a tempting and easily accessible target owing to their geographic extent; they too vary in size and volume, and their vulnerability to contamination is directly related to size. Transport systems are not as large as source waters, because they represent the actual supply that is going to the treatment plants for use; therefore, they represent only a fraction of the volume of the source water from which they are derived. Transport conduits do, however, tend to be quite large, and those mechanisms that are left open to the elements, like ditches, do have some of the same characteristics, with regard to natural attenuation and degradation of contaminants, that apply to source water.

Furthermore, the location of transport conduits in the system prior to treatment means that they offer the same barriers to contamination as the source water itself. While not all contaminants would be removed at treatment, it does provide a substantial line of defense. The largest threat to these systems is not

Table 4–2. Past incidents of accidental fluoride poisoning

Incident Date	City, State	Details
10/24/03	Marlboro, MA	A valve malfunction caused excess fluoride to enter into the water system, bringing the fluoride level to 24 ppm (6 times the legal maximum)
6/4/2002	Dublin, CA	23 employees of Humphrey Systems Inc. feel ill after using water fountains. Tests at Humphrey Systems on Tuesday showed concentrations of up to 200 milligrams per liter.
7/28/2000	Wakefield, MA	Water system overdosed with fluoride—people were exposed to 23 ppm
11/1993	Middletown, MD	Excess amounts of water fluoridation treatment entered the water supply, raising the level to 70 ppm. Citizens were informed not to drink or cook with the water
8/1993	Poplarville, MS	40 persons poisoned; 15 sought treatment at hospital. Pizza Inn manager was the first to notify city officials after several customers became ill.
7/16/1993	Chicago, IL	Three dialysis patients died and five experienced toxic reactions to the fluoridated water used in the treatment process.
5/1993	Kodiak, AK	Although equipment appeared to be functioning normally, 22–24 ppm of fluoride was found in a sample.
1/1993	Sarnia, ON Canada	Computer-controlled system had failed to shut down.
5/1992	Hooper Bay, AK	Poor equipment and lack of a qualified operator. One death, 260 poisoned; one airlifted to hospital in critical condition.
2/1992	Rice Lake, WI	High winds caused volt lines to connect, causing conductors to burn to ground and a jumper to fail, resulting in failure of the anti-siphoning device, causing fluoride to pour through the pipes. Pump overfed fluoride for two days. Residents vomiting, levels thought to have reached 20 ppm.
1991	Portage, MI	Injector pump failed. Fluoride levels reached 92 ppm and resulted in approx. 40 children developing abdominal pains, sickness, vomiting, and diarrhea.
10/1990	Westby, WI	Equipment malfunctioned, fluoride surged to 150 ppm. The water utility supervisor said he had expected the fluoride to be ten times normal since it had burned his mouth. The fluoride corroded the copper off the pipes in area homes, 70 times higher than the EPA recommended limit.
3/1986	New Haven / N. Branford, CT	The fluoride peaked at 51 ppm. 18% of customers had acute health effects.
10/6/1981	Jonesboro, ME	Equipment had been shut down due to faulty valve controlling the quantity of fluoride going into the drinking water. 57 students, teachers and principal taken to hospital. 38 were administered regurgitants to make them vomit the fluoride, and milk to counteract the poison. Two were admitted to the hospital for several hours for fast heartbeat.
8/10/1981	Potsdam, NY	The diffuser, a plastic pipe that controls flow of fluoride into the water system broke off, allowing the entire contents of a drum of fluoride, ten times a normal "dose," into the water supply. Village residents were without potable water, and in a state of "water emergency" from 2:00 p.m. until 11:00 p.m.
8/30/1980	Vermont Elementary School	A water fluoridator at a local elementary school was accidentally left running, elevating fluoride levels to 1041 ppm (250 times the legal amount), poisoning 22 individuals attending a farmers market hosted at the school.
11/1979	Annapolis, MD	Valve at water plant had been left open all night. One patient died and eight became ill after renal dialysis treatment. The fluoride level was later found to be 35 ppm.
5/1979	Island Falls, ME	Fluoride machine let extra fluoride into water system while motor head was being changed. "The exact water fluoride level was not ascertained although a water sample at a manufacturing plant was greater than 10 ppm." 5 people suffered gastrointestinal illness.
11/17/1978	Los Lunas, NM	Faulty electric relay switch caused concentrated fluoride to be pumped into water system without being diluted with non-fluoridated water. 34 people had acute fluoride poisoning.
11/22/1977	Harbor Springs, MI	Power lines controlling city water system electrical signal lines were down. Approximately 189 lbs. of fluoride was accidentally pumped into the city's water system. Four people experienced nausea or vomiting and weakness.
4/16/1974	Manly, NC	Fluoride feeder pump malfunctioned, causing the fluoride solution to be fed into the water system continuously while water pump not operating. 213 individuals experienced nausea after drinking orange juice mixed with water. 201 students and 7 adults vomited.
6/6/1972	Rome, PA	Blockage of BIF feeder by-pass occurred sending excess fluoride into water system as high as 67 mg./L 150 students attending a school picnic vomited after drinking orange juice made with the water.

Nematocides

Nematocides are designed to kill nematodes in the soil and have many of the same characteristics as insecticides. Despite a few exceptions, they are more soluble than insecticides, allowing greater penetration into the soil. An example is oxamyl, with a solubility of 280,000 mg/L. Many of these compounds have uses specific to certain types of crops and geographic areas. As agricultural chemicals, they may be obtained in large amounts by a potential terrorist. Many of these compounds are cholinesterase inhibitors with structural similarities to nerve agents (e.g., see fig. 4–14). Their high potential for lethality, combined with their ready availability and their solubility, makes them agents of concern. Like insecticides, nematocides are a definite threat to water supplies.

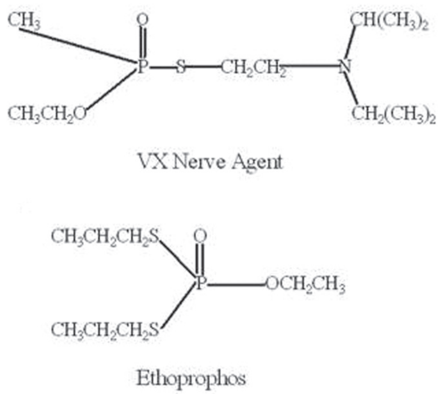

Fig. 4–14. Ethoprophos, a nematocide, and VX, a nerve agent, have many similar structural characteristics.

Rodenticides and predicides

Rodenticides are designed to kill rodents, and predicides are designed to kill predators such as coyotes. While these are technically agricultural chemicals, they are not used nor are they available in the same volumes as other agricultural chemicals. The very fact that these chemicals were designed to kill higher life-forms indicates that they would be toxic to people as well. These chemicals are diverse and work via a variety of modes.

Compound 1080, or sodium fluoroacetate, is one of the most troubling potential threats in this class. Compound 1080 is designed to kill coyotes and other predators. It was used in the United States for many years to poison the carcasses of animals on which scavengers would feed. It is very toxic (LD_{50} of 140 mg), extremely soluble, and virtually odorless and tasteless. Once exposure has occurred, there is no known antidote. It is currently banned for private use in the United States. It is legal only in some states when used in a special collar that U.S. government trappers use to