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Terrorists and Ground Water: Is Weaponization Possible?

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In the days since September 11, 2001, much discussion and work have been devoted to the issue of the protection of water supplies from terrorist attack. A quick search on Google indicated some of the organizations involved in this effort: the Environmental Protection Agency, Department of Homeland Security, American Water Works Association, Association of Metropolitan Water Agencies, Federal Emergency Management Agency, Department of Energy, Sandia National Laboratories, and even NGWA. There are WWW sites (e.g., Meinhardt, 2003) devoted to educating health-care professionals about the threat to water supplies from chemical, biological, and radiological (CBR) agents.

Most of the concern for water terrorism has rightly emphasized the protection of water intakes and other entry points into water distribution systems and the development of emergency supplies and response procedures. The contamination of reservoirs is generally considered difficult because of the large volumes of water involved and the resulting significant dilution. For example, Danneels (2001) reported that most storage tanks for large municipal systems range from about 3 to 30 million gallons. He also noted that it would take four dump-truck loads of sodium cyanide mixed in 1 million gallons of water to produce a lethal dose to anyone drinking the water. So it is obvious that a huge amount of a chemical toxin might be required to contaminate a storage tank or reservoir.

However, one can argue that more toxic substances than cyanide exist - for examples, biotoxins, which can be lethal at the nanogram exposure level and are some of the most toxic substances known to humankind (Meinhardt, 2003, Section 5). Although biowarfare agents are generally aerosolized, Meinhardt (2003, Section 5) reported that many biotoxins are stable in water and do not produce readily detectable changes in the physical characteristics of the water.

But what about the intentional introduction of a CBR agent into an aquifer so as to cause a large number of deaths? At first glance, this appears so ridiculous as to promote immediate dismissal of the concept. If the contamination of a reservoir or storage tank with a lethal dose of a CBR agent is difficult to accomplish, then what about aquifers, whose volumes are often measured in the millions of acre feet? But perhaps a biotoxin (pathogen) might prove more appropriate than a chemical. Let's assume for the moment that a terrorist organization is considering the biotoxic (chlorine-resistant, of course) contamination of a municipal ground water supply through an aquifer. What kind of aquifer should they seek? How about an aquifer: 1) whose recharge areas are well-known and accessible; 2) has short travel times (days or weeks) from a recharge area to a supply well; 3) provides little opportunity for a pathogen/toxin to disperse, sorb, react, or degrade; and 4) has a relatively low storage volume between the recharge area and well.

Aquifers with the aforementioned characteristics exist: karst, fractured rock, and volcanic aquifers. Recall the tragedy in Walkerton, Ontario, in 2000, where *E. coli* O157:H7 contamination in ground water caused 7 deaths and an estimated 2,300 serious illnesses (Hrudey et al. 2002). The aquifer involved was a fractured, likely karstified, carbonate aquifer (Worthington, 2002). Travel times from recharge areas to wells in such aquifers can be on the order of days, and, depending upon the rock matrix, little opportunity for toxin dilution might exist through matrix diffusion. But storage volumes might be large.

Let's say we have a karst aquifer with a single conduit between a recharge area (sinkhole) and production well 2 kilometers away. The cross-sectional area of the conduit is 5 square meters. The total volume of the conduit between the sinkhole and the production well is 10^4 cubic meters or over 2.6 million gallons. In terms of mass, this is 10^{10} grams of water. For a biotoxin lethal at the nanogram level, 100 grams might produce a lethal dose. And, in a karst aquifer, a travel time of a couple of days for 2 kilometers is not unheard of, so the upshot might be a public-health disaster with virtually no warning.

The above case is highly idealized and simplified. But it is a believable-enough scenario that certainly warrants investigation. And remember, a credible *threat* from a terrorist organization would produce not *directly* produce fatalities, but could induce panic (which might lead to

injuries/fatalities). An admittedly brief Internet search did turn up some work in ground water, but mainly from the standpoint of the contamination of distribution systems. I found no specific cases of people concerned with toxins purposely introduced into aquifers by terrorists. My limited research suggests that biotoxins might be the weapon of choice.

My recommendations are that: 1) existing CBR toxins suitable for introduction into aquifers be identified and thoroughly investigated as to their toxicity and viability in the subsurface aqueous environment; 2) emerging toxins be identified and isolated; 3) aquifer characteristics vis-à-vis CBR vulnerability be identified; and 4) susceptible aquifers and water supply systems be identified and steps taken to ensure security. With regard to (1), the substantial research performed on virus and bacteria fate and transport in porous media would not doubt prove beneficial.

Could terrorists contaminate some of our aquifers with lethal doses of CBR agents? Recall that four years ago, few of us believed that our own commercial airliners could be used as weapons. The events of 9/11 should have taught us to expect the unexpected. We need to be vigilant about all our water supplies, not just those we can see.

References

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