Ground Water Ills: Many Diagnoses, Few Remedies

Concern about pollution of ground water is growing, but legislative remedies remain elusive

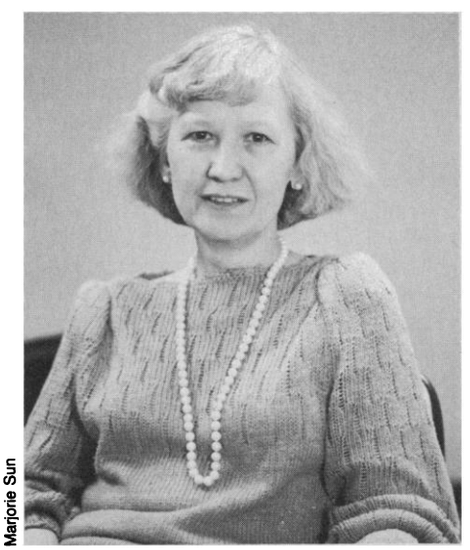
FROM California to Florida, the nation's ground water, a vast unseen resource beneath the earth's surface, is far more polluted by a greater number of contaminants than previously believed. The more authorities sample underground water, the more they are finding toxic chemicals, pesticides, and other possibly hazardous substances. According to growing consensus among authorities in government, industry, and environmental groups, the trend indicates a serious environmental problem that merits national attention. But few agree what the regulatory solutions should be.

The biggest concern is the potential health threat posed by drinking contaminated ground water. Half the nation depends on ground water, rather than lakes and rivers, for potable water. According to government estimates, thousands of wells across the nation have been closed because the concentrations of toxic substances exceed federal safe drinking water limits. With other ground water supplies, where pollutants have been detected in trace amounts, the fear is that long-term exposure may eventually lead to health problems. Although data on many pesticides are often scant regarding potential health effects from low-level, chronic exposure, many state and federal officials take the position that exposure to polluted water should be minimized as a precaution.

The contamination of ground water is a particularly troubling environmental problem because, unlike the pollution of air or lakes, ground water is inaccessible, making cleanup virtually impossible. Also, purifying ground water tainted with toxic substances is expensive; in its pristine state, ground water can generally be used with little or no additional treatment, such as chlorination. But chlorination only kills bacteria and does not neutralize toxic substances.

Americans depend heavily on ground water for drinking and irrigation. Last year, the nation pumped 100 billion gallons of water per day from ground water, a 12% increase over 1980 figures, according to estimates by the American Institute of Professional Geologists. Ground water is the main water supply for drinking and irrigation for 95% of the country's rural households and one-third of the nation's 100 largest cities.

The federal government estimates that roughly 1 to 2% of the nation's ground water is at least moderately polluted by "point sources" alone, such as leaking landfills or hazardous waste dumps. "Although this may seem small, it is significant because contamination is often near heavily populated areas where ground water is being increasingly relied on for a variety of uses," says the Reagan Administration's Council on Environmental Quality in its most recent annual report,* which was published in March. Eugene Patten, chief of ground water branch at the U.S. Geological Survey, says that the extent of the ground water pollution is even greater if agricultural use of chemicals is factored in.



Marjorie Sun

Marion Mlay of EPA *says the current statutes protect ground water and that no new laws are needed.*

Estimates of ground water pollution are based largely on best guesses because there has not been systematic monitoring nationwide, but the pollution is believed to be common because of the wide range of sources. In addition to hazardous dumps, lagoons, and ponds, and agricultural use of pesticides and fertilizers, pollution sources include corroding septic tanks, mining activities, radioactive waste sites, and the deicing of roads with salts. According to the Office of Technology Assessment (OTA), which in 1984 published a lengthy report on ground water quality and protection,† there are gaps in information about potential contamination of private wells and few reliable figures on the number of hazardous waste sites, leaking underground storage tanks, and other polluting sources.

But, the OTA report says, "Despite the paucity of quantitative details, sufficient information is available . . . to justify national action to protect ground water quality." And, the report warns, ground water contamination will likely increase.

"For many ground water supplies, our problems are just beginning," says George Hallberg, chief of the Iowa Geological Survey. Consider these examples:

■ The California Department of Health Services says in a report soon to be released that pollutants in one-fifth of the state's large drinking water wells fed by ground water exceed the state's pollution limits, according to David Storm, head of the survey. Industrial solvents, often potential human carcinogens, are the most common contaminants, especially around Los Angeles and Silicon Valley.

■ According to a March study by the Iowa Department of Water, Air and Waste Management, pesticides and other synthetic chemicals have been detected in half of Iowa's city wells. Nitrate concentrations, due to fertilizer use, have exceeded the federal limits in one-fifth of the private wells in Iowa. Although moderate levels of nitrates are relatively nontoxic, high concentrations can cause acute anemia in infants and set off a chain of events that could result in the formation of *N*-nitrosamines, which are potential human carcinogens.

■ In Florida, where the subsurface of sand and limestone acts like a sieve, more than 1000 wells have been shut down as drinking water sources because they are contaminated with the nematocide EDB (ethylene dibromide), a potential human carcinogen. The average contamination level was 6.5 parts per billion; the state limit on EDB in drinking water is 0.1 ppb. EDB was banned for most uses by the federal government in 1983, but it is still showing up in well samples. The state has appropriated $3 million and Dow Chemical, a former maker of EDB, has contributed about $250,000 to supply potable water to communities that depended on these wells.

For decades, it was widely assumed that ground water was impervious to contamination because soil would bind chemicals and

cleanse water as it percolated through, according to the report by the Council on Environmental Quality. It was also a common belief that pesticides would degrade or volatilize rapidly in the soil. Data on the environmental fate of pesticides were not required by the federal government until pesticide regulations were tightened in 1975.

Susan Sherman, an official at the Environmental Protection Agency in charge of pesticides and ground water protection, says, "There was not a full appreciation of the potential for ground water contamination. We woke up to ground water [problems] a lot later than more obvious pollution problems. For too long people thought nature would take care of itself. We've gotten smarter. It's been an evolution."

According to the OTA report, there is not enough information to rank the importance of the many sources polluting ground water, but hazardous waste dumps and underground storage tanks are regarded as a huge contributor. OTA estimates that billions of gallons of hazardous waste have been disposed at hundreds of landfills and thousands of surface impoundments from coast to coast, and many of these sites are assumed to be leaching toxic substances based on the limited monitoring that has been conducted so far. An investigation by the House Energy and Commerce Committee last year concluded that hazardous waste is infiltrating ground water at half the Superfund sites that conduct monitoring. (The committee found that ground water at many Superfund sites has not been monitored, although sampling is required by law.)

In Florida alone, state authorities in 1979 tallied up 6000 lagoons and ponds filled with toxic waste. "To our dismay," says Rodney DeHan, head of the state's ground water program, 95% of them were unlined and 90% were unmonitored. In fact, he said, some of the sites were designed to percolate. The state initiated a ground water program that year, DeHan says.

Leaking underground storage tanks are also considered a major source of contamination. Most of them were built of steel and buried decades ago, and now they are corroding, says Velma Smith, head of the ground water project at the Environmental Policy Institute in Washington. The Steel Tank Institute estimates that across the nation 350,000 tanks filled with gasoline alone, excluding containers of hazardous waste, will leak during the next 5 years.

In just the past year or two, there has been increasing recognition that pesticides and fertilizers are leaching into aquifers, according to Toby Clark, a senior analyst at the Conservation Foundation in Washington.

USDA

Pesticides and fertilizers *are infiltrating ground water and are increasingly recognized as a major source of pollution. Farming practices might have to be changed.*

According to the OTA report, 260,000 tons of active ingredients in pesticides and 42 million tons of fertilizer are spread annually over the equivalent of 280 million acres across the country. Contamination occurs through conventional application on farmland and an increasingly common method of irrigation called chemigation, in which water is mixed with pesticides. As a result, agricultural practices may have to be modified in many parts of the country where aquifers are especially vulnerable, says Charles Benbrook, staff director of the Board on Agriculture at the National Academy of Sciences which recently released a report on pesticides, and groundwater quality.‡

EPA scientist Stuart Cohen and colleagues in March reported§ that 17 pesticides have now been detected in the ground water of 23 states; the concentrations typically ranged from trace amounts to several hundred parts per billion. Two years ago, the count was 12 pesticides found in 18 states. Agency scientists said that the increase is "significant," and attributed the rise to an increase in the quality and quantity of studies rather than an increase in the problem.

A class of pesticides most commonly found in ground water is nematocides. Cohen says, "Nematocides in general are particularly worrisome; they are designed to be mobile, persistent and toxic. That's a perfect ground water contaminant." EDB, DBCP (1,2-dibromo-3-chloropropane), and aldicarb, which are all nematocides, have been found in ground water.

EDB and DBCP were banned by the federal government after they were discovered in high concentrations in ground water in Florida and California, but aldicarb (also known under the trade name Temik) is still widely used. Aldicarb was banned by New York state in 1982 after it was discovered that the sole aquifer in Long Island, where the soil is primarily limestone and sand, was heavily contaminated with the pesticide. Aldicarb was applied to the area's potato crops.

Now the pesticide is showing up in many other states, and EPA is currently weighing a variety of options to restrict aldicarb's use, according to Michael Branagan of EPA. One plan would limit its application on a county-by-county basis nationwide, depending on the hydrogeology of an area. Any restrictions on aldicarb are sure to be controversial in the agricultural community.

Atrazine, which is one of the most widely used herbicides in the country and is used in the cultivation of corn, is also being detected regularly in ground water, and Cohen of EPA predicts that it will be one of the most common pesticides to be detected in ground water. But Cohen says, "There aren't enough data to say whether it's clean or not. Ciba-Geigy, the main manufacturer of atrazine, has contended that the concentrations found so far are innocuous.

In addition to agricultural use of pesticides, fertilizers are polluting ground water. Nitrate pollution "is likely [to be found] throughout the Corn Belt," says Hallberg, Iowa's chief geologist. Contamination in Iowa poses particular concern because three-quarters of the population relies on ground water for drinking. Two years ago, 40 public water sources in Iowa fed by ground water exceeded the federal standard for nitrates, including the ground water for Des Moines. Hallberg says that farmers are applying far more fertilizer than the crops are taking up and the excess nitrogen is leaching into shallow aquifers. Cutbacks in fertilizer

application would be a logical way to prevent more contamination and save money, he says. But growers, faced with dire financial problems, keep heaping on the fertilizers, hoping to improve their yields, he says.

States and different branches of the federal government have been debating for the past several years ways to protect ground water, but have yet to agree on a broad plan. They have not yet resolved several fundamental issues, including what roles each should play and whether a national goal should be set. The issues have been difficult to grapple with because of the vast array of polluting sources and because ground water pollution involves a complex set of environmental and geological factors and politically sensitive issues of land use and large expenditures of money for activities such as monitoring and research.

EPA asserts it can adequately protect ground water under current statutes and that no new laws are needed. The agency manages ground water problems based on a game plan issued in 1984 called the "Groundwater Protection Strategy." Marion Mlay, director of EPA's ground water program, acknowledges that the task is complex. "It is extremely difficult to coordinate an agency this size" to protect ground water, she says.

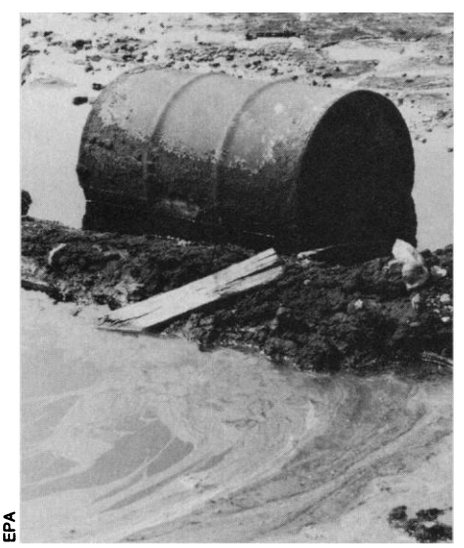
But many leaders from industry, environmental groups, and state government said last November in a forum sponsored by the Conservation Foundation‖ that present laws are "a regulatory patchwork" that "provides inadequate protection and largely fails to address directly the complex technical, economic, and political demands of ground water management." Other sources have given EPA low marks for enforcing present laws to protect ground water:

■ The General Accounting Office in May released a report that cited lengthy delays—up to 2 years—in cleanups at Superfund sites. The auditing agency faulted EPA and other parties responsible for cleanup, such as companies or state governments, and said that the delays jeopardize ground water, which in some cases is relied upon for potable water. And, according to an investigation last year by the House Energy and Commerce Committee, ground water is not being monitored at many federally approved hazardous waste sites as required by law.

■ In May, Congress, frustrated with EPA's slowness in setting safe drinking water standards, passed legislation that would speed up the establishment of limits on hazardous substances in ground water. Since 1974, the agency on its own has not established any new standards. There are currently formal limits on only 38 chemicals out of more than 200 that have been detected in ground water.

■ Big agricultural chemical manufacturers and a coalition of activist groups say that EPA needs more statutory clout to regulate pesticides that are detected in ground water. Mlay says that EPA can try to restrict the application of agricultural chemicals through labeling, but concedes that "enforcement is difficult. EPA depends on the good senses of people applying it." The National Agricultural Chemicals Association and the coalition together in May proposed amendments to the current pesticide law that would require EPA to expedite agency action on pesticides for which there are already limits and the establishment of standards for other pesticides once they are detected in ground water.

■ The OTA report notes that significant sources of pollution fall beyond EPA's regulatory reach, such as leaking underground storage and septic tanks.



EPA

Hazardous waste, *billions of gallons of it, have been disposed at hundreds of landfills across the nation, and many sites are assumed to be leaching.*

According to a GAO survey,¶ states want EPA to provide money for protection programs and to speed up standard setting for drinking water. Last year, EPA spent only $7 million in grants to help states develop their own programs. So, with increasing evidence of aquifer contamination, some states have taken regulatory matters into their own hands because they are tired of waiting for federal action.

Victoria Tschinkel, secretary of the Department of Environmental Regulation in Florida, and officials from other states express impatience with EPA and the federal government. Tschinkel says, "Without a national goal, other states won't do anything. A federal program would take pressure off the states to fight locally for ground water legislation." Hallberg, chief of Iowa's Geological Survey, remarks, "EPA has an important role to play in setting standards . . . because there is a need for uniformity. We don't have the time or expertise to make judgments. It's a very complicated task."

Tschinkel adds that EPA should conduct much more research on projects for which the states do not have the money or expertise. She suggests, for instance, that EPA should more vigorously develop computer software to model aquifers. According to a report last July by EPA's science advisory board on ground water research, the agency should greatly expand its ground water research in general, although it did not offer a precise figure. EPA last year spent $18 million on ground water research.

While states argue for more aid, they generally do not want the federal government to establish prescriptive goals. Tschinkel says, "we're not excited about a detailed federal program." States have two main concerns: those that already have started ground water programs fear that a federal program would undermine their achievements; and, states in general are passionately opposed to federal action that would infringe their land use rights.

Joan Harn of the Office of Technology Assessment says that "a little message from Congress could go a long way to get [other] states to act. A federal program needs flexibility and, at the same time, must be perceived by states to be a strong mandate" so they are compelled to develop programs. "It's a difficult balance."

The problems in formulating a national policy are illustrated well by a recent fight in Congress over a provision in the Safe Drinking Water Act, which Congress reauthorized in May. As originally passed by the House, the bill would have protected ground water based on current and potential use as a public drinking water well. The provision barred contamination within a zone around current or future wellheads.

But Senate legislators argued in conference that the measure, by mandating protection of well water based on its future use, intruded on states' rights because it indirectly would require extensive land use planning. Especially vociferous were Senate conservatives from the West, who traditionally have been the strongest opponents of federal law that could disrupt established water rights in their regions. They argued that states would have to project, for example, whether a chemical company eventually could site a plant over ground water that is not now used for drinking water.

Another conferee, Senator Dave Durenberger (R–MN), who is chairman of the toxic substances oversight subcommittee,

had different objections to the measure. Durenberger, who favors a bigger federal role in preventing ground water contamination and has talked about introducing ground water legislation in the future, argued that the House provision did not establish clear minimum standards of protection. The legislation merely says that well water should be protected from contaminants that are hazardous to human health, but leaves it to the states to set limits.

The fight over the provision threatened to tie up the whole bill. Then, after several months of negotiation, House and Senate conferees reached a compromise that only affords ground water limited protection, according to staff aides from both chambers. House legislators agreed to drop the language regarding future use of ground water. And, "it was never resolved what 'contaminants' should mean," an aide to Durenberger's subcommittee says. Although the wellhead protection plan would require states to develop their own strategy to protect public wells, the penalty is mild if they do not.

In the wake of the battle, one Senate subcommittee aide remarked, "We came away feeling that federal ground water legislation was impossible." Another staff member acknowledges the difficulties in crafting federal ground water legislation, but adds, "It's doable. We just have to find the right incentives," such as money for federal programs.

Congress probably will not consider any major ground water legislation before this session ends. A ground water bill was introduced last fall in the Senate, but hasn't gone anywhere. Legislators who would have jurisdiction over ground water issues have been devoting most of their attention to the reauthorization of Superfund this year, which still has not been settled. As a practical matter, any ground water legislation on the House side would have to pass through five committees. An aide to Durenberger says the next session might be the right time to introduce a bill. When Congress gets around to it, ground water protection may be one of the toughest national environmental issues that federal legislators, states, and EPA have faced yet. ■ **MARJORIE SUN**

**Environmental Quality*: 15th Annual Report of the Council on Environmental Quality, 1986.
†*Protecting the Nation's Groundwater from Contamination,* Office of Technology Assessment, 1984.
‡P. Holden, *Pesticides and Groundwater Quality,* National Academy Press, 1986.
§S. Z. Cohen, C. Eiden, M. N. Lorber, "Monitoring ground water for pesticides in the U.S.A.," American Chemical Society Symposium Series, in press.
‖*Groundwater: Saving the Unseen Resource,* The National Groundwater Policy Forum sponsored by the Conservation Foundation, 1985.
¶*Hazardous Waste: Responsible Party Clean Up Efforts Require Improved Oversight*, General Accounting Office, May 1986.

GAO Blasts Bigeye Chemical Weapon

A new study says that technical problems and inconsistencies in test results indicate that the bomb should not be produced

FOR nearly a quarter-century, the Department of Defense has been working to develop a persistent, highly toxic chemical weapon that could be safely delivered by aircraft far behind enemy lines. After spending roughly $75 million, it now believes that the item is in hand, and that Congress should approve the initial production of a chemical bomb widely known as the Bigeye.

Until 10 June, the Bigeye's prospects on Capitol Hill looked fairly good. An energetic lobbying effort was undertaken to convince legislators that the Bigeye's technical bugs have finally been eradicated. That morning, however, the proposal ran into a buzz saw in the form of Eleanor Chelimsky, the director of the program and evaluation division of the General Accounting Office (GAO).

Reporting on the results of a lengthy, independent Bigeye review, Chelimsky said that tests of the bomb "present major and continuing inconsistencies," that significant test data have not been collected, and that several technical repairs had created new "constraints and uncertainties," some of which may be intractable. As a result, she said, "the GAO believes that the bomb is not ready for production" and suggests that the Bigeye be shunted aside in favor of a new bomb, as yet undeveloped.

Although the GAO analysis does not specifically challenge the need for a new long-range chemical weapon, it provides considerable fodder for those who do. The report was released at a press conference called by several of the program's strongest opponents, including Representative Dante Fascell (D–FL), chairman of the House Foreign Affairs Committee, and Senator Mark Hatfield (R–OR), chairman of the Senate Appropriations Committee. "The only reliable bombshell we have today is this report by the GAO," Fascell said. "The evidence is overwhelming: the Bigeye bomb is a persistent failure with no reasonable prospect of it ever working properly or safely."

Some of the data in the new report were released last October, immediately creating a fierce debate between Chelimsky and Donald Hicks, the under secretary of defense for research and engineering (*Science*, 15 November 1985, p. 784). Since then, the GAO has not only refused to back down, but added substantially to its list of complaints about the program and its management. Details of various tests, as well as a substantial portion of the GAO's comments, have been excised from the unclassified version of the study, complicating an assessment of the debate. But a few themes are apparent.

One is that the Bigeye tests conducted thus far are inadequate. A so-called "binary," the bomb consists of two compartments filled with nonlethal chemicals, which combine in flight to produce a deadly nerve agent. As such, proper mixing is considered essential. Yet, out of 41 mixing tests, only a dozen replicated the conditions likely to be experienced in battle, and of these, only a few generated results that met DOD's minimum stated requirement, the report indicates.

Part of the problem is that mixing creates enormous pressure inside the bomb, a phenomenon that the Pentagon first learned about in 1966 and acted on in 1982, when a shell exploded during a test. Since then, most of the bombs have been vented during critical tests in order to prevent another explosion. Unfortunately, GAO says, none of the bombs to be produced for actual combat will have such vents, and some could explode prematurely as a result. The risk is not to the planes or pilots that will transport the Bigeye, as the mixing sequence will not begin until after the bombs are released. It is instead that an explosion would cause the bomb "to be rendered useless," the GAO says.

Similarly, the report complains, no tests were performed to determine the likelihood of another potential failure scenario caused by a phenomenon known as flashing. This would occur when a small explosion at the cap of the bomb, generated to facilitate the nerve agent's dissemination, instead causes it to catch fire and fall harmlessly to the ground. "GAO believes the likelihood of flashing in Bigeye is speculative, but *a very important issue to address*," the report says.

GAO is also critical of the fact that, since the decision in 1961 to use the binary method, no tests have been performed of the