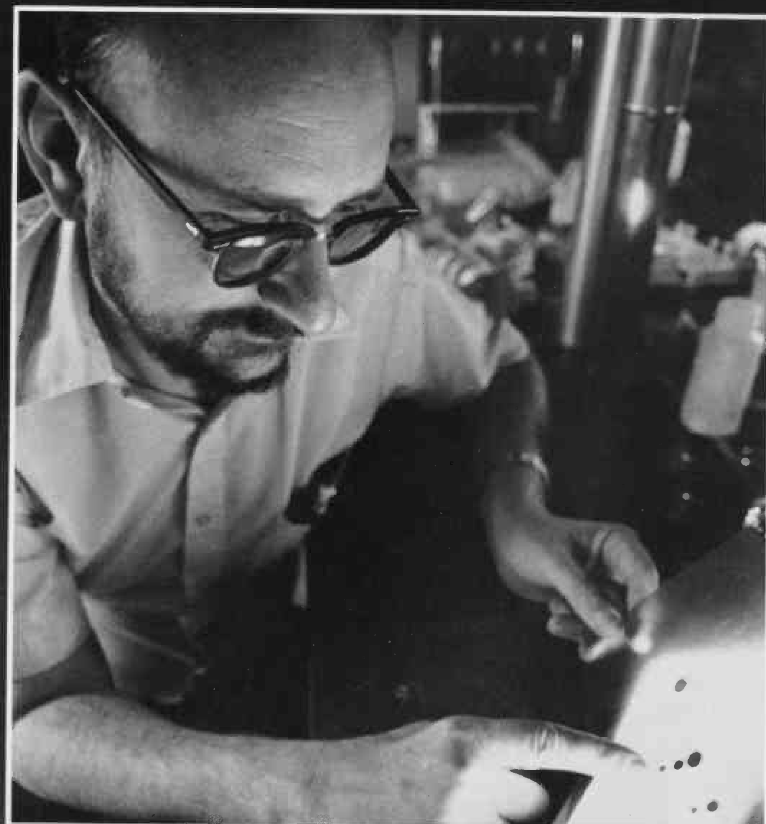
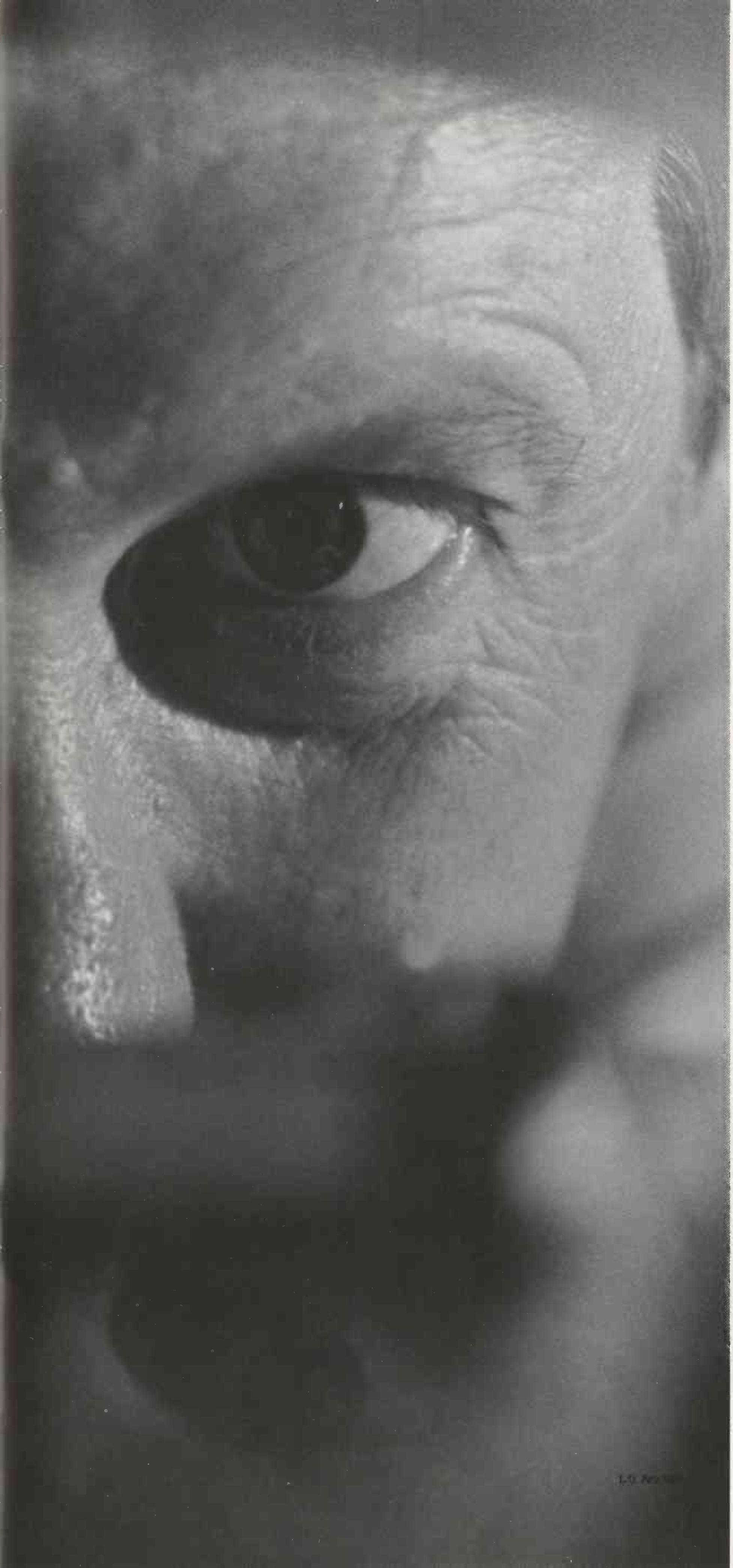


WATER QUALITY WATCHDOGS

by Lorraine B. Kingdon

UA environmental microbiologist Dr. Charles Gerba (inset) and UA veterinary parasitologist Dr. Charles Sterling are developing ways to quickly detect harmful waterborne viruses and parasites.



Bacteria and viruses contaminating the water pose a thousand times greater danger to your health than do any other contaminants, including chemicals.

UA environmental microbiologist Dr. Charles Gerba can prove that rather startling statement. He's tested water—wastewater, drinking water, well water, water in rivers and streams—in Arizona, all over the United States and in many other parts of the world.

Outbreaks of waterborne diseases are increasing in this country; an average of 40 outbreaks are reported every year. That's just the tip of the iceberg, Gerba believes. "Most cases are never reported because people usually get over the diarrhea without going to the doctor." Viral contamination causes 65 percent of those outbreaks.

The water treatments that routinely control bacteria don't efficiently remove enteroviruses. Nor is the presence or absence of bacteria in the water correlated with that of viruses. Unfortunately, an extremely low level of viral contamination can be an infectious dose and cause disease problems.

Gerba found that 20 percent of the ground water samples he tested were contaminated with viruses. And, he says, viral contamination may be more common than expected, particularly in rural areas.

Poorly placed septic tanks are the primary villain; septic tanks should not be used when the ground water table is too high or if there isn't enough soil for water to percolate effectively. Gerba has developed a computer model for microcomputers that will predict the safe distance between a well and a septic tank.

Currently, Arizona is the only state that sets standards for allowable levels of viral contamination in wastewater. If the water is used to irrigate food crops, only one virus per 40 liters (approximately 40 quarts) is allowed. For recreational use—to irrigate golf courses, for example—the state standard is 125 virus per 40 liters of wastewater, Gerba says.

Nationally, the Environmental Protection Agency (EPA) recently established zero level for virus in drinking water. In the future, water supplied for drinking will have to be disinfected or the water company will have to prove that viruses are not present.

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Gerba believes no one really has a good idea how many people are being exposed to viral contamination in their drinking water. Tests weren't being done, and people thought conventional water treatments were getting rid of any viral contamination.

By the way, substituting bottled water or drinking mineral water isn't necessarily any safer than water from the tap. In the U.S., bottled water doesn't have to meet the same standards as drinking water from the faucet. Gerba says bacteria can grow to fairly high levels in either bottled or mineral waters. The EPA is working on standards, both for bacterial and viral contamination.

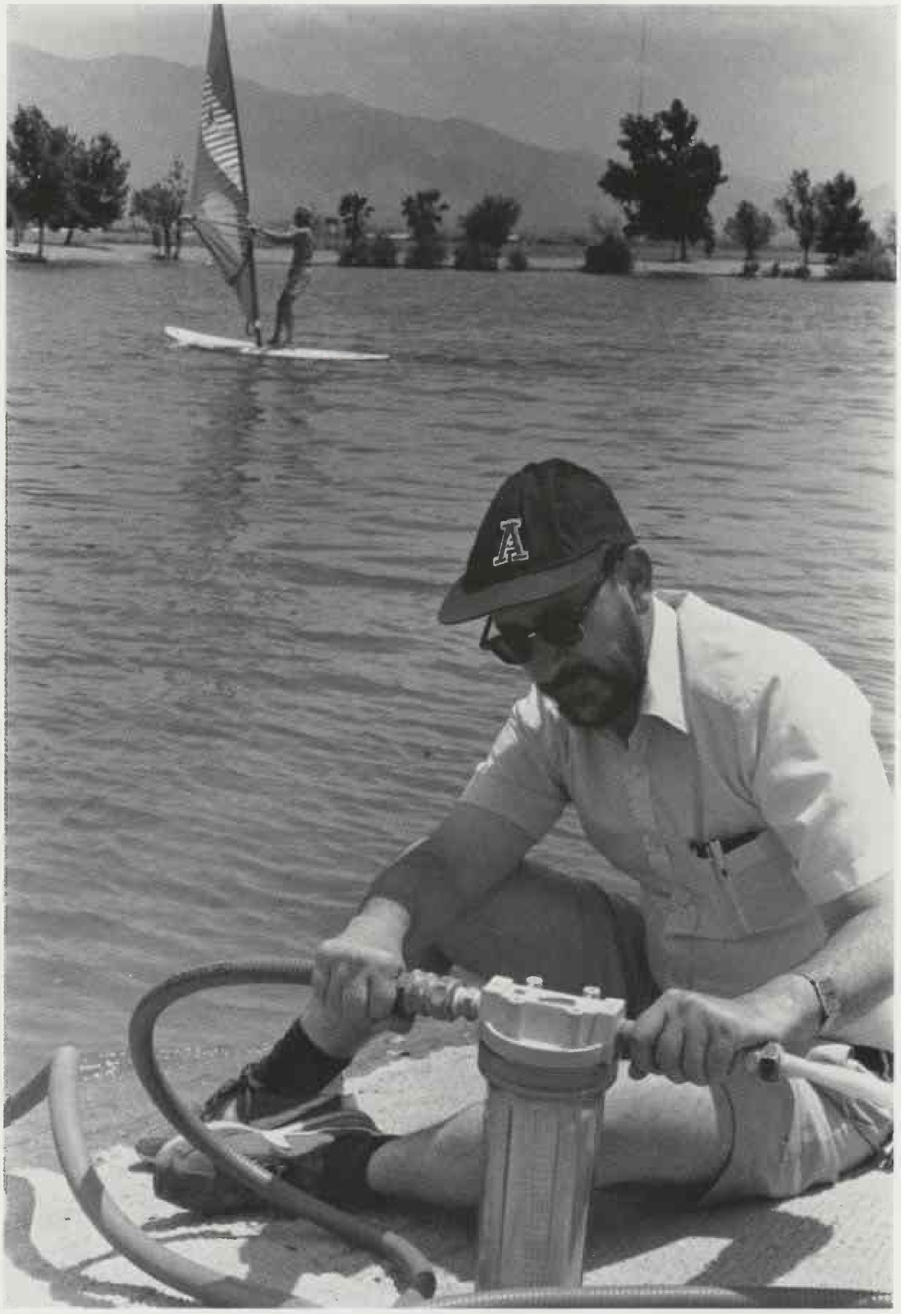
Until very recently, testing for viruses in water has been a tedious, expensive process. Using the standard cell culture tests takes a minimum of two weeks; only one kind of virus can be tested for each time; the price ranges from $300 to $2,000.

Gerba has developed a gene probe test that is so sensitive it can detect one virus particle in 1,000 liters of water—phenomenal accuracy. Test results are available within 48 hours; it's possible to test for more than 70 different viruses at one time; the cost of the gene probe probably will eventually be less than $100 per test, Gerba says.

He labels pieces of nucleic acid either radioactively or by an enzyme; the labeled pieces, or probes, are complementary to the viral nucleic acid. The virus is exposed to the probe which hybridizes with the labeled piece of nucleic acid.

At that point, Gerba exposes the sample to film if the probe is radioactive. The labeled virus shows up as a black spot. Viruses change colors on the filter if an enzyme probe is being used.

The water-testing laboratory at the UA is monitoring effluent from 12 Arizona communities; all the effluent meets the state standards, Gerba says. Often, the water is considerably purer. For example, water going to irrigate La Paloma's golf course in Tucson usually tests at



Dr. Charles Gerba tests not only drinking water, but water used for recreation. Here he takes a sample from Tucson's Silverbell Lake.

one or two virus per 400 liters. At a minimum, treatment plants must have the effluent tested twice a year; however, Tucson monitors on a monthly basis.

Approximately 100 sites in Arizona currently reuse water for irrigation and "non-contact" recreation, such as boating and fishing. Phoenix is doing a feasibility study of using treated wastewater for domestic purposes. Los Angeles, Denver and El Paso, Texas, already reuse carefully—and expensively—treated effluent for drinking water.

"By the time the treated water is ready for drinking, it's probably better water than most people in most cities get," Gerba comments.

In southern Arizona, you have another factor working to keep your drinking water safe. High temperatures. So don't complain when water straight from the faucet seems lukewarm even in winter. Higher temperatures in ground water kill viruses more effectively than any other factor, Gerba says.

He compared ground water samples from sites throughout the United States in a research project conducted for the EPA. He studied water acidity, nitrate and sulphate chemical content, mineral content and water temperature. When he related these conditions to virus survival, he found that water temperature had the strongest effect.

He explains, "Ground water is usually at the mean annual average temperature. In the Tucson aquifer, for example, the water is around 76 degrees." Knowing the temperature of the ground water and the rate it flows through the ground, Gerba can predict the distance the water can travel before disease-causing viruses are killed. This is the basis for the already-mentioned computer model that gives safe distances between drinking water wells and septic tanks.

A California study tracked survival rates of viruses on selected crops irrigated with treated wastewater. During May, June and July, two or three days were all that were needed for a 90 percent reduction in the number of virus present. However, in the cooler months of April and October, up to four days were required for the same reduction in viral numbers.

Other studies show that viruses survive for shorter periods of time on grass—eight hours, or less, in summertime temperatures between 86 and 100 degrees. Naturally, in the winter, viruses survive longer. These survival times become increasingly important as more treated effluent is used.

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Within ten years, so-called grey water will probably be recycled to a much greater extent to irrigate home lawns and gardens. Grey water is wastewater saved from bathroom sinks, baths, showers, laundry and dishwashers. A family of four may produce 1,300 gallons of grey water in only one week; using that water over again is one of the few options homeowners have to conserve water after they've desert-landscaped their yards.

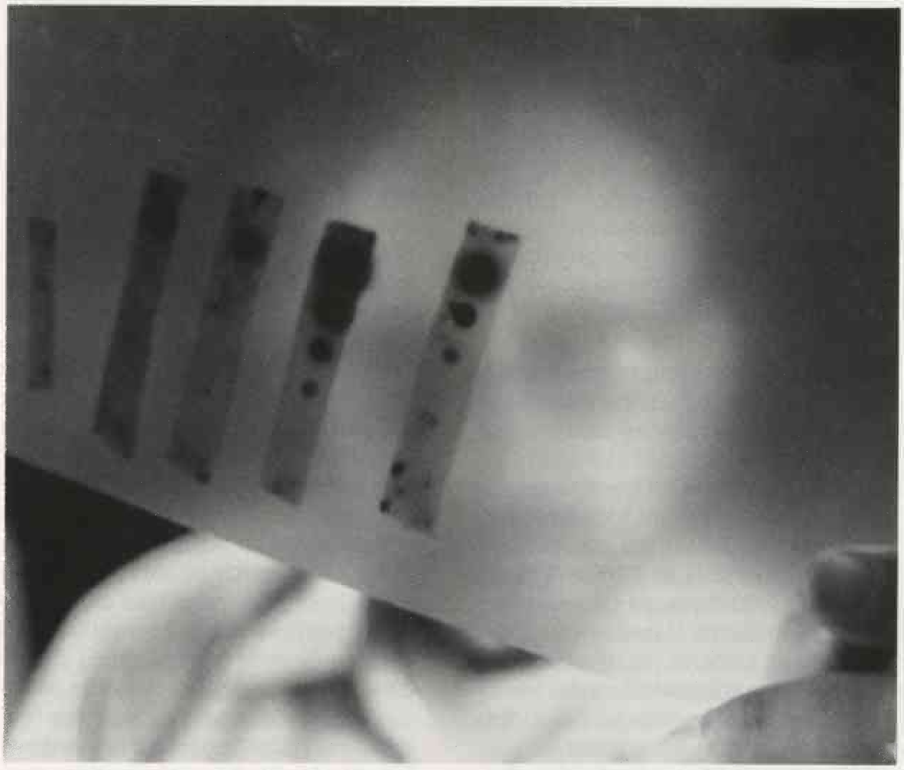
An intensive study by Gerba of the growth and survival of microorganisms in grey water showed that it could safely be used for underground drip irrigation on lawns and flower gardens. Other uses, such as surface irrigation, would require chlorination, or some other type of disinfection, before the grey water would meet state standards.

Of course, that assumes the treatment system is as effective as the one being used at the experimental conservation house at Casa del Agua, 4366 Stanley Place, Tucson. The grey water is collected in a sump, passes through two tanks containing water-purifying water hyacinths and through sand filters. The hyacinths use organic matter and bacteria as food, reducing contaminant levels by 99 percent. The sand filters take out more bacteria and reduce turbidity. By this time, bacterial levels are cut 99.9 percent from when the water was collected.

Gerba also compared microorganisms in water after it had been used in other locations by six families in Tucson. The families were an older couple, two young couples and three families with young children. The total bacterial count was not significantly different among the households. However, the kind of bacteria he found in the water varied with the number and ages of the children, what kinds of diapers were used and the kinds of activities engaged in, such as gardening.

Before treatment, grey water could contain bacteria that would present a public health hazard if reused at that point. He was particularly concerned about the hazard if someone were ill in the house.

Viral contamination of grey water could be high, he believes. "They are very resistant to detergents and soaps and even to disinfectants." Indirect contact with the wastewater through contaminated surfaces or plants might transmit the viruses and possibly cause disease problems.



L.G. Ketchum

With Gerba's "super sensitive" gene probe test, a waterborne virus shows up as a black spot on X-ray film.

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Let's complicate the issue of safe water a little more. Bacteria and viruses aren't the only organisms that cause problems; don't forget parasites. Giardia, cryptosporidium (crypto) and E. histolytica are three disease-causing parasites commonly found in water. Just how common they are is still unknown, but Gerba has started surveying the surface water for the three contaminants at 100 sites across the United States.

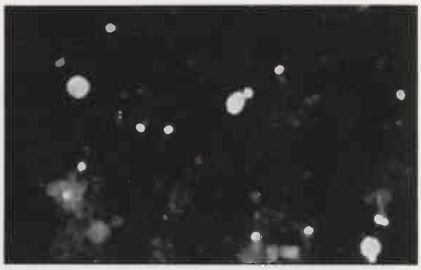
His job is made a great deal easier because Dr. Charles Sterling, UA veterinary parasitologist, has developed highly sensitive tests for crypto and giardia. The tests have federal Food and Drug Administration approval and are commercially available.

The test for crypto, for example, takes only 30 minutes to prove the presence of the parasite in water or fecal samples. Sterling uses monoclonal antibodies that recognize antigens from the crypto parasite. The antibodies are bound with a chemical that produces fluorescence, which shows up dramatically under a microscope.

Sterling has tested water samples for crypto from many locations in Arizona. The parasite turned up in samples of surface water from the Oak Creek Canyon resort area, the San Pedro River and from the confluence of the Salt and Verde Rivers, which feed the Phoenix water supply. Since Tucson's city water system relies on deep wells, parasites in drinking water should not be a problem. Also, the sophisticated water filtration treatments used in many communities should reduce crypto contamination, Sterling believes.

Most water-borne incidents of crypto infections have been in smaller towns served by surface water that is only treated with chlorine; this common water disinfectant is not effective against parasites. When Sterling used his diagnostic test in Peru, he discovered he could even detect crypto in houseflies. Unfortunately, the flies may be able to transfer the crypto-caused disease to animals or humans.

Crypto can be a serious problem. In humans, this parasite can cause severe nausea and diarrhea lasting from one to three weeks. Crypto is the major cause of severe diarrhea for people with acquired immune deficiency syndrome (AIDS); it attacks a large percentage of AIDS victims. The U.S. Center for Disease Control, Atlanta, has reported that the parasite is an increasing problem for young children, particularly youngsters in day-care centers—where the disease can spread quickly.



With the aid of microscope, Dr. Charles Sterling views the parasites giardia and cryptosporidium (crypto). Using Sterling's FDA approved test, the disease-causing parasites become glowing fluorescent spots under a microscope.

The disease has no known cure. Therefore, diagnosing crypto is especially important so people can take supportive therapy instead of wasting time on ineffective drugs.

Crypto also is one of the causes of a serious disease that is widespread in dairy calves. Calf scours results in an annual loss of at least $200 million to the cattle industry, says UA extension livestock specialist Al Lane.

The living bacteria, viruses and parasites that may contaminate water sometimes present a serious problem. Yet, many people worry more about the possibility of pesticide contamination. Current Arizona law calls for regulating pesticides according to the way they move through the soil and, presumably, then into the water table underground.

Pesticide contamination of underground water is very complicated, says Dr. Jack Watson, UA water quality specialist. For example, EDB and DBCP are pesticides that move as quickly through the soil as the water itself. However, other pest control chemicals stick to the soil particles or may break down into less hazardous chemicals.

Watson checked the concentration of a test chemical, nitrogen (a common fertilizer) in the ground under a field drip-irrigated with only 60 percent of the estimated water needs of the crop. He compared that concentration with the amount of nitrogen in the soil under a field drip-irrigated with 100 percent of the estimated water needed.

Interestingly, the level of nitrogen found in the field with lower water use was five times as high as in the other field, using the kind of monitoring required by Arizona law. Watson emphasizes that, in this case, the monitoring process does not accurately reflect the potential ground water contamination.

The type of irrigation system makes a difference in pesticide movement into the soil, too. Some water moves vertically, and some laterally, away from a drip system. When farmers use furrow irrigation, however, most of the water moves directly downward into the soil.

Complicated enough? There's more. The real movement of chemicals below the plant root zone into the water table depends on the irrigation efficiency, the amount of chemicals used, the type of soil, and how long it's been since water was applied.

Watson used nitrogen as a test chemical in his research; he says his findings apply to organic pesticides as well; organic pesticides are, by far, the most commonly used insect-fighting chemicals. Organics would probably move more slowly through the soil than the nitrogen. Also, they might break down into simpler, less contaminating compounds.