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SCIENCE

Groundwater Contamination

Nearly 50 percent of the people of the United States are dependent on groundwater for their supplies of drinking water. Both nature and humans act to contaminate this essential resource, and public concern about its quality has been building. Recently, two publications* have appeared that describe the extent of such pollution, indicate scientific considerations, outline steps to be taken, and note laws bearing on the matter.

The sources of pollution are many, and they differ from place to place. Industrial wastes have received most of the publicity, but other sources are of comparable importance. Agriculturally related contamination in the western United States is extensive and is likely to become increasingly serious. Municipal landfills let loose a complex collection of pollutants. Effluents from septic tanks on Long Island contaminate the drinking water of some of the 3 million people living there.

The total effect from all sources is to pollute badly about 1 percent of the aquifers. Because many of these aquifers are close to large population centers, the impact is disproportionately large.

The various contaminants interact with the background environment in different ways. In the aerobic zone, bacteria oxidize many of the organic constituents. But, in general, hydrocarbons are not metabolized under anaerobic conditions. In contrast, chlorinated organic compounds seem to be more likely to be attacked in anaerobic environments than under aerobic ones; chlorine atoms are removed.

The underground environment has considerable binding tendencies. For example, where present, zeolite compounds have an ion exchange binding capacity that is effective in holding cationic forms of toxic heavy elements. Most sedimentary horizons contain some organic matter to which hydrophobic organic molecules tend to be adsorbed. Thus, depending on the path that groundwater traverses, some of its contaminants may be removed.

The rate of motion of the fluid is related to the permeability of the material through which it flows. A typical rate is about a foot per day. However, differences in permeability of 15 orders of magnitude have been noted. In general, the deeper the horizon, the less the permeability. Motion in a fine-grained material like clay is much slower than in a coarse-grained sand.

Most drinking water comes from wells that are less than 100 meters deep. Thus in some areas, waste fluids with a density greater than 1.0 could be safely injected if emplaced below 100 meters. An even more secure disposal area is in the arid Basin and Range country of the West. In that region there are basins that have no outflow.

One of the lessons of the past is that careless disposal of wastes can lead to problems that cost billions of dollars to correct. An obvious method of avoiding future additional groundwater problems would be to stop pouring wastes into the ground. For example, combustion of organic wastes would change them to simple products. Proper design of waste lagoons can guarantee that little of toxic substances escape to the environment.

The two publications make it clear that we are only at the beginning of gaining knowledge about underground transformations of substances and about the motions of their carrying fluids. New, sensitive analytical instrumentation will be crucial in identification and quantification of migrating species. Laboratory development of bacteria with metabolic capabilities for wastes may prove helpful. Mapping of the underground aquifers should make it possible to protect our sources of potable water.

The rate of contamination of groundwater appears to have slowed but residuals from earlier carelessness remain. Ultimately we must move toward improved methods of dealing with waste problems. Better knowledge of the underground environment will be an essential element in that progress.—PHILIP H. ABELSON.

*V. I. Pye, R. Patrick, J. Quarles, *Groundwater Contamination in the United States* (University of Pennsylvania Press, Philadelphia, 1983); Geophysics Research Forum, *Studies in Geophysics: Groundwater Contamination* (National Academy Press, Washington, D.C., 1984).