Unexpected Leakage Through Landfill Liners

For years, the standard way to dispose of hazardous chemicals was to bury them in landfills. Intended as permanent resting places, most of these graves incorporated a bathtub-shaped liner of compacted clay to keep water — and buried toxic wastes — from escaping. While clay does limit water leaks fairly well, new field research shows it fails to block the major route by which many toxic chemicals, such as organic solvents, escape.

The researchers say this finding carries grave implications not only for the safety of hazardous-waste landfills begun prior to 1985, but also for the adequacy of current techniques of containing landfill leaks and toxic chemicals spilled on land.

Water provides the two primary means by which pollutants move from landfills. Through a "vehicular" pathway, water can carry dissolved wastes as it flows from areas of high pressure, such as pools collected on the inside of a landfill, to regions of low pressure, such as drier soils underneath. A second pathway uses water quite differently — as a potentially fixed "conduit" through which dissolved contaminants "diffuse" from regions where their concentrations are higher to areas where they are lower.

Today, notes Richard Johnson, an environmental scientist at the Oregon Graduate Center in Beaverton, engineers work at controlling the vehicular pathway only. Until recently, the standard approach was to line landfills with "impermeable" clay barriers — ones designed to leak no more than 89 gallons of water per acre daily, according to Environmental Protection Agency (EPA) engineer Kenneth Skahn of Washington, D.C. Diffusion control was all but ignored, Skahn says, because of a prevailing attitude that "diffusion really will never be much of a factor" in landfill leaks. Unfortunately, Johnson says, this attitude fostered a false sense of security.

Johnson's research, reported in the March ENVIRONMENTAL SCIENCE AND TECHNOLOGY, shows significant toxic-chemical diffusion into the barrier of a five-year-old, clay-lined hazardous-waste landfill in Sarnia, Ontario. As expected, there was wide variability in contaminant mobility, with the most water-soluble pollutants moving fastest. Chloride ions, for example, had penetrated about 28 inches into the clay floor. Less water-soluble organic chemicals spent more of their time preferentially clinging to carbon in the clay. Acetone and ketones, among the more water soluble of these organics, traveled only about 5 inches — three to 20 times farther than would be expected for far less soluble solvents, like benzene and toluene.

Owing to the unusual depth of this landfill's natural clay floor — about 130 feet — no contaminant broke through this barrier. However, Johnson says, if the clay's thickness had been more typical of hazardous-waste landfills — perhaps 3 feet — his data suggest the more mobile contaminants might have broken through in just five years, and slower ones, like benzene, in 70 years.

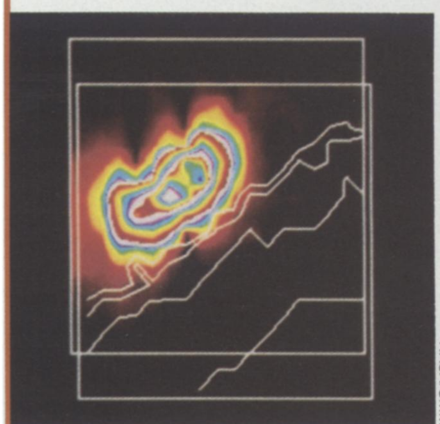
So closely do these field data mirror theory, Johnson says, "that if I know what a contaminant's solubility is, and the [barrier's] organic carbon content, I can now predict how fast a chemical will [diffuse through]."

Comments Donald H. Gray, a civil engineer at the University of Michigan in Ann Arbor, "There are important implications here for the design and construction of containment envelopes around hazardous-waste landfills." The new findings show that once water permeability is well controlled, diffusion becomes the dominant exit route for interred wastes.

Since 1985, EPA has banned landfilling of solvents — like benzene — and required that new hazardous-waste landfills use multiple barriers of clay and synthetic materials. Less water-permeable than clay, plastics also provide a major barrier to diffusion. Thus, Johnson says, the real concern is with landfills built before 1985. EPA's Robert Landreth says agency officials don't know how many U.S. hazardous-waste landfills rely on clay barriers, but a good guess might be "more than 10 and less than 50." Johnson says a more likely estimate is "at least hundreds."

The new findings are relevant also to current containment efforts, says Walter Weber, a colleague of Gray's at the University of Michigan. Today, engineers commonly cordon off chemical spills in soil and leaking landfills by digging a thick trench around them, preferably down to a natural clay deposit, and filling the trench with a slurry of clay and soil. Once it hardens, the slurry wall becomes relatively impermeable to water. However, this barrier — often the only one surrounding the toxic chemicals — offers little protection from diffusion, Weber notes. So he and Gray are studying ways to increase its carbon content — currently by incorporating fly ash — to slow the diffusion of trapped organics. — *J. Raloff*

Solar Max snaps a big, brilliant flare



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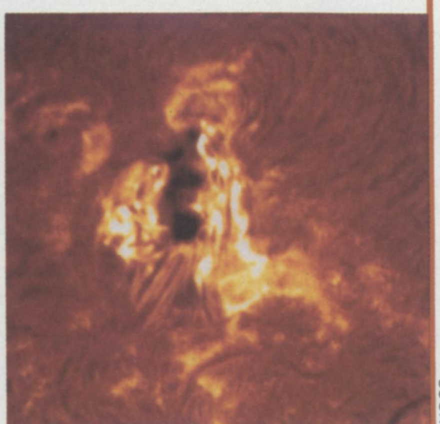

SOON

On March 6, a giant solar flare, one of the largest of the last decade, erupted from the sun's eastern edge. An X-ray detector on NASA's Solar Maximum Mission satellite managed to capture images of the flare at its peak. The computer-processed image (left) shows the intensity of X-rays at a wavelength of 1.85 angstroms, which represents radiation emitted by iron atoms stripped of all but two electrons. Such X-rays are detectable only when a solar flare erupts. The temperature within the flare's hot plasma exceeded 10 million kelvins, contrasting with the balmier 3-million-kelvin temperatures typically observed in the sun's corona. The jagged white lines mark the sun's edge.

The flare erupted from a large cluster of sunspots, which remained visible for about two weeks as the sun rotated on its axis. The sunspot image (right) from the Solar Optical Observing Network station in Holloman, N.M., shows the cluster on March 9, when it was farther from the sun's edge. By the time the cluster directly faced Earth, researchers had observed seven large, or "X," flares and many smaller ones. However, none of these later flares matched the intensity of the first one, rated near the top of the scale at X15.