Environment

Groundwater cleanup—the bad news

Toxic chemicals pollute groundwater—which provides more than 50 percent of U.S. drinking water—at some 300,000 to 400,000 sites. The public has generally responded to this threat by demanding that the tainted water be restored to drinking-water quality, observes Michael C. Kavanaugh of ENVIRON Corp. in Emeryville, Calif. But at many sites, that may be unreasonable, according to an expert panel he headed for the National Academy of Sciences.

The most common approach to cleaning groundwater involves temporarily pumping it to the surface, where it can pass through a decontamination system. Such pump-and-treat systems have been employed at about 75 percent of the perhaps 4,000 sites where cleanup has gotten under way. But with no evaluation of this technology's efficacy, U.S. reliance on it has amounted to "a large-scale national testing program," Kavanaugh says.

His panel's review of data on 77 pump-and-treat locations concludes that sometimes—owing to the geology, degree of contamination, mix of pollutants present, and comprehensiveness of the subsurface terrain's mapping—the process may prove unable to achieve drinking-water-quality cleanup, even if employed continuously for 50 to 1,000 years. Particularly troublesome are spills involving dense liquids that are fairly insoluble in water, such as trichloroethylene.

If full cleanup isn't possible, the panel says in a new report, settling at the outset for 80 percent restoration may allow cleanup to begin sooner—thereby limiting pollution's spread and saving precious resources for places where they might be better used. The panel also argues that pollution containment may be an acceptable interim goal where full cleanup is not possible—until improved technologies are available.

Finally, those responsible for the most intractable spills could ante up an annual "infeasibility fee" to pay for the development and on-site testing of innovative cleanup technologies, the panel says. Such fees also might finance expert panels to help government agencies identify and evaluate the best cleanup options for the sites they regulate.

When offshore wells shut down

As of last December, 3,800 oil and gas platforms dotted U.S. coastal waters. By law, when such wells cease to produce economical quantities of fuel, their owners must plug them and clear the site in a manner that will prevent unreasonable harm to marine life. But a new report by the General Accounting Office (GAO) charges that the federal government should do more to police well plugging and the safe removal of rigs.

In the last 2 years, 343 offshore wells have been removed, usually with underwater explosives. Though the blasts have a reputation for being better than arc cutters or mechanical cutters, they kill nearby fish and marine mammals. With cutters, by contrast, damage to marine life may be all but nonexistent, GAO reports. Moreover, the congressional agency adds, some oil companies find cutters as effective as blasting.

Though the Minerals Management Service (MMS) regulates oil companies to limit marine damage, it "has not adequately studied the costs and benefits of nonexplosive technologies nor taken actions to encourage their use," GAO says. Indeed, GAO found, some MMS actions may encourage the use of explosives.

Moreover, GAO notes, lacking the inspectors needed to police all wells, MMS relies on oil companies to verify that they have cleared their abandoned sites and plugged wells to prevent oil from seeping into the water. But with properly closing a well costing up to $100 million, companies may be tempted to cut corners at the environment's expense. GAO therefore recommends that MMS begin at least random inspections of abandoned wells, using industry funds if necessary.

Physics

Ivars Peterson reports from Baltimore at a meeting on fundamental problems in quantum theory

Flipping a quantum mechanical coin

Physicists generally regard the emission of light by an excited atom as a random process. They assume it's impossible to predict precisely when one of the atom's electrons will drop from a higher to a lower energy level, emitting a photon in the process. But this randomness doesn't follow automatically from the other fundamental principles of quantum theory, says Thomas Erber of the Illinois Institute of Technology in Chicago.

To test for randomness, Erber analyzed data obtained from Wayne M. Itano, David J. Wineland, and their coworkers at the National Institute of Standards and Technology (NIST) in Boulder, Colo. The NIST researchers had studied light absorbed and emitted by a single mercury ion held in a special trap and irradiated continuously by laser light of a certain frequency. In response, the suspended mercury ion flashed on and off at irregular intervals, acting like an optical telegraph.

Applying a variety of techniques developed in recent years to search for patterns in encrypted data and other strings of digits, Erber has studied a sequence of 20,000 numbers representing the time intervals between successive quantum jumps in the NIST data. So far, no discernible patterns have emerged. To be sure of his result, however, Erber needs to check longer sequences of numbers. If no patterns are found, the quantum jumps of a single ion may prove an infinite source of "cryptographically invulnerable" random numbers, Erber notes.

Real cool: Evading atomic recoil

It's awfully hard to keep atoms still. A variety of techniques involving laser beams can bring atoms virtually to a halt, but when these atoms absorb and spontaneously emit photons, they recoil in random directions. This effect makes it very difficult to cool atoms to a temperature below that corresponding to the recoil velocity of a single photon.

Alain Aspect of the Institute of Theoretical and Applied Optics in Orsay, France, and his collaborators at the École Normale Superieure in Paris have developed a technique for overcoming this apparent limitation on achieving extremely low temperatures. They pioneered a method—known as velocity-selective coherent population trapping—in which two oppositely directed laser beams of exactly the same frequency illuminate slowly moving or nearly stationary atoms. An atom caught between the laser beams moves around in a random fashion as it emits photons until by chance it stops for an instant. Because of quantum interference effects, the atom can no longer absorb or emit photons and remains in this state.

In 1988, the researchers demonstrated that they could use this technique to cool excited helium atoms down to about 2 microkelvins—well below the recoil limit. But they achieved this cooling only in one dimension. Now, by using four laser beams to tickle the atoms, they have cooled helium in two dimensions to a temperature of 250 nanokelvins. "We are now trying to do it in three dimensions," Aspect says.

Photonic crystals in metal

Photonic crystals have structures with just the right kind of geometry to prevent the absorption or emission of electromagnetic radiation at wavelengths that fall within a specific range, or band gap. So far, researchers have studied the characteristics of photonic crystals made from electrically insulating materials (SN: 9/25/93, p.199). Now, Eli Yablonovitch and Mike Sickmiller of the University of California, Los Angeles, have started to investigate a metallic photonic crystal consisting of a three-dimensional wire mesh with the same geometry as the arrangement of carbon atoms in diamond. Initial results show that this structure has a number of unexpected features, including an extra forbidden band.