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The Colloid Threat

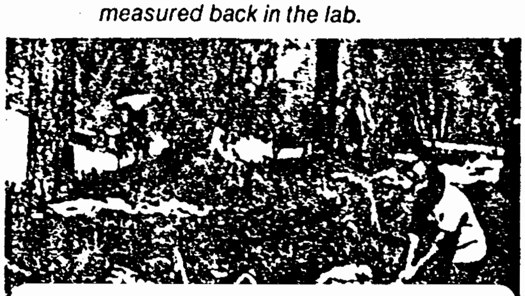
Small, nontoxic particulates may enhance water pollution

By JANET RALOFF

Eight years ago, scientists from Argonne National Laboratory near Chicago began studying the contamination of a shallow aquifer underlying part of another federal lab. Since 1963, workers had routinely dumped liquids from the central waste-treatment plant onto the ground of Mortandad Canyon at Los Alamos (N.M.) National Laboratory (LANL). Though these wastes contained residual low-level concentrations of plutonium and americium, LANL analyses suggested they offered no cause for concern. Laboratory calculations predicted each radioactive contaminant would tightly bind to the soil, allowing the pollutants to travel a few meters at most.

At radioactive-waste sites in Hanford, Wash., and Sheffield, Ill., field studies by the Argonne team found that soil indeed quickly ties up trace quantities of escaping radionuclides, notes William R. Penrose, a member of the 1982 Argonne team and now an environmental scientist with Transducer Research Inc. in Naperville, Ill. But at Los Alamos the radioactive wastes have not behaved as expected. They've migrated into the underground aquifer, more than 2 miles from where workers first dumped them.

Water is sampled from a well in the shallow aquifer underlying Mortandad Canyon at LANL. While pH is recorded at the site, plutonium and americium are measured back in the lab.



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Though LANL's tainted aquifer has never served as a source of drinking water, the radioactive wastes' lengthy migration raised a troubling question: Why had pollution-transport models failed to predict it?

The answer now appears to be colloids – particulates too small to settle out of water, ranging from a nanometer to a micron in size. In the February ENVIRONMENTAL SCIENCE AND TECHNOLOGY, Penrose and his colleagues at Argonne and LANL report data indicating that LANL's radioactive wastes have been trapped by colloids and are therefore prevented from binding to much larger soil particles. Their work is one of two reports in that issue presenting evidence that conventional methods for predicting the movement of pollutants through the water in soils, streams and underground aquifers can greatly underestimate the hazards posed by a range of pollutants – from organic chemicals leaking out of landfills or waste dumps to radioactive wastes and pesticides applied to soil.

Penrose says LANL's pollutant-migration model – typical of most designed to characterize the transport of insoluble chemicals in soil or water – erred by assuming plutonium and americium would behave as if they were "free" to chemically bind to large particles, like those making up soil. Instead, the team found that colloids of some yet unidentified material had trapped (and probably encapsulated) the toxic radionuclides, thereby shielding these pollutants from chemical processes that might otherwise allow them to bind to the soil – or settle out into bottom sediment should they ever reach groundwater.

Filtering the aquifer's water showed that the colloids trapping americium are different – and much smaller – than those transporting plutonium. Not only might this allow the americium to move through water faster than the plutonium, but it also apparently explains why americium is a more persistent polluter. Plutonium levels at the most distant groundwater-sampling well (3,390 meters) are just one-thousandth those at the well nearest the waste's discharge. Americium levels, by contrast, remain constant between wells, indicating that once it enters water, no further removal occurs, Penrose says.

Both radioactive contaminants "are well within safety limits" at the most distant water-sampling well, Penrose says, and remain within the lab's boundaries. He therefore believes the real lesson here is in forecasting what might happen if high levels of other water-insoluble contaminants – radioactive or otherwise – are released into similarly colloid-laden waters.

A second paper in the same journal indicates that for very insoluble organic chemicals – such as DDT, PCBs and dioxin – microscopic emulsions (stable mixtures) of surfactants and oil may play a water-pollution-enhancing role conceptually similar to that of the colloids.

Surfactants reduce the surface tension between two normally immiscible, or unmixable, materials, allowing them to mix. One class of surfactants frequently found contaminating wet environments is a group of petroleum-sulfonate compounds used in oil drilling, enhanced oil recovery, ore extraction and lubrication of automotive parts. Because they contain mineral oil, these surfactants stably mix with water to form long-lasting emulsions. When a normally water-insoluble organic pollutant encounters such an emulsion, it readily dissolves into the emulsion's oil. And a pollutant may stay dissolved in the water – spreading with the currents – as long as this emulsion's protective outer layer of surfactants lasts.

Even low concentrations of these stable emulsions can dramatically modify water's ability to dissolve and hold normally insoluble toxicants, explains chemist Cary T. Chiou with the U.S. Geological Survey in Denver, who led this research. For example, he and his co-workers found that a 50 parts per million concentration of these surfactants in water "increased the solubility of DDT almost 100 times over plain water." In some tests, these microemulsions increased the organics' water solubility 1,000-fold.

Chiou's data should come as no surprise to chemical engineers and surfactant chemists, says John M. Zachara, an environmental surface chemist at Battelle Pacific Northwest Laboratory in Richland, Wash. However, he notes, environmental scientists and water-quality engineers may be quite surprised, since their research journals contain almost no references to emulsion-trapped organics. Moreover, he says, the improved water solubility of organic chemicals that Chiou reports may not be restricted to water containing emulsions formed by petroleum-sulfonate surfactants. Under certain conditions, he suspects, even conventional chemical solvents may mix with oil and form similar stable, water-polluting emulsions.

The Penrose paper, by contrast, may be thought of as potentially iconoclastic, Zachara suggests, since a vocal school of water-pollution scientists "feel that colloids do not really exist in groundwater" — except as "artifacts of sampling." You can't dig a water-monitoring well without disturbing some of the soil above the groundwater, he notes. Many researchers have argued that any colloids detected in groundwater resulted either from digging the well or from removing water for testing.

At last, he says, the "Penrose paper lays this issue to rest." There's no way to explain the vast migration of the LANL radionuclides without colloids, he says.

Philip M. Gschwend agrees. An environmental organic chemist at the Massachusetts Institute of Technology in Cambridge, he says the "exciting" Penrose paper "confirms what many of us had begun to worry about: [In the disposal of low-solubility hazardous wastes,] we can no longer be sure that they will attach to large particles such as soil and stay put."

A second major implication of this paper, he says, is that traditional groundwater-sampling techniques may have to change. Currently, analysts hunting for pollutants migrating from toxic-chemical sites filter water drawn from monitoring wells to eliminate any particles too large to be transported great distances in water. But "I don't think it's possible to take out the big particles [which don't matter] and not lose some of the little ones [that do]," Gschwend says. Such filtering, therefore, risks greatly underestimating the chances that insoluble pollutants are hitching long rides with passing colloids.

"We still don't know much about how colloids form or the tendency of soils to trap and catch colloids as they're flowing by," Gschwend notes. His group began investigating both about four years ago.

Penrose's work suggests these endeavors will prove challenging for groundwater researchers. With regard to anticipating the presence and involvement of colloids, he says: "We found surface waters were boringly predictable. Once you've studied half a dozen, they start to look pretty familiar. But groundwaters are really different. Every one is a new story." □

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suffer allergic reactions to injections of cells taken from animal tissue. In addition, Crocker points out, injections of fetal sheep cells may transmit agents such as the microorganism causing scrapie, a degenerative central nervous system disease that afflicts sheep. That concern prompted the National Down Syndrome Congress, a Park Ridge, Ill.-based parent and health professionals group, to issue a 1986 statement that advises parents against the "life-threatening" treatment. However, Lang says the risk of scrapie transmission has been overblown. "We don't have any evidence at all that the slow viruses of sheep are transmissible to man," Lang says.

Even those opposed to cell therapy can understand the human motives behind it. "These parents are very much at a loss as to know what to do for their children," Lang says. "The medical profession offers them precious little."

"We do not want to be fooled," says Statham, whose group includes 1,000 parents nationwide. She notes there has never been a large, double-blind study of cell therapy's efficacy. Most scientists involved in the issue agree the therapy has not been put to an airtight test, but they say the existing data show the treatment is powerless to improve symptoms of Down's syndrome. □