Janet Raloff and Richard Lipkin report from Atlanta at the American Association for the Advancement of Science annual meeting

Cleansing water with natural slimes...

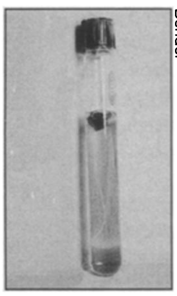
"It looked like science fiction," recalls Judith Bender, describing how a yellow film of slime reached down from a floating community of bacteria and in 3 days surrounded a glob of toxic chlordane at the bottom of a beaker of water. Over the next few days, this slime not only corralled the banned insecticide — a suspected human carcinogen (SN: 8/15/87, p.102) — but ferried it back to the water's surface. There, within 3 weeks, its parent mat of bacteria degraded the viscous chemical.

Bender and Peter Phillips, both at Clark Atlanta (Ga.) University, have since patented the design and use of these microbial mats for detoxifying water and moist, near-surface soils contaminated with heavy metals or organic chemicals.

The pair initially developed the microbial mats as an inexpensive, troublefree food for rural fish farmers in the Dominican Republic. They dumped grass clippings and filamentous blue-green algae into ponds, then let the mix spontaneously organize into a leathery slime on the surface. Fish loved the resulting fare.

The researchers only discovered their technology's cleansing potential after an accident dumped lead into a mat-growing tank. Close examination showed that the toxic heavy metal traveled and bound to the slimy, surface-floating mats — which now held other bacteria as well as microalgae. Follow-up studies indicate that these mats also filter out chromium, cobalt, copper, cadmium, selenium, arsenic, and other metals from stagnant or circulating water.

Where chlorinated organic pollutants pose problems, Bender's team seeds the slimy mats with purple photosynthetic bacteria. They've watched these colorful microbes forage from the mats for organics in tainted soils or water.



Bender

Biofilm hoists a pebble.

Bender's group now pieces together its cleansing "multispecies quilt" by growing several types of bacteria on a 3-foot by 8-foot mesh of coconut hull fibers. Once it's established, they dry it, roll it up, and haul it to the pollution site.

The Tennessee Valley Authority (TVA) is entering its third year of tests on one mat in Alabama, Bender reports. This mat filters manganese from coal mine drainage at a rate of 2.5 milligrams per square meter of mat per day. Other mats are undergoing field tests to filter metals from gold and silver mine drainage in Colorado and to cleanse groundwater pumped from a gasoline-tainted aquifer in Maryland.

But "the weirdest thing I've ever seen," Bender says, is the ability of these mats to reach out with biofilm tendrils and pick up a pebble (photo) several thousand times their own weight. Imagine, she says, "if you have a product with that kind of tensile strength and elasticity, what other kinds of unique products can this stuff produce?"

... and with heat, pressure, and oxygen

In a more technological approach, chemical engineer Michael Modell, formerly of the Massachusetts Institute of Technology and now with Modell Environmental Corp. in Waltham, Mass., has devised an alternative method of cleaning hazardous wastewater.

Using a system called "supercritical water oxidation," he has built a pilot plant in Pfinztal, Germany, to process 1,500 liters of community wastewater per day. In essence, the system takes domestic or industrial wastewater, cooks it, pressurizes it, and exposes it to liquid oxygen. As a result, waste materials break down, become oxidized, and reform as nontoxic products.

In the end, one has reusable water, nonhazardous gases, and benign sludges for recycling or burial.

Specifically, this detoxification system takes in water contaminated with organic or inorganic compounds ranging from household refuse, bacteria, and viruses to toxic and heavy metals. Under normal conditions, none of these materials degrades in water.

Yet when exposed to water heated to 400°C to 600°C and pressurized to 250 atmospheres, the materials break down into smaller component molecules. When liquid oxygen enters the system, the breakdown products recombine to form hydrocarbons, alcohols, minerals, salts, carbon dioxide, and nitrogen.

Tests show that the system destroys more than 99 percent of organic and biological wastes, including sewage, pesticides, dioxin, propellants, chemical warfare agents, and low-level radioactive waste, Modell reports. He also says that this sealed "stackless" system emits no odors, polluting gases, or effluents.

Modell has geared the system to serve municipalities and industries that produce 5 to 100 tons of waste in water per day, such as pharmaceutical, paper, textile, and food companies. The cost of waste destruction comes in at roughly $400 per ton, making it a relatively inexpensive process.

Research on this method of waste destruction began nearly 20 years ago as a NASA project for use in self-sufficient space colonies. Scientists aimed to produce a recycling system that would allow astronauts to recover and reuse water, oxygen, and other organic materials. Yet the system's value for earthly uses quickly became apparent, and efforts to adapt it for civilian purposes soon began.

In addition to the German site, other pilot plants may soon begin operation in the Netherlands and Sweden, where there is "strong interest and need for cost-effective waste-processing systems," Modell says.

A digital notary

In an increasingly paperless society, information often exists only in the digital netherworld of electronic files. As such, documenting records has become a dicey affair.

For instance, during the 1991 Senate confirmation hearings of Clarence Thomas as a justice of the U.S. Supreme Court, telephone logs arose as evidence. When Thereza Imanishi-Kari's laboratory came under investigation for scientific fraud, the authenticity of notebook entries became relevant. On Wall Street in 1992, officers of a computer corporation came under fire for allegedly backdating financial records.

How does one prove that no one has tampered with or altered computer files needed to confirm legal facts?

To solve this problem, Stuart Haber and W. Scott Stornetta, both at Bellcore in Morristown, N.J., and Surety Technologies in Chatham, N.J., have created a "digital notary system."

Haber describes the system as "a publicly verifiable insurance policy," which proves that a computer record "existed in a specific form at a specific time" and that the file "has not been altered."

When linked to an individual's or company's computer system, the digital notary certifies files by producing a coded fingerprint of a document, using a mathematical process called one-way hashing. The process distills the document down to a short, unique string of characters. Changing even one letter or number in the notarized document would create a totally different coded string.

The fingerprint itself contains no data from the document. Rather, it functions as a code that can be used to reconstruct and authenticate a file, Haber says. Every time a document gets certified, the system generates a so-called electronic time stamp. The stamp becomes part of a collective file whose code is publicly logged on the Internet and published weekly in the New York Times.

"Publishing the code in a public place guarantees that it existed in a particular form at a particular time," Haber says. "There's no way to falsify it."