# Bioremediation

## *Using Microbes to Clean Toxic Environments*

*by Chris Walters*

As product demos go, it is one of the better ones, simple, quick, and borderline astonishing. On a sweltering fall day in his Austin office on a hidden street near the railroad tracks, Dr. Carl Oppenheimer sits at a table talking to a reporter who seems a little slow on the uptake.

Oppenheimer is not a man given to em phatic horn-blowing, yet the revolutionary potential of the compound he's developed from ancient bacteria is obvious even after hearing a dry, factual description. The problem is that it sounds too good to be true. If Dr. Oppenheimer's bacterial arrays can do what he says they can, the implications for the environment n general and agriculture in particular are immense.

Oppenheimer pours a few tablespoons of motor oil into a porcelain bowl, then spoons some grayish powder onto it, and stirs the mess around a little bit. Fizzing occurs. "You can see the action," Oppenheimer says. "See? It's gone." Sure enough, further spoon-work reveals a total lack of motor oil. The powder has thickened slightly. "It turns into fish food," Oppenheimer concludes. He walks over to a conveniently placed aquarium and sprinkles the transformed oil onto the water's surface. The fish jump for it and gobble away. The reporter is goggle-eyed.

"What is it now?" he wants to know.

"Fatty acids," Oppenheimer answers.

From petroleum product to fish food in under five minutes. Think about it: since Oppenheimer's microbial arrays can eliminate most pesticide residues, the time it takes to effect a transition from conventional to clean farming could be reduced dramatically, far below the regulation three years. On the scattered occasions when a controlling authority has taken a chance and hired Oppenheimer to clean up a major oil spill, his microbes have performed far more effectively than the expensive, clumsy dispersal technology usually deployed. Because these bacteria can break down rocks in soil and release minerals for root uptake — especially silica, an underrated component of productive soil — they would seem to have enormous potential for farmers in parts of the world that are normally dry or afflicted by drought.

Typical city gardeners who have applied the bugs to their plots or compost heaps report unusually large, green and prolific plants, bearing fruit or vegetables of surpassing richness and taste — this after diluting an ounce of the lively gray powder in water and sprinkling it over 30 square feet, meaning a two-pound bottle of powder can revitalize almost a thousand square feet of garden or cropland.

Germination times shrink, and transplant shock is reduced. The soil holds more moisture, reducing water requirements by as much as one-fourth. The microbes die off when their work is done, but the vitality of the soil goes on. One application per growing season is usually enough.

Bioremediation — as the use of microbial arrays to alter the environmental in beneficial ways is called — is not a late career hobby for Carl Oppenheimer, who researched it for four decades before going into business. Nor is its potential a state secret. Oppenheimer cleaned up his first major oil spill off the Texas coast in 1990, when the Finnish oil tanker *Mega Borg* ruptured its hull. A controlled study conducted that year under the aegis of Garry Mauro, then Texas land commissioner, found that Oppenheimer's microbial array eliminated 99.9 percent of the spilled oil.

All well and good. You would think that Oppenheimer's bugs would be studied far and wide by universities and government think tanks, then widely used to create — the advertising copy almost writes itself — a cleaner, greener world. And you would be wrong.

*Dr. Carl Oppenheimer demonstrates how natural microorganisms can turn petroleum waste products into non-toxic fatty acids.*

### OLD BUGS ARE GOOD BUGS

Born in sleepy, sun-washed Los Angeles in 1921, Carl Oppenheimer could now pass for a rugged 68-year-old. Lean, fit and intellectually sharper than many people in their 30s, he grew up in the foothills between Pasadena and L.A., where he "walked the traditional mile-and-a-half to school the old-timers always talk about." When he went to the beach, he was fascinated by the oil seeps that washed onto shore in the years before California's coastline was thoroughly drilled and pumped.

"I grew up along with technology," he says now, remembering with evident pleasure how he built a crystal radio from scratch when he was a boy. The U.S. Navy spotted his potential and let him skip basic training so he could spend the Big One in a medical laboratory. College on the G.I. Bill followed, culminating in 1951 with a Ph.D. in marine microbiology from the University of California's

Scripps Institution of Oceanography.

"In those days all the marine people were seagoing people," he recalls. "We were a small, close-knit community, and we all knew each other — around the world."

The next 30-odd years of Oppenheimer's curriculum vitae are hard to absorb at one sitting. He did research for the Pan American Petroleum Corporation and taught in Oslo, Naples and Miami. He served on presidential advisory panels and chaired a panel for NATO, to cite only two of a long list, and authored dozens of scientific articles, reports and scientific papers. He accepted a position with the University of Texas at Austin as professor emeritus of marine microbiology in 1980, also researching and lecturing at the university's Marine Science Institute in Port Aransas until his retirement in 1992.

*Oppenheimer at Lake Maracaibo, Venezuela, 2001.*

But Oppenheimer's dedication to useful microbes dates back to the '70s and a trip to an extreme landscape you wouldn't expect to support any life, even microbes.

"Back in 1975, when I first became interested, I visited a place called the Flagarian Fields north of Naples — an old volcano that still has vents and hot, boiling soil. The Romans built a sauna in the side with different compartments — deeper was hotter.

"A group of microbiologists I visited there indicated that their microorganisms consumed hydrocarbon — the naturally occurring microorganisms found on the volcano's caldera.

"Doing my research, I found that single microorganisms were not very efficient, but teams of microorganisms were far more efficient. In my teaching I use the example of whaling — breaking down the whale by teamwork — the end result is no more whale."

"When I retired, I had to have something to do — it was an easy jump for my mindset. The microorganisms were there, but something was there that didn't allow them to work, and sometimes the right balance of microorganisms was not there.

"In some places it was a lack of microorganisms, and in other places it was a lack of water, a lack of nutrients, a lack of oxygen. So our first step was to develop more efficient microorganisms, and we found that the most efficient came from adverse environments."

They're called *archaeobacteria*, and they're found at salt pans and hot springs as well as volcanic sites. They are different from the normal microorganisms we carry in our bodies and swat in the kitchen.

"From an evolutionary standpoint the archaeobacteria are a special group of bacteria, because their cell wall is made up of hydrocarbons, while the basic wall structures of higher bacteria are fatty acids. It's the difference between RNA and DNA bacteria."

## RNA CONSORTIUMS

Though they be simple creatures who suffer not the cares of the multicellular world, like property taxes or presidents from Texas, microorganisms are like everybody else in one respect: they need their space.

After he figured out how to arrange the primitive microbes into what he calls "RNA consortiums" and calibrate one set for oil cleanup, another for soil mineralization, and so forth, Oppenheimer's biggest challenge consisted of finding a way to pack enough of them together without killing them off. A typical product featuring natural bacteria will keep them alive in a solution, explains Guy McGowen, who markets the plant feeder array as a product called BioZome.

"Typically, there will be 10 million microorganisms to the gram. Dr. Oppenheimer developed a process to pack 100 billion into a gram."

The good doctor's process is a trade secret, and the functioning of an RNA consortium — along with the difference between RNA and DNA bacteria — is beyond the scope of this article. The important fact here is that the stuff seems to do exactly what it's supposed to do.

"I'm a nurse," McGowen explains, referring to his day job as a provider of hospice care. "I was taking care of Carl's mother. She liked fresh vegetables, and I had a garden out back. He said, 'Try this, it helps,' and it was up to me to figure out how. A normal okra plant from a standard seed packet grew 14 feet tall and 4 inches across.

"You can test it yourself. Step One is the seed germination time test. Step Two is the composting-breakdown test in a simple garden, not timed. Step Three would be full-scale use in a field. One farmer I know had 10,000 acres, and he used the product on his compost pile, which was in his barn along with the horses and cows. After that he had no methane, couldn't smell it.

"He used it on 100 acres. His relatives were jealous that his crops were coming in faster and greener."

Although it is possible to use too little, it is not possible to use too much, as the redundant bacteria dies off.

"You can't accelerate the process by adding more, however," McGowen noted.

## NEEDS FURTHER STUDY

Oppenheimer conceived of the plant feeder array while cleaning up 50,000 cubic meters of oily ground in Louisiana.

"It was an expensive job, and it was half done when a hurricane came along and wiped us out," Oppenheimer recalls. "But we knew enough then to know it was successful. Every time we went back to look at the site, the weeds were twice as tall. We did some experiments and found that germination was occurring twice as fast."

Oppenheimer has conducted bioremediation studies in Denmark, Canada, Venezuela, Trinidad, Malaysia, Japan, South Africa, Taiwan and Italy. "Our consortia of archaeaobacteria have commercially cleaned up more than a thousand water and soil sites worldwide, including such pollutants as chlorinated hydrocarbons.

"No two are alike. You have to have a knowledge of geochemistry, biology, physical and surface chemistry in addition to microbiology to successfully complete a remediation project."

When a big oil spill makes headlines, however, you probably will not read that Carl Oppenheimer or someone he's educated has been hired to clean it up. Less-effective dispersal technology is still the industry standard.

"We can't do it on the ocean because that's politicized by the International Oil Spill Response Association. Who finances them? The oil companies. They have a physical process that they are heavily invested in — booms and skimmers and so on — and we'd put them out of business."

"Some other scientists refuse to recognize that the RNA consortium works at all," says McGowen. "They'll say, 'It just naturally occurred, your bacteria had nothing to do with it.'"

The government isn't much better. On a website devoted to oil and chemical management, the National Oceanic & Atmospheric Administration delicately concludes that bioremediation "is becoming an option of choice under certain conditions for eliminating the last traces of oil from beaches and similar habitats." Translation: even though it works, let's not get carried away.

An outburst of weaselly language in an otherwise cogent Environmental Defense Fund paper on biotechnology serves as a vivid illustration of the myopia that clouds the best intentions (available online at <www.agbiotechnet.com/nabc/nabc8/0763_7.pdf>).

"Following the oil spill from the tanker *Mega Borg* off the coast of Texas in 1990, for example, one Texas company promoted heavily the success of its bioremediation product — bacteria that supposedly 'eat' oil on the surface of the ocean," begins the relevant section. "According to a report published by the Texas General Land Office, these bacteria largely dissipated an oil slick from the Mega Borg in just seven hours, with portions of the slick breaking up in just 30 minutes."

So far, so accurate, but from here on it's right off the deep end:

"The speed of this degradation is difficult to believe, especially given that the experimental design had no replication of treatment and control areas, and because the oil in the treatment area simply may have been dispersed by wind and water. The relatively low cost of such bioremediation techniques makes them attractive to government agencies and companies that must remediate waste, but also signals caution to many environmentalists. Reliance on inexpensive but unproved bioremediation products could cause considerable environmental harm if the result is that more efficacious cleanup methods are not used.

"Not just skepticism, however, has caused bioremediation's relatively low profile in the environmental community. Many environmentalists are now focused on pollution prevention rather than remediation of wastes. Changing industrial processes to minimize the amount of waste produced is regarded as the best way to end the problems caused by chemical wastes. Over the long term, biotechnologists may do more for the environment by developing novel enzymes and other tools that allow the redesign of industrial processes, than by developing bioremediation methods."

The author's obvious ignorance of the controlled study sponsored by Garry Mauro's department is not the most appalling thing about this passage, and the "dispersed by wind and water" passage must be regarded as comic relief. What is horrifying is the implication that cleaning up severely polluted regions of the United States — southern Louisiana comes to mind, as do the many Superfund sites still extant — is really not so important anymore. It's no wonder that the giant agribusiness conglomerates do not embrace (or sponsor studies of) a technology that could render much of what they sell superfluous. But to discover this kind of language in a document published by a leader in environmental litigation (it popped right to the top of my Google search) is shocking and dismaying.

"There is 1 percent or less that the microorganisms can't clean up," Oppenheimer concedes, referring to oil spills. "That's not good enough for the government authorities" — that is, the authorities who would have to muscle the global oil industry to adopt bioremediation as its cleanup standard.

Let's not end on a sour note, however. As Galileo or Elvis Presley could tell you, new ideas always encounter fierce resistance from certain authorities. Industrial pollution and its kissing cousin, industrial agriculture, are wrecking the planet at a good clip, so eventually Dr. Oppenheimer's hungry microbes will have to be pressed into service on a fairly massive scale. If the appropriate authorities refuse to consider this, they won't be missed very much when they too are dinner for microbes.

*More information on Dr. Oppenheimer and his bioremediation process is available from Biozome, 4606 Copano Court, Austin, Texas 78749, phone (512) 282-2087, fax (512) 292-6419, website <www.biozome.com>.*