Green Technology Cleans Up With Waste

Cornell Center for Technology Enterprise and Commercialization
Cornell University

Cornell University opened its Technology Farm in Geneva, N.Y., in 2005 to foster new, innovative technologies and the startup companies that develop them. Since its builders had asked plant biologist Gary Harman, Ph.D., to solve the facility's soilcontamination problems, there was a karma-like symmetry to his founding a company for new water-remediation techniques — and basing it there.

"We didn't solve the Technology Farm's soil problem," notes Harman, a professor in Cornell's Department of Horticultural Sciences, "but the experience started a thought-process that led to ways to clean up pollutants in water — oils, heavy metals and hydrogen sulfide. It was a direct link."

He adds: "These are ecologically friendly techniques that are less expensive and more easily handled than traditional approaches."

Like a lot of old farmland in upstate New York, the campus at the Technology Farm — officially Cornell's Agriculture and

Food Technology Park — was laced with lead arsenic, a consequence of heavy pesticide use over the years.

Harman and his Cornell colleagues, chemist Terry Spittler, Ph.D., and technician Robert Patrick, began with the idea of planting ferns to take up the substance. The reality, they concluded, was that while ferns would do this, they couldn't accumulate enough to be effective, since much of the soil-based contaminate isn't soluble. At present, the only solution in such a case is to scrape up the polluted soil and haul it to a hazardous waste site.

The Lignin Solution

"The episode started us thinking about the general problem of heavy metal contamination," Harman says. "Then, we were at a conference where we heard a discussion about bioproducts' capacity for removing heavy metals from watery materials like sewage sludge. We wondered, 'If so, how?' That led us to think about lignin, a complex compound that binds cellulose and strengthens the cell wall of plants, and its potential for binding with contaminates."

Lignin fills the spaces between cellulose and other components in trees and plants and helps strengthen cell walls. The Cornell team knew that its complex structure gives it strong negative binding capabilities.

"It binds heavy metals very tightly, in a way that the accumulated pollutants won't leach out," Harman notes. "Then, it usually can be placed in a regular landfill without having to be taken to a hazardous waste site. The remediated water can then be dealt with according to local regulations — for instance, returned to the groundwater or disposed into a waste stream."

The question was where large quantities of inexpensive lignin could be obtained. In fact, they found a number of sources, testing 30 to 40 materials that might be feasible, such as ground-up cornstalks. One good source was the plant fiber in cow manure, as the ruminants' digestive process strips away the cellulose, leaving a high-quality lignin. Manure fiber proved to be a highly effective absorbent for oil and other contaminants.

Tree bark, the material accumulated in massive amounts by landscapers and used as mulch around shrubs and flowers, also proved to be an excellent binding substance for heavy metals like nickel, copper and iron. Among the varieties tested, hardwood barks proved to be the best. The team published its results in the Winter 2007 issue of the journal *Industrial Biotechnology*.

Enter Terrenew

"Once Gary and his associates had promising results, they did two things," notes Jeff Fearn, senior technology commercialization and liaison officer in Cornell's Center for Technology Enterprise & Commercialization. "They brought their results to our office, and they established a company, Terrenew.

"Gary felt that starting a company was essential," Fearn says. "He felt that even though he had a patentable result, there are wide gaps between patents and viable products. Larger companies tend to be reluctant to take on new, unproven technologies that need extensive work to become commercially feasible. Smaller companies and startups tend to be more innovative in that way."

While the university filed a patent on the technology in early2005, Harman and four colleagues established Terrenew LLC,and the university subsequently licensed it back to the new organization,which moved quickly to pursue a range of productsbased on the work.

"Soon, all our products will have been commercialized, and we'll be at a point of needing additional investors to move to the next level," notes Terrenew CEO Thomas Bourne.

He adds: “There’s no shortage in the world of polluted water supplies that we can serve — contaminated groundwater, industrial process water and mining waste-water sites.”

Bourne is an environmental engineer whose background involves extensive consulting on economic development for environmental companies. He and Harman met at a scientific meeting, heard each other speak, liked what each said and began talking about the intellectual properties related to Harman’s work.

“Gary asked me to help start the company and help find aCEO once it was formed,” Bourne says. “After a while, I was intrigued by the company and what it could accomplish, so I dropped the ‘interim’ label.” Harman serves as the company’s chief scientific officer, Spittler as its director of research and development.

Harman’s early research was supported with funding from the Cornell Center for Advanced Technology and the United States-Israel Binational Agriculture Research and Development Fund. Since its establishment, Terrenew has received support in the form of small business innovation research grants through the National Science Foundation and the U.S. Department of Agriculture.

The Process and the Products

Terrenew’s offices are based at the Cornell Technology Farm in Geneva, but its operations are located in 18,000 square feet of leased space about four miles away. There, agriculture wastes are collected and processed — manure is dried in a mechanical dryer, tree bark is collected in 10-to 15-feet-high piles for sorting and shipment.

Terrenew placed its first remediation product, OilMaster, on the market in 2008, producing it in granular forms for dry-surface oil spills and in a pad form for oil spills in water. As with alltheir products, they stress its qualities as lighter-weight, lessexpensive,easier to handle and more effective than traditionalagents — and far safer ecologically.

SulfaMaster uses lignin fiber from manure to remove hydrogen sulfide from biogases, as might be produced and recovered in waste-water treatment plants. Since hydrogen sulfide causes acid rain, corrodes machinery and can be toxic to humans and animals, the ability to strip it out enhances the prospect of biogases as alternative fuels.

As a separate line, the company also produces an AgriMaster category of growing products, including organic potting soil, dry cow manure soil conditioner and mushroom compost concentrate.

MetalMaster

The newest product to approach commercialization is MetalMaster, which uses tree bark to take up heavy metals in water. As a waste product from logging operations, the bark is purchased from landscapers who otherwise collect it for use as mulch.

While it’s important that manure fiber be thoroughly decomposed for oil treatment, the tree bark for heavy metal work doesn’t require extensive decomposition. Preparation is primarily a matter of sifting through to remove twigs and other inappropriate matter and to produce a medium that is properly sized for the vessel and use anticipated. The ability to achieve an even flow of water through the tree bark mass is essential.

And whereas treatment of oil contaminants tends to be fairly straightforward, each MetalMaster treatment needs to be individualized for the site, depending on the target metal, the quantity of water to be remediated, the concentration of the contaminant and the pH of the tree bark (which affects its ionic binding capability).

“MetalMaster works well on three situations,” Harman notes, “including large bodies of polluted water, metal processing operations that produce contaminated water as a byproduct and contaminated drinking water. It binds up a range of contaminates, including magnesium, potassium, nickel, copper, iron and lead. A project to treat water used in a jewelry manufacturing operation removed some 90 percent of the silver, zinc and copper present."

> *Essentially, the remediation of contaminated water involves a process of filtering it through a mass of MetalMaster tree bark placed within a containment vessel, making sure the water moves at a consistent rate.*

The desired flow dynamics determine how big the vessel needs to be. For an early project to clean up chromium from a groundwater spill in upstate New York, the vessels consisted of a series of 55-gallon steel drums. More often the vessels are specially designed and constructed by affiliate companies. The size depends on how long the water needs to be in contact with the tree bark. The water is pumped in at the container's bottom, rising through the bark mass to exit at the top. This approach ensures an even flow through all of the bark mass, as opposed to a trickle-down approach whose flow might be erratic.

"Besides being more effective, easier to deal with and less expensive than other approaches," Harman says, "the bark binds the pollutants very tightly — they won't wash out. It's 'green' to start with — it uses natural waste products — and it ends in 'green' results — the water is remediated and the remediating material used can be treated as normal landfill, not as hazardous waste.

"It can have a significant impact on environmental cleanup efforts, with nothing but positive outcomes. It's very gratifying to have something to do with that."

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