

Innovations

Alternatives to Incineration: There's More Than One Way to Remediate

Hazardous waste is everywhere. It comes from paints, motor oil, hair spray, household cleaners, automotive chemicals, and all kinds of toxic medical, industrial and military products. Most industrial processes—from which come cosmetics and pharmaceuticals, computers and garden pesticides—generate wastes that the EPA, acting under the Resource Conservation Recovery Act (RCRA), says can harm human health or the environment if not properly managed.

As a waste-disposal technology, incineration has been around for about 500,000 years—an interesting spinoff of that timely *Homo erectus* discovery, fire. For millennia, incineration looked like a pretty good way to turn big piles of hazardous waste into air emissions, smaller piles of ash, and sometimes energy. And it's still a good idea. The EPA, for one, calls high-temperature incineration the best available technology for disposing of most hazardous waste. But incineration has drawbacks. When hazardous waste goes into an incinerator, it comes out as potentially harmful air emissions, although these emissions are strictly controlled, and as ash that's treated to meet EPA standards and then disposed of in an authorized landfill. It doesn't just vanish into thin air.

"Hazardous waste incineration can be very safe," says Stan Cannon, spokesperson for the Washington, DC-based Environmental Technology Council, formerly the

Hazardous Waste Treatment Council. "We're probably the most regulated industry in America, and the industry is very willing to work with EPA to hammer out the best, toughest standards the equipment can achieve."

American industry alone produces 320 million tons of hazardous waste every year. According to the EPA, 288 million tons of this is wastewater managed in treatment systems or pumped into injection wells. Twenty-seven million tons of industrial and household hazardous wastes are disposed of by methods other than incineration, and 5 million tons are incinerated each year.

"If an incinerator is designed well and run efficiently, it should be no problem," says William Suk, chief of the Chemical Exposures and Molecular Biology Branch at the NIEHS. "The problem is they're not designed that well, not run that efficiently, and they present a problem."

The RCRA was enacted in 1976 to address widespread contamination caused by disposing of municipal and industrial solid waste. Managed by the EPA or authorized states, the RCRA seeks to reduce the generation of hazardous waste, and conserve energy and natural resources. In 1981, the EPA announced regulations for burning hazardous waste in incinerators. Regulations for burning hazardous waste in boilers and industrial furnaces went into effect in August 1991.

To date, Cannon says, the industry has achieved "99.99 percent cleaning in stack emissions from incinerators. Millions of dollars have been spent to secure the best air pollution control devices. But we're not absolutely perfect. It's an ongoing process. We try to learn all the time from our industry and develop even better technology. It's something we do very well and hope to do better."

They're not the only ones helping the industry evolve. A growing number of research organizations, universities and private companies are cooperating to improve the way waste is changed from one form to another.

Some of the most innovative methods are alternatives to incineration or dumping. Others are modified forms of incineration that reduce the end product headed for a landfill. They include thermal desorption for manufactured gas sites, microwaving medical waste, turning hazardous and radioactive waste into glass for long-term storage, and bioremediation.

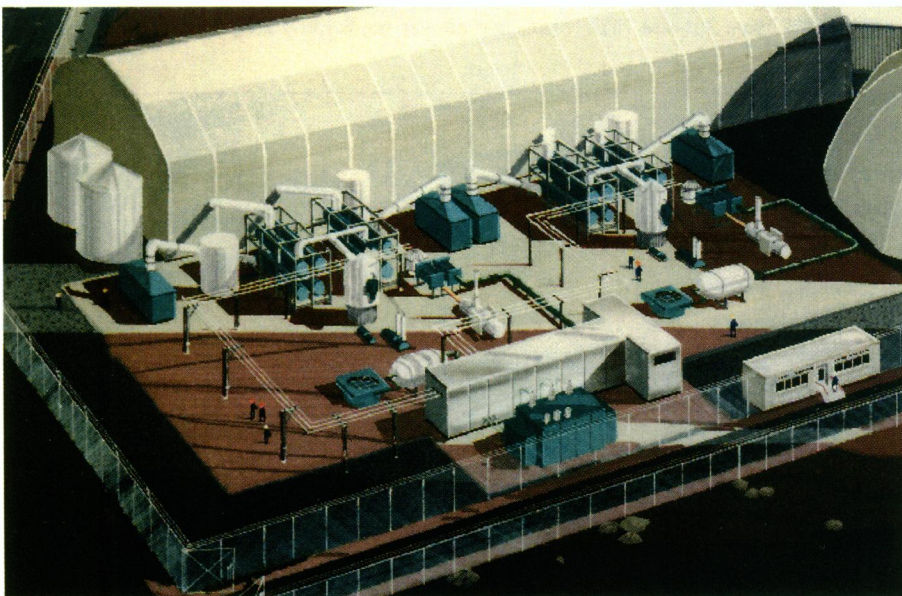
Thermal Desorption

Seaview Thermal Systems, based in Blue Bell, Pennsylvania, uses a hybrid of incineration and recycling to replace incineration and landfilling of the mix of coke, coal tar, coal oil, and traces of aromatics found at former manufactured-gas plants like PSE&G in Paterson, New Jersey.

The plants, used mainly in the northern United States in the early 20th century, produced fuel gas for utilities. They heated coal with steam, then quenched the stream with no. 2 fuel oil to produce a fuel gas. Hazardous leftovers were dumped into pits and later sold as fuel or buried on site. The EPA estimates that 1800 former sites are contaminated with coal tar, sludge, and other waste products.

"These gas plants are all in heavily populated areas," says Seaview's Jack Tyrrell, vice president of marketing. "Every little town has a gas plant in it somewhere. There are 78 in New Jersey. PSE&G is 13 acres. It's not the biggest, but it's a large one." Seaview has a patent on the HT-6 recycling process, first developed by TDI Thermal Dynamics with research and development contributions from Browning-Ferris Industries and Xytel-Bechtel Inc., which now builds the units. Here's how the process works. The HT-6 loads contaminated soil into a hopper and transports it to a feed hopper. It mixes and equalizes the soil, adding nitrogen and establishing anaerobic conditions. The sys-

Seaview Thermal Systems



Vapor makers. In thermal desorption, waste products of gas plants are vaporized and recycled.

tem is sealed until segregated effluents leave the process. An automated control system monitors all temperatures, pressures, and flows, displaying the data graphically for operators.

Next the process transfers waste feed material to an externally heated distillation chamber, then through another chamber that's kept at a much higher temperature. In the first chamber, water and volatiles are vaporized. In the second chamber, higher-boiling-point organics are vaporized to completely remediate the soil. The optimum operating temperature depends on the boiling points of contamination in the waste, but the HT-6 can operate to 2000° F.

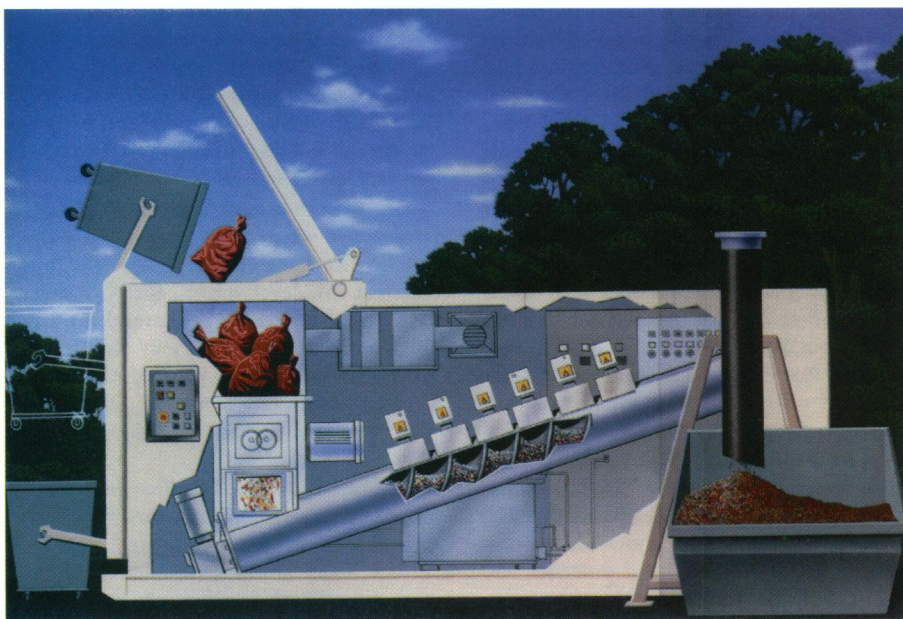
"We condense the vapor stream into a liquid," Tyrrell says, "then separate it into oil and water. We run the water through a purification system starting with a steam stripper, making it qualify for local groundwater standards so we can put it back in the soil." As for the oil, it now contains the contaminants, says Tyrrell, "because most of them are hydrocarbons. . . . So we take the remaining vapors, which are methane and lighter, and run them through an inert-gas generator where we compact them with heat and turn the hydrocarbon into carbon dioxide and water. Then, along with the nitrogen [already in the system], they become the sweep gases. It's a recycling system; it's not combustion."

And HT-6 costs less than incineration, Tyrrell adds. "Using New Jersey as a basis, the cost of landfill will run \$450 to \$1,000 a ton depending on where you go and whether it's all RCRA waste. The price for incineration, including hauling the waste to a licensed incinerator, is \$1,500 to \$1,800 a ton, depending on how much waste there is and where it's hauled. Our price depends on how much we process, whether we set up the unit for you or you brought the waste to a site. But it's something like \$250 to \$350 a ton." A standard job would be about 10,000 tons.

Until the HT-6 process was developed, the only remediation option available was incineration or a landfill. But, Tyrrell says, "it's not like incinerators are much of an alternative anymore because of availability, remoteness, and transportation. You may have to haul the waste under permit through one or more states, and it's hazardous waste, so the hauling alone can be expensive."

Microwaving

Every year in the United States, according to the EPA, hospitals generate an estimated 2.5 million tons of solid waste, 15% of which is infectious. Laboratories, clinics, and medical offices generate even more biomedical waste, which can be anything from bandages, vials, syringes, hypodermic needles,



Nuking the nasties. Microwaving offers an environmentally sound alternative to incinerating medical waste.

dles, and plastic tubing to blood, chemicals, drugs, laboratory cell cultures, and human and animal tissues.

Unless the waste is treated, state and local governments usually prohibit municipal landfills from accepting it, prompting hospitals to either treat infectious waste onsite or ship it to a hazardous-waste facility. This means many hospitals either own or share incineration facilities. But ABB Sanitec, based in Lisle, Illinois, has a better idea.

The ABB Sanitec microwave disinfection system, originally developed in Germany, is now used in the United States. The process combines shredding, steam injection, and conventional microwaves to disinfect biomedical waste.

According to Wayne Taubken, Sanitec vice president of sales and marketing, "Microwave technology is environmentally clean, efficacious in its ability to disinfect medical waste, produces no harmful air or water emissions, and uses very few utilities. It's cost effective because the equipment

averages 96 percent or 97 percent up-time." The alternative, incinerators and autoclaves, are available for waste disposal on average between 80% and 85% of the time.

The microwave process begins when an operator fills the loading bucket with waste. An automatic hoist dumps the material into a hopper at the top of the unit. Before opening, the hopper air is treated with high-temperature steam, then extracted with a high-efficiency particulate air filter to capture airborne pathogens. Computers control the entire process, prompting the operator to feed more waste.

Material feeds evenly into a shredder and emerges as small bits, unrecognizable as medical waste. The granules are automatically conveyed into a treatment chamber where they're moistened by high-temperature steam. This mixture runs under a series of conventional microwave generators that disinfect each granule. The treated end product is ready for municipal solid waste landfills or waste-to-energy plants.

"The waste goes in as 10 bags and

Government Waste

American industry alone produces 320 million tons of hazardous waste every year, but this number doesn't account for the millions of tons of hazardous waste produced by the planet's most prolific generator of hazardous waste—the U.S. government.

In fiscal year 1991, 17,660 sites were part of the Defense Department's Installation Restoration Program, where potential contamination at DOD installations and formerly owned or used properties is investigated and, if necessary, cleaned up.

The Department of Energy's nuclear weapons complex is made up of 14 facilities in 13 states and covers 3,350 square miles. In the 1990s, the legacy of producing tens of thousands of warheads over five decades is widespread environmental contamination from the waste products of this process, concern about possible public health threats, and an uncertain fate for waste generated in the future. The cost of overall clean-up is expected to take more than 30 years and cost \$200 billion.

comes out as 2, but the weight is the same," Taubken says. "There are no obnoxious odors, it's quiet, and, depending on a hospital's waste-collection system, the waste is only handled once—when it's loaded into a transportable cart. It eliminates needle sticks and back problems."

The cost for microwaving is about the same as for incineration. Taubken calculates that, on average, to get the waste to an incinerator, have it processed, then transported off-site to dispose of residual waste costs about \$0.11 a pound. Overall, to own the microwave technology, plus labor, utilities, and off-site disposal for the residual material averages \$0.11 to \$0.12 a pound.

The Sanitec unit that works best for most hospitals costs about \$375,000, has four microwave generators and handles 220 lbs. to nearly 500 lbs. an hour. A larger unit sells for about \$650,000 and processes 550 lbs. to 900 lbs. per hour. The microwave system also works as mobile technology.

The technology's biggest drawback, Taubken says, is that it's not a co-generation process like incinerators. Hospitals that have incinerators "throw everything in the incinerator. They use the resulting steam as a power source for the hospital. That's the downside of all the medical-waste technology—it's strictly for medical waste. You can't generate heat or anything else out of the process."

Among its advantages over incineration is that the microwave system is easier to get permitted because it doesn't generate potentially toxic air emissions. The technology is only approved for disinfecting medical waste, but Taubken says microwaving would work for application markets like industrial sludge and as a grain-drying process.

Vitrification

A vitreous state is a noncrystalline solid or rigid liquid formed by supercooling a melt. It's also called a glassy state. For hazardous or radioactive wastes, vitrification is the process of cooling a liquid fast enough to prevent crystallization. This process turns waste material, even high- and low-level radioactive wastes, into glass. Until recently, vitrification technology cost too much to treat low-level wastes. But Columbia, Maryland-based GTS Duratek and the Vitreous State Laboratory at the Catholic University of America in Washington, DC created proprietary formulations and used their patented furnace to make glass from low-level wastes.

"The advantage of vitrification is that it converts a waste product into recyclable, reusable glass that has value," says Bob Prince, GTS Duratek president and chief executive. "With incineration, you end up with ash at the end of the day—you still have the waste product. With vitrification you have clean air, clean water, and glass."

During vitrification, contaminants are subjected to extremely high temperatures in the melter. The organic compounds are destroyed and the remaining organic elements become part of the glass's molecular structure. Hazardous metal components in the waste are converted to nonhazardous oxides. Radioactive elements can't leach out, so they won't pollute the environment.

GTS Duratek's vitrification process was tested on-site at the Department of Energy's first Minimum Additive Waste Stabilization Project (MAWS), conducted at the Fernald Environmental Management Project near Cincinnati, Ohio. Fernald processed uranium for nuclear weapons from 1951 to 1989, when cleanup began. MAWS simultaneously processes conta-

minated water, soils, sludge, fly ash, and building siding, combining them so they help stabilize each other. Unlike conventional waste treatment, which requires adding nonwaste material to stabilize the waste, MAWS reduces the cost of cleanup and the final volume of waste that must be stored or disposed.

GTS Duratek began working on the concept in 1991 under a DOE research contract. Soon after, VSL scientists perfected glass formulation using DOE wastes. GTS Duratek and VSL conducted continuous melter tests in the lab with Fernald wastes. By fall of 1993, a Duratek furnace was operating on site, processing surrogate material chemically identical to Fernald wastes. This year, GTS Duratek will process Fernald wastes on site.

In a joint venture with Chem Nuclear Systems Inc., GTS Duratek will design, build, and operate a furnace at Chem Nuclear System's low-level radioactive disposal site in Barnwell, South Carolina. The venture will convert low-level radioactive waste from commercial nuclear power plants, hospitals, and labs. The facility may be operational in 1995.

Prince says vitrification and incineration cost about the same amount, but vitrification generates recyclable glass that can be resold. The process can be used for medical waste, soils, sludges, radioactive waste from hospitals and commercial nuclear reactors, and asbestos.

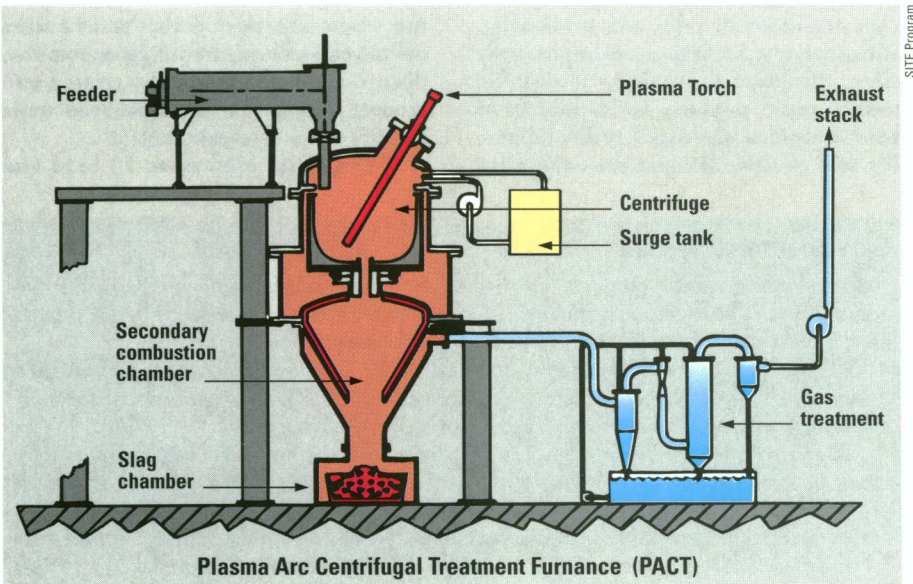
"Glass is the best waste form known," Prince says, "even if you break it into pieces. Contaminants dissolve into the glass and will stay in there for millions of years. Some glass brought back from the moon was 70 billion years old."

Bioremediation

Using technology developed at the University of Idaho and licensed by the J.R. Simplot Co., Envirogen Inc. has started phase one of its first commercial application of a biologically based toxic clean-up method. The new process uses naturally occurring microorganisms to clean soils contaminated with Dinoseb, a widely used nitroaromatic-based pesticide banned in 1985. In May, Kittitas County officials hired the Lawrenceville, New Jersey-based bioremediation firm to use its process at a former pesticide mixing and loading site at the Bowers Field airport near Ellensburg in eastern Washington.

The chemical compound called Dinoseb is an aromatic ring with two nitrogen groups. Anaerobic microbes cleave the rings, and the by-products are further broken down by aerobic microbes. The technology, developed with Superfund support, is a low-cost alternative to incineration.

"The only alternative for disposing of



Molten materials. Vitrification uses heat to turn hazardous wastes into glass.

SITE Program

Dinoseb is incineration,” says Craig Nowell, business manager of remediation services at Envirogen. “Dinoseb is a RCRA waste and land-banned—it can’t go into landfills. Only three incinerators in the country will take it. And incineration is expensive. It runs between \$400 and \$1,000 a ton. The Envirogen process averages out between \$100 and \$175 a ton.”

In a 1993 field trial, Envirogen and Simplot demonstrated the new technology at the site, reducing contamination by 99.9%. They conducted the project under EPA’s SITE (Superfund Innovative Technology Evaluation) program. In a Missouri SITE demonstration, the companies showed that the technology removes another nitroaromatic, TNT, from soil.

The major equipment used is a bioreactor and agitation and suspension devices. Support equipment includes earth-moving equipment (to excavate, screen, and load the bioreactor) and monitoring equipment (to track pH, redox potential, and temperature).

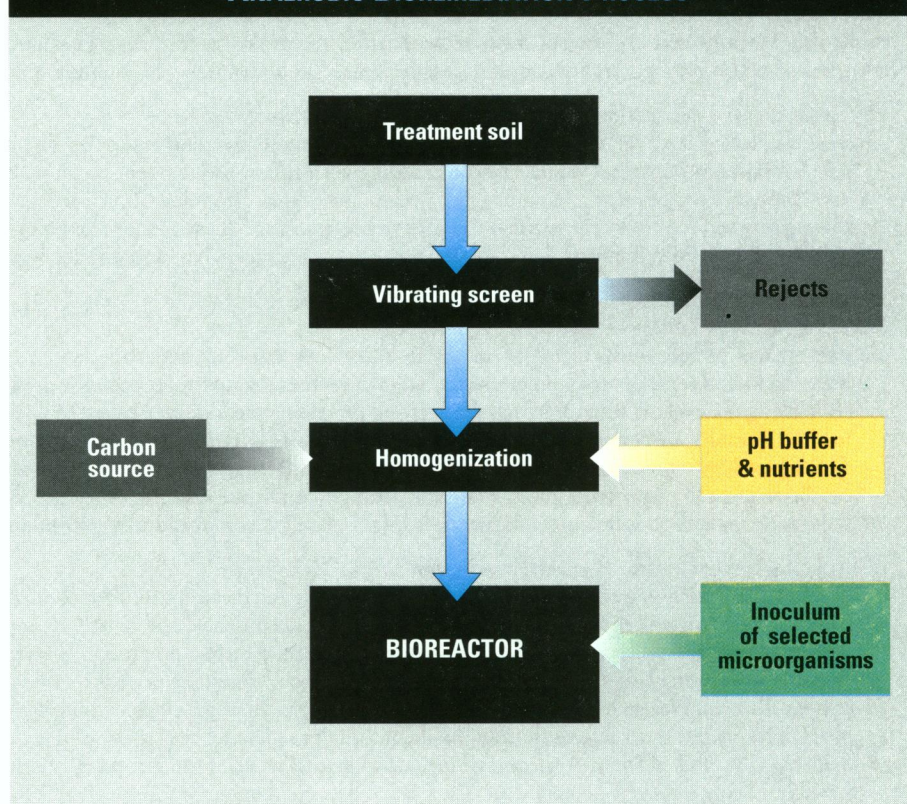
In the anaerobic bioremediation process, excavated soil is screened to remove large rocks and other debris. Oversized material is washed with hot water, separated, then put in a clean area. Wash water goes into the bioreactor. Contaminated soil is blended with a pH buffer, nutrients, and an inoculant and added to the bioreactor. Aerobic bacteria use the carbon source to consume available oxygen, creating anaerobic conditions needed for degradation. Anaerobic bacteria turn the nitroaromatic contaminants into nontoxic, nonaromatic, mineralizable end products.

The process is designed to destroy nitroaromatic compounds without forming toxic intermediates. The theory behind the technology is that soils contaminated with nitroaromatic compounds can be treated using an anaerobic “consortium”—a group of microorganism populations that form a community structure without oxygen with a certain symbiosis or interrelationship.

This method of bioremediation has been field-proven for TNT and other energetic compounds, as well as Dinoseb. Research programs are underway to expand the applicability of the process for other chemical compounds and to develop an *in situ* process for subsurface soil and groundwater. Currently, the process can be used at sites larger than 100,000 cubic yards. Plans have been developed for above-ground reactors, with batch sizes ranging from 40 cubic yards to 100,000 cubic yards.

Bioremediation costs are less than half the costs of incineration. The *ex situ* process remediates soils on site, thereby reducing the potential liabilities associated with off-site transport, treatment, or disposal of contaminated material.

ANAEROBIC BIOREMEDIATION PROCESS



Soil savers. Bioremediation uses anaerobic bacteria to degrade wastes and detoxify soil.

Nowell says one advantage of bioremediation is that it’s a natural process that doesn’t sterilize the soil like traditional incineration. Incineration requires the contaminated soil to be excavated, loaded into containers, and transported off-site to one of several approved incineration centers in the United States.

The fact that the process is a liquid-phase treatment “tends to limit its applicability for year-round use in northern-tier states,” according to Nowell. “And it’s an *ex situ* process. If we could develop an *in situ* process, that would save a lot of money.”

Back to the Source

Many of these waste disposal technologies got their start through the EPA’s SITE program, administered by the EPA Office of Research and Development. SITE’s purpose is to speed the development and use of innovative cleanup technologies for Superfund and other hazardous-waste sites.

At NIEHS, Suk is program director of the Superfund Basic Research Program, a precursor to SITE. The program is a university-based, multidisciplinary program of basic biomedical and technical research whose aim is to assess and evaluate human exposure to substances emanating from Superfund sites and remediate those exposures. “It’s probably the only program of its

kind in the world,” says Suk. “It’s different; we see it as a prevention program.”

“We run a basic research program,” Suk adds. “Some regulatory agencies have a mentality that says we need to clean everything up *today*. EPA says we must do it with the *best available technology*. But the other part is, you have to make an investment in the future. Let’s clean it up with the best available technology but also put money into new technology, or our grandchildren will be moving it around using *their* best available technology.”

“The point is,” Suk continues, “there are available technologies out there, but there are also new and possibly better ways of dealing with hazardous waste. We try to look at it holistically, using engineers, ecologists, hydrogeologists, biologists to get a different answer than just moving [the environmental waste] around. That’s what we’re getting at here.”

And they’re doing it with about 2% of EPA’s \$1.5 billion Superfund budget. The program is small, but it’s grown from about 0.2% of the budget. “We’ve done well because seven or eight years ago Congress did an important thing,” Suk says. “They established this program and placed it somewhere that was not a regulatory agency—where there was an established peer-review process so that what is funded is technically excellent work.”

The Superfund Innovative Technology Evaluation (SITE) program was authorized by the Superfund Amendments and Reauthorization Act (SARA) of 1986. The program is administered by the EPA Office of Research and Development. SITE speeds the development and use of innovative cleanup technologies for Superfund and other hazardous-waste sites. Following are examples of demonstrated technologies that can be used as alternatives to incineration.

1. Pyretron thermal destruction (*American Combustion Inc., Norcross, Georgia*)

This technology controls heat input into an incineration process by using oxygen-air-fuel burners and controlling excess oxygen levels available for oxidizing hazardous waste. The combustor mixes auxiliary fuel, oxygen, and air to enhance the flame envelope's stability, luminosity, and flame core temperature and reduce the combustion volume per million BTU of heat released. The computer-controlled system adjusts the primary and secondary combustion chamber temperatures and the amount of excess oxygen. The system can be fitted to any conventional incinerator to burn liquids, solids, and sludges; it treats any waste that can be incinerated but isn't suitable for processing aqueous, heavy-metal, or inorganic wastes.

2. Cyclone furnace (*Babcock & Wilcox Co., Alliance, Ohio*)

The cyclone furnace burns high-ash coal. High heat-release rates and high turbulence in cyclones create the temperatures needed to melt high-ash fuels. Inert ash leaves the water-cooled cyclone furnace as vitrified ash. For dry-soil processing, soil and natural gas enter tangentially along the cyclone furnace barrel. For wet-soil processing, an atomizer sprays soil paste directly into the furnace. Soil is captured and melted. Organics are destroyed in the gas phase or molten slag layer that's formed and kept on the furnace barrel wall by centrifugal action. This technology applies to inorganic hazardous wastes, sludges, and soils that contain heavy metals and organic constituents. The wastes can be solids, soil slurry (wet soil), or liquids. Because the furnace captures heavy metals in the slag and renders them nonleachable, an important application is treating soils that have lower-volatility radionuclides like strontium and transuranics.

3. Circulating bed combustor (*General Atomics, San Diego, California*)

The CBC uses high-velocity air to entrain circulating solids and create a turbulent combustion zone that destroys toxic hydrocarbons. The combustion chamber can treat up to 150 tons a day of contaminated soil. The CBC operates at a relatively low temperature, reducing operating costs and potential emissions like nitrogen oxides and carbon monoxide. Waste material and limestone feed into the combustion chamber with recirculating bed material from the hot cyclone. Limestone neutralizes acid gases. A conveyor takes treated ash out of the system for disposal. Hot gases produced during combustion pass through a convective gas cooler and baghouse before release into the atmosphere. The process treats liquids, slurries, solids, and sludges contaminated with cyanides, dioxins, furans, inorganics, metals, oxidizers, pesticides, PCBs, and phenols. Applications include industrial wastes from refineries, ammunition and chemical plants, manufacturing-site wastes, and contaminated military sites. The CBC is permitted to burn PCBs in all 10 EPA regions.

4. Infrared thermal destruction (*Gruppo Italimpresse, Rome*)

This is a mobile thermal processing system that uses electrically powered silicon carbide rods to heat organic wastes to combustion temperatures. Remaining combustibles are incinerated in an afterburner. Waste feeds into the primary chamber and is exposed to infrared radiant heat emitted by silicon carbide rods above the belt. A blower delivers air to areas along the belt to control the waste feed oxidation rate. Ash in the primary chamber is quenched with scrubber-water effluent, moved to the ash hopper, then to a holding area, and analyzed for organic contaminants like PCBs. Volatile gases from the primary chamber flow into the secondary chamber, where they are destroyed. Gases from the secondary chamber are ducted through the emissions control system, where particulates are removed in a venturi scrubber. An induced-draft blower draws cleaned gases from the scrubber into a free-standing exhaust stack. Scrubber-liquid effluent flows into a clarifier, where scrubber sludge settles out for disposal. The liquid flows through an activated carbon filter for reuse or to a publicly owned treatment works for disposal. The technology can be used for soils or sediments with organic contaminants. Liquid organic wastes can be treated after mixing with sand or soil.

5. Flame reactor (*Horsehead Resource Development Co., Monaca, Pennsylvania*)

This hydrocarbon-fueled, flash-smelting system treats metal-containing residues and wastes. The reactor processes wastes with a hot reducing gas produced by burning solid or gas hydrocarbon fuels in oxygen-enriched air. In a compact reactor, feed materials react quickly. End products are a nonleachable slag (a glasslike solid when cooled), a potentially recyclable, heavy-metal-enriched oxide, and, in some cases, a metal alloy. Volatile metals are fumed and captured in a product dust-collection system; nonvolatile metals go to the slag or can be separated as a molten alloy. Trace metals are encapsulated in the slag. The system requires that wastes be dry enough to be pneumatically fed and fine enough to react rapidly. The current system has a 3-ton-per-hour capacity. Individual units can be scaled to 7 tons per hour.

6. Radio frequency heating (*IIT Research Institute, Chicago, Illinois*)

This process uses electromagnetic energy *in situ* to heat soil, enhancing removal of volatile and semivolatile contaminants using an array of electrodes embedded in soil. Contaminants are removed by conventional soil-vapor extraction methods. Extracted vapor can be treated by existing technologies like granular-activated carbon or incineration. Radio frequency heating can be used to remove petroleum hydrocarbons, volatile and semivolatile organics, and pesticides from soils.

7. Steam-enhanced recovery (*Hughes Environmental Systems, Manhattan Beach, California*)

The steam-enhanced recovery process removes volatile organic compounds and semivolatile organic compounds from contaminated soil *in situ* above and below the water table. Steam is forced through soil by injection wells to thermally enhance the recovery process. Extraction wells pump and treat groundwater and transport steam and vaporized contaminants to the surface. Recovered nonaqueous liquids are separated by gravity separation. Hydrocarbons are collected for recycling, and water is treated before being discharged to a storm drain or sewer. Vapors can be condensed and treated by vapor-treatment techniques. Compounds suitable for treatment are gasoline and diesel and jet fuel; solvents like trichloroethylene and dichlorobenzene; or a mixture of these compounds. After applying the process, subsurface conditions are excellent for biodegradation of residual contaminants.

SUGGESTED READING

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U.S. EPA. Superfund Innovative Technology Evaluation Program. Technology profiles, 6th ed. EPA/540/R-93/526. Washington, DC: EPA Office of Research and Development, 1993.

trying to develop new and innovative ways to do just that, rather than going to a site at the end and looking for the best available technology. We see this program as a prevention program from the standpoint of environmental technology and health," Suk

says, "because you can't look at one without looking at the other."

Cheryl Pellerin

Cheryl Pellerin is a freelance writer in Alexandria, Virginia.

CHEMICAL MIXTURES AND QUANTITATIVE RISK ASSESSMENT

The Second Annual Symposium of the Health Effects Research Laboratory

The Health Effects Research Laboratory of the U.S. Environmental Protection Agency is pleased to announce that its Second Annual Symposium will be held November 7 - 10, 1994 at the North Raleigh Hilton in the vicinity of Research Triangle Park, North Carolina. This second in the Annual HERL Symposium Series on Research Advances in Health Risk Assessment will focus on recent progress in chemical mixtures research, emphasizing advances in mechanistic understanding of chemical interactions. Topics for discussion include: current risk assessment guidelines and practices; experimental approaches, methods, and models to evaluate mixtures; and, pharmacokinetic and pharmacodynamic interactive mechanisms. The purpose is: to identify current chemical mixtures research, critical data needs and important future research directions; and, to provide an opportunity for active dialogue on the role of mechanistic research on chemical mixtures in future risk assessment strategies. The format will include invited platform presentations and contributed poster presentations. For more information, please contact:

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 c/o RSD Conference Coordinator, MD-70, Health Effects Research Laboratory
 U.S. EPA, Research Triangle Park, NC 27711
 Phone: 919-541-5193 Fax: 919-541-4002
 Internet: MEETING\$MAIL@HERL45.HERL.EPA.GOV

