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Back in high school, I learned the importance of being “cool.” Thankfully, over time, my definitions of what is cool have evolved. For example, I no longer think it is cool to wear a poodle skirt with my saddle oxfords. So now that you know how cool I am, you must believe me when I tell you how cool it is that Soils magazine now has an electronic version out on the Internet in the World Wide Web!

For the vast majority of you who are “Net-Experts,” old pros with the Internet and the Web, please indulge the excited rantings of a newbie such as myself. This Web is so cool! It is the neighborhood on the Internet where it is safe to conduct business and commerce. Built on a governmental and academic foundation, traditionally, the Internet has discouraged anything resembling buying or selling. And, we’re all grown-ups here—let’s face it, there is a certain amount of “commercial intercourse” going on in Soils magazine. Visit our website! Condensed versions of key articles are there, along with photos and Soils’ famous illustrations. Several of our “Here’s How It Works” features are there, and more are added all the time. Manufacturers, suppliers and new products are there. Every day, I am adding directories, glossaries, contact points and new developments.

The instantaneous timeliness of the web is the coolest new toy I’ve run across since the salad spinner. After nearly five years of publishing nine issues of Soils per year, imagine my awe at being able to update the web version every day.

But friends, the very coolest part of this web Soils is that it is interactive! You can post messages, comments, requests for information. I can post questions, survey your thoughts, collect solutions to problems. I’m told I will soon be able to put videos and animation—even music—on my web Soils site. Frankly, I haven’t thought in what musical direction I might go, but can you just imagine what an animated “Here’s How It Works” feature will look like?

As recently as two months ago, I was skeptical about the Internet—skepticism borne of ignorance. I had never bothered to pursue the Internet to learn anything about it. Now look how silly I’m acting. I guess I’m the last one to figure out the marvels of being on line, but I’m too excited to act nonchalant (cool?) about it.

I’m still a little giddy with all this... I feel a little like it’s halfway through Christmas morning, and I still have some packages left to open. The potential is so exciting.

So! Let this be your official invitation to visit Soils on the web. Browse around, see what’s there. But, don’t exit without leaving me a message, a question or a request. URL www.wavelinx.com/soils.

From the editor

Soils in a day’s work

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Abbreviations and acronyms used throughout articles include:
EPA Environmental Protection Agency
UST Underground Storage Tank
ppm parts per million
ppt parts per billion

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Soils May 1998 5
Engineered bioreactor systems are being used in both remediation projects and in industrial plant pollution control applications to destroy organic contaminants. The key to their success is creating the appropriate process conditions necessary to allow microbial transformations to take place cost efficiently. There are two more advanced types of aqueous phase treatment systems. One is based on fluidized bed and the other is based on membrane biological reactor technology.

The first type, a fluidized bed bioreactor, is a fixed film reactor which immobilizes microbes on a hydraulically fluidized bed of media particles, granular activated carbon or sand, as shown in figure one, right. These particles provide a vast surface area for biological film growth. Use of granular activated carbon as the fluidized bed medium enables the integration of the removal mechanisms of biotreatment with physical-chemical adsorption into a single reactor configuration. The granular carbon bed enhances the ability of the reactor to treat more recalcitrant organics, and mitigates microbial inhibition due to various toxic inputs.

Envirogen Inc., Lawrenceville, N.J., designs commercial scale fluidized bed bioreactor systems. The contaminated influent stream, as shown in figure one, above right, is mixed with nutrients, oxygen, pH control chemicals, and fed into the lower portion of the reactor which operates in a plug flow fashion. As microbes grow on the fluidized bed, their diameter increases and their effective density is reduced, resulting in a bed expansion beyond that due to fluidization of the unseeded media. The thickness of the biofilm is controlled to prevent the density of the bioparticles from decreasing to the point where bed carryover occurs. Oxygen needed for the metabolism during aerobic operation is supplied by a packaged PSA system. Liquid nutrients and pH control chemicals are metered into the reactor from an ancillary feed and process system.

The second type of bioreactor system is based on membrane bioreactor technology. Unlike the fixed-film bioreactor, maintaining a high biomass concentration in the suspended growth reactor portion of the system depends on the performance of the downstream separation step and subsequent biomass recycle. The membrane bioreactor system consists of a suspended growth reactor coupled to ultrafiltration modules, as shown in figure two, page 8. Aerobic or anaerobic reactions take place in one or more suspended growth reactors. Following biological oxidation and/or reduction, the contents of the reactor(s) are pumped to the ultrafiltration membrane module for solid-liquid separation. The ability of the membrane bioreactor system to control solids retention times is also key to the development and maintenance of specific microbial communities.

Steven Cohen is director of water treatment systems for Envirogen Inc., Lawrenceville, N.J. Brian Folsom, Ph.D. is manager of the water treatment program for Envirogen, and Paul Sutton, Ph.D., is a principal at P.M. Sutton and Associates, Bethel, Conn.
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MBR process schematic

Nutrient and chemical additions

Contaminated influent

Variable volume suspended growth bioreactor

Ultrasound membrane system

Concentrate recycle

Treated effluent

Figure two

populations. Solids retention time, or microbial growth rate, is controlled by removal of excess biomass directly from the reactor. Precise control of retention time prevents loss of selected microbes that have the ability to degrade a specific compound or grow at low contaminant concentrations.

The choice of which type of bioreactor to choose (figure three) for a particular site is governed by:
- influent flow rate
- mix and concentration of organic contaminants
- build up and retention of biomass
- required effluent quality
- space available

The fluid bed reactor is useful over a broad range of influent flowrates and low to moderate contaminant levels. Higher flow rates can result in lower per unit treatment costs. Single train units can be configured for systems approaching 5,700 liters per minute of lightly contaminated feed. The membrane bioreactor, on the other hand, produces better cost efficiency for lower flow rate streams which are high in oxygen demand concentrations because costs of the membrane portion of the system do not have the same economies of scale as the fluid bed system. Ultimately, selection of the proper system depends on conditions at each site.

In 1994, Envirogen completed a demonstration for the U.S. Department of Defense at Robins Air Force Base to

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8 May 1995 Soils
evaluate performance of a fluid bed system being fed with a groundwater stream contaminated with petroleum and chlorinated organics. Results of that trial indicate that the fluid bed bioreactor system had lower life cycle costs than air stripping with dry carbon adsorption, wet carbon adsorption or ultraviolet peroxidation systems.

Precise control of solids retention times is particularly important at chemical plants, where it is necessary to develop microbial populations to treat specialized process waste streams. P.M. Sutton & Associates played a role in guiding pilot plant studies conducted at General Motors Corp. involving application of membrane bioreactor technology to automotive manufacturing plant waste waters. (Novel Biotreatment of Oily Wastewater: Results from Full Scale Operations, Stroup, D., Sutton, P.M., Mistrow, P.M. and Jason, A., proceedings WEF Industrial Waste Conference, Pittsburgh, Pa., March 1995.) Four different wastewater streams were treated at three GM plant sites using two membrane bioreactor pilot plant systems. The pilot plant performance convinced GM to install a full scale membrane bioreactor system at their Mansfield, Ohio plant. The system is designed to handle over 150,000 liters per day of in plant wastewater.

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Soils May 1995
Where is the UST market going?
Changing regs, iffy compliance deadlines emerging technologies—all contribute to uncertain future

Future Technology Surveys Inc., of Lilburn, Ga., put together a panel of 13 experts in the underground storage tank industry, and asked them where the industry is headed. Here are their responses:

Q: What advances will occur within the next five years?
- better leak detection,
- improved design integrity
- longer lasting composites
- low cost 2-3 product systems with compartmentalized tanks and minimal piping
- more automation in spill and overfill controls, tank monitors and leak detection
- more attention to installation problems
- remote monitoring of tanks
- retrofit double wall tanks
- wireless monitors that can be installed with no site construction cost

Q: What will be the total UST products and services expenditures for the decade of the 1990s?
Median response: $25.0 billion
Mean response: $27.5 billion

Q: In what year will the market peak?
Median response: 1996
Mean response: 1998

Q: What will be the 1998 annual market for UST products and services?
Median response: $4.0 billion
Mean response: $4.6 billion

Q: What will be the 1998 market distribution by expenditure?
New tank purchases 20%
Removals and closures 25%
Tank and soil testing 7%
Soil and groundwater remediation 17%
Consulting and lab services 12%
Monitors 6%
Cathodic protection 5%
Spill and overfill 4%
Retrofit liners 2%
Other 2%

Continues on page 12 ➤
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Write in 268
Where is the UST market going?, from page 10

Distribution of UST by material (1998)

- fiberglass: 45%
- fiberglass-coated steel: 35%
- cathodically protected steel: 15%
- other underground types: 5%

Q: What will be the distribution of expenditures?
   - industrial and commercial: 23%
   - government: 18%
   - major oil companies: 21%
   - independent oil companies: 19%
   - independent jobbers: 17%
   - other: 2%

Market Distribution by monitoring equipment type (1998)

- tightness: 50%
- groundwater monitors: 13%
- interstitial monitors: 20%
- vapor monitors: 8%
- all others: 7%

Q: Who are the tank market leaders?
   - fluid containment—Houston, Texas
     (formerly ovens-Corning tank div.)
   - xerxes—Anaheim, Calif.
   - highland tank—Manheim, Pa.
   - joor manufacturing inc.—Escondido, Calif.
   - modern welding co. inc.—Owensboro, Ky.
   - brown-Minneapolis tank—Eagan, Minn.
   - central tank co. inc.—Marlow, Okla.
   - clawson tank co.—Clarkston, Minn.

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12 May 1995 Soils
Q: What percentage of USTs will be replaced with aboveground storage tanks?
   Median response: 15%
   Mean response: 20%

Q: What will be the market distribution by monitoring equipment type in 1998?
   - Tightness test monitors and instruments 13%
   - Automatic tank gauging 50%
   - Groundwater monitors 8%
   - Interstitial monitors 20%
   - Vapor monitors 7%
   - All other 2%

Q: Who are the UST monitor market leaders?
   Veeder Root—Simsbury, Conn.
   Gilbarco—Greensboro, N.C.
   Tidel Engineering—Carrollton, Texas
   Arizona Instrument Corp.—Tempe, Ariz.
   Emco-Wheaton Inc.—Cary, N.C.
   Heath Consultants—Houston, Texas
   Ronan Engineering Co.—Woodland Hills, Cal.

Q: What are the most important recent advances in commercial UST monitoring technology?
   - Tying monitoring to SIR concepts for more consistent data
   - Ability to pass precision test requirements
   - Communications ability
   - Double wall tank options with simpler interstitial monitoring techniques
   - Increased sensitivity in interstitial systems to detect 0.75 mm of liquid
   - Inventory control with leak detection monitoring in automatic tank gauge systems

Q: What is the relative emphasis in terms of expenditures on various technologies for soil and groundwater remediation due to leaking underground storage tanks?
   
<table>
<thead>
<tr>
<th>Technology</th>
<th>Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioremediation</td>
<td>6.50</td>
</tr>
<tr>
<td>Air stripping</td>
<td>5.75</td>
</tr>
<tr>
<td>Venting</td>
<td>5.50</td>
</tr>
<tr>
<td>Enhanced volatilization</td>
<td>5.25</td>
</tr>
<tr>
<td>Vacuum extraction</td>
<td>5.00</td>
</tr>
<tr>
<td>Off-site soil treatment</td>
<td>4.50</td>
</tr>
<tr>
<td>Landfill disposal</td>
<td>4.25</td>
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<tr>
<td>Incineration</td>
<td>4.25</td>
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<tr>
<td>Biodegradation</td>
<td>3.25</td>
</tr>
<tr>
<td>Soil washing</td>
<td>3.25</td>
</tr>
<tr>
<td>Cut-off wells</td>
<td>1.75</td>
</tr>
</tbody>
</table>

*Line leak detection
* More accurate and easily operated monitoring systems
* Product specific sensors
* Recalibration technology
* Tracer leak detection
* VOC detectors

*Who are the UST services market leaders?
  Tyree Organization—Farmingdale, N.Y.
  Camp Dresser & McKee Inc.—
  Cambridge, Mass.
  Dames & Moore—Los Angeles, Calif.
  McLaren Hart Environmental—Rancho Cordova, Calif.
  Metcalf & Eddy—Wakefield, Mass
  Omega Environmental Inc.—Bothell, Wash.
  Science Applications Int’l. Corp.—
  San Diego, Calif.
  Tanknology Environmental Inc.—
  Houston, Texas
  Versar Inc.—Springfield, Va.
  Roy F. Weston Inc.—West Chester, Pa.
Where is the UST market going? from page 13

VOC extraction using
ozone, ultraviolet,
ultrasonics 4.50
Excavation and landfelling 4.25
Excavation and off-site soil treatment 4.25
Incineration, thermal methods on site 4.25
Biodegradation using denitrification 3.25
Soil washing 3.25
Cut-off wells 1.75

Q: What trends will develop over the next five years among UST owners and operators in dealing with regulations and environmental liabilities?
- ASTM D-50
- Compliance to minimal levels on all but the most sensitive sites
- Continued switch to double wall tanks
- Fewer problems due to improved UST systems
- Increased enforcement
- Improved knowledge of regulations, remediation methods and reliable contractors
- Independent jobbers, if they comply at all, will do the minimum and deter implementation as long as possible
- Management contractors brought in to manage sites and assume financial responsibility
- Many contaminated sites will never be cleaned up
- Many owners of low throughput tanks will continue to close them
- Many retail locations with marginal volume will close
- Many tank owners will continue to take a wait-and-see attitude
- More insurance requirements
- Most oil companies have been upgrading their tanks for some time, which has resulted in a substantial portion already in compliance with the regulations
- Property transfers will drive the UST remediation market, not enforcement
- Significant increase in activity to get into compliance
- Fear of cost of remediation will drive companies to monitor and comply
- Majority of all tanks over 20 years old will be replaced and the balance closed. Since these tanks are nearing the end of their expected life, replacement is more cost effective than installing cathodic protection.

Q: What are the most significant threats to the growth of the UST market?
- Aboveground tanks
- Changes in interpretation of regulations
- Closure of tanks
- Depressed pricing
- Environmental laws
- Expense of cleanups
- Inconsistent enforcement
- Inexperience and poor judgment in managing projects
- Lack of insurance
- Natural gas as a primary source of fuel
- Phased-in regulations, distant deadlines, deadline extensions and slow compliance will shift many expenditures beyond the 1990s
- Profitability of the oil companies
- States lack manpower for enforcement

Q: What are the areas of best opportunity related to this field?
- Remediation
- Implementation of cost effective remedial techniques
- Annual site visits to test and service existing systems (cathodic protection, lines, leak detectors, etc.)
- Cost effective bioremediation
- Engineering
- Improved UST systems
- Industrial and commercial markets in the industrial heartland of the U.S.
- Innovative remedial technologies that are low in cost and least disruptive
- Legal
- On-line monitoring
- Removals
- Tank management system planning
- Testing and project management
- Turnkey service

The complete report is over 40 pages, was conducted by Richard Miller and Marcia Rupnow, and focuses on how future technology, markets and applications will evolve in the underground storage tank business. It costs $200, and is available from Future Technology Surveys Inc., 700 Indian Trail, Lilburn, GA 30247. Call 404-717-0779. FTS also has market surveys on immunoassays, aboveground storage tanks, PCBs, leak detectors, waste minimization, bioremediation, groundwater remediation, geographic information systems and other environmental issues.
As part of a RCRA Corrective Action, the Tennessee Valley Authority (TVA) was required to remediate leaking underground storage tanks from two diesel-fuel storage areas at its Environmental Research Center in Alabama. Under state regulations, the groundwater and soil required remediation to very conservative cleanup levels. TVA retained ENSR to determine the best remediation approach to satisfy the Alabama Department of Environmental Management (ADEM) and EPA Region IV requirements.

ENSR reviewed past site investigations and found that the sampling and analysis techniques previously used may have been misleading. They implemented a detailed site characterization which used modified EPA analytical procedures to better define the extent of contamination. In addition, they conducted a site-specific risk assessment to determine if alternative clean up levels were appropriate, and a treatability study to evaluate the effectiveness of the alternative remedial technology. Based on this thorough and accurate data, ADEM approved much less stringent cleanup levels and the use of on-site bioremediation.

Accurate data produces savings

One of the keys to the site solution occurred when, in an unprecedented step, ADEM approved the use of modified EPA analytical procedures. In place of ADEM specified methods, gas chromatography and mass spectrometry testing were used to define the extent of contamination. These accurate analytical techniques and refined sampling methods, pinpointed the specific site contaminants and the true extent of contamination at the two locations.

The volume of contaminated soil was actually twice the original estimate, and the contaminants were

Continues on page 16

By Blair Burgess and Scott Huisman

Blair Burgess, P.E., is program manager in ENSR's Florence, Alabama office. Scott Huisman, P.E., is a senior project engineer for ENSR.
characterized as diesel fuel #4 at one site and diesel fuel #2 at the other. Although a greater volume of contaminated soil was discovered, negotiating the lower cleanup levels resulted in a lesser project cost. The health-based risk assessment incorporated the site's industrial setting and the toxicological properties of the two diesel fuels.

This evaluation demonstrated that a much less stringent cleanup level than originally proposed—5,000 ppm instead of 100 ppm—would remediate the site while clearly protecting human health and the environment. ADEM took another unprecedented step by approving this higher level based on results of the health risk assessment. Consequently, the volume of soil requiring remediation was reduced by over 4,200 cubic meters. Moreover, because contaminant levels at one of the two sites were already within these levels, only one of the sites required remediation.

**Bioremediation solution slashes cleanup costs**

The original corrective measures study identified off-site thermal desorption as the most effective remedial option, with bioremediation a close second. Upon ADEM’s approval of the higher cleanup levels, a treatability study was launched to simulate land farming conditions at the sites. This demonstrated that bioremediation technology could reduce contaminant concentrations to levels even below target levels.

Under the original, stringent cleanup criteria, bioremediation was not feasible. However, under the new cleanup levels, bioremediation could be completed in about 10 weeks—at a lower cost than thermal treatment. In original estimates, the cost of thermal treatment was about $200,000, but it rose to about $550,000 under the more detailed characterization. Bioremediation under the less stringent cleanup levels cost $50,000.

The land-farming solution also averted the liabilities associated with off-site treatment and disposal. In addition, contaminated groundwater was removed and treated as the excavation was dewatered. With ADEM’s approval, the remedial soil was backfilled and restored the site to original grade. Quarterly groundwater monitoring has shown that contaminant levels in the groundwater have consistently remained below drinking water standards. The site was closed in March 1995.

_write in 766 for more information_

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May 1995 Soils
Bioremediation is cool in Minnesota summer
With the right enhancements, hydrocarbon levels drop

By Bill Lashmett

As state pollution control agencies see results of successful bioremediation projects, they are becoming more approving of the process. In St. Louis County, in northern Minnesota, the Pollution Control Agency approved a series of bioremediation projects at several sites contaminated with a variety of hydrocarbons.

As far back as the summer of 1992, state regulators were interested in methods to treat contaminated soil piles with bioremediation, rather than land farming. The state agency staff expressed concern about volatility and leaching, but wanted verification that the process would break down various fuel contaminants in different soils.

At four leak sites in the county, soil types varied from sandy to clay soils. Pollutants included gasoline, diesel fuel and waste oil. Because the Pollution Control Agency considered the project as an experimental procedure in 1992, the soil at each site was divided into four piles, and each pile was designated to undergo a different treatment protocol:

1. bioremediation, uncovered
2. bioremediation, covered
3. untreated, uncovered
4. untreated, covered

Covering half the piles with plastic liner enabled researchers to determine whether the treatment actually worked, or if contaminant levels declined simply because of volatilization. Initially, the agency requested that the soil treatment be staged on an asphalt pad or other impermeable surface, surrounded by a berm to trap runoff. Eventually, the decision was made to treat the soil on natural ground and sample beneath the piles to determine if there was any leaching from the test piles.

Because there was such a variety of soil types and contaminants, three methods were used to divide and treat the soil piles. One site involved 9 cubic meters of sand contaminated with fuel oil. Piles were divided with a front end loader into smaller piles about 300 mm thick.

Workers from B&S Research Inc., Embarrass, Minn., applied a solution of naturally occurring soil bacteria and fungi to the piles from a pressurized tank with a spray wand. The solution was sprayed on top of the piles and mixed in with a garden tiller.

Larger piles were separated and divided with a dozer or grader into windrows about 600 mm high. Two maintenance garage sites contributed about 250 cubic meters of soil contaminated with gasoline, diesel and fuel oil. About 3.8 cubic yards of this total was contaminated with waste oil. After being treated with the bioremediation solution, the windrows were mixed with a heavy industrial mixer or tiller. The soil was treated twice to ensure coverage of the solution.

One site had especially heavy clay soils, and compaction proved to be a problem. An automotive garage had 750 cubic meters of soil, of which over 225 cubic meters was contaminated with gasoline, and the remainder with waste oil. The clay soils were run through a screen to separate rocks and break up clods.

Figure one: Results of bioremediation at four Minnesota sites.

<table>
<thead>
<tr>
<th>Location</th>
<th>Contaminant</th>
<th>Initial concentration (ppm)</th>
<th>Final concentration (ppm)</th>
<th>Percent reduction</th>
<th>Days of operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virginia site</td>
<td>TPH</td>
<td>156</td>
<td>0.002</td>
<td>100.00</td>
<td>102</td>
</tr>
<tr>
<td>Calvary site</td>
<td>TPH</td>
<td>124</td>
<td>0.002</td>
<td>100.00</td>
<td>150</td>
</tr>
<tr>
<td>McQuade site</td>
<td>TPH</td>
<td>1015</td>
<td>72</td>
<td>92.91</td>
<td>150</td>
</tr>
<tr>
<td>Hibbing site</td>
<td>TPH</td>
<td>1115</td>
<td>0.002</td>
<td>100.00</td>
<td>77</td>
</tr>
</tbody>
</table>

Bill Lashmett is president of B&S Research Inc., Embarrass, Minn.
Minnesota summer, from page 17

of clay. The soil was sprayed with the bioremediation solution as it traveled out of the screen on the conveyor belt. The conveyor dropped the soils in a dump truckbed, which was used to spread the treated soils in rows about 300 mm thick. This screening and spreading process helped to aerate the heavy clay.

The process worked well within one cool and rainy Minnesota “summer” season—cool and rainy weather not being the most conducive condition for natural microbial activity. The best results were obtained where soils were thoroughly mixed with the bioremediation solution. Soil texture also affected the results. Sands or sandy loam soils are easier to treat and mix. One site contaminated with fuel oil achieved below target contaminant levels in about 14 weeks. Other sites that were contaminated with heavier fuels, such as diesel and fuel oil, took longer to reach targeted safe cleanup levels. At the clay site, where soils were screened and treated on the conveyor, target cleanup levels were achieved in just 11 weeks.

These results confirmed the importance of air supply to successful bioremediation. Compacted soils without adequate air supply took longer to bioremediate.

Covering the soils with plastic slowed the bioremediation process compared to the uncovered piles of soil. Cooler and wetter soils, as are often encountered in northern climates, also slowed down the breakdown of contaminants, but did not stop microbial activity altogether.

No volatilization was measured from uncovered piles after mixing. Sample results from several of the sites detected no leaching under the soil piles.

“I must conclude that bioremediation does indeed work, and that it can work faster than soil farming, especially on waste oils,” says Tom Tri, environmental project manager for St. Louis County. “Although the cost compares with composting, bioremediation with cultured bugs does not have the manure smell or the management difficulties of handling manure.”

Costs of the bioremediation treatment, including mixing labor costs of heavy equipment ranged from $7.60 to $11.50 per cubic meter, plus hauling costs. By comparison, costs in St. Louis County for thermal treatment or soil farming range from $26 to $57 per cubic meter.

Soils that emerged from treatment with less than 5 ppm total petroleum hydrocarbon content were returned to their sites as controlled backfill. Soils that measured less than 10 ppm were used for road fill. Treated clay soils were combined with gravel and also used for road fill.

Write in 767 for more information

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**Bioenhancement Poster Session**

**The 10th Annual Conference on Contaminated Soils**

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**Special Poster Session**

A special poster session will be held at the Tenth Annual Conference on Contaminated Soils at the University of Massachusetts, Amherst, October 23-26, 1995. The poster session, now in its third year, will focus on bioenhancement products and processes applicable to bioremediation of petroleum contaminated soils with particular emphasis on diesel fuel. In addition to viewing by the general conference attendees, a special review session for representatives of the railroad industry will be hosted. In previous years the review has resulted in a report on the poster presentations that was widely circulated among the railroad environmental community. This is a unique opportunity for the presenters to introduce their products and/or processes while directly interfacing with the railroad industry's environmental community as well as other potential industrial customers and federal, state, and military agencies.

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Write in 269

18 May 1995 Soils
Monitoring is key to intrinsic bioremediation
But site must prove degradation is occurring

By Kevin Powers

Intrinsic bioremediation, also called passive bioremediation or natural attenuation, is the naturally occurring biodegradation of organic contaminants. It is natural because nothing is done to stimulate or enhance the process. It is not, however, a no action, walk away from the site option, but rather a remediation alternative that must be approached like any other method. While it is often less expensive than conventional active remediation, there are certainly costs involved.

As with all environmental regulations, the perspective on intrinsic bioremediation depends on the jurisdiction the site is in. Intrinsic bioremediation is mentioned in the National Contingency Plan and in the proposed Superfund reauthorization. In addition, the EPA Office of Underground Storage Tanks is issuing a new Guide for Corrective Action this fall which will include intrinsic bioremediation.

The state perspective varies. Several states, such as Michigan and Wisconsin, among others, accept intrinsic bioremediation as a remedial option. One of the main obstacles to the acceptance of intrinsic bioremediation is the common misperception on the part of both regulator and responsible party that is a no-action option.

There are actually two main areas of concern for the proper use of intrinsic bioremediation. The first is the site characterization, which may very well be more intensive than with other remedial options. The second is site monitoring.

Thorough site characterization is critical to determine if intrinsic bioremediation is an option at any given site. Some states have developed guidelines which lay out the requirements for intrinsic bioremediation. For example, Wisconsin has published a guidance document for soil remediation using intrinsic bioremediation, and is preparing to issue further guidance for groundwater remediation.

The basic information needed includes the type and concentration of contaminants present, whether any natural organisms are found that can biodegrade the contaminant, whether the subsurface is aerobic or anaerobic, and whether there are enough nutrients and electron acceptors present to allow bioremediation to occur. The goal of the site characterization is to prove intrinsic bioremediation is actually occurring at the site, and that it can continue to effectively consume the contaminant. This usually includes extensive sampling of both soil and groundwater.

If enough historical data exists on the site, it may not be necessary to prove bioremediation is occurring, only that the contaminant plume is not migrating and the contaminant concentrations within the plume are declining. This is indirect evidence that a naturally occurring process is containing the contaminant. Again, the tradeoff between indirect and direct evidence depends on the controlling agency.

Once intrinsic bioremediation has been chosen as the remedial measure for a specific site, a monitoring program must be established. The monitoring requirements are geared towards ensuring that remediation continues to occur and that the plume is not presenting a threat to human health or the environment. Often the agreement to pursue intrinsic bioremediation contains some trigger mechanism requiring action if certain conditions are met—such as the plume migrates beyond an acceptable limit, or contaminant concentrations reach a certain level.

One of the biggest deterrents to using intrinsic bioremediation is the time factor. Because there is no active removal of contaminants, the process may take considerable time to clean up a site. A responsible party may be more concerned with closing a site so it can use or dispose of the property. While intrinsic bioremediation could take years to clean a site, active remediation can also require a long period of time—witness the many pump and treat systems that have been in operation for over a decade.

In addition, many states, including all six states in EPA Region V, have voluntary cleanup programs which seek to recycle contaminated property as quickly as possible. By cooperating with the agency, the responsible party may be able to sell property otherwise considered untouchable, giving intrinsic bioremediation the time to work.

Kevin Powers is vice president of Leggette Brashears & Graham Inc., St. Paul, Minn.

Continues on page 20 →

Soils May 1995 19
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Monitoring is key, from page 19

![Effect of IB on TCE/DCE ratio](image)

**Figure one: Effect of intrinsic bioremediation on TCE/DCE ratio.**

Bioremediation can occur in both aerobic and anaerobic conditions, although aerobic biodegradation is more efficient. Case studies presented at a recent EPA symposium on intrinsic bioremediation focused on petroleum hydrocarbons such as gasoline, oil, jet fuel and crude oil. The presentations demonstrated that intrinsic bioremediation works on a variety of contaminants in a number of different aquifer types.

In some cases, intrinsic bioremediation was used in conjunction with active remediation, either concurrently or sequentially. In one case presented, intrinsic bioremediation was used to address the residual contamination that would not have been cost effective to remediate with active techniques.

It is important to note that intrinsic bioremediation may be applicable to chlorinated solvents as well as petroleum hydrocarbons. The chlorinated solvent group consisting of perchloroethylene, trichloroethylene, dichloroethylene, vinyl chloride and ethylene was discussed in several presentations.

The effects of intrinsic bioremediation can be seen in figure one, above, which shows the ratio of trichloroethylene as the original contaminant to CIS-DCE, the primary breakdown product of trichloroethylene, at a manufacturing facility in the midwest. The ratio decreases with increasing distance from the source, and the intrinsic bioremediation process has more time to work on the contaminant. At the downgradient edge of the plume, no trichloroethylene is detected, while the levels of CIS-DCE are above regulatory limits.

While chlorinated solvents are usually broken down in anaerobic conditions, there are reports that the biotransformation can also occur in aerobic conditions. Unlike bioremediation of hydrocarbons, the bugs do not consume the chlorinated compounds, rather they use them in co-metabolism. Some other carbon source is required for the process to take place. Usually, biotransformation of chlorinated solvents is not as efficient, and therefore not as fast as the bioremediation of hydrocarbons.

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MILLIPORE
Selected grass roots can pull up hydrocarbon contaminants

By A. Paul Schwab, Ph.D.

For eight years, Kansas-based Chem-Rail Transport Inc., has processed requests for rail rates to haul vast amounts of soil from a multitude of manufacturing businesses, whose processes generate soil contaminated with hydrocarbons.

As Chem-Rail became aware of the high costs involved in transportation and disposal of contaminated soils, it was natural that they would seek out a less expensive, yet effective alternative to the hauling solution.

They found phytoremediation, a plant-based technology that combines conventional in situ bioremediation with an active root system of plants. So they started a new company, Soil Solutions Inc., to market plant-based bioremediation of soils contaminated with organic chemicals as a passive, low management approach that is less expensive than nearly all alternative approaches.

The usual bioremediation of contaminated soil typically involves stimulation of the native population of microbes which can degrade the target compounds. A drawback to conventional bioremediation is that degradation of the contaminants is rapid in the early stages, then slows to an imperceptible rate, even though site evaluation includes an assessment of the type and extent of contamination, determining the extent of contamination, cataloging the soil properties and charting the climatic conditions of the locale.

Occasionally, information about the type and extent of pollution may be available from previous assessments. If not, the soil must be extensively sampled to determine the depth and lateral extent of pollution. If the soil is contaminated deeper than about 2.5 meters, phytoremediation may not be a good choice due to the limitation of the active rooting zone of most plants.

After the area of contamination has been mapped, it is essential that a thorough characterization of the soil be made. This is relatively inexpensive, but provides information crucial to the success of the remediation plan. Characterization of the soil includes identification of the physical and chemical properties of the soil, including:

- particle size distribution,
- pH,
- organic carbon,
- hydraulic conductivity,
- nutrient concentrations,
- soluble salts,
- soil series.

Determination of these elements of the soil characterization provides enough information to decide whether the soil requires fertilization, leaching or other treatment to make it suitable for supporting plant growth.

The remediation plan must include site preparation, plant
species selection, sampling schedule and management guidelines.

The soil properties and climate of the region dictate the species of plant to be selected. It is imperative that the plants chosen are adapted to the locale. In general, perennial grass species are best suited to phytoremediation, but there are other choices.

The end result of a well designed and executed remediation strategy is only as good as the final chemical analysis of the soils and subsequent interpretation. Therefore, inadequate sampling or inappropriate statistical analysis can easily lead to unreliable conclusions.

The proper number and frequency of sampling is determined by site characterization data, and although chemical analysis of the samples is one of the more expensive aspects of phytoremediation, properly executed sampling is a valuable investment.

As with site preparation, the management plan depends entirely of the climate and soil characteristics of the site. Site specific conditions determine:
- rate and frequency of fertilization,
- mowing or harvesting of plants,
- tillage,
- irrigation.

Regular fertilization with nitrogen and phosphorus is necessary to maintain a highly active microbiological pool. Mowing and harvesting is needed with many perennial plants to ensure maximum root activity. Tillage and irrigation are needed only under special circumstances.

Periodic sampling of soil and plant tissue is central to the monitoring effort. Sampling design must reflect the lateral distribution of the contaminant as well as its depth and penetration in the soil. Plant tissues need to be analyzed only in cases where the contaminant is assimilated by the vegetation. Results are used to determine if concentrations of the contaminants are high enough to warrant special management of the harvested material.

Phytoremediation takes more time than some traditional or intensive treatments, but the savings of financial and natural resources can offset the time factor. Safety and training programs are not complicated, expensive engineering is not necessary, personnel requirements are not great, and setup costs are minimal. Phytoremediation is effective on petroleum hydrocarbons, including ‘F’ listed wastes and chlorinated hydrocarbons.

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Soils May 1995 23
Solvent solves crude cleanup
Makes bioremediation of paraffinic crude oil possible

By David Reel

"This case reflects a growing trend, proving that industry can be more personally involved in their own cleanup work by incorporating bioremediation into their in-house maintenance programs."

Soil encrusted with aged, paraffinic crude oil. Before (above) and after (below) treatment to disperse crude oil into the soil for bioremediation.

Paraffinic crude oils are often a problem in a bioremediation project. Thick viscosity typically makes it difficult to disperse into the soil, and often, the native soil microbes are not effective on the paraffin. As concentrated crude oil is toxic to the microbes, paraffinic crude must be liquefied and dispersed before biodegradation can proceed.

A cleanup project at an oil field production and storage site illustrates the problems presented by the presence of paraffinic crude oil, the type of crude requiring heat treatment to move it through the pipeline.

David Reel is vice president and general manager of Serengeti Environmental, Houston.
At this site, paraffinic crude had been leaking from pipes and fittings for years, small spills had occurred over time, and a recent tank overflow spilled crude oil on the soil. Gravel, shell and soils around the tanks were encrusted with up to 50 millimeters of hardened crude. Patches of new crude up to 75 mm thick stood in spots around the tanks, and the soil was contaminated with 1,000 to 16,000 ppm TPH (total petroleum hydrocarbons) to at least 300 mm depths.

The client asked Serengeti Environmental, of Houston, to create a bioremediation system within the earth berm enclosing the storage tanks. In addition, the client wanted to take a proactive role in the cleanup. They retained control over the maintenance of the bioremediation system, as well as all communications and reporting to the regulatory agency.

A remediation plan was developed to provide:

- appropriate nutrient loading to support biodegradation of the approximately 380 cubic meters of affected soils;
- soil acidity correction;
- addition of a specifically cultured strain of microbes to attack the paraffinic crude; and
- an aeration and moisture control program.

The system was to be put into place, then turned over to the client for maintenance.

The only serious difficulty in installing the system was dispersion of the concentrated paraffinic crude into the soil, to make it more accessible and less toxic to the degrading microbes. Soil washes typically used to disperse hydrocarbons were unsuccessful in dissolving or emulsifying the problem crude. The situation was complicated by the requirement that the product used must not be detrimental in any way to microbial activity, nor could the product add additional hydrocarbon contamination to the soil.

The desired dispersion of the paraffinic crude was accomplished.

Continues on page 26 ➔
Solvent solves crude cleanup, from page 25

by the selection of a biodegradable chemical compound which can function as either a solvent or an emulsifier, depending on formulation. This treatment quickly dissolved the heavy oil. In a solvent bath, it was found that the treatment, with agitation, removed and floated the crude oil, which could then be removed for reinjection into the pipeline. Incorporation of the solvent also improves both the viscosity and Btu content of recovered crude, and the leftover solvent can be reused.

In this case, the client was not interested in recovering usable oil, preferring that all crude oil be removed in the bioremediation process. It is worth noting, however, that application of oil microbes to degrade the crude oil, and it also absorbed liquefied oil to prevent further movement of the contamination. Paraffinic oil degrading microbes were sprayed over the treatment area, and the soil was tilled again. A program of scheduled tilling and watering was designed to assure adequate aeration and moisture, and a testing schedule defined to monitor degradation progress.

The maintenance of the bioremediation system was turned over to the client’s field operator. While the client does not wish to release quantitative results, they indicate that they are pleased, and are in communication with the regulators.

This case demonstrates that a technique is available to disperse paraffinic crude oil to make it better suited for a bioremediation cleanup treatment. In addition, this case suggests that it may be possible to recover a quantity of usable product from paraffinic crude oil contaminated soil, which might offset the cost of remediation. And finally, this case reflects a growing trend, proving that industry can be more personally involved in their own cleanup work by incorporating bioremediation into their in-house maintenance programs.

Write in 770 for more information.
Changes in LUST and UST
The federal perspective

By Lisa C. Lund

Like a child poised on the brink of the difficult teenage years, where living life finally starts to mean something, the underground storage tank (UST) program faces a difficult period of crucial decisions. After early successes in the program's infancy, will building on the innovations of the past be enough to ensure success in the day-to-day implementation of the future? While the program is still young, the time is ripe for a critical look at how the program has progressed. While it is too soon to judge whether the program is a success in achieving any final result, it is valid to look at basic approaches and evaluate whether the set course is correct.

The UST program attempted to regulate an enormous universe of owners and tanks, both numerically large and tremendously diverse. The costs of the UST program were initially estimated at approximately $50 billion over time. Those estimates to date seem to be on target. But are the costs being incurred truly necessary? Are there better ways of doing what needs to be done? What lessons have the EPA and the states learned over the last seven years that might lead us to improve program performance and reduce costs, both to government and the regulated community?

Change — it's Inevitable
There are several areas where trends have emerged in the UST program. Changes in the numbers and types of tanks, facilities, and owners are continuing to take place as the regulations are phased-in. We can look at the areas of leak detection and state program approval and see trends that point to a need for change. We can try to understand the long-term impacts of financial responsibility and where it might lead in the future. And we can plan and be proactive in our approach to the 1998 upgrading deadlines.

The universe
When the regulations came out in 1988, the universe consisted of approximately 2 million tanks at 700,000 facilities, owned by approximately 250,000 companies. Those owners were approximately equally split between marketers, or those that sell regulated substances, and non-marketers, or those that store substances for their own consumptive use. Examples of marketers include gas stations and convenience stores, while examples of non-marketers include fleet owners, manufacturers, and government facilities. It should be noted that many UST owners in both categories are small 'Mom-and-Pop' operations.

What changes have we seen? We know today from state data that there are approximately 1.2 million active tanks. EPA has never updated the number of facilities or owners, due to the data gathering constraints of the Paperwork Reduction Act and a hesitancy to burden states with the task of collecting and submitting data that, while interesting, wouldn't serve a direct regulatory purpose. A June, 1993 study by Havill & Company entitled, "The United States EPA Regulated Retail, Commercial, and Industrial Gasoline Service Station Markets, 1992-1998" estimates that there are approximately 389,000 facilities. According to Havill, retail (marketer) tanks counted for 59 percent of the 1.2 million active tanks, while private (non-marketer) tanks accounted for 41 percent. What does this mean? The inference is that over 800,000 tanks have been permanently closed. This information corresponds very closely to data provided by the states through EPA's quarterly reporting system. These closures could be due to a variety of reasons, including non-marketer business decisions to not store their own product, shifts to aboveground tanks, consolidation of product, or decisions to get out of the storage business entirely. While these decisions are distinct, there is the underlying common theme of closure to avoid or minimize the UST regulatory burden. It also appears that more non-marketers have chosen to close their storage tanks, thus shifting the majority of tanks into the marketing arena. This makes intuitive sense; tanks owned by marketers "earn" income, while for non-marketers, tanks are a part of overhead costs.

What also is evident is that the petroleum distribution marketplace has changed. Major oil has moved to consolidate their operations, resulting in shifts in territories and closing of less profitable locations. Trends show shifts from corner gas stations to convenience stores, loss of independent retail facilities, and the closing of smaller rural stations that often serve as sole source supplies for the community. In these economically depressed times, Havill indicated that over 16,000 oil stations closed in 1992 and projected that 7,000 would close in 1993. The UST regulatory program is not...
Changes in LUST and UST, from page 27

entirely responsible for these closings, as evidenced by industry surveys that showed trends to close traditional service stations before the 1988 UST regulations. However, it’s evident that the UST program further exacerbated a current trend in 1988 and beyond.

Leak Detection
The deadlines for compliance with leak detection have passed. How has the partnership between EPA and the states been doing on promoting compliance and carrying out enforcement? EPA is just beginning to look at rates of compliance with leak detection requirements. But the initial cast is not good. Due to the sheer numbers of facilities and tanks and the lack of resources for the preventative side of the program, EPA and states have generally not been able to mount effective inspection programs. The progress that states have been able to make has not been consistent, due to differences in enforcement philosophies and state funding mechanisms for support of UST inspection and enforcement programs. While EPA has made progress in developing expedited enforcement tools, such as federal field citation or “ticketing” programs, states to date have been constrained in developing like programs primarily because they lack administrative penalty authorities. Several states are making progress in this area, and have been highly successful. EPA and the states have also made some progress with alternative compliance mechanisms, such as self-certification, tank tagging and permit programs.

Targeting inspections and enforcement can also serve to focus resources on areas of greatest concern. While these bode well for the future of informal actions, formal enforcement is still slow and cumbersome. Few states have demonstrated the ability to work through the formal enforcement process in an efficient manner. EPA is looking to expand efforts, initiated in the corrective action arena, to assist states on flowcharting processes, identifying barriers or delays, and working to deal with identified problems. This work is what OUST calls ‘process streamlining,” and it is now being applied to UST enforcement processes. The goal is to ensure, through training, guidance and streamlined processes, that state staff are ready and able to take timely enforcement actions. One approach is to develop a few good models that can be used as examples for other states.

One final issue that is important in considering leak detection compliance is the questionable adequacy of available technologies. Experienced field inspectors believe that few of the methods listed in the regulations work in actual practice as they were envisioned to when the rules came out in 1988. These methods are generally technically capable of passing third party reviews, however, are often not installed, operated or maintained properly in the field. While much of the non-compliance found is due to poor record keeping and operator practices, the variability both in the capabilities of the methods and the training of the vendors performing the methods creates confusion as well as sometimes inadequate results. EPA still believes strongly in providing flexibility for private industry to develop marketable technologies to fill these compliance gaps, but will need to evaluate how to deal with the problems encountered in the leak detection technology arena. In fact, some efforts are underway, as evidenced by EPA’s involvement in the American Society for Testing Materials (ASTM) revision of the Statistical Inventory Reconciliation third party evaluation protocol.

Preparing for the 1998 tank upgrading deadline
One thing we did learn from the leak detection phase-in was not to expect that owners and operators will consistently work towards compliance within the regulatory deadlines. While there isn’t a known compliance rate for leak detection, Havill estimated that in 1992, only about 50% of all facilities were even close to being in compliance with
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program requirements. Concerns are starting to arise, not only from a regulatory compliance view, but also from the manufacturers' and vendors' perspectives. In August 1994, the Petroleum Equipment Institute projected that, out of the 1.2 million tanks then active, about 400,000 had already been upgraded or replaced (primarily by major oil and large industry) leaving approximately 800,000 tanks to be upgraded, replaced or closed by 1998. Current manufacturing production is around 30,000 tanks per year, although this only employs one manufacturing shift.

Clearly, manufacturers can increase production to meet demand. Unfortunately, many owners and operators are not yet thinking about a strategy for compliance in 1998. EPA and ASTSWMO have published a joint strategy that includes different approaches to encouraging early compliance. Some ideas include:

1. Outreach to owners and operators explaining the requirements and the options available;
2. Exploring a public interest campaign in concert with environmental groups;
3. Working with trade associations and industry to develop and market incentives for early upgrades/replacements;
4. Benchmarking what approaches have been used in both the public and private sectors to accomplish a similar end; and
5. Investigating what state and local governments with earlier deadlines have done and sharing that information with other states.

The fickle world of LUST!

The world of leaking underground storage tanks is one that has experienced revolutionary changes in thinking and direction. EPA projected that the number of tanks with confirmed releases would be large (upper estimates were around 20 percent), and the numbers have certainly met that expectation. Currently, there are over 278,000 reported releases (around 14 percent of 1988 total tank population), and that number is continuing to grow. At the national level, in FY94, over 650 releases were newly reported each week to the states. While progress has been substantial (216,000 cleanups have been initiated and 112,000 have been completed), the gap between the total number of confirmed releases and the number of cleanups completed is growing. While EPA and the states are tremendously proud of the level of effort and environmental protection that has occurred in this program, no one is satisfied with the rate of progress at LUST sites or with the growing backlog of sites that are piling up on desks at the state (and for Tribal Lands, federal) level.

The problems are numerous: burdensome administrative oversight processes that don't promote timely corrective actions, workloads of state staff sometimes exceeding over 400 cases at a time, lack of clear guidance to the
regulated community and their consultants on how to proceed at a site; use of ineffective technologies because of unfamiliarity and the need for shorter review times, actions required at sites where the risk posed by the level of exposure potential of contamination does not warrant them, and finally the overwhelming price tag on required LUST corrective actions.

What we have come to realize is that traditional cleanup processes don't work with the number of sites in the LUST program. EPA has taken a four-pronged approach to try to deal with the major problems presented by the tremendous workload. The cornerstones of this approach include streamlining administrative (oversight) and technical (in the field) processes, promoting alternative technologies, using risk-based decision-making to move all sites forward, and assisting states in building strong assurance fund programs that promote timely action.

(1) Streamlining corrective action processes. This includes:

Administrative oversight processes:

Streamlining in this area has been ongoing, and many states are now actively pursuing process improvements on their own. It involves using the tools of total quality management to flowchart processes, identify barriers, delays or duplicative effort and attempts to introduce change to resolve those problems.

Technical processes in the field: Site assessments are a critical step in the handling of a LUST case, and the LUST program is supporting expedited ways to gather enough information in the field to make field decisions and to implement remedial options in a timely fashion.

(2) Promoting alternative technologies: Historically in the LUST program, the remedial default options have been excavation and landfiling for soils and pump-and-treat for groundwater. These technologies are not very effective in improving the environmental condition of the contaminated media. This continues to be an area of great interest to the states, and one that will continue to be a priority for EPA.

(3) Risk-based processes: Using the knowledge we have gained over time, OUST believes that it is possible to categorize sites, based on information gathered in the site assessment process, according to the risk posed by the type and extent of contamination. These categories would undergo proactive analysis, so that clear guidance and training would be available for an owner or consultant to enable them to move forward with remediation in a timely fashion, once the category of their site is determined by the state. This guidance would indicate what level of oversight the state would require at the site, which could range from very close supervision at a high risk site, to no interaction beyond reporting a confirmed release and the submission of a cleanup completed report. In the latter, the state could substitute audit reviews of a portion of the sites, or other means to ensure that requirements were met. It also might be possible for that review to occur during state fund claims review.

Continues on page 39
Wrap up site insurance in one package
Consolidated program covers all players, the whole job

By James Kenney, Arl Altman and John Bugalla

Legal liabilities and environmental risks on remediation projects can be managed and minimized with innovative wrap-up insurance programs. A wrap-up program is a consolidated insurance program that covers the job site risks of the project owner, the environmental engineering firms, science firms, contractors and all subcontractors throughout the entire remediation project. The term ‘wrap-up’ is used here in a general sense, and is not always included in the name of the program.

Each wrap-up program is uniquely structured, and state laws may dictate limits on their use. Participants may find themselves participating in an owner-controlled insurance program, or an owner-controlled environmental insurance program, or a contractor-controlled environmental insurance program.

The language pertaining to environmental coverage is complex, and its minimum premiums tend to exclude purchase by many smaller firms. The many parties participating in a typical large hazardous waste project generally operate under various insurance companies, types of environmental coverage and limits.

A wrap-up program creates centralized and consistent coverage. While the different types of wrap-up programs have their differences, depending on which party is in control, they do have much in common and are for use in large projects which require a centralized loss prevention and insurance program.

The contractor-controlled program addresses the unique environmental liabilities which would not be covered under a consolidated program due to exclusions. Characteristics of the contractor-controlled program include:

- Consolidated coverage—The principal advantage to a contractor controlled program is that it consolidates into a single insurance program with a reputable insurer under common coverage limits all the job site risks of one or multiple remediation projects. Consolidated coverage is important to all the parties covered, because the size of a loss usually bears little relationship to the size of a contract that a firm may have, its project responsibility, or responsibility for the loss.

It is possible that participation in a consolidated program may increase a firm’s loss experience. A firm’s participation in a wrap-up program should be coordinated with its own insurance program to avoid duplicate coverage and protect against the risk of the wrap-up program’s inability to cover an individual firm’s loss due to an exclusion or inadequate coverage limits. Larger limits of the wrap-up program should be considered due to the reduced number of insurers involved.

- Reduced cost of coverage—Volume purchasing achieves the economics of mass purchasing power, enhances cash flow, and eliminates multiple minimum premiums for subcontractors and subconsultants pollution liability policies.

- Centralized claims administration—The interests of all participants in a wrap-up program are merged into a single “insured” and a blanket waiver eliminates subrogation actions between the insurers of each party. A firm loses, therefore, the right to subrogate. The centralized claims administration of a wrap-up program reduces the involvement of each party’s carriers or third party administrators. However, the administrative workload is transferred to the central administrator, which may carry the burden after the project is completed.

- Management and control—Project risk management achieves uniform comprehensive coverages for all subcontractors and professionals for the entire project. The administrative burden of receiving and checking many...
policies, forms and insurance certificates furnished by various contractors and subcontractors is reduced. Uniform safety, loss control, and claims management programs produce efficient administration, which eliminates inter-carrier coverage disputes, inter-carrier litigation and duplicate expenses. A firm may, however, lose control over the terms and conditions of coverage and involvement in the loss prevention process.

- Available to small firms—Smaller business firms can participate in the program, which allows them to be competitive with the larger, more established firms with the same insurance protection.

A contractor controlled plan can include several environmental insurance products designed specifically to address the environmental liability exposures which fill the gap that exists in standard insurance policies.

Coverage for remediation projects includes:

- Contractor’s pollution liability—This is claims-made coverage for third-party claims and defense arising out of bodily injury or property damage due to the release of pollutants arising from contractor described operations.

- Pollution professional liability—This is claims-made coverage for protection against first-party and third-party claims that result in pollution incidents due to a negligent design error as well as the traditional coverage for damages arising out of a negligent design error.

- Combined pollution liability and errors and omissions—This is a seamless risk management approach to cover the intertwined operations and professional services exposures of design professionals and contractors.

There are several benefits to wrap-up insurance programs:

- Coverage under such programs is specifically designed to cover the environmental loss exposures that would not be covered under the contractor’s standard insurance program. Standard coverage can be wrapped into the program as well.

- Coverage terms and conditions are consistent for everyone on the site. Limits of liability are typically higher than individual subcontractors carry and coverage is usually broader.

- Concerns about subcontractors’ insurance policy renewals, adequacy of coverage, changes in terms and conditions and potential cancellation of coverage are no longer an issue.

- One insurance company underwrites the coverage for the entire project, rather than numerous carriers.

With so much at stake on a hazardous waste job, the elements and economics of environmental wrap-up insurance is an option for firms in search of more efficient and effective solutions. A properly conceived and managed wrap-up program transfers legal liabilities and environmental risks on remediation projects for the individual participants.

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Soils May 1995 33
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Fundamentals of Project Management for Environmental Professionals #5103, October 18-20 in Albuquerque, N.M. $700.


Aeration Technologies for Soil and Groundwater Remediation #5105, June 14-16 in Baltimore; and October 18-20 in Albuquerque, N.M. $850.


Geochemical Processes in Groundwater Movement, June 26-29, Chicago, $850.


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Statistics for Environmental Compliance, August 16-18, Hartford, Conn., $800.

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Continues on page 37 ➔
**On Site Bioremediation**

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<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
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<tr>
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<td>E (&lt; 2 PPB)</td>
</tr>
<tr>
<td>X 13,729 PPB</td>
<td>X (&lt; 4 PPB)</td>
</tr>
</tbody>
</table>

**Total BTEX:**

44,934 PPB (< 10 PPB)

Batched treated 45,000 gallons per day

---

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Environmental Management and Technology Conference & Exhibition
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Pennsylvania Convention Center
Philadelphia, Pennsylvania
• Environmental and Engineering Geophysical Society—
  Application of Surface Geophysics to Environmental Problems, June 9-10, Denver, cost, $650. Call 303-771-6101.

• Environmental Products & Services Inc.—
  8-Hour Supervisor Training, June 6, Syracuse, N.Y. 8-Hour Confined Space Entry Training, June 7, Syracuse, N.Y. 8-Hour Confined Space Rescue Training, June 8, Syracuse, N.Y. Contact Melanie Burke, 800-843-8265.

• Environmental Resources Expo, June 14-15, Orlando, Fla. Contact Trish Forhane, 407-740-7950.

• Environmental Resource Center—
  Hazardous Waste Management, 2-day seminar, code 9510, June 1-2, Cincinnati, Ohio, $699. Call 800-537-2372.

• Environmental Systems & Technologies Inc.—
  Assessment, Control & Remediation of NAPL Contaminated Soils and Groundwater, May 31-June 1, Seattle, and June 1-2 in Anchorage, Alaska. $520. Fax 703-951-5307 for information.

• Federal Publications Inc.—

• Georgia Tech Research Institute

• Major Industrial Accidents Council of Canada

• National Environmental Management Information & Software Technologies Congress, July 11-14, Boston, conference only, $995, workshop only, $495 or both for $1,190. Call 508-481-6400.

• National Ground Water Association

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Lot to learn, from page 37

August 13-18, San Francisco.
• National Registry of Environmental Professionals—Registered Environmental Manager/Certified Environmental Auditor, $595:
  June 8-9 in Woburn, Mass.
  June 15-16 in Corapolis, Pa.
  June 29-30 in Memphis, Tenn.
  July 20-21 in Tukwila, Wash.
  August 10-11 in Newark, N.J.
  September 7-8 in Salt Lake City
  September 14-15 in San Antonio
  October 12-13 in Des Plaines, Ill.
  November 9-10 in West Palm Beach, Fla.
  December 7-8 in Phoenix, Ariz.
  Call 404-486-9253 for more information.

• Network Environmental Systems Inc.—
  Manifesting, August 4 and November 10;
  Advanced Manifesting, August 31 and November 27;
  Stormwater Pollution Prevention, September 5
  All classes are held in Sacramento, Calif.
  Each class costs $135.
  Call 800-637-2384 for more information.

• Petroleum Equipment Institute,
  Convex 95, October 17-19, Denver.
  918-494-9696

• Petroleum Marketers Assn. of America—
  June 2-5, Annual expo and convention, San Jose, Calif. 703-495-0100
  August 9-10, Annual oil heat conference, Baltimore, Md., 703-351-8000.

• Northwest Truck Heavy Equipment Exposition—
  September 20-22, Portland, Ore.
  Call 800-848-7469.

• Oklahoma State University Engineering Extensión—
  Design of Stormwater, Sediment and Erosion Control Systems,
  August 1-4, $795. Stillwater, Okla.
  Call 405-744-9223

• Pacific Oil Conference, trade show, September 20-22,
  Renc, Nev. 916-373-9202

• Semcor, Environmental Auditing Roundtable—
  September 19-20, Philadelphia.
  Call 216-327-6605.

• Texas Engineering Extension Service, Texas A&M University System—

Tricpe III—Washington state’s Hanford site trade show, August 9-10, Kennewick, Wash. Call 503-385-8964.

• University of Wisconsin-Madison, Department of Engineering Professional Development—
  Using Vegetation and Structures to Control Erosion, Protect Slopes and Restore Environmental Quality,#5500, June 12-15, Portland, Ore. $795.
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May 1995 Soils

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Changes in LUST and UST, from page 31

(4) Building strong state assurance funds
EPA needs to work with states closely to monitor fund solvency and to take steps to maintain a fund's viability. Funds are extremely interested in cost control measures, and therefore can dictate the use of effective tools and processes. Funds can also serve as an enforcement tool, as many states have compliance requirements tied to fund eligibility.

So, where did the money go?
As was mentioned earlier, projections were that the program over time would cost owners and operators $50 billion. Of that estimate, corrective action comprised 63 percent of the total cost ($32 billion), tank upgrading and replacement comprised 24 percent ($12 billion). Leak detection costs run $46 billion (9 percent), and financial responsibility, 4 percent at $2 billion. Those figures do not add in the cost of regulations. There is no argument that compliance is expensive.

Knowing that the costs of regulation were going to be high regardless of what the requirements were, EPA took several steps to reduce the financial burden of the UST program. These include:
(1) Phase-in periods for compliance.
There are three areas where phase-in dates were used: leak detection, financial responsibility, and upgrading existing tanks. By allowing owners and operators to plan for expenses, the likelihood of a business surviving those expenses is increased. Though financial responsibility doesn't comprise the majority of costs associated with the program, an indirect effect of financial responsibility has been to force owners and operators to incur regulatory costs earlier than required by the phase-in dates. While there are benefits associated with earlier upgrading/replacement and leak detection, the original intent of flexibility has been somewhat overridden.

(2) Flexibility in the methods or mechanisms used to comply with requirements. The 1988 regulations provided numerous opportunities for owners and operators to choose how they comply with the regulations. These have been most notable in financial responsibility, leak detection and corrective action. In financial responsibility, a variety of mechanisms were outlined in the regulations to demonstrate financial capability. This was critical to the development of state assurance funds, as the owners and operators of self-insured funds had difficulty in finding affordable options. Assurance funds came to the rescue. Assurance funds raise and pay out over a billion dollars annually toward LUST corrective actions. They also are primarily responsible for the fairly high compliance rates found in 1992. In a survey conducted by a trade association, compliance was determined to be 95 percent with financial responsibility requirements, with 90 percent of that compliance due to state funds.

In leak detection, again, a variety of methods were allowed with associated costs covering a very broad range. What we have seen is that the cheapest methods are the ones most widely used, but they are not very accurate and generally introduce a high degree of human error. The more expensive methods may be more reliable as far as installation and instrument reliability, but to the degree that they require human intervention, they also introduce error. OUST believes that the trend that should be encouraged is away from inventory reconciliation and toward methods that don't rely on the human element for accuracy.

Corrective action is the area where costs can be most directly affected by degree of flexibility. The regulations allow the use of any method that ensures the protection of human health and the environment. The state programs have taken different approaches to how cleanups should progress, what technologies should be, and to what degree the cleanups need to achieve pristine levels of contaminants. We have learned in the past that the traditional methods not only don't work with the number of sites in our program, but that they are terribly costly and inefficient in cleaning up the environment. OUST believes that flexible approaches can make a tremendous difference in the costs of corrective action over time, as evidenced by the risk-based approach that is now being discussed.

(3) Financial assistance programs: 17 states have financial assistance programs to help owners and operators with the costs of compliance. These are probably the most direct way for states to reduce the financial burden to targeted groups of owners and operators. While state funds can reduce the likelihood of business failures, owners still face severe financial distress from the regulatory program. This distress is most felt by small business, and financial assistance programs are a good way to assist those owners.

Conclusions
Where does this leave the UST program; this child on the verge of becoming an adult? Let's look at some of the questions we have asked. Will building on past innovations be enough to ensure the program's long term success? The answer is that while these innovations have become the baseline for actions in the programs, it is critical for EPA and the states to be able to accept and adapt to the dynamic conditions of the real world. Innovations are necessary, and will continue to be, if the program is to meet the challenges of tomorrow.

Are the costs being incurred by the program necessary? While the basic categories of costs and the basic requirements of the program are believed to be reasonable, there is no question that actions can be made to be more efficient and cost effective. Corrective action costs alone can be greatly reduced by major process revisions and better technologies.

The future of environmental programs, of which USTs are a good example, rests on the ability to change and adapt. That ability is based on taking the time to evaluate where you are, how you got there, and where it is you want to go. We are trying to do that in the UST program, and on that rests our belief that we will be able to succeed.
Soil analysis must consider numerous factors

By Alfred Conklin, Ph.D.

Soil contains a great variety of organic and inorganic compounds and ions. These occur in the gaseous, liquid and solid state and as solutes in soil water. However, not all of these are in the same form in all phases, nor are they all biologically or chemically available or active. The word ‘available’ refers to biological availability, which is the ability of organisms to use or take up the compound in question. Most compounds in soil are biologically unavailable. ‘Active’ refers to availability for chemical reaction or detection.

Biological availability and chemical activity are important concepts from an environmental and remediation perspective.

A chemist would naturally take a soil sample and ask, how can I extract all of the compound I am interested in? This is exactly what early chemists did to try to understand the relationship between soil composition and plant growth. The result of such an investigation is that all soil is found to contain an abundance of the elements that plants need for growth. However, it is easy to prove that plants respond to the addition of water soluble fertilizer elements. Thus, from a biological perspective, the total amount of an element in soil is not a good indicator of its availability.

With modern analytical techniques, most, if not all, elements can be detected in soil. This means that soil contains not only those elements essential for life, but also toxic elements. However, natural soils contain concentrations of these elements in trace quantities that are generally harmless. For instance, arsenic, cadmium and mercury have average soil values of 25, 3 and .01 mg/kg in soil. These levels are natural and do not represent polluted conditions.

Agronomists take a soil sample and ask, how much of the nutrient or element in the soil is available to plants? Answering this question is difficult. What is needed is an extractant that will extract all available plant nutrients, but none of the unavailable nutrients. Also, the extractant must not interfere with the analysis of the nutrient or element of interest.

Problems arise because soils vary greatly in their physical and chemical characteristics depending, in part, on their location. In New Jersey, you would expect to find sandy soils that are acidic and contain some organic matter. Midwestern soils are commonly silt loam, and may be acidic or basic, and contain 1 to 3 percent organic matter. Arizona soils can be of any texture, but they are usually basic and have very low organic matter content. Soils in the north tend to have higher organic matter than those in the south.

The location of soil not only affects its characteristics, but also the type of analysis that needs to be performed. Soil scientists use different extractants for acid soils than they do for basic soils. For instance, acid.
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<th>pH water buffer</th>
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<th>Potassium Lbs/a K</th>
<th>Calcium Lbs/a Ca</th>
<th>Magnesium Lbs/a Mg</th>
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<th>Cation exchange capacity</th>
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Figure one: Soil Analysis Report

extractants used in basic soils react with carbonates releasing carbon dioxide and nutrients that are not normally available to plants. In other cases, the acid may be neutralized before it can extract the component of interest.

I was once involved in analyzing a soil for phosphate content. At the time, I was told the soil was acidic. Upon extraction, I found the soil to be high in phosphate. Yet, the plants showed a phosphate deficiency. Going back to basics, I determined the pH of the soil and found it to be basic. Using an extractant designed for basic soils, little phosphate was found.

Phosphate is an excellent example of the type of problem one can have with soil extraction and analysis. Available phosphate added to acid soil reacts with iron and aluminum to form insoluble phosphates. In basic soils, it reacts with calcium to form calcium phosphates. These phosphates remain unavailable unless the mineral is in contact with a strong acid such as concentrated sulfuric acid. Under normal environmental conditions, these phosphate minerals never become available to plants. Analysis must account for this natural unavailability of phosphate.

Different soils vary dramatically in the concentrations of different components. There can be a one hundred-fold variation in phosphate and potassium from one soil to another. In areas of high rainfall, soil pH may commonly be between 5.0 and 5.5, while in desert areas, it may fall between 7.5 and 8.0. This is a 1000-fold change in the hydrogen ion concentration—more correctly—hydrogen ion activity. With the great variation in concentrations of compounds found in different soils, one must determine the natural concentration of a compound before deciding that compound is present in an unnatural concentration.

This can even be true of compounds and elements that are considered toxic and thus should be removed. There are well-known examples of natural soils that contain toxic levels of selenium, arsenic, mercury, etc. Is it natural to remove something from a soil that is naturally a part of that soil? Is it economical to do so? In some cases, the toxic elements or compounds may be in equilibrium with unavailable forms. Thus, removing the available toxic material may shift the equilibrium such that more of the toxic material is released.

There are two types of laboratories that conduct soil analyses. The traditional environmental analytical laboratory normally attempts to determine the total amount of something in soil. Traditional soil analysis labs test soil for a limited number of elements, compounds, cations and anions that are important for plant growth. Feed and food analysis labs do the same thing for animal feeds and human food. In these traditional labs, the analysis is specifically aimed at determining the amount of biologically available compound present—that is, the amount that plants or animals can use, not the total amount that can be found in the sample. An example of the type of results from this type of analytical lab is given in figure one, above.

If one is concerned about bioavailability or the determination of standard soil characteristics such as pH and nutrient availability, including nitrogen content, then a soil analysis lab is the place to have the analysis performed. Such a lab can do the analysis faster and more economically than labs specializing in other types of analysis. An excellent source of assistance in interpreting the results is your local university extension agent.

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**COST EFFECTIVE SOIL REMEDIATION**

Write in 043

Soils May 1995 41
For best results, start at the end
Consider what you want to accomplish in a cleanup
to establish scientifically credible cleanup levels

By David Belluck and S.L. Benjamin

Some government agencies are considering changing the way they calculate soil screening or cleanup concentrations to protect groundwater as a drinking water source. Site-specific cleanup concentrations, which reflect risk assessment findings, would be replaced by generic concentrations, which are essentially risk management determinations, not simplified risk assessments. A generic soil cleanup concentration for a given chemical contaminant reflects only its chemical and physical characteristics within a single modeled soil type, based on predetermined risk management decisions. In contrast, current risk assessment techniques select the most scientifically valid fate and transport models, and use chemical and site-specific data to calculate cleanup concentrations. Debate over the credibility of generic soil cleanup concentrations to protect groundwater focus on their benefits and limitations. Benefits include improved cleanup consistency and reduced cleanup time and costs, while limitations include a lack of site-specific plausibility and credibility that result from ignoring site-specific factors.

Decisions to clean soil to levels established by generic or site-specific concentrations can be flawed, since they are based on the predicted ability of preremediation soils to retain chemical constituents. Risk assessors and managers miss the point—it is the chemical and physical properties of remediated soils, not the properties of unremediated soils, that are critical to calculating a scientifically credible cleanup concentration to protect groundwater.

In their simplest form, fate and transport models calculate how much of a contaminant can remain in soil while protecting groundwater. The greater a soil’s capacity to hold a contaminant, the less of the contaminant must be removed to protect human health. Soil-to-groundwater models commonly use characteristics of soils before remediation—and less commonly use fully characterized soils. Remediation removes, immobilizes, modifies or destroys contaminants which can result in remediated soils with physical or chemical properties significantly different from fully characterized soils. Changes in pH, available binding sites, organic content, microbial populations, porosity, permeability can reduce or augment the soil’s ability to hold contaminants and prevent their migration to groundwater.

Because the remediation process can alter a soil’s chemical and physical properties, predictions of

Dave Belluck is a toxicologist for the Minnesota Pollution Control Agency, St. Paul, Minn. S.L. Benjamin is with Merritt, Ferber & Timmer, Minneapolis, Minn.

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contaminant behavior based on pre-remediation soil characteristics may not accurately predict a remediated soil's capacity to hold residual contaminants. Therefore, soil cleanup levels must be based on site- and chemical-specific risk assessment analyses, using the properties of remediated soils as factors in soil-to-groundwater fate and transport models.

To generate reasonable site-specific soil cleanup goals, a recalibration process has been developed which uses the measured physical and chemical properties of remediated soils to establish final soil cleanup levels. The recalibration process uses an iterative process to develop a preliminary, interim and final cleanup concentration. All three cleanup concentrations are calculated using the physical and chemical properties of site soils and contaminants. While a chemical specific preliminary concentration is based on preremediated soil properties, the interim concentrations are based on the measured properties of bench scale remediated soils. The final concentrations are based on the measured properties of field remediated soils. The same fate and transport model is used to calculate all three cleanup concentrations. If the preliminary concentration is a credible number, then the other two should be more so. Following remediation, soils can be monitored for their key physical and chemical parameters to ensure that mobility of residual soil chemicals does not increase beyond an acceptable point.

When actual measurements of remediated soil properties indicate that more residual chemistry will be retained than preremediation soil measurements or modeling indicate, soil cleanup levels can be set at less conservative concentrations. Reductions in cleanup stringency can reduce remediation costs significantly, especially if the remediation technology is at the edge of its efficacy. This cost saving is accomplished without decreasing health protection.

The recalibration process offers regulators and the regulated community a scientifically valid method to generate chemical- and site-specific cleanup concentrations. It permits responsible parties to calculate less stringent cleanup concentrations by encouraging the selection of remediation technologies that maximize the contaminant binding capacity of remediated soils.

Remediation actions taken using the recalibration process can increase confidence in cleanup decisions and result in less costly cleanups without sacrificing health protection.

Use of generic cleanup concentrations ignores the unique biotic and abiotic complexity of a site, an can result in inadequate or overly stringent cleanup. Embracing complexity an formulating innovative responses, such as the recalibration process can result in cleanups that are more credible, more affordable and thus more publicly acceptable. While regulatory agencies recognize the need to improve cleanup performance, improvement should not come at the expense of good science or environmental and legal equity. Use of generic concentrations can reduce or eliminate scientific and legal discourse on the appropriateness of a cleanup and limit useful public and responsible party involvement in decision-making.

Write in 778 for more information
Infrared analyzer measures gases
Servomex Co., Norwood, Mass., introduces the Xendos 2510 gas filter correlation infrared analyzer to continuously measure HC1, CO, NO and CO2 from distances up to 450 meters. The brushless DC chopper motor is designed for long term performance with minimum maintenance under harsh conditions, says the company.
Write in 779 for more information

New tubing
Norton Performance Plastics Corp., Wayne, N.J., introduces Tygon® 2000, a clear, flexible tubing, free of plastic and phthalates and resistant to most chemicals.
Write in 780 for more information

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Direct push sampler means business
Precision Sampling Inc., San Rafael, Calif., introduces a new direct-push Enviro-Core® sampling system consisting of small-diameter drive casing and an inner sample barrel that are simultaneously pushed, driven or vibrated into the ground. Samples are collected in stainless steel liners. SVE wells and sparging points can be installed as the casing is withdrawn, says PSI.
Write in 781 for more information

Mini detector beeps danger
The CEA Instruments Inc., Emerson, N.J., MD-16 is a series of single gas detectors for toxic gases. Wall-mounted units are available for a variety of gases. They systems issue a warning, then a danger signal, says CEA.
Write in 782 for more information

Brochure describes refined use of carbon adsorption systems
Write in 783 for more information
Molecular reaction restores metal contaminated sites

National Technical Systems has developed a proprietary combination of catalytic reagents that react with hazardous contaminants in soil. The resulting molecular changes and further processing yield non-hazardous constituents in the soil, says Tom Jennings, manager of the Environmental Services Division of the company, based in Fullerton, Calif. Variations on the process have proven to be effective in treating metals, PCBs and volatile organics at ambient temperatures. The end product is not leachable. Only small volume increases occur in treated materials, which can be backfilled after curing.

One process, which chemically alters the molecular and ionic structure of metals, causes a chemical reformation that renders the soluble metals inert. The molecular metal compound in its altered state is equal to its original benign state as an ore.

In some cases, contaminants can be converted into beneficial fertilizers or green waste additive. Some alkali metals may require the use of high pressure steam at temperatures up to 120°C. Treated sites are generally able to support plant life, and are suitable for building, road base, roads and asphalt construction.

Write in 784 for more information

Millipore offers immunoassay tests for variety of compounds

Millipore Corp., Bedford, Mass., has a full line of immunoassay screening tests for use in the field or lab. Products include SW846 accepted tests for PCBs, PCP, petroleum and pesticide compounds. Immunoassay kits provide accurate results at a fraction of the cost and time needed to run conventional tests, says the company.

In addition, the EPA recently accepted Millipore’s ColiSure growth culture medium for potable water testing, including bottled water analysis. ColiSure Medium confirms the presence or absence of total coliforms and E. coli in water, with results in 24 to 28 hours. A distinct color change, easily read by eye indicates a positive total coliform test. The test is available in two versions: a single vial presence/absence test, and a multiple vial most-probable-number test.

The company also offers the QPAK3 purification pack for use in all their Milli-Q-Lab water purification systems. The pack contains a combination of purification media that effectively polishes water pretreated by regenerated ion exchange resin, which can contain high levels of contamination.

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ReTank upgrades existing tank to double wall status

Fluid Containment Inc. (formerly Owens-Corning Tank Division) Houston announces the ReTank™ system, which upgrades existing single wall tanks by constructing a second tank inside the existing tank—at an average savings of 40 percent of the cost of complete replacement. The company constructs an inner tank at its factories then installs it inside the existing tank while it is still in the ground, with only minimal excavation required. In the photo, left, the new tank bottom is in place as workers guide the top half into position. Write in 786 for more information.

Don't Let Your Soil Be Left Out In The Cold

Dumping Petroleum contaminated soil into a clay pit or landfill will not eliminate the liability. At STALITE ENVIRONMENTAL we pride ourselves on immediately storing the soil indoors and thermally treating it soon thereafter at temperatures up to 2300°F.

Packed tower absorbs emissions

Anderson 2000 Inc., Peachtree City, Ga., single stage and multiple stage packed tower scrubbers are available for gas absorption of HC1 emissions, HF emissions, toxics and other gases. Individual packed tower absorbers are for gas flow rates up to 300,000 acfm, says the company. Write in 788 for more information.

Train by computer

Williams Training System, from Williams Knowledge Systems Inc., Tulsa, Okla., provides an extensive library of environmental topics for training on PCs. Write in 787 for more information.
Emulsion treatment has multiple applications

Ultra Coatings Inc., Seattle, Wash., says their UC-40™ Oil Breaker is a bioaugmentation emulsion that breaks the hydrocarbon molecular chain to give microbes an immediate food source. Oil Breaker continues to work as long as there is a petroleum food source such as oil, gasoline, benzene or toluene. It works within temperature ranges between 2°C and 49°C, in pH ranges between 4 and 11.

The product can be used in a bioreactor, or injected directly into the soil, topically sprayed on soil surfaces, biopiles or berms, or poured into holding tanks and sumps. The microbes must have an adequate and consistent supply of water to maintain a soil saturation level of about 20 percent.

At a petroleum distributing company site in Oregon, approximately 3,150 square meters of contaminated soil (86,000 ppm TPH) was equipped with a six zone sprinkler system to provide adequate moisture for microbes. The UC-40 product was applied over a two week period. After 45 days of consistent watering, remediation was complete. All samples met regulatory limits, and with the exception of two spots, all areas rested at non-detect levels.

A landfill operator in Arizona with a waste oil contamination problem wanted to compare the results of bioaugmentation against biostimulation. The test plot used 76 cubic meters of soil in a biocell, 12 by 13.5 meters, and half a meter deep. Soil was aerated weekly and indigenous bacteria stimulated with a urea based fertilizer applied monthly. After nine months, TPH levels dropped from 90,000 ppm to below 4,000 ppm. But, TPH levels would drop any lower. The reductions were attributed to volatilization rather than microbial degradation. Two treatments with the UC-40 product were applied to the bio cell and TPH levels dropped below regulatory limits within 30 days.

At a service station site, leaking underground storage tanks were removed. The soil was placed in berm biocells and treated with the Oil Breaker product. In addition, to speed up the remediation as much as possible to minimize disruption to the owner, the tank pit was sprayed with a concentrated solution of UC-40.

According to the company, Oil Breaker creates ideal conditions for bacterial consumption of petroleum hydrocarbons, while assuring the proper balance of micro and macro nutrients for cell construction and rapid reproduction.

Write in 774 for more information

Critters dine beneath resort hotel

Biotreatment Inc., The Critter Company, of San Diego, Calif., helped a seaside, luxury resort contaminated with diesel to levels as high as 144,000 ppm clean up in four months without disturbing hotel guests or staff.

To make matters worse, the contamination had settled beneath one of the buildings, and 5 or 6 millimeters of free product was floating on the groundwater—which fluctuated up to a meter twice a day with the tides. The contamination actually consisted of two plumes, about 750 cubic yards each, located in the capillary fringe over a meter below the building foundation.

The inoculation consisted of a combination of naturally occurring microbes, enzymes, nutrients and an oxygenated water, acting as a biocatalyst. The inoculation was carried out over a 60 day period, and the biocatalyst was dripped into the plume in small doses.

After four months, free product was gone, and within six months, the water tested non-detect. TPH levels were reduced from 75 to 95 percent within 12 months. Closure was granted after groundwater tested clean for three consecutive quarters.

Write in 775 for more information
New technology lets sleeping sediments lie

Golder Applied Technologies, Atlanta, introduces Limnofix, a process for in situ bioremediation of sediments and industrial sludges. The technology generates in situ biodegradation by infusing liquid additives into sediments contaminated with organic compounds, explains Hal Hamilton, president of Limnofix Inc., a subsidiary of Golder Associates.

"The nutrients and oxidants we inject into the sediments facilitate the breakdown of pollutants without bringing those pollutants up into the water column," he says.

An injector system is lowered to the bottom of the water bed and towed behind the work boat. The work boat drags the injector system across the water bottom to embed into the sediment nutrients and oxidants to enhance the activity of indigenous microorganisms.

The process can also be used as a pre treatment of materials to be dredged, improving their quality and reducing the cost of disposing them.

Golder says that a project involving one or two passes with Limnofix technology costs about one-third the price of dredging and disposal or treatment. Tests have revealed as much as an 80 percent reduction in pollutants over a period of several weeks, says the company.

A recent demonstration of the process was conducted in Hamilton Harbour, Ontario to restore a healthy fishery, which requires treatment of carcinogenic substances. Dredging the harbor was calculated to be extremely expensive, and physical limitations indicated that dredging might not remove all the contaminated sediment.

Golder is the U.S. licensee of the Limnofix technology, developed jointly with agencies of the Canadian government as part of the Great Lakes initiative. The pilot project, performed in conjunction with the Great Lakes cleanup fund and Dofasco Inc., also included treatability tests successfully performed on refinery wastes in a lagoon in New York, and on the sediments in the canals of Venice, Italy.

The company feels that Limnofix technology is far superior to dredging, because it does not stir up contaminated sediment that can cloud the waters and even kill marine life. Sediments missed by the dredge can leave hills that can collapse, recontaminating the surface sediments.

Write in 776 for more information

Hydrocarbons don't stand a chance under turbo power

The H&H EcoSystems Inc., Triangle approach to bioremediation has been cleaning up contaminated sites in the northwest. The Triangle approach refers to the chemical, biological and mechanical components in the process. The chemical component is Simple Green™ cleaning solution that breaks down large globs of oil to create microscopic droplets called micelles. Simple Green also acts as a vapor suppressant, and does not interfere with the growth of indigenous microorganism populations already in the contaminated soil.

The chemical treatment breaks up the contaminant and increases the total surface area available for attack by the microorganisms. This physical change in the structure of the contaminants gives the microorganisms the best opportunity to metabolize and degrade hydrocarbons to harmless CO₂ and water.

The biological component consists of two biological diets to stimulate the growth of naturally occurring microorganisms that degrade petroleum hydrocarbons. The biological component also contains nutrients to encourage rapid growth of the microorganisms.

The mechanical component is the HH System 616 Turbo-Rator, which can microenfractionate up to 450 cubic meters of soil per hour and homogenize the hydrocarbon contaminants, soil, nutrients, chemicals and soil amendments to between 85 and 95 percent.

The unit can process contaminated soil in a windrow that is up to 4.2 meters wide at the base, 1.5 meters wide at the top and 1.8 meters deep—with no limit in length. The larger model HH 617 can handle windrows up to 5 meters wide at the base.

The mixing power of the machine eliminates hot spots of contamination, as well as anaerobic clumps, which decreases bioremediation time, says the company. Paddles on the 4.2 meter long rotating drum create a vortex that not only mixes soil, nutrients, chemicals, water and microbes, but supercharges the mixture with fresh air and purges it of accumulated CO₂. More frequent turning of soil during bioremediation can considerably speed up the process.

Thorough testing must be completed at a site before the Triangle process is implemented, because nutrients, surfactant and other solutions depend on the type and level of contamination at a specific site. The company custom blends formulas for each site. Soil type also affects the implementation of the process.

Write in 777 for more information
Geometrics Inc. Statagem™ Subsurface Conductivity Imaging

- Geometrics Inc., Sunnyvale, Calif., introduces the Statagem™ EH-4 electrical conductivity imaging system for groundwater surveys, engineering studies, porosity surveys and geological structure mapping applications. The system provides high resolution electrical conductivity imaging of the subsurface to depths of 10 meters to one kilometer. It records orthogonal electric and magnetic fields which are processed to provide tensor impedance measurements to interpret complex two-and three-dimensional structures. A sounding consists of measuring the resistance or conductivity for a progression of frequencies, and inferring the variation of the resistivity with depth. The apparent resistance of a layered ground at a given frequency is proportional to some weighted average of the ground conductivities down to a skin depth—the depth where signal strength is reduced to 37 percent. Though the depth of exploration can vary considerably from site to site, a common assumption for electromagnetic sounding is that the depth of exploration is equal to one skin depth.

The transmitter is normally placed a minimum distance of four times the skin depth from the survey profile. Typical range for the transmitter is about 500 meters. Structures more than 100 meters deep are imaged using source fields provided by background MT signals, or conventional CSAMT sources. For shallow features, a low power portable transmitter is used to supplement natural field signals. The data acquisition unit accepts four channels. High resolution image output is via an IBM compatible computer. True conductivity sections are produced in the field, which allows surveyors to detect partially traversed targets and add additional coverage.

Write in 772 for more information.
Hewlett Packard 6890 series gas chromatography system

- Hewlett Packard offers the HP 6890 series gas chromatography system with electronic sensing and control of all gas pressures and flows. The electronic control monitors and compensates for changes in atmospheric pressure and temperature to enhance chromatographic stability and increase retention time and area repeatability. Internal gas connections are designed to decrease the probability of leaks. Particle filters protect control components and a chemical filter on the split line prevents sample damage to the back pressure regulator. Electronic flow control of incoming gas in the back pressure regulated split mode allows the user to set split ratios directly from the keyboard or the ChemStation. The ability to control flow and pressure at the same time makes it possible to automatically switch the split/splitless inlet from a back pressure regulated system for split injection to a forward pressure-regulated system for splitless injection without changing the flow through the column. A color-coded keypad gives quick access to the most frequently used functions. All instrument settings are recorded in a method file and can be recalled. All aspects of a method, including system parameters, can be ported to similarly configured instruments. The automatic liquid sampler is controlled from the GC keyboard. Multiposition valve automation enables users to inject samples from different gas streams in whatever sequence they wish, and analyze them with different methods. The system can be configured for simulated distillation applications to provide reproducible and fast determination of the true boiling point distribution of hydrocarbon streams and mixtures ranging from light naphtha to mid-distillates. The company's flame ionization detector and thermal conductivity detector have been redesigned to process data at 200 Hz speeds.

Write in 773 for more information
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<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Media</th>
<th>% Reduction</th>
<th>Elapsed Days</th>
</tr>
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<tr>
<td>Bunker oil</td>
<td>Rock</td>
<td>97</td>
<td>3</td>
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<tr>
<td>Gasoline</td>
<td>Soil</td>
<td>99.9 Non detect</td>
<td>7</td>
</tr>
<tr>
<td>Diesel</td>
<td>Soil</td>
<td>89</td>
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<td>Pond</td>
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<td>Crude oil</td>
<td>Beach</td>
<td>90</td>
<td>10</td>
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<tr>
<td>Crude oil</td>
<td>Pond</td>
<td>95</td>
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