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From the editor

Soil in a day’s work

In litigation...the “L” word. It’s everywhere. A year or two ago, I happened to see part of a television interview with some indignant, pompous public relations hack who had been hired by some group of lawyers (fortunately, all the details elude me) snarling into the camera that lawyers are degraded and unappreciated in our society. He was pouting because lawyers are getting sick of lawyer jokes (like: What do you have when you have 100 lawyers chained at the bottom of the ocean? A good start... Or: What do you do when you’re trapped in a room with Hitler, Mussolini and a lawyer, and you only have two bullets in your gun? Shoot the lawyer twice. And the one about—well, you’ve heard them all.) And they are tired of how lawyers are portrayed in the entertainment media (like that really cool scene in the movie *Jurassic Park* when the lawyer in the outdoor privy got blown up and everyone in the audience cheered).

The spokesperson was convinced—as was the group that hired him—that lawyers just don’t get the respect they deserve. Of course, I would argue that in general, lawyers get more respect than they deserve! I think what may be upsetting the lawyers and their spokesperson is that they really want the kind of respect that other people earn—which is a key distinction. It is a distinction, I have found, that if you need to have it explained to you, you’re never going to get it.

I see where Newt Gingrich says, “Let’s move to cleaning up sites, not paying lawyers.”

Indeed, how respectable is the percentage of environmental cleanup dollars that the lawyers have “earned” out of Superfund over the years? Exactly how much respect do they think they deserve for that?

I know that some of you are lawyers, and that you are fuming by now. I know that you are convinced that I am clearly deranged. You would want to make the point that you did not initiate a single iota of environmental litigation, that you simply were retained to represent selfish site owners and accused polluters who were determined to dodge, dilute or pass along their responsibility to someone else. “F. Lee Bailey is not the problem, O.J. is the problem,” you would argue. Sorry, but this explanation is just a pale reworking of the Nazi concentration camp guard defense, “I was just following orders.” “I just serve my clients. I can’t earn a living defending innocent people.”

I think lawyers are objects of ridicule—or, I should say, “don’t get the respect they deserve”—for two primary reasons: first, their obvious bottom-feeding greed, and second, in order to justify their huge fees, they have conspired to make their work seem far more complicated than it is.

Most conflicts are reasonably tractable. A harms B, but A does not want to pay, or B wants more reimbursement than is fair. That’s pretty much what it all boils down to, but don’t let a lawyer hear you say that! “No way!” they cry. Witness the bizarre theatrics in the O.J. trial... ‘nuff said.

Shame on us. We allowed the legal profession to swipe Superfund. We fell for the lawyer tactic of making us believe it was far more complicated than it really was.

I would like to thank my friend Mr. D. Simple (not his real name) for the swell lawyer jokes.

---

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

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Micro encapsulation in action

Mushy waste transforms to flowing, sandy soil

By Ed Malachosky and Francis J. Hartke

Oil-based drilling fluids are used to facilitate drilling in the exploration and production drilling for hydrocarbon products. The liability and environmental problems associated with the disposal of oil-based drilling fluids and drill cuttings contaminated with the fluids caused many to seek acceptable substitutes—some costing as much as 12 times as much as oil-based fluids. A silica micro encapsulation process can treat this contaminated material efficiently, on site to the extent that treated cuttings can actually support plant life within a short period of time.

Oil-based drilling fluids, commonly known as oil-based muds (OBM), is useful to solve drilling problems such as:
- impaired permeability in dirty sands or partially depleted zones,
- drilling deepholes in the presence of high formation temperatures in excess of 175°C,
- drilling salt, gypsum, anhydrite, cement and formations containing CO₂ and H₂S,
- drilling problem shales,
- coring,
- to decrease torque, drag and friction in crooked, horizontal and slim holes,
- to minimize water and solids blockage during perforation,
- to mitigate corrosion,
- to minimize sticking problems.

In addition, OBM is low in cost compared to the alternatives, and is typically recirculated during drilling operations.

These oil based fluids are composed of an organic phase, an emulsified brine phase, various additives used in the preparation of the mud and the solids from the rock formations that have been drilled with the mud. The organic liquid fraction phase of OBM is called the continuous phase, and is usually composed of diesel fuel,

Ed Malachosky is an independent consultant in Coppell, Texas, and former principal environmental research engineer for Atlantic Richfield Co. Francis J. Hartke is president of Chemecon, Inc., Houston.

Continues on page 8 ➔
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Write in 189
Micro encapsulation, from page 6

mineral oil and some other organic liquid. The organic phase generally contains a brine that has been emulsified into the organic phase through the addition of emulsifiers and agitation. Usually this internal brine phase is a calcium chloride brine.

Solids that are collected by the mud during drilling are removed at the surface before the mud is recirculated downhole. This results in the accumulation of cuttings at the surface. These mud-covered cuttings take the form of a very thick slurry and, after quiescence, may separate into two phases. The first phase consists of a free floating organic liquid such as diesel fuel, and the second phase is a sediment containing a solid residue of oil wet cuttings.

Traditionally, cuttings are collected in containers and transported to a land disposal facility where the fluids are typically injected down a disposal well and solid waste cuttings are buried. In some cases, land disposal may be in a lined disposal pit located on site. Once the pit is filled, it is sealed and covered with a conventional earthen cap.

The amount of oil contaminant in OBM drill cuttings depends on the size of the cuttings and the type of equipment used to separate the cuttings from the oil based mud on the drilling rig. A range of 10 to 25 percent oil by weight is typical. Because of the nature of the organic liquids used to prepare OBM and the affinity of the solids for the liquid, the cuttings maintain a mushy consistency, even when stored for prolonged periods in open pits. Any oil not adsorbed to the surface of the solids tends to float and form a free oil layer as the cuttings settle in the pit. This mushy consistency and free oil layer are poor support for a cap. The potential for contamination of surface or groundwater because of a faulty liner or, more commonly, overflow of the pit during heavy rains, is high. Both of these types of pit failure are common when cuttings are disposed in this manner.

Occasionally, oil based mud
<table>
<thead>
<tr>
<th>Sample #</th>
<th>Quantity of Waste</th>
<th>Quantity of Permull</th>
<th>Quantity of Siallon</th>
</tr>
</thead>
<tbody>
<tr>
<td>110 S</td>
<td>4000 grams</td>
<td>230 grams PM 110</td>
<td>230 grams SI-94</td>
</tr>
<tr>
<td>320 S</td>
<td>4000 grams</td>
<td>230 grams PM 320</td>
<td>230 grams SI-94</td>
</tr>
<tr>
<td>110 K</td>
<td>4000 grams</td>
<td>230 grams PM 110</td>
<td>230 grams SI-70</td>
</tr>
<tr>
<td>320 k</td>
<td>4000 grams</td>
<td>230 grams PM 320</td>
<td>230 grams SI-70</td>
</tr>
<tr>
<td>320 SX (2 stage treat)</td>
<td>4000 grams</td>
<td>330 grams PM 320</td>
<td>230 grams SI-94</td>
</tr>
</tbody>
</table>

**Figure one**

Cuttings are landfarmed. Because of the high organic load of the waste and the fact that the solids are oil wet by design, the ability of natural processes to degrade the waste is limited. The permeation of air through the waste is very limited, and water typically runs off rather than soak into the waste and carry or float any free oil with it. Open pits containing the waste and lab experiments simulating pit conditions fail to show any significant biological activity in the waste material unless steps are taken to mechanically irrigate and aerate the waste. As a result, the load of waste per unit area of land is low, and large areas are required to accommodate the large volume of oily waste generated during a drilling operation.

The Siallon process, a patented silica encapsulation technique of Encapsulation International LLC, of Houston, treats oil based mud wastes with surfactants, acids and silicates in a two stage procedure. The first stage desorbs hydrocarbon from the cuttings and emulsifies it with Permull, a proprietary emulsifier. In the second stage, Siallon, a silicate based material is added that forms non-soluble silica cells. The result is the generation of a sand-like, friable, non-oily, free-flowing product—produced from the mushy waste.

Laboratory tests and practical experience indicate that the Permull emulsifier is key to the efficiency and completeness of the process. A range of Permull products and application processes have been developed for different hydrocarbons and soil types.

Among other ingredients, the emulsifier contains acidic surfactants. The Siallon chemicals are a solution with a pH of about 10.5. When the alkaline second stage reacts with the materials generated during the acidic first step, a simple acid base reaction takes place. The neutralization of the silicate produces silica, water and a trace amount of salts.

In laboratory tests of the process, five samples of OBM waste were prepared, and treated with Permull and Siallon. The samples were agitated in a blender and split in half. One half was sealed to preserve its state and the other half was air dried. Portions of these 10 samples were sent to Southern Petroleum Laboratories for analysis. High resolution images of higher atomic number elements appear brighter in the electron microscope images. Samples were exposed to TCLP (Toxicity Characteristic Leaching Procedure) acid digestion and the leachate analyzed for extractable petroleum hydrocarbons, sulfates, phosphates, chlorides, iron, calcium, potassium and sodium. In addition, samples were exposed to EPA Method 418.1.

Continues on page 10 ➤
### Process Analytical Results

<table>
<thead>
<tr>
<th>Permull</th>
<th>Freon Solv Ext mg/Kg</th>
<th>Pet Ext mg/L</th>
<th>Sulfate mg/L</th>
<th>Ophos mg/L</th>
<th>Method Chloride mg/L</th>
<th>3010 Iron mg/L</th>
<th>Digestion Calcium mg/L</th>
<th>Potassium mg/L</th>
<th>Sodium mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBM Waste</td>
<td>120000</td>
<td>95</td>
<td>16</td>
<td>24</td>
<td>185</td>
<td>0.5</td>
<td>780</td>
<td>20</td>
<td>1380</td>
</tr>
<tr>
<td>PM-110S</td>
<td>99000</td>
<td>60</td>
<td>36</td>
<td>79</td>
<td>150</td>
<td>ND*</td>
<td>654</td>
<td>20</td>
<td>1440</td>
</tr>
<tr>
<td>PM-110K</td>
<td>95000</td>
<td>7</td>
<td>21</td>
<td>81</td>
<td>170</td>
<td>ND*</td>
<td>586</td>
<td>10</td>
<td>1440</td>
</tr>
<tr>
<td>PM-320S</td>
<td>93000</td>
<td>2</td>
<td>21</td>
<td>53</td>
<td>160</td>
<td>0.4</td>
<td>684</td>
<td>20</td>
<td>1420</td>
</tr>
<tr>
<td>PM-320K</td>
<td>94000</td>
<td>3</td>
<td>20</td>
<td>35</td>
<td>170</td>
<td>0.2</td>
<td>668</td>
<td>190</td>
<td>1330</td>
</tr>
<tr>
<td>PM-320SX</td>
<td>96000</td>
<td>4</td>
<td>24</td>
<td>49</td>
<td>190</td>
<td>ND*</td>
<td>651</td>
<td>20</td>
<td>1520</td>
</tr>
</tbody>
</table>

*ND indicates non-detectable concentrations.

**Figure two**

Modified. In this modification, the samples were leached with Freon directly and the leachate analyzed for total petroleum hydrocarbons. The photograph A below shows the electron microscopic image of the raw OBM waste. This untreated cuttings sample appears to be a relatively homogenous mixture of solids and liquid with the consistency of a thick slurry. The image shows large amounts of very fine, solid particles ranging in size from -1μg to 20μm dispersed in a thick liquid. The particles appear bright to medium gray, while the lower atomic number fluid appears dark. X-ray analysis indicates that the bright particles are barite (barium sulfate) particles. The medium gray particles are a mixture of silica (quartz) and possibly calcium, aluminum and iron bearing clays. A strong absorption peak in the x-ray spectrum at 0.28 keV is from the dark fluid and represents a carbon absorption which indicates that the fluid is organic. Based on knowledge of the source of the waste, the organic component is diesel fuel.

The photograph B on page 11 is an image of one of the treated samples. It consists of particles that have a predominant size range from ~2μm to >500μm. The image shows a large 463 μm capsule produced by the Siallon treatment at a magnification of 135x.

The photograph C on page 12 is an image of the surface of the of the 463 μm particle taken at a
Photograph B

magnification of 3550x. Note the very high concentration of very small particles, <2µm that appear to have been imbedded into the surface of the capsule. The dark areas are most probably hydrocarbon trapped in these very small pores as indicated by the relatively high carbon absorption peak shown in the x-ray pattern.

Other samples produced images that differed in only the apparent amount of fine material converted into capsules by the specific process and chemicals used, or in the size of the capsules produced. Generally, the capsule size range for other samples was less than that observed in the sample in photograph B. In other samples, the predominant size of the capsules ranges from ~2µm to 250µm.

Figure two, page 10, presents the results of the analyses on the raw waste and the treated samples. The first column gives the results of the Freon solvent

Continue on page 12 ➔
Micro encapsulation, from page 11

extraction of the samples. The raw waste shows a 12 percent total petroleum hydrocarbon content, while the other samples range from 82.5 percent solvent extractable to 77.5 percent extractable. The second column shows the results of the method 1310 acidic digestion of the sample followed by a solvent extraction of the leachate from the digestion. This data shows the range of extractable hydrocarbons from the treated material to be from 2 ppm to 60 ppm.

The images prove that Sallion treatment processes produce capsules of material and that those capsules are composed of aggregations of much finer particles. These capsules contain hydrocarbon material within the capsule as well as hydrocarbon trapped on the surface of the capsules in the pores created by the fine particles embedded in the capsules. This conclusion is drawn from the x-ray data taken from certain particles where there was obviously no surface adsorbed oil, and yet a high carbon peak appeared in the x-ray spectra. The conclusion as corroborated by the failure of aggressive leaching procedures to recover all the original hydrocarbon from treated material. In addition, samples from various field tests subjected to the same Freon extraction procedure have shown hydrocarbon recoveries of only 20 to 40 percent.

The difference in the amount of extractable material between the direct Freon extraction of the samples and the acid digestion extracts provides an indication of the availability of this hydrocarbon material. In the natural environment where neither of these two aggressive leaching techniques would be expected to occur, the amount of leachable hydrocarbon material is expected to be even lower than that shown in the acid digestion extract. For practical purposes, the end product of the Sallion process is non-leancheable.

The end product has the consistency of sand and a high surface area with a high permeability to both moisture and gas. Hydrocarbon material that is leachable at the rates shown for the acid digestion leach provides a ready source for the establishment of microbial communities that will degrade the hydrocarbon and become the base for the establishment of a fertile soil in which higher order plants can and do become established. The combination of encapsulation and slow release of hydrocarbon that can be degraded by microorganisms provides two significant advantages. Any hydrocarbon contamination threat to groundwater and surface water is immediately eliminated or greatly reduced, while the treated material provides a slow release bridge to natural bioremediation and eventual elimination of the contaminant.

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Washing process cleans up multiple contaminants

Versatile surfactants attack organics, metals, PCBs

By Richard Magee, Sc.D., P.E., DEE and Itzhak Gotlieb, Ph.D.

A single process that would completely clean up complex mixtures of contaminants at a reasonable cost could save industry and government hundreds of billions of dollars. Researchers at the Northeast Hazardous Substance Research Center at the New Jersey Institute of Technology have been developing a process that may do the job.

Cleaning up a site that is contaminated with organics, heavy metal effluents and residues from industrial and governmental operations can cost anywhere from $50 to $5,000 per metric ton of contaminated soil. It is expensive because the contaminants are so complex and variable. Cleaning up a site contaminated with only one contaminant is not too costly. For example, a site contaminated by a gasoline spill may be treated by soil vapor extraction for about $60 per metric ton of soil. A lead-containing soil can be stabilized for $50 to $70 per metric ton of soil. But most sites contain complex mixtures of contaminants, and the cost to treat jumps to more than $1,000 per metric ton.

The reason for the substantially higher cost of treating complex mixtures is that no single process is effective for multiple contaminants.

Now, however, researchers at the Northeast HSRC are developing a soil washing process called the Ghea process to treat highly complex mixtures of contaminants. “Ghea” means “remedy” in Hebrew. Soil washing is a method of treating contaminated sites by extracting contaminants with water plus additives such as surfactants, chelating agents, acids and alkalis. The method is largely in developmental or early commercialization stages in the U.S. and Europe. The Ghea process shows exceptional cleaning efficiencies at estimated costs of around $50 to $80 per metric ton of soil. Since 1989, researchers have conducted extensive bench and pilot plant tests on treated and untreated soils with high clay contents, oily sludges, coal tars, sediments, industrial wastewater effluents and groundwater. The contaminants include PCBs (polychlorinated biphenyls), petroleum hydrocarbons, aromatic compounds and heavy metals. The tests performed to date have yielded removal rates better than 99 percent for most treated contaminants and contaminated soil or water. The contaminants are isolated as a highly concentrated, small volume fraction, and the silt, clay and topsoil portions are purified to the same extent as the sand and coarser portions of the soil.

The cleansing properties of surfactants and other additives are well known and...
Grant launches Ghea

The process of bringing a technology to commercialization involves both strategic planning and taking advantage of opportunities when they present themselves. Itzhak Gotlieb recognized an opportunity when he saw a notice of a Center-based Innovation Partnership Grant Program at the National Science Foundation Industry / University Cooperative Hazardous Substance Management Research Center (HSMRC), which is affiliated with the Northeast Hazardous Substance Research Center at New Jersey Institute of Technology in Newark.

Gotlieb wrote a proposal, which led to his small New Jersey-based company, Ghea Associates, receiving a two-year grant for $41,809. This backing created very desirable conditions for Gotlieb to form a partnership with an academic researcher to further develop and demonstrate the Ghea process, to obtain laboratory space in an advanced environmental research facility, funds to fabricate his pilot-scale facility, and to foster connections with other researchers, government and industry.

His technology quickly attracted attention. He received funding from EPA’s Emerging Technology Program to use the Ghea process to decontaminate soil and water, and by the New Jersey Department of Environmental Protection to apply it to soils that have been contaminated with chromium. Interest from industry has led to additional demonstration opportunities, which Gotlieb is carrying out under the wing of the Center.

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Write in 260
Washing process cleans up, from page 15

The Ghea process consists of physical and chemical operations, rather than biological transformations. Therefore, toxicity of the pollutants does not diminish process efficiency, as can be the case with methods that rely on biodegradation, in which useful bacteria may be harmed by toxic chemicals. The versatility of the Ghea process stems from the fundamental properties of surfactants, which interact with both oil-soluble organics and water-soluble metal ions.

"The versatility of the Ghea process stems from the fundamental properties of surfactants, which interact with both oil-soluble organics and water-soluble metal ions."

Furthermore, surfactant formulation and strength can be varied as required to attain the desired separation. In comparison, solvent extraction methods are limited to organics, incineration is limited to combustibles, vapor stripping is limited to volatiles, and carbon adsorption is cost effective only for low strength water solutions of regenerable contaminants.

Pilot studies have provided a sound basis for scaling the Ghea process up to commercial applications. A commercial treatment facility will be designed to minimize storage, handling and operating labor. It will consist of shop-fabricated, skid-mounted process modules which are transported to the site for assembly. This modularity will provide maximum flexibility and cost savings in assembly, disassembly and applicability to widely different sites and site conditions.

Write in 746 for more information
Geophysical techniques protect groundwater
Electromagnetic energy probes subsurface secrets

By Y. Lynn Clark, REM

New generation geophysics offers advanced methods of tracking groundwater and soil contamination by incorporating the remote sensing of subsurface conditions and anomalies. The best method of determining subsurface conditions has always been, and remains, the direct observation and measurement of the subsurface. However, extensive excavation of observation pits or trenches is often impractical, due to the presence of buildings, parking lots and utilities. And, having a network of observation and monitoring wells that has been logged by a professional geologist for use in subsurface correlation of lithology is an expensive luxury. New generation geophysics is a more cost effective and less disruptive means to collect subsurface data.

Geophysics has been developed and used in the petroleum industry to search for deep targets for years, but the adaptation of different geophysical technologies to projects, along with geologic mapping, analytic geochemistry, geotechnical testing and aquifer pumping tests. By using geophysics along with drilling and other traditional assessment approaches, the company develops a practical, working definition of the exact nature of a subsurface problem, thus reducing costs and increasing the efficiency of the remediation effort.

Two of the more useful tools are ground penetrating radar (GPR) and shallow three-dimensional resistivity (3DR) surveys. Both of these techniques rely on the transmission and propagation of electromagnetic energy. GPR is an active remote sensing technique that uses non-ionizing low power pulses of electromagnetic energy that are reflected by shallow environmental problems is a relatively new practice. The first shallow applications of geophysics have been for Superfund-type projects and the protection of major sole source aquifers. Lynn Clark Associates Inc., Dallas, adopted geophysical investigations as a routine investigation tool for smaller

Y. Lynn Clark is vice president of Lynn Clark Associates Inc., Dallas.

Continues on page 18
Geophysical techniques, from page 17
velocity of the electromagnetic waves to change.
The 3DR technique relies on a movable electrical coil on the surface of the ground. The electrical current in the coil creates an electromagnetic field that can be measured at different locations by raising and lowering receivers inside cased wells or open holes. The electromagnetic field is impacted by the resistivity of the material through which it passes, and this resistivity is affected by the nature of the material itself—clean vs. oil-saturated soil, or the unsaturated shallow subsurface vs. the saturated subsurface at the water table contact.
Both these techniques rely heavily on computer processing to sort out the minute differences that may mean the difference between a correct interpretation of subsurface contaminant migration and a misleading picture. By using the methods in conjunction with insightful geologic evaluation of depositional history, hidden features such as old river beds, clay layers and limestone shelves can be identified. Geologic features such as forgotten creek channels are often found near flood plains. These old channels are extremely important, because they act like

“Computer processing sorts out the minute differences that may mean the difference between a correct interpretation of subsurface contaminant migration and a misleading picture.”

sand super-highways, providing a preferential migration pathway for petroleum hydrocarbons and other contaminants. Knowing where these migration routes occur can not only help to intercept contaminants before they migrate off site onto neighboring property, but can also help determine if all the contaminants found on a property actually originated on that property.
In one case, Clark Associates found that the petroleum contaminants on a client’s property were being reinforced by unrelated migration onto the client’s property from a neighboring source. The migration route was straight down an old, buried stream channel surrounded by clay. The resulting co-neglected contaminant stream was a mixture of the two sources, the client’s underground storage tank release and the neighbor’s contaminated groundwater. Geophysics provided the means to indirectly identify the change in water quality as the different contaminants at different points in the groundwater caused the electromagnetic properties of the water to change.

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Write in 246
Natural attenuation requires attention

Valid remedial strategy involves more than just ‘leave it alone’

By Stephen Testa

The fact that natural attenuation of petroleum hydrocarbons occurs in the subsurface is well established. Natural attenuation is rapidly gaining momentum as an alternative to the high costs and limitations of engineered solutions to meet cleanup levels. However, its acceptance among regulators and other decision-makers is still evolving because of its tendency to be misunderstood or incorrectly labeled as a no action alternative. If properly demonstrated, natural attenuation has a valid place in the arsenal of site remediation tools, provided defensible and logical conditions for its use are established.

Natural attenuation is defined as unenhanced physical, chemical and biological processes that act to limit the migration and reduce the concentration of contaminants in the subsurface. The most important process for petroleum hydrocarbons is aerobic bioremediation because it can destroy a large percentage of hydrocarbon contaminant mass. Destruction occurs as a result of bacteria oxidizing reduced hydrocarbons to obtain energy. Their metabolism removes electrons from the hydrocarbon donor via a number of enzyme-catalyzed steps along respiratory or electron transport chains to the final electron receptor, typically oxygen. The metabolized hydrocarbon ends up as a new cell mass with the by-products being carbon dioxide, water and the growth of new microorganisms. Under anaerobic conditions, other compounds such as nitrate, ferric iron and/or sulfate can be used as electron acceptors.

Other significant natural attenuation processes include volatilization, dispersion and adsorption. Volatilization, for example, can significantly reduce hydrocarbon contaminant mass in soil. Light end volatilized hydrocarbons are typically degraded in the vadose zone or slowly released to the atmosphere. Volatilization can, of course, be harmful if vapors travel to points of human exposure or increase explosive hazards in confined spaces. Dispersion is the primary mechanism in groundwater for transporting soluble contaminants away from source areas where little degradation occurs, to where they can be readily degraded, typically at the fringes of a plume where oxygen levels in groundwater are not depleted. Alternatively, adsorption can limit migration. Organic-rich soils such as peat may be effective adsorbers of petroleum, implying containment which can be an effective way to manage low-risk sites. These secondary processes are not viewed as important because they do not result in contaminant destruction, but rather mass transfer. However, these secondary processes should still be considered as playing an important part in natural attenuation.

Regulatory perception of attenuation

Most state cleanup regulations do not address natural attenuation and in fact, use of it may run counter to many states’ anti-degradation policies. There is clearly a regulatory and public perception that the polluter must use engineering and technology to clean up a particular site, and a natural attenuation approach may be no more than a loophole used to avoid paying the high costs of engineering. Agencies responsible for establishing cleanup levels for soils and groundwater at affected sites are gradually moving toward a position that, at some sites, less than pristine conditions will prevail where cleanup to regulatory levels is economically or technologically unfeasible. One of the biggest hurdles to overcome is the perception that natural attenuation is

Stephen Testa is president of Testa Environmental Corp., San Juan Capistrano, Calif.

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Attenuation, from page 19

Equivalent to No Further Action. The difference is that natural attenuation must be demonstrated, often implying additional site characterization, and development of a long term groundwater monitoring program, which can result in considerable cost over the years. Demonstration means that evidence must be produced to prove that contaminant reduction has been achieved and that intrinsic bioremediation is responsible for that reduction. Another difference is that natural attenuation, if properly demonstrated, increases the overall protection of the environment by either containment or destruction of contaminants. The No Further Action alternative implies no additional investigation or monitoring is required, regardless of whether the contaminants are degrading or migrating.

Natural attenuation should not be perceived as a permanent remedy or as a means to achieve cleanup levels. Instead, it is an interim measure until technologies are developed to fully remediate the site, and as a management tool to reduce site risks. It can also be a bridge from active engineering to No Further Action.

No Further Action may be preferable to natural attenuation in very low risk situations, since it eliminates the burden of site monitoring and further documentation. For example, sites that have low levels of contaminants or non-discernible plumes may be better candidates for No Further Action. Very minor releases of hydrocarbons may not be enough to support bioremediation. Alternatively, sites with elevated levels of contaminants in non-potable aquifers may be better addressed with a risk assessment.

### Summary of Site Conditions Favorable For Natural Attenuation of Diesel-Range Hydrocarbons in Soil
(Washrack/Treatment Area, McChord AFB, WA)

<table>
<thead>
<tr>
<th>Parameter for Evaluation</th>
<th>Site Specific Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Permeability</td>
<td>Unconsolidated outwash gravels and sand; K=2 cm/sec</td>
</tr>
<tr>
<td>Recharge</td>
<td>+1100mm annual rainfall; annual water table fluctuations typically 500-900mm.</td>
</tr>
<tr>
<td>Depth to Groundwater</td>
<td>2.5-3.5 meters</td>
</tr>
<tr>
<td>Soil Moisture Content</td>
<td>Upper smear zone - 18% of field capacity</td>
</tr>
<tr>
<td>Soil pH</td>
<td>Neutral - 6.8</td>
</tr>
<tr>
<td>Soil Gas O2 CO2</td>
<td>Not measured</td>
</tr>
<tr>
<td>Hydrocarbon Type</td>
<td>Jet fuel and light diesel mixture</td>
</tr>
<tr>
<td>Hydrocarbon Concentration</td>
<td>Average for Upper Smear Zone - 1,000 mg/kg TPH (a) Average for Lower Smear Zone - 10,000 mg/kg TPH</td>
</tr>
<tr>
<td>Total Heterotrophs</td>
<td>Upper Smear Zone - 106 CFU/g soil Lower Smear Zone - 105 CFU/g soil Background - 102 CFU/g soil</td>
</tr>
<tr>
<td>Total Hydrocarbons</td>
<td>Upper Smear Zone - 105 CFU/g soil Lower Smear Zone - 105 CFU/g soil Background - 102 CFU/g soil</td>
</tr>
<tr>
<td>Degraders (b) Microscopic Examination of Bacteria</td>
<td>Upper Smear Zone - Bacteria intact, healthy Lower Smear Zone - Bacteria grainy, unhealthy appearance, many protozoans appearance, no protozoans</td>
</tr>
<tr>
<td>Chromatographic Interpretation</td>
<td>Loss of volatiles and degradation of n-alkanes in the upper smear zone soil; Lower smear zone relatively less degraded.</td>
</tr>
<tr>
<td>% Volatiles (c)</td>
<td>Upper Smear Zone - 10% Lower Smear Zone - 25%</td>
</tr>
</tbody>
</table>

(a)TPH measured as sum of total volatile and total extractable hydrocarbons. (b)Determined using Sheen Screen. (c)% Volatiles defined as (total volatile hydrocarbons/total extractable hydrocarbons) x 100.

Parameters for evaluation

There are a number of lines of evidence to demonstrate that natural attenuation is occurring. However, because sites differ dramatically in complexity, the level of documentation that can be reasonably obtained varies. A review of some of the fundamental parameters of evaluation includes:

- Group I: Hydrogeologic Factors
- Hydrogeologic factors include gradient, permeability, recharge capability, depth to groundwater, moisture content / field capacity, dissolved oxygen, depth to contamination, extent of contamination and plume stability.

Groundwater gradients should be consistent seasonally, with moderate steepness such that a steady flow of electron acceptors is supplied to the plume without being too steep to cause migration of a plume beyond the ability of microbes to contain it.

The rate of microbial ability to metabolize hydrocarbons is limited primarily by the availability of electron acceptors and nutrient supply. In general, uniform soil zones of moderate to high permeability (sand and gravel) are more favorable for natural attenuation because of their ability...
to transmit fluids. Deposits that tend to channelize groundwater flow may be undesirable. Hydraulic conductivities greater than 10E-4 cm/sec and intrinsic permeabilities greater than 10E-9 are considered acceptable.

Strong recharge of meteoric water to water-bearing zones provides an annual source of oxygen-enriched waters and, in fertilized areas, also provides nutrients for microbial growth. In addition, for releases to the vadose zone, the downward infiltration of wetting fronts displaces oxygen depleted and CO₂-rich soil gas with fresh, oxygenated gas. However, excessive ponding of water or climates with heavy precipitation can cause water sealing to occur, which stops diffusion of oxygen and may curtail microbial activity.

For investigations of natural attenuation within the vadose zone, a determination of the moisture content is important in the zone of interest. Microbial growth is limited by excessively wet or dry soil. Moisture content, especially expressed as a percentage of the field (or holding) capacity indicates the ratio of moisture to air in the soil. The recommended range for optimal growth is between 40 and 70 percent.

In general, for releases in the vadose zones, the shallower the depth to the contaminant, the more rapid the diffusion of soil gas, and the greater the indigenous microbial density.

For groundwater plumes, the presence of dissolved oxygen is

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critical to maintain aerobic conditions. A dissolved oxygen concentration of at least 1 to 2 milligrams per liter is considered a minimum value to sustain a microbial population. Anaerobic conditions may cause growth of bacteria capable of degrading hydrocarbons using alternate electron acceptors such as iron and nitrate. Dissolved oxygen should be a standard field parameter measured as part of any groundwater monitoring program. Dissolved oxygen measurements need to be taken in a closed cell, and should not be measured on groundwater samples retrieved with bailers. Submersible low-flow or bladder-type pumps are recommended for this purpose.
The minimum oxygen concentration in unsaturated soil that can support aerobic metabolism is approximately 1 percent. Oxygen diffuses into soil because of pressure gradients, and carbon dioxide moves out of soil because of a diffusivity gradient. Excess water restricts movement of oxygen into and through soil. A minimum air-filled pore volume of 10 percent is considered adequate for aeration. Soil gas surveys are a valuable tool to demonstrate a zone of enhanced microbial metabolism over the site.

Defining the extent of subsurface contamination is a fundamental objective of any investigation and lays the foundation of the natural attenuation alternative. An adequate groundwater monitoring well network must be in place to determine the lateral and vertical extent of hydrocarbon affected soil and groundwater. If the

<table>
<thead>
<tr>
<th>Parameter for Evaluation</th>
<th>Site Specific Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Recovery</td>
<td>Former USTs and hydrocarbon-affected soil have been removed.</td>
</tr>
<tr>
<td>Depth of Groundwater</td>
<td>Shallow at 3.5-4.5 meters.</td>
</tr>
<tr>
<td>Gradient</td>
<td>Seasonally consistent.</td>
</tr>
<tr>
<td>Extent of Contamination/Plume Stability</td>
<td>Extent of plume reduced via pump and treat plume is stable; asymptotic conditions reached.</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>Aerobic biodegradation occurring as evidenced by inverse relationship between dissolved BTEX and DO.</td>
</tr>
<tr>
<td>Continued Groundwater Monitoring</td>
<td>Adequate groundwater monitoring system in place.</td>
</tr>
<tr>
<td>Water-Bearing Zone Imported</td>
<td>Non-beneficial use groundwater.</td>
</tr>
</tbody>
</table>

Figure three
release is relatively recent, it is also important to demonstrate natural attenuation is limiting plume migration. Older releases should be generally stabilized. For groundwater, asymptotic concentration limits should be achieved. Regardless, it is critical to demonstrate plume stability via soil borings, soil gas data and wells.

Group II: Chemical characteristics
Chemical characteristics include hydrocarbon type and concentration, pH, and nitrogen and phosphorous content.
The light hydrocarbons generally degrade more readily than heavier hydrocarbons. A significant percentage of the specific hydrocarbons found in light-to-medium range distillates (gasoline, jet fuels and diesel) are all amenable to biodegradation. The monoaromatic hydrocarbons (BTEX—benzene, toluene, ethylbenzene and xylenes) are the most soluble and degrade easily, followed by the straight-chained alkanes. Compounds that resist degradation are the isoprenoids (branched-chained alkanes) such as pristane and phytane hydrocarbons, and asphaltenes. For diesel-range hydrocarbons, a useful indication of degradability is the C17/pristane ratio.
Sample chromatograms often contain evidence that natural attenuation has occurred. If chromatograms of the fresh petroleum that was released can be obtained, then a solid comparison can be made between fresh and weathered samples. Fuel weathering often starts to occur relatively quickly after a release.
The concentration of hydrocarbons in both soil and groundwater is important. High concentrations of BTEX, greater than 10 mg/kg, and other volatile hydrocarbons have solvent properties which are toxic
to cell membranes. High total petroleum hydrocarbon concentrations require more oxygen and nutrients for degradation. Total petroleum hydrocarbon concentrations over 10,000 mg/kg can be detrimental by inhibiting water or air flow by obstructing soil pores. For these reasons, active remediation of source areas of the release by excavation, LNAPL (light nonaqueous phase liquids) recovery or vapor extraction concentrations is always recommended when practical. On the other hand, very low concentrations of hydrocarbons may not be sufficient to stimulate microbial growth.

Soil pH can be used to monitor and evaluate the extent of bacterial respiration. Soil pH should be in the range of 6 to 8 to maintain cell turgidity and promote enzymatic reactions. Soil buffers, such as carbonate minerals, can be valuable to neutralize acidic groundwater as a result of high carbon dioxide concentrations because of microbiological activity. The redox potential can be used to evaluate qualitatively the overall oxidation-reduction state of the water bearing unit. A negative redox potential indicates strongly reducing conditions, and thus significant bacterial decomposition. A positive redox potential indicates this point has not been reached or that bacterial degradation has not yet occurred.

Soil with carbon / nitrogen / phosphorous ratios of 100 / 10 / 1 are recommended for optimal bacterial growth. However, suboptimal ratios are not thought to impede intrinsic bioremediation, as oxygen is typically the factor that limits microbial growth in the subsurface. Typically, low concentrations of these nutrients are recycled and made available to new microbial colonies through the growth, death and decay of older colonies. Sulfur and low levels of other various minerals such as iron and manganese may also serve as nutrients.

Group III: Biological characteristics

Biological characteristics include microscopic examination and chromatographic examinations, plate counts, total heterotrophs, petroleum degrading, total hydrocarbon degrading, bacteria, microscopic examination and total organic carbon.

Group IV: Circumstantial factors

The time required for natural attenuation to reduce contaminant levels is difficult to predict. Time, however, should not be a controlling factor in the decision to use natural attenuation. Sites that are located in industrial areas are not likely to change land use or ownership in the foreseeable future have the advantage of time. If it can be demonstrated that contaminant concentrations are declining, then the absolute time for cleanup should not be critical, providing the site is monitored. However, natural attenuation may not be appropriate for sites that must be remediated to cleanup standards within compressed time frames.

The age of the release can play an important role in the use of natural attenuation. Microbial populations need to adapt to the presence of petroleum hydrocarbons before they can metabolize the hydrocarbons and reproduce in concentrations above background levels. With older releases, if natural attenuation is occurring, associated groundwater plumes may have stabilized and shrunk, and maximum seasonal water table fluctuations have occurred and distributed LNAPLs over a greater area. This maximum distribution results in less obstruction to groundwater flow through the zone of contamination, dissolves out the more toxic compounds and brings oxygen to the microbes. It is much easier to gather evidence for natural attenuation in older releases than in recent ones. Natural attenuation is more difficult to document in recent releases or when the release has not stabilized.

All these factors—hydrogeologic, chemical and biological characteristics and site specific circumstances—should be routinely considered at the beginning of and throughout the site characterization process to assess the possibility or eventual need for remediation with natural attenuation.

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Soils April 1995 23
Answers from EPA
New guide reveals how to evaluate remediation technologies

By Debby Tremblay

Editors note: The new EPA Guide for state regulators is the best overview of soil remediation technologies for petroleum contaminated soils I have seen. In over 280 pages the Guide clearly explains eight cleanup technologies—and, better still, it goes on to tell the regulator, or anyone who cares to read it, how each technology should be reviewed for approval. It's like the professor handing out the answers to the exam the day before the test!

During the past two years, EPA’s Office of Underground Storage Tanks (OUST) has been promoting the use of alternative technologies at leaking underground storage tank sites. Alternative technologies—technologies that are proven but not yet widely used—can make cleanups faster, more effective and less costly than traditional options such as pump and treat or landfiling.

Although the use of alternative technologies has increased at an encouraging rate, significant roadblocks to their widespread use still exist. According to state regulators, one of the most common barriers is the lack of technical guidance explaining how to review corrective action plans (CAPs) that propose alternative technologies. Without such guidance, state regulators are not confident of their review of CAPs that propose alternative technologies. Regulators have requested assistance on what to look for in a CAP, what’s critical, what’s not, and how to tell if a technology will actually reach cleanup goals.

In response to state needs, the Office of Underground Storage Tanks developed a manual entitled How To Evaluate Alternative Cleanup Technologies For Underground Storage Tank Sites: A Guide For Corrective Action Plan Reviewers. This guide is designed to help state regulators answer two basic questions:

• Has an appropriate cleanup technology been proposed?
• Does the CAP offer a technically sound approach to the cleanup?

Written in simple, straightforward, “plain English,” the manual takes the reader through the many steps involved in reviewing a CAP. The manual does not advocate the use of one technology over another; rather it focuses on appropriate technology use, taking into consideration site-specific conditions and the nature and extent of contamination.

Each chapter discusses one technology and describes its soil and groundwater applications in detail. The following technologies are covered:

• Soil vapor extraction
• Air sparging
• Biosparging
• Bioventing
• Biopiles
• Natural attenuation
• Land farming
• Thermal desorption

The guide has been distributed to state program offices, field offices, state fund offices and EPA regional offices. Consultants, contractors and other firms can obtain the guide for $22 from the U.S. Government Printing Office (GPO) by writing to the Superintendent of Documents, Box 371945, Pittsburgh, PA 15250-7954 and ordering stock number 055-000-00479-0.

Or call the GPO at 202-512-1900; fax 202-512-2250.

At the end of each chapter in the Guide is a summary checklist for regulators to use in their evaluation. Those eight checklists follow:

Checklist—Can soil vapor extraction be used at this site?

1. Factors that contribute to permeability of soil
   Yes No
   ☐ ☐ Is the intrinsic permeability greater than 10\textsuperscript{-6} cm\textsuperscript{2}\textsuperscript{s} ?
   ☐ ☐ Is depth to groundwater greater than one meter? (If not, this parameter alone may not negate the use of SVE. However, provisions for use of a surface seal, construction of horizontal wells, or for lowering the water table should be incorporated into the corrective action plan.)
   ☐ ☐ Are site soils generally dry?

2. Factors that contribute to constituent volatility
   Yes No
   ☐ ☐ Is contaminant vapor pressure greater than 0.5 mm Hg?
   ☐ ☐ If the contaminant vapor pressure is not greater than 0.5 mm Hg, is some type of enhancement (such as heated air injection) proposed to increase volatility?
   ☐ ☐ Are the boiling points of the contaminant constituents less than 300°C?
   ☐ ☐ Is the Henry's law constant for the contaminant greater than 100 atm?

3. Evaluation of SVE system design
   Yes No
   ☐ ☐ Does the radius of influence for the proposed extraction wells

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Answers from EPA, from page 24

fall in the range of 1.5 to 30 meters?
☐ ☐ Has the radius of influence been calculated for each soil type at the site?
☐ ☐ Examine the extraction flow rate. Will these flow rates achieve cleanup in the time allotted for remediation in the action plan?
☐ ☐ Is the type of well proposed (horizontal or vertical) appropriate for the site conditions?
☐ ☐ Is the proposed well density appropriate, given the total area to be cleaned up and the radius of influence of each well?
☐ ☐ Do the proposed well screen intervals match soil conditions at the site?
☐ ☐ Is the blower selected appropriate for the desired vacuum conditions?

4. Optional SVE Components
Yes ☐ No
☐ ☐ Are air injection or passive inlet wells proposed?
☐ ☐ Is the proposed air injection/inlet well design appropriate for this site?
☐ ☐ Are surface seals proposed?
☐ ☐ Are the sealing materials proposed appropriate for this site?
☐ ☐ Will groundwater depression be necessary?
☐ ☐ If groundwater depression is necessary, are the pumping wells correctly spaced?
☐ ☐ Is a vapor treatment system required?
☐ ☐ If a vapor treatment system is required, is the proposed system appropriate for the contaminant concentration at the site?

5. Operation and Monitoring Plans
Yes ☐ No
☐ ☐ Does the CAP propose daily monitoring for the first 7 to 10 days of flow measurements, vacuum readings, and vapor concentrations from each extraction vent, the manifold, and the effluent stack?
☐ ☐ Does the CAP propose biweekly to monthly monitoring for the first 7 to 10 days of flow measurements, vacuum readings, and vapor concentrations from each extraction vent, the manifold, and the effluent stack?

Checklist—Can bioventing be used at this site?

1. Site Characteristics
Yes ☐ No
☐ ☐ Is the soil intrinsic permeability greater than 10⁻⁶ cm²?
☐ ☐ Is the soil free of impermeable layers or other conditions that would disrupt air flow?
☐ ☐ Is the total heterotrophic bacteria count > 1,000 CFU/gram dry soil?
☐ ☐ Is soil pH between 6 and 8?
☐ ☐ Is the moisture content of soil in contaminated area between 40% to 85% of saturation?
☐ ☐ Is soil temperature between 10°C and 45°C during the proposed treatment season?
☐ ☐ Is the carbon: nitrogen:phosphorus ratio between 100:10.5 and 100:1:0.5?
☐ ☐ Is the depth to groundwater > one meter?

2. Constituent Characteristics
Yes ☐ No
☐ ☐ Are constituents all sufficiently biodegradable?
☐ ☐ Is the concentration of Total Petroleum Hydrocarbons < 25,000 ppm and heavy metals, < 2,500 ppm?
☐ ☐ If there are constituents with vapor pressures greater than 0.5 mm Hg, boiling ranges above 300°C, or Henry's law constants greater than 100 atm/mole fraction, has the CAP addressed the potential environmental impact of the volatilized constituents?

3. Evaluation of the Bioventing System Design
Yes ☐ No
☐ ☐ Will the induced air flow rates achieve cleanup in the time allotted for remediation in the CAP?
☐ ☐ Does the radius of influence (ROI) for the proposed extraction or injection wells fall in the range of 1 to 30 meters?
☐ ☐ Has the ROI been calculated for each soil type at the site?
☐ ☐ Is the type of well proposed (horizontal or vertical) appropriate for the site conditions?
☐ ☐ Is the proposed well density appropriate, given the total area to be cleaned up and the radius of influence of each well?
☐ ☐ Do the proposed well screen intervals match soil conditions at the site?
☐ ☐ Are air injection wells proposed?
☐ ☐ Is the proposed air injection well design appropriate for this site?
☐ ☐ Is the selected blower appropriate for the desired vacuum conditions?

4. Optional Bioventing Components
Yes ☐ No
☐ ☐ If nutrient delivery systems will be needed, are designs for those systems provided?
☐ ☐ Are surface seals proposed?
☐ ☐ Are the proposed sealing materials appropriate for this site?
☐ ☐ Will groundwater depression be necessary?
☐ ☐ If groundwater depression is necessary, are the pumping wells correctly spaced?
☐ ☐ Is a vapor treatment system required?
☐ ☐ If a vapor treatment system is required, is the proposed system appropriate for the contaminant concentration at the site?

6. Operation and Monitoring Plans
Yes ☐ No
☐ ☐ Is monitoring of offgas vapors for VOCs and carbon dioxide concentration proposed?
☐ ☐ Is subsurface soil sampling proposed for tracking constituent reduction and biodegradation conditions?
☐ ☐ Are manifold valving adjustments proposed for the start-up phase?
☐ ☐ Is nutrient addition (if necessary) proposed to be controlled on a periodic rather than continuous basis?

Checklist—Can biopiles be used at this site?

1. Soil Characteristics That Contribute To Biopiles Effectiveness
Yes ☐ No
☐ ☐ Is the total heterotrophic bacteria count > 1,000 CFU/gram dry soil?
☐ ☐ Is the soil pH between 6 and 8?
☐ ☐ Is the soil moisture between 40% and 85%?
☐ ☐ Is the soil temperature between 10°C and 45°C?
☐ ☐ Is the carbon:nitrogen: phosphorus ratio between 100:10:1 and 100:1:0.5?
☐ ☐ Does the soil divide easily and tend not to clump together?

2. Constituent Characteristics
That Contribute to BioPile Effectiveness
Yes ☐ No
☐ ☐ Are products to be treated primarily kerosene or heavier (i.e., not gasoline), or will air emissions be monitored and, if necessary, controlled?
☐ ☐ Are most of the constituents readily degradable?
Are total petroleum constituents < 50,000 ppm and total heavy metals < 2,500 ppm?
3. Climatic Conditions That Contribute to Biopile Effectiveness
   Yes No
   Is the rainfall less than 750
   millimeters during the biopile season?
   Are high winds unlikely?
4. Biotreatability Evaluation
   Yes No
   Has a biotreatability study been conducted?
   Biodegradation demonstrated, nutrient application and formulation defined, and potential inhibitors or toxic conditions checked?
5. Evaluation of Biopile Design
   Yes No
   Is sufficient land available considering the biopile depth and additional space for berms and access?
   Is run-on and runoff controlled?
   Are erosion control measures specified?
   Are the frequency of application and composition of nutrients and pH adjustment materials specified?
   Is moisture addition needed?
   Are other sub-optimal natural site conditions addressed in the biopile design (e.g., low temperatures, poor soil texture, and excessive rainfall)?
   Is the site secured?
   Are air emissions estimated and will air emissions monitoring be conducted?
   Are provisions included for air emissions controls, if needed?
6. Operation and Monitoring Plans
   Yes No
   Are frequencies of aeration, nutrient addition, and moisture addition provided in the operation plan?
   Is monitoring for constituent reduction and biodegradation conditions proposed?
   Are air, soil, and surface runoff water sampling (if applicable) proposed to ensure compliance with appropriate permits?
   Are the proposed number of samples to be collected, sampling locations, and collection methods in accordance with state regulations?
   Is quarterly (or more frequent) monitoring for soil pH, moisture content, bacterial population, nutrient content, and constituent concentrations proposed?

Checklist—Can landfarming be used at this site?

1. Soil Characteristics That Contribute To Landfarming Effectiveness
   Yes No
   Is the total heterotrophic bacteria count > 1,000 CFU/gram dry soil?
   Is the soil pH between 6 and 8?
   Is the soil moisture between 40% and 85%?
   Is the soil temperature between 10°C and 45°C?
   Is the carbon:nitrogen: phosphorous ratio between 100:10:1 and 100:1:0.5?
   Does the soil divide easily and tend not to clump together?
2. Constituent Characteristics That Contribute To Landfarming Effectiveness
   Yes No
   Are products to be treated primarily kerosene or heavier (i.e., not gasoline), or will air emissions be monitored and, if necessary, controlled?

Continues on page 28
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Answers from EPA, from page 27
- Are most of the constituents readily degradable? Yes
- Are total petroleum constituents < 50,000 ppm and total heavy metals < 2,500 ppm? Yes
- Climate Conditions That Contribute To Land Farming Effectiveness
  - Yes No
  - Is the rainfall less than 750 millimeters during the land farming season? Yes
  - Are high winds unlikely? Yes
- Biotreatability Evaluation
  - Yes No
  - Has a biotreatability study been conducted? Yes
  - Was biodegradation demonstrated, nutrient application and formulation defined, and potential inhibitors or toxic conditions checked? Yes
  - Is sufficient land available considering the land farm depth and additional space for berms and access? Yes
  - Are run-on and runoff controlled? Yes
  - Are erosion control measures specified? Yes
- Evaluation of Land Farm Design
  - Yes No
  - Is the site secured? Yes
  - Are air emissions estimated and will air emissions monitoring be conducted? Yes
  - Are provisions included for air emissions controls, if needed? Yes
- Aeration and Monitoring Plans
  - Yes No
  - Is monitoring for stormwater discharge or air quality permits (if applicable) proposed? Yes
  - Does the operation plan include the anticipated frequency of aeration, nutrient addition, and moisture addition? Yes
  - Does the monitoring plan propose measuring constituent reduction and biodegradation conditions in the land farm soils? Yes
  - Are air, soil, and surface runoff water sampling (if applicable) proposed to ensure compliance with appropriate permits? Yes
  - Are the proposed numbers of samples to be collected, sampling locations, and collected methods in accordance with state regulations? Yes
- Is quarterly (or more frequent) monitoring for soil pH, moisture content, bacterial population, nutrient content, and constituent concentrations proposed? Yes

Checklist—Can LTTD be used at this site?

1. Evaluation of LTTD Effectiveness
   - Yes No
   - Do soils have high plasticity?
   - Do soils contain large rocks or debris?
   - Is moisture content > 35%?
   - Is the TPH concentration > 2% by weight?
   - Are hydrocarbons highly volatile?

If the answer to any of the above questions is yes, then the soils require pretreatment.
- Are the soils a high concentration of humic material?
- Are contaminant Kows relatively high?
- Are dioxin precursors present in the soils?
- Is the depth of contaminated soil 7.5 meters or less below land surface?
- Is contaminated soil contained within site boundaries?
- Is there no contamination beneath buildings or near building foundations?

If the answer to any of the above questions is no, then excavation of the soil is not practical; therefore, LTTD is not practical. Consider an in situ remedial technology instead.
- Is sufficient land area available for operation of equipment and temporary storage (staging) of contaminated soil and treated soil?
- Is the distance to an off-site facility prohibitively far?
- Will surrounding land use permit operation of an onsite system in the neighborhood?

If the answer to any of the above questions is no, then excavated soils must be transported to an off-site facility for treatment.
3. Evaluation Of The Effectiveness Of Using LT TD
   Yes No
   ☐ ☐ Will an adequate number of in situ soil samples be collected and analyzed?
   ☐ ☐ Will an adequate number of treated soil samples be collected and analyzed?
   ☐ ☐ Has the proposed desorption unit successfully treated similar soils with similar contaminant concentration levels?
   ☐ ☐ Is the proposed ultimate disposal of the soil (e.g., return to excavation, transport to landfill for cover) acceptable?
If the answer to any of the above questions is no, then additional information is necessary to evaluate whether LT TD is likely to be an effective remedial technology.

Checklist—Can air sparging be used at this site?

1. Factors That Contribute To The Vapor/Dissolved Phase Partitioning Of The Constituents
   Yes No
   ☐ ☐ Is the Henry’s law constant for the contaminant greater than 100 atm?
   ☐ ☐ Are the boiling points of the contaminant constituents less than 300°C?
   ☐ ☐ Is the contaminant vapor pressure greater than 0.5 mm Hg?
2. Factors That Contribute To Permeability Of Soil
   Yes No
   ☐ ☐ Is the intrinsic permeability greater than 10⁻⁶ cm²?
   ☐ ☐ Is the soil free of impermeable layers or other conditions that would disrupt air flow?
   ☐ ☐ Is the dissolved iron concentration at the site < 10 mg/L?
3. Evaluation of the Air Sparging System Design
   Yes No
   ☐ ☐ Does the radius of influence (ROI) for the proposed air sparging wells fall in the range 1 to 30 meters?
   ☐ ☐ Has the ROI been calculated for each soil type at the site?
   ☐ ☐ Examine the sparging air flow rate. Will these flow rates provide sufficient vapor/dissolved phase partitioning of constituents to achieve cleanup in the time allotted for remediation in the CAP?
   ☐ ☐ Examine the sparging air pressure. Will the proposed pressure be sufficient to overcome the hydraulic head and capillary forces?
   ☐ ☐ Is the number and placement of wells appropriate, given the total area to be cleaned up and the radius of influence of each well?
   ☐ ☐ Do the proposed well screen intervals account for contaminant plume location at the site?
   ☐ ☐ Is the proposed well configuration appropriate for the site conditions present?
   ☐ ☐ Is the air compressor selected appropriate for the desired sparge pressure?
4. Operation And Monitoring Plans
   Yes No
   ☐ ☐ Does the CAP propose starting up the SVE system prior to starting the air sparging system?
   ☐ ☐ Are manifold valving adjustments proposed during the first 7 to 10 days of operation?

Continues on page 30

---

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Two free catalogs and disk describe new soil sparging/vapor extraction compressors and regenerative blowers from Gast.

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Write in 255

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Answers from EPA, from page 29

- Is monitoring for sparge pressure and flows, vacuum readings (for SVE), groundwater depth, vapor concentrations, dissolved oxygen levels, carbon dioxide levels, and pH proposed for the first 7 to 10 days of operation?
- Is weekly to biweekly monitoring of groundwater pH and levels of contaminants, carbon dioxide, and dissolved oxygen proposed following startup?
- Is weekly to biweekly monitoring of the effluent stack for levels of contaminants, oxygen, and carbon dioxide proposed following startup?

Checklist—Can biosparging be used at this site?

1. Site Factors
   - Yes No
   - Is the aquifer clear of floating free product?
   - Is the soil intrinsic permeability greater than 10⁻⁶ cm²/s?
   - Is the soil free of impermeable layers or other conditions that would disrupt air flow?
   - Is soil temperature between 10°C and 45°C during the proposed treatment season?
   - Is the pH of groundwater between 6 and 8?
   - Is the total heterotrophic bacteria count > 1,000 CFU/gram dry soil?
   - Is the carbon:nitrogen:phosphorus ratio between 100:10:1 and 100:1:0.5?
   - Is the dissolved iron concentration at the site < 10 mg/L?
   - Is vapor migration of constituents controlled?

2. Constituent Characteristics
   - Yes No
   - Are constituents all sufficiently biodegradable?
   - Is the concentration of Total Petroleum Hydrocarbon < 50,000 ppm and heavy metals < 2,500 ppm?
   - Are the constituent vapor pressures less than 0.5 mm Hg?
   - Are the Henry's law constant for the constituents present lower than 100 atm?

3. Evaluation Of The Biosparging System Design
   - Yes No
   - Examine the sparging air pressure. Will the proposed pressure be sufficient to overcome the hydraulic head and capillary forces?
   - Is the proposed well density appropriate, given the total area to be cleaned up and the radius of influence of each well?
   - Do the proposed well screen intervals account for contaminant plume location at the site?
   - Is the proposed well configuration appropriate for the site conditions present?
   - Is the air compressor selected appropriate for the desired sparge pressure?
   - If nutrient addition is needed, are nutrient formulation and delivery rates appropriate for the site, based on laboratory or field studies?
   - Have background concentrations of oxygen and CO² (measured in pilot studies) been taken into account in establishing operating requirements?

4. Operation and Monitoring Plans
   - Yes No
   - Are manifold valving adjustments proposed during the first 7 to 10 days of operation?
   - Are hourly recordings of injection and extraction rates, pressures, depth to groundwater, hydraulic gradient, and VOC levels proposed during the first 7 to 10 days of operation?
   - Is daily monitoring of injection rates proposed during the first 7 to 10 days of operation?
   - Are biweekly to monthly measurements of contaminant levels in groundwater, vapor wells, and blower exhausts proposed?
   - Are biweekly to monthly measurements of vapor concentration proposed?

Checklist—Can natural attenuation be used at this site?

1. Initial Screening
   - Yes No
   - Are there no nearby human or sensitive ecological receptors near the site that could be exposed to the petroleum contamination in soil?
   - If potential receptors are present, are they located at a distance that represents a minimum two year travel time?
   - Are maximum total constituent concentrations less than 20,000 to 25,000 ppm TPH?
   - Are there potential receptors who could be exposed to contaminated groundwater, soil, or vapors?

2. Detailed Evaluation — Site Factors Affecting Constituent Degradation
   - Yes No
   - Are the soils well aerated, allowing for transfer of oxygen to subsurface soils?
   - Is the absorption potential of the constituent/soil combination high enough to adequately retard constituent migration?
   - Is the seepage velocity low enough to prevent rapid migration of constituents?
   - Is soil oxygen content > 2 percent and dissolved oxygen content > 1 to 2 mg/L?
   - Is moisture available for transport of microorganisms (soil moisture of 40 to 85 percent of field capacity)?
   - Is the pH of the soil between 6 and 8?
   - Are concentrations of heavy metals and other toxic compounds below levels that could inhibit microbial activity?
   - Is rainfall moderate to heavy (i.e., 250 to 1500 millimeters/year)?
   - Is the climate moderate to warm (i.e., 5° to 45°C)?
   - Does the soil have a C:N:P ratio of about 100:1:0.5 to 100:10:1?

3. Detailed Evaluation — Chemical Constituent Factors Affecting Migration For Those Constituents Requiring The Most Significant Concentration Reduction
   - Yes No
   - Are the majority of the hydrocarbon constituents at most slightly soluble in water?
   - Are the majority of the hydrocarbon constituents not highly volatile as measured by vapor pressure, Henry's law constant, and boiling point?
   - Are the Koc and Kd values of constituents high enough to adequately retard migration?
   - Are the constituents sufficiently biodegradable?

4. Remedial Monitoring
   - Yes No
   - Will soil samples be collected?
   - Will a minimum of four groundwater wells be sampled?
   - Is the groundwater monitoring frequency at least quarterly during the first year?
   - Are the groundwater wells placed to detect the reductions of constituent concentrations in the plume and potential migration of constituents?
Steam injection melts cleanup time

With vapor extraction, treatment time can decrease dramatically

By David Noffsinger

The use of steam injection to enhance production of oil from declining oil fields is widespread. Steam injection was used to boost production rates in oil fields as early as the 1940s. Now, the technology is being applied to boost remediation rates at contaminated sites. The temperature of the steam and the amount of steam adsorbed by the contaminated medium are the controlling factors of steam pressure propagation through porous media. In contaminated soils, latent heat tends to volatilize and reduce the viscosity of the contaminants by increasing the vapor pressure of the contaminants. This phenomenon, combined with the pressure differential caused by the steam pressure and vacuum extraction, increases the mobility of contaminants in the media. The rate of contaminant migration depends on the chemical properties (boiling point, vapor pressure and polarity) of the specific contaminant compounds, and on the physical and chemical properties of the media, such as permeability to steam, moisture content and affinity for the contaminant compounds.

In a field study to assess the performance of steam injection and vacuum extraction in California, steam was injected into six wells surrounding a single vacuum recovery well. A mass flow rate of steam of 112 kilograms per hour was maintained for 140 hours as the total mass flow rate in all six wells. At the end of the treatment period, the average contaminant concentrations were reduced from 1,200 mg/kg to less than 22 mg/kg.

Due to lower mass transfer rates associated with the greater water content in low permeability units, higher concentrations of contaminant compounds remained in those

Note: Experiment vessel was placed at a slight angle to promote flow to drain.

**Figure one: Experiment vessel**

---

David Noffsinger is a senior hydrogeologist, formerly with URS Consultants Inc., Cleveland, Ohio. The author would like to acknowledge as references for this article: W.N. Herkelrath, A.F. Moench, C.F. O'Neal, K.S. Udell and L.D. Stewart.

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units after treatment, suggesting that a longer treatment period would be required to remediate the lower permeability units.

Three methods for steam stripping have been tested and are widely used in the design of most steam injection / vacuum treatment systems:

- Steam is injected through wells into the media, where the contaminants are vaporized,
- Steam and super-heated air are injected through drill bits while drilling in the contaminated media, resulting in soil mixing and vaporization of contaminants. The contaminants collect beneath a shroud placed over the borehole and are then recovered with a vacuum recovery system.
- Steam is injected through injection wells below a phreatic zone of contamination to lift it toward an extraction well. The contaminants are recovered by pumping the well.

Each method relies on the concept of introducing steam into the contaminated zone to mobilize the contaminants, then recovering the contaminants by some other means. The steam may be injected into the vadose or phreatic zones, or both. For vadose zone methods, stripping efficiency increases with increasing steam injection pressure, then sharply decreases from the point

![Diagram of Steam Injection System](image)

**Figure two: Steam injection system**

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Write in 233
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Figure Four

where soil fracturing or steam channeling occurs. The maximum
treatment pressure for the medium
depends on the permeability of the
medium to steam, and the
geological conditions of the site.

A bench scale study was
undertaken at Kent State University
to evaluate the performance of
vacuum assisted steam stripping
for remediating gasoline range
compounds from low permeability
soils in northeastern Ohio. The
purpose of the investigation was to
evaluate steam stripping combined
with vacuum extraction to remove
a simulated gasoline mixture from
the homogenous sandy soils and
from silty layers with a large
number of USTs. Four experiments
were conducted in each medium,
vacuum extraction with no steam
and vacuum extraction with steam

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injection pressures of 3-, 6- and 9- PSIG.
A pressure cooker, 550 millimeters in diameter and equipped with a lid that sealed was modified to serve as an experiment vessel as shown in figure one, page 31. Four holes were drilled in the lid to allow installation of three steam injection wells and one central vacuum extraction well. A hole was bored through the side of the vessel near the bottom to serve as a drain valve and manometer port. Soil vapor sampling ports were installed at three levels: 25 millimeters below the surface of the medium, midway in the medium and 25 millimeters above the bottom of the medium. Soil vapor samples were continuously collected from the sampling ports and analyzed.
During each experiment, sweep air was injected into the headspace above the media at a rate of 4 liters per minute to purge BTEX ((benzene, toluene, ethylbenzene, xylenes) vapors that collected in the headspace during treatment.

The steam injection system, shown in figure two, page 32, consisted of a steam boiler, a steam manifold and three steam injection wells. The steam boiler was actually a modified aluminum pressure cooker. The lid was equipped with a rubber seal, a steam vent with a valve and a safety blowout plug. It was heated with Bunsen burners. The steam was generated from deionized, distilled water.
The vacuum system consisted of a pump, gauge, manifold and rotameter. Charcoal adsorption tubes were packed with 15 grams of mesh size 16 activated...
For the steam and vacuum experiments, the boiler was allowed to build pressure for about 30 minutes. The headspace sweep air was started, the vacuum pump turned on, and the steam throttle valve opened to permit steam to enter the steam injection wells from the steam manifold.

Once the experiments were started, vapor samples were continuously collected from each of the sampling ports and analyzed with the gas chromatograph.

The results, shown in figure three, page 34, indicate that treatment time required to reduce BTEX in the sand ranged from 24 hours for vacuum extraction alone, to two hours with steam injection. The till experiments ranged from eight hours with steam injection to 40 hours for vacuum extraction alone. The experiment was continued until the total concentration of the

What is it, and where did it come from?

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Often, in the mad rush to satisfy state or federal regulators, characterization and identification analyses are overlooked. After the regulators are gone, questions come up like: “Was it all ours?” or “Just how old was it?” It is usually too late to ask these questions because all of the evidence needed (oil sheens, contaminated soils) has been removed.

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BTEX compounds in the soil vapor was consistently below 10 ppm. Steam injection treated the sand up to 16.2 times faster than vacuum extraction alone. On average, stripping of BTEX from the till took four times longer than for the sand. A total of 93 to 94.4 percent of the mass of BTEX was removed from the till by steam with vacuum treatment.

Liquid and solid samples were also collected for chemical analysis. The reason to analyze these samples was to determine the concentrations of BTEX compounds in water removed from the model, in the media after treatment and that adsorbed onto the activated charcoal in the adsorption tubes. The results are shown in figure four, page 33.

“Perhaps the greatest advantage of steam injection and vacuum extraction treatment is that it is performed in situ, saving excavation and disposal costs... and contaminants can be removed faster than ambient temperature methods which may also result in cost savings.”

Perhaps the greatest advantage of steam injection and vacuum extraction treatment is that it is performed in situ, saving excavation and disposal costs. Contaminants can be removed faster than ambient temperature methods which also may result in cost savings. A quicker remedy tends to reduce risk to sensitive receptors in high risk areas. The method works for a full range of volatile organic compounds, and may be effective for semi-volatiles.

On the other hand, initial mobilization and equipment and labor costs to enhance vapor extraction with steam injection are higher than costs for vapor extraction alone. But, the speedier treatment by adding steam injection may work out to cost less over the lifetime of the project. Steam injection may not work in low permeability media without artificially fracturing the media. Channeling through the permeable layers and around impermeable layers may occur in heterogeneous media. Required treatment time may be controlled by the diffusion of the BTEX through the impermeable layers. And, high temperature treatment may hinder or destroy microbes that naturally biodegrade hydrocarbon compounds.

For more information write in 749

Write in 001
Air and water fight for space in soil
Soil air, water and temperature are linked in the subsurface

By Alfred Conklin, Ph.D.

The relationship between soil air, water and temperature is simple. As the water content of soil increases, the air content and temperature decrease—and vice versa. The air component of soil is different from atmospheric air, particularly in its oxygen and water contents. Under natural conditions, even the driest soil contains significant water. For bioremediation, we need to maintain enough water and a moderate temperature for suitable microbial growth. Too much water leads to anaerobic conditions that are not favorable to microbial decomposition. Air and water content control soil temperature by making soil easier or harder to heat.

Soil air is made up of nitrogen, oxygen, carbon dioxide and water vapor plus other minor constituents. It is not composition, but the amounts of the various constituents which makes soil air different. It contains more carbon dioxide and less oxygen than atmospheric air. Some carbon dioxide dissolves in soil water to form carbonic acid (H₂CO₃) which tends to keep the soil solution acidic. Soil air is usually between 95 and 100 percent relative humidity.

Below the surface, it is always at or close to 100 percent humidity.

The relationship between soil air and soil water is not as simple as indicated above. Oxygen is the most important gas in soil air. Thus, changes in this component are what we wish to follow. The amount of air in soil decreases as water is added. Eventually the soil is saturated with water. However, even under these conditions, there is oxygen trapped in soil pores and dissolved in the water. In time, aerobic microorganisms take up trapped and dissolved oxygen. When this happens, the soil is truly anaerobic. The change from aerobic to anaerobic and from aerobic to anaerobic is a gradual process.

The movement of air in and out of soil is important because it provides the oxygen needed by plant roots and by aerobic bacteria. There are two major ways in which this movement occurs. One is through changes in water content, and the other is through heating and cooling. Air moves out as water moves into soil—as water moves out, it is replaced by air. As soil warms, air expands and moves out. When soil air cools, it contracts, drawing fresh air in. Obviously, this process follows a night and day cycle.

From a traditional soil scientist point of view, soil water is related to the growth of plants. If a column of soil is saturated with water and then allowed to drain, a limited amount of water will come out. This water is pulled out of the soil by gravity and is called gravitational water. As gravitational water drains, it is replaced with air. The speed at which gravitational water is removed depends on the texture and structure of the soil. Soil high in clay content drains much more slowly than sandy soils. Also, clay soils have pores that do not drain, and thus will stay anaerobic for some time.

When the gravitational water is drained, remaining water is held with a pressure of -0.03 MPa, or more positive pressures. Soil scientists often use bars or atmospheres (atm) to express water in soil. Thus, -0.03 MPa would be 0.3 bars, which is approximately the same in atm. Gravitational water percolates or leaches through soil. It leaches compounds and ions into lower layers of rock or water. Thus, this water is very important to consider in remediation efforts—particularly if one is concerned with possible contamination of adjacent sites.

At more negative pressures, water is removed by evaporation or by plant use. From -0.03 MPa to -1.5 MPa soil water is available to plants. This is the range of water pressure that is essential for plant growth, and is considered best for microbial growth as well.

Even the driest soil contains water. To remove all soil water, a soil sample is dried in an oven at 110°C for 24 hours. The amount of water lost, divided by the dry weight of the soil sample times 100 gives the percent water on a dry weight basis.

Weight of water lost    X 100 = % water
Dry weight of soil

This is an easy measurement, but it does not reveal whether the water is available to plants. If the oven dry soil is exposed to the atmosphere, it picks up water from the air. This is called hygroscopic

Continues on page 38 ➔

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Air and water fight, from page 37

water. Under the driest, dustiest conditions, soil contains hygroscopic water.

There are a number of other ways to measure soil water content, and many can be used in situ. Probably the easiest to use is a porous block, as in the photograph above. A porous block, usually gypsum, with two electrodes in it is inserted in the soil. As the water content of the soil increases, the block absorbs water and its resistance decreases. As soil water decreases, the block loses water and its resistance increases. The leads on the blocks are long enough such that the blocks can be inserted at various depths in soil. Resistance can be measured periodically using a moisture meter and converted to a percentage of water. From this information, one can tell if a soil is saturated with water—an aerobic or anaerobic. For bioremediation, this is an essential piece of information.

Air and water also have a relationship with soil temperature. Dry soil is easier to heat than wet soil. The specific heat of water is 1 cal per gram, while the heat capacity of dry soil is 0.2 cal per gram. Thus, the drier a soil is, the easier it is to heat.

A trick question is to ask which will warm up faster in the spring—a black soil or a light colored soil, assuming both are at an equal angle to the sun? The logical answer is that the dark color soil should absorb the sun’s rays faster. However, dark color in soil comes from organic matter. The wetter a soil, the more plants grow, and thus the more organic matter, the darker the soil. Also, darker soils are often saturated with water during several months out of the year. Under anaerobic conditions such as soil saturated with water, organic matter is slower to break down—again, the more organic matter and darker color. Thus, because of the high water content and the large amount of energy needed to heat water, dark colored soils are commonly slower to warm up in the spring.

In soil remediation, control of water is essential. The presence of gravitational water allows for the leaching of contaminants. For bioremediation, there must be sufficient water for microorganisms, but there must not be so much water as to exclude air. Also, soil water content is very important in any effort to control soil temperature.

Put the heat on the haz

Process Heating Co., Seattle Wash., offers an industrial electric heating system for use in hazardous locations. The new immersion systems are engineered for use in locations where explosive or flammable materials are stored or processed. The systems are approved by ETL Testing Laboratories Inc.

New software draws for you

SoftShell International Ltd., Grand Junction, Colo., releases a software program with more than 250 modular drawings to create publication-ready illustrations in only a few minutes. The Chemical Engineering Symbols Collection includes towers, valves, pumps, towers and other engineering elements. The company also offers Entropy as the only chemical database software that stores structures and text on database pages that do not require formatting. Users can import their old files from ChemWindow, ChemIntosh and other chemistry drawing products to create a chemical database. Entropy stores lab notes, drawing collections, common forms, test results, presentations, and can inventory chemicals or keep track of literature references, says the company.
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**Soils April 1995**

**Environmental Marketplace**
New sparge system feeds two gases

KVA Analytical Systems, Falmouth, Mass., offers a new, pallet-mounted sparging system with dual tanks for multiple gas injection to enhance biodegradation. The gases are fed via plastic tubing to 10 Microporous Spargepoints™ to remove gasoline contamination and dissolved solvents in groundwater. Write in 755 for more information

New pump slurps deep water

Remtech Engineers of Marietta, Ga., introduces the Model 0.25 Slurp, depression and free product removal pump as a controllerless downhole pump that runs wet or dry without damage. It has variable flow rates up to 17 liters per minute at heads exceeding 30 meters. Write in 756 for more information

How about a nice hot cup of evaporated oil?

Though it looks like a coffeemaker, EM Science, Gibbstown, N.J. says their new Aquastar® EV-6L oil evaporator is the only available alternative to manual distillation in moisture analyses of liquids and solids. It determines moisture levels by direct titration of vapors produced through distillation of solvent and sample. Write in 757 for more information

Cast alloy gate valves laugh at high thermal temperatures

Airlock Technologies Corp., Colchester, Vt., introduces two all-cast double gate valve series to handle temperatures up to 980°C, abrasive materials and pressure/vacuum applications. According to the company, the gates are for thermal desorption, dry or abrasive material handling and dust control applications. Write in 758 for more information

Lysimeter secrets revealed

Timco Manufacturing Inc., of Prairie du Sac, Wisc., will sponsor a one-day lysimeter training program at the Hyatt in San Jose, Calif., on Monday, May 15, 1995. The program will cover lysimeter methodology, definitions, installation and applications, sample collection, sampling techniques, trouble-shooting tips and a question and answer session. Featured speakers include Art Moss of Utah State University, Ron Peterson from Stone Environmental, Montpellier, Vt., and Mark Radecke of Geraghty & Miller, Raleigh, N.C. Cost is $150. Call 800-236-8534.

If you must check crude, check this

EnSys Environmental Products Inc., of Research Triangle Park, N.C., introduces Crude Check™ Soil Test System. Users of this immunoassay kit can find the concentration of crude oil in soils in less than five minutes, says the company. EnSys also announces new immunoassay test kits to detect TNT and RDX, major components in munitions formulations at ammunition manufacturing sites. The tests exhibit broad recognition of nitroaromatic compounds with a high degree of accuracy. Write in 759 for more information

How to monitor ammonia

Environmental Technologies Group Inc., Baltimore, Md., unveils fixed point analyzers for ppb to percent concentration monitoring of ammonia and n-methylpyrrolidone, which are used in the semiconductor industry. Using ion mobility spectrometry, the only technology that can achieve detection limits as low as one ppb on a continuous, real-time basis, each analyzer is factory calibrated to monitor a specific gas. The analyzers are solid state, with no moving parts or optics requiring alignment, says the company. Write in 760 for more information

40 April 1995 Soils
Cancel the drill rig

Geoguard Inc., Medina, N.Y., says their new Terraprobe soil gas/water sampling system can take the place of a drill rig by penetrating the subsurface up to 9 meters deep for soil and water sampling, soil gas surveys and water level determination. The systems can also be used as dedicated sampling points in permanent monitoring sites. Write in 761 for more information

Rolling sampler service carries various attachments

TVG Environmental Inc., Nashville, Tenn., introduces the Steam-Probe, a truck-mounted rig that conducts comprehensive sampling and assessments, including a steam-heated, soil vapor analysis. According to the company, the Steam-Probe is hydraulically inserted to conduct soil samplings, which are analyzed in its on-site mobile lab. It carries a bailer, peristaltic pump, downhole pump and vacuum lift, and is operated by a crew of experienced engineers, geologists and scientists, says the company. Write in 762 for more information

Packer inflates

Keck Instruments Inc., Williamston, Pa., designed their new inflatable packer to isolate specific sampling intervals within a 100 mm drill casing. Write in 763 for more information

Meter measures moisture

Gilson Co. Inc., Worthington, Ohio has a new soil moisture meter, HM 672 that reads moisture content at various depths with a range of 0.1 to 15 bars tension. Write in 764 for more information

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Write in 259 Soils April 1995 41
The BIO-PRO Corp. Module B is a portable soil climate control system to enhance soil conditions for bioremediation, says the company, located in Butte, Mont. The unit is operated by a control computer which monitors and maintains soil temperature, moisture and aeration, as well as ambient temperatures and fresh air addition during biostimulation. When coupled with a biopile, or enclosed treatment cell, Module B uses heated, forced aeration to maintain soil temperatures at or above a designated setting for optimum degradation. The unit allows soil temperature to be maintained without drastic ambient condition influence. Up to eight sensors are used to monitor soil temperature. A soil moisture meter monitors and maintains target soil moisture content. Once the meter is calibrated to the target soil moisture, it reads moisture data and regulates the addition of moisture to the treatment cell as needed. The unit also provides timed fresh air sparging to maintain high levels of oxygen throughout the soil mass. Timed sparging, combined with continuous soil air circulation creates a uniform soil environment for biodegradation. The aeration system is adaptable for various treatment pile volumes. The Module comes in a pilot scale size with treatment capacity up to 76 cubic meters and a commercial scale size with capacity up to 1900 cubic meters. Both units provide soil aeration retention times of five to 10 minutes, and require a supply of 38 to 57 liters of water per minute to draw from. The units require three-phase power. The company also makes a Module C unit designed for ex-situ bioaugmentation and bio composting. It regulates soil composting temperatures in a biopile or treatment cell, and uses natural oxygen depletion to control metabolic activity in the treatment cell.

Write in 750 for more information
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The ChemSensor from ORS Environmental Systems, Greenville, N.H., provides in situ, real time detection of volatile organic compounds in water — without the burden of retrieving samples, says the company. It is suitable for groundwater and surface water monitoring as well as industrial and wastewater applications in water temperatures ranging from 5°C to 60°C. The unit's probe contains a sensing element that incorporates a short optical fiber core with a hydrophobic / organophilic chemical coating. Light is launched into the fiber from a light emitting diode and detected at the opposite end by a photodiode. A reference detector monitors the light output and compensates for light source fluctuations. The amount of light transmitted to the detector depends on the difference in the refractive index of the optical fiber core and the chemical coating. When the probe is immersed in water that contains volatile organic compounds, the compounds partition into the organophilic coating and change the effective refractive index of the coating, allowing light to escape. The resultant loss of light reaching the detector correlates to the concentration of volatile organic compounds present. The 25 millimeter diameter probe fits into small diameter wells and is sensitive to less than 1 ppm. The unit continuously displays chemical concentration and temperature on an LCD readout.

According to ORS, the unit allows the user to take more readings in the field in less time than conventional sampling, resulting in more accurate characterization of the site. It also facilitates the selection of samples for laboratory analysis, and allows for multiple analyses on a single sample, reducing false negatives. The unit comes in a carrying case with cleaning and calibration solutions and battery recharger.

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