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Full-Spectrum, Non-Hazardous Soil Remediation

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 capacities of up to 160 tons-per-hour, soil
 discharge temperatures of 650 to 1200°F
 and thermal oxidizer gas stream destruct zone
temperatures of 1450 to 1800°F with a 1.2
to 1.5 second dwell time.
was chatting with a non-environmental business person the other day. When she learned that I am editor of an environmental magazine, to be polite, she shared with me the latest slice of information she had heard about "the environment." She told me that her broker had advised her to look at residential water treatment system manufacturers as the hot investment of the immediate future, because there will be a growing perception that the entire water supply is hopelessly contaminated, everyone will be terrified, and rush out to buy some kind of gizmo to attach to their kitchen faucet to clean whatever is oozing out into something potable. What shall we call this—end point remediation? My response to this prediction was to ruefully patronize this woman, and murmur something to indicate gently that she and her broker were frightfully naive.

But, the more I think about it, I am not so sure that I could guarantee that such a scenario might not come about. Two or three times a year, I get a little plastic bag hanging on my front door that contains a small plastic bottle, and instructions for me to "take a sample" of my water, and send it in for a "free analysis." I've always thought it would be fun to fill the bottle with a sample from my faucet, perhaps a droplet of tabasco, and a whiff of dog spray, and a couple of cat hairs—just to see what kind of results I would get. ("Miz Parker, we think you may have a problem...") We have to keep fighting for the groundwater. In fact, we have to fight harder. I don't think any of us want to see groundwater remediation ultimately taking place in our kitchen sink. I don't want stock brokers urging folks to invest in faucet gadgets...I want the investment to be in source protection and remediation by trained, qualified and experienced industry experts. The notion of massive and widespread contaminated groundwater could quickly become an hysterical wave of nationwide panic with just an isolated episode or two spun out by the right public relations firm. En garde!

Susan Parker

sparker@gvi.net

Cover: Thermal desorption plant, owned and operated by Southwest Soil Remediation Inc., at a project in Tucson, Ariz. The plant was designed and manufactured by SPI/Astec of Chattanooga, Tenn., and is currently remediating contaminated soils at a temporary facility in California.

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June-July 1996 Soil & Groundwater Cleanup
Army tests thermal desorption against pesticides
Treatability study tests direct, indirect systems
By Carl Swanstrom, Ch.E., Mark Gowdy, C.E., and Mark Besmer, C.E., P.E.

How to figure fuel costs
Fuel is the most expensive cost in thermal oxidation treatment
By Stephen M. Hirt

Superheater boosts thermal plant performance
Control hydrocarbon condensation
By Al Dishian

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By Yue Rong, Ph.D.

AcadeMix: How does your water flow?
...Very differently in unsaturated soils than in saturated soil
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Powerful bugs from Siberia may revolutionize bioremediation

It's not the heat, it's the humidity
Combined technologies address sorption problem
By Troy T. DuGuay and Arthur J. Pyron, P.G.

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TANK RACER gives cost estimates for LUST sites

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Army tests thermal desorption against pesticides
*Treatability study tests direct-fired and indirect systems*

By Carl Swanstrom, Ch.E., Mark Gowdy, C.E., and Mark Besmer, C.E., P.E.

Argonne National Laboratory, in Argonne, Ill., and the U.S. Army Rocky Mountain Arsenal, (RMA) performed a pilot-scale, direct-fired thermal desorption treatability study on pesticide contaminated soils from the Rocky Mountain Arsenal near Denver. The objectives of the study were to measure the removal efficiencies for organic contaminants, including chlorinated pesticides; to determine the effect of direct-fired thermal desorption on heavy metals; and to monitor for the formation of undesirable organic by-products such as polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs).

The U.S. Army used the (RMA) for the manufacture, testing, storage and destruction of chemical warfare agents and incendiary and explosive munitions from 1942 until 1970. In 1947, the Army leased part of the facilities to a private company for the manufacture of pesticides.

In 1952, a second company assumed the lease and continued to manufacture pesticides and herbicides until 1982. Another company leased facilities from 1946 to 1948 to produce chlorobenzene and dichlorodiphenyltrichloroetherane (DDT). Production of military agents, munitions and agricultural chemicals took place at the South Plants facilities. Liquid wastes generated by the manufacturing processes were discharged into Basin A—unlined, Basin F—asphalt-lined, and other unlined basins at the site. Spills, leaks and releases from past production and disposal activities have left a variety of contaminated areas at the site.

The Army began a remedial investigation and feasibility study at RMA in 1984. Numerous soil-medium groups were defined that were contaminated with a wide variety of organic and metallic contaminants, including volatile halogenated organics, volatile hydrocarbons, volatile aromatic organics, organosulfur.

---

*Carl Swanstrom, Ch.E., is a chemical engineer, and Mark Gowdy, C.E., is a civil engineer at Argonne National Laboratory, Argonne, Ill. Mark Besmer, C.E., is a project engineer for Rocky Mountain Arsenal, Commerce City, Colo.*

**Figure 1**
compounds, organophosphorus compounds, dibromochloropropane, polynuclear aromatic hydrocarbons, semivolatile halogenated organics and organochlorine pesticides. Soils also contained arsenic, mercury, cadmium, chromium, copper, lead and zinc. As part of the investigation, RMA established preliminary remediation goals for 27 of these organic and inorganic contaminants. At the time the pilot-scale testing was performed, only two of the soil-medium groups were under consideration for thermal treatment: the asphalt-lined Basin F and the South Plants area, totaling nearly 380,000 cubic meters.

Thermal desorbers come in two basic types: direct-fired and indirect-heated. The majority of full scale thermal desorption systems are continuously fed, direct-fired rotary kilns. For most applications direct-fired systems thermally destroy offgas in an afterburner. A direct-fired system is very similar in design and operation to an incinerator. Temperatures in the kiln are the major operating difference. The offgas from an incinerator is typically 700 to 1100°C and the ash 480 to 780°C. A direct-fired system operated in the parallel flow mode typically has exit gas temperatures of 260 to 650°C, with treated soil exiting at 315 to 650°C. Since the gas temperature in a direct-fired system is considerably lower than in an incinerator, refractory lining of the kiln is not used in most direct-fired systems, so the kiln is much lighter for transport and requires less setup time and maintenance. The burner nozzle may protrude into the kiln or be backed out so that only a small portion of flame, or none of the flame, is in the kiln. The carrier gas in a direct-fired system is air mixed with products of combustion from the burner. The amount of oxygen in the carrier gas can be adjusted over only a limited range, since there must be enough oxygen for proper burner operation. A direct-fired system with an afterburner generally has feed limitations based on the metals concentration of the feed soil and the type of air pollution equipment used. These limitations may or may not restrict the maximum feed rate to the direct-fired system. Significant levels of arsenic, cadmium and chromium, such as concentrations found in several areas at the arsenal, could restrict feed rates, depending on system design. Mercury could also be a problem if it is present at high levels.

An indirect-heated system has a heat source that is separated from the contaminated medium by a metal wall. For lab-scale testing, electric resistance heating is frequently used. At the bench and pilot scales, electric resistance heaters or fossil-fueled burners are the most common heat sources. Fossil fueled burners, electric resistance heating, microwave heating and heat-transfer fluids have all been used at pilot and full scales. The solids exit temperature for a full scale indirect system is similar to that of a direct-fired system, but rarely exceeds 540°C. The temperature profile of the solids can be more closely controlled in a multiple burner indirect system. The exit gas temperature in an indirect system is typically in the 90 to 425°C range, which is considerably lower than that of a direct-fired system. The exit gas temperature is important if the offgas is to be chilled to condense the volatilized organics and water. The composition of the sweep gas (carrier gas) can be controlled in an indirect system. Many systems use nitrogen and can maintain oxygen levels below 1 percent. The sweep gas used in the bench-scale tests was a mixture of air and nitrogen with 5 percent oxygen.

<table>
<thead>
<tr>
<th>Actual Test Conditions at South Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test ID</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Actual Test Conditions at Basin F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test ID</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
</tbody>
</table>

Figure 2

"The temperature profile of the solids can be more closely controlled in a multiple burner indirect system."

Figure 3

Continues on page 12 →

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How to figure fuel costs

Fuel is the most expensive cost in thermal oxidation treatment

By Stephen M. Hirt

In each step of an environmental remediation project, it is important to evaluate both the cost and time to site closure. Seeking the lowest costs and fastest methodologies is a science in and of itself. In recent years, thermal oxidation has become an increasingly popular method of destroying highly concentrated hydrocarbons because of its efficiency and cost effectiveness. Thermal oxidation destroys contaminants with an efficiency rate up to 99 percent. The most expensive operational portion of thermal oxidation treatment is the cost of auxiliary fuel. The most common methods of lowering thermal oxidizer operating costs are heat recovery using a heat exchanger, or lowering the system operating temperature by using catalysts. Several factors must be considered to make an accurate

Stephen Hirt is director of sales for Environmental Products Inc., Vadnais Heights, Minn.
evaluation of possible cost savings. These include capital costs associated with purchasing additional equipment, maintenance costs and the possibility of reducing treatability of hydrocarbon concentrations due to the extra equipment.

The amount of fuel required to operate a remediation thermal oxidizer is directly related to hydrocarbon concentrations in the fume stream from a soil vapor extraction and groundwater air sparging system, the total air flow of the system, and the method used to remediate—see figure one, page 8. As the site is cleaned and the hydrocarbon concentrations decrease, auxiliary fuel requirements increase. The purpose of auxiliary fuel is to maintain the thermal oxidizer operating temperature necessary to accomplish complete combustion.

An air to air heat exchanger reduces costs by preheating incoming fumes with exhaust gases. This can be accomplished by a plate type, open channel or tube and shell design configuration. Incoming air is preheated, passing through chambers heated by outgoing exhaust gases, as in figure two, above. In cases in which the concentration can fluctuate a significant amount, or if the exact concentration cannot be determined, a bypass should be installed. The bypass is a duct with a damper inside which allows the flow to be routed around the heat exchanger if the concentrations are too high. This is a concern since the possibility of explosion exists if rich fumes are preheated above their lower explosive limit. The bypass operation is controlled by operating burner. Fumes exiting the burner contact the surface area of the module which is coated with a precious metal, often platinum. Contact with this surface raises the effluent gas temperature from approximately 315°C to 650°C. This effectively reduces operating costs because the burner only needs enough fuel to operate at 315°C as opposed to 760°C. Catalysts are designed and built based on the characteristics of the process stream. Characteristics which factor in the design are concentration of compounds, type of compounds and whether the stream contains any particulate. Catalysts can be poisoned by chlorinated compounds. The poisoning from chlorinated hydrocarbons results in an ineffective catalyst.

In many cases, optional equipment, as mentioned above, can increase thermal oxidation cost effectiveness. Evaluating what type of optional equipment may be best for your application can be accomplished with a simple equation. Just compare total cost of fuel requirements without additional equipment to the total costs of additional equipment, reduction in fuel consumption, additional maintenance costs and approximate length of remediation time.

"The amount of fuel required to operate a thermal oxidizer is directly related to hydrocarbon concentrations in the fume stream..."
Superheater boosts thermal plan performance

Control hydrocarbon condensation

By Al Dishian

Counterflow rotary thermal desorption plants, capable of rotary drum temperatures of over 540°C can be enhanced with a superheating technique and other equipment modifications to remediate soils contaminated with heavy hydrocarbons.

In conventional counterflow thermal desorption processing plants, the baghouse is immediately downstream of the thermal desorber. This improves the operation of the downstream thermal oxidizer by eliminating fines that can produce fouling and slagging in the oxidizer. However, heavy hydrocarbons condense, for the most part, in the cooler operating ductwork, baghouse and ID fan.

To illustrate condensation behavior,

Al Dishian is president of DBE Consulting, Heathrow, Florida

take a typical flue gas stream from a desorber operating at, say, 45 metric tons per hour, 12 percent moisture, soil discharge temperature of about 540°C and a desorber flue gas temperature of 175°C. From published data on the partial pressure of a petroleum hydrocarbon which boils at 480°C, is approximately 0.01 mmHg at 175°C. Therefore, the amount of this hydrocarbon which can be present in the gas stream is 1.32 X E-5 by volume, or slightly more than 0.001 percent. For convenience, if we assume the molecular weight of this hydrocarbon to be 180 kilograms and the volume of flue gas at 480 cubic meters per minute, the approximate weight of thin oil that can be held in this gas stream at saturation is: 

\[
\frac{480 \text{ m}^3 \times 1.32 \times 10^{-5} \times 180 \text{ kg}}{11.3 \text{ m}^3/\text{Mol}} \times 60
\]

or 6 kg per hr

Counterflow thermal remediation with superheating
Even this small amount, which represents only 0.01 percent of the soil feed, will condense at 175°C and below.

By superheating the gases leaving the desorber and insulating the cooler downstream ducting and equipment, this condensation can be controlled, with the heavy hydrocarbons carried over for destruction in the oxidizer. Superheating can readily be accomplished by recycling a portion of the oxidizer stack gases, which are clean and, in most cases, available at about 870°C.

In addition, flue gas temperatures should be reduced to 93 to 120°C with heavy flighting and possibly higher drum speed, to allow superheating of 38°C or more.

"Superheating can be accomplished by recycling a portion of the oxidizer stack gases, which are clean and available at about 870°C."

With this modification, additional equipment may also be required to process the baghouse dust. The fines that are removed from the baghouse can have reasonably high levels of heavy oil contamination. Factors that influence this include the temperature of the gases leaving the drum, and the corresponding amount of superheating which can be accomplished. High temperature bags improve this capability also. In addition, if the proportion of fines is high, mixing with clean soil leaving the hot end of the desorber may not meet acceptable cleanup criteria.

A method to remediate the fines in such cases is to mix the fines with high temperature soil from the desorber in a separate piece of equipment, and vent the gases back to the desorber at the burner end.

To assure that such a superheating condition is being reached, temperature indicators should be placed in the cold drum breach and exit of the baghouse, with a temperature controller actuating a control valve in the recycle duct from the oxidizer.

Write in 695
Thermal tests, from page 7

content. This concentration was chosen to approximate the oxygen level in a direct-fired system. An indirect system using an offgas condensing system typically does not have any waste-feed metals limitations, with the possible exception of mercury.

The lab-scale treatability studies showed that organochlorine pesticides in the arsenals soils at levels up to several thousand ppm were reduced to less than 50 ppb in the 250 to 650°C range. On the basis of these data, and known thermal desorption performance data, Roy F. Weston Inc., environmental consulting firm, coordinated a series of bench-scale tests using indirect heated equipment to examine the removal of all contaminants of concern, and to determine the effect of thermal treatment on the leachability of metals.

The indirect system equipment used for the Weston study consisted of a 125 mm diameter by 300 mm long Incoloy cylinder, rotated at 5 rpm, and externally heated by a custom-made electric furnace. Test soil was charged into the cylinder in the batch mode, and the heat-up rates of the soil bed were controlled automatically by thermocouples in the soil. The sweep gas was prepared by mixing nitrogen and air in a ratio of 3:1, to yield an oxygen concentration of approximately 5 percent by weight. Ten tests were run on Mixed Basins soils consisting of soils collected from Basins A, D and F, and nine tests were run on the Mixed South Plants soils, collected from two central processing locations and salt storage pads. Temperature, time at temperature and sweep gas rates varied among tests, but were held constant during each test after the system stabilized at 200 to 400°C for five to 20 minutes, with sweep gas flows ranging from 1 to 3 liters per minute.

At 10 minutes residence time at 400°C, pesticides in Mixed South Plants soils were reduced below detectable levels. At both 300°C and 350°C, some DDE remained in the treated soil just below the goals. These results suggested that 350°C was a good baseline value for the pilot-scale direct-fired thermal desorption testing. The only other organic in the feed above the goal value was DBCP, which was effectively removed at 300°C. Both benzene and toluene appeared to increase in concentration after treatment, but the levels of these organics were considerably below their respective goal values. As expected, there was no evidence of significant metals removal at any temperature, except for mercury. Mercury was removed even at the lowest temperature. The slightly alkaline feed soil was reduced in pH to near neutrality at all temperatures. Similar results were obtained with the Mixed Basins soils at somewhat lower temperatures. At 350°C, all pesticides were below detection limits.

The pilot-scale direct-fired testing took place at the EPA Incineration Research Facility in Jefferson, Ark., which is operated by Acrex Environmental Corp. The rotary kiln system at the facility consists of a 1 meter diameter by 2 meter long refractory-lined rotary kiln with a 3.8 million kJ/K per hour burner mounted at the feed end of the kiln. Offgas is treated sequentially by a 2.8 million kJ/K per hour
<table>
<thead>
<tr>
<th>Basis for Calculation</th>
<th>Test A</th>
<th>Test B</th>
<th>Test C</th>
<th>Test A</th>
<th>Test B</th>
<th>Test C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Based on Dry Solids @ 105°C</td>
<td>94.9</td>
<td>97.1</td>
<td>97.6</td>
<td>92.1</td>
<td>92.0</td>
<td>94.0</td>
</tr>
<tr>
<td>Based on Ash Solids @ 550°C</td>
<td>98.8</td>
<td>99.7</td>
<td>98.3</td>
<td>105.6</td>
<td>102.2</td>
<td>104.1</td>
</tr>
<tr>
<td>Average of two methods</td>
<td>96.8</td>
<td>97.9</td>
<td>97.9</td>
<td>98.9</td>
<td>97.1</td>
<td>99.1</td>
</tr>
</tbody>
</table>

**Figure 4**

afterburner; a primary air pollution control system consisting of a quench, an ionizing wet scrubber and a fabric filter baghouse; and a secondary air pollution control system consisting of an activated carbon bed and a HEPA filter. For the pilot-scale study, the rotary kiln system was equipped with a 64 mm screw auger and hopper system capable of continuously feeding soil at rates up to 405 kilograms per hour. The rotary kiln is also equipped with seven thermocouples to measure soil bed temperatures at approximately 300 mm intervals along the axis of the kiln. A schematic of the kiln system at the facility is shown in figure one, page 6.

The planned direct-fired test conditions are shown in figure two, page 7. During the baseline test (A), the soil was heated to 355°C, just above the minimum value determined for the Mixed South Plants soil by bench-scale testing. Heating to 355°C would put the soil at or above 350°C for five to 15 minutes. The design of

**Continues on page 14**

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>South Plants</th>
<th>Basin F</th>
<th>PRGs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldrin</td>
<td>1,030</td>
<td>663</td>
<td>0.72</td>
</tr>
<tr>
<td>Chlordane</td>
<td>66.6</td>
<td>&lt;0.69</td>
<td>3.7</td>
</tr>
<tr>
<td>4,4-DDE</td>
<td>&lt;19.8</td>
<td>&lt;7.92</td>
<td>13</td>
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<tr>
<td>4,4-DDT</td>
<td>&lt;24.0</td>
<td>&lt;9.59</td>
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<tr>
<td>Dieldrin</td>
<td>2,542</td>
<td>341</td>
<td>0.41</td>
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<tr>
<td>Endrin</td>
<td>600</td>
<td>275</td>
<td>230</td>
</tr>
<tr>
<td>Isodrin</td>
<td>74.2</td>
<td>35.0</td>
<td>52</td>
</tr>
</tbody>
</table>

**Figure 5**

When it comes to the management of soil contaminated with lead and other metals, extraction is often the best approach for minimizing both short-term and long-term liability. An important part of the solution to these contamination problems is Western Environmental Science and Technology (WEST), a company specializing in the development and application of soil-washing technology. Provides on-site remediation of shooting ranges and industrial properties nationwide, and we look forward to working with you and your team.

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Davis, California
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## South Plants Pesticides Before and After Thermal Desorption

(All concentrations in mg/kg on a dry-weight basis)

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Feed</th>
<th>Product</th>
<th>% Removal</th>
<th>Test A: Baseline</th>
<th>Feed</th>
<th>Product</th>
<th>% Removal</th>
<th>Test B: High Temperature</th>
<th>Feed</th>
<th>Product</th>
<th>% Removal</th>
<th>Test C: Short Residence Time and High Temp</th>
<th>PRGs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldrin</td>
<td>993</td>
<td>0.211</td>
<td>99.979</td>
<td>1,310</td>
<td>&lt;0.005</td>
<td>99.9996</td>
<td></td>
<td>1,220</td>
<td>0.041</td>
<td>99.9966</td>
<td></td>
<td></td>
<td>0.72</td>
</tr>
<tr>
<td>Chlordane</td>
<td>75.2</td>
<td>1.13</td>
<td>98.499</td>
<td>74.6</td>
<td>&lt;0.006</td>
<td>99.992</td>
<td></td>
<td>78.1</td>
<td>&lt;0.006</td>
<td>99.993</td>
<td></td>
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<td>3.7</td>
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<tr>
<td>4,4-DDE</td>
<td>&lt;22.5</td>
<td>&lt;0.008</td>
<td>NA</td>
<td>&lt;22.7</td>
<td>&lt;0.008</td>
<td>NA</td>
<td></td>
<td>&lt;22.6</td>
<td>&lt;0.008</td>
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<tr>
<td>4,4-DDT</td>
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<td>&lt;27.5</td>
<td>&lt;0.010</td>
<td>NA</td>
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<td>&lt;27.3</td>
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<td>NA</td>
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<tr>
<td>Dieldrin</td>
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<td>99.9996</td>
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<td>3,260</td>
<td>0.157</td>
<td>99.9952</td>
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<td></td>
<td>0.41</td>
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<tr>
<td>Endrin</td>
<td>631</td>
<td>0.047</td>
<td>99.993</td>
<td>749</td>
<td>&lt;0.027</td>
<td>99.996</td>
<td></td>
<td>674</td>
<td>&lt;0.027</td>
<td>&gt;99.996</td>
<td></td>
<td></td>
<td>230</td>
</tr>
<tr>
<td>Isodrin</td>
<td>80.7</td>
<td>&lt;0.01</td>
<td>99.992</td>
<td>86.6</td>
<td>&lt;0.006</td>
<td>99.993</td>
<td></td>
<td>86.3</td>
<td>&lt;0.006</td>
<td>&gt;99.993</td>
<td></td>
<td></td>
<td>52</td>
</tr>
</tbody>
</table>

## Basin F Pesticides Before and After Thermal Desorption

(All concentrations in mg/kg on a dry-weight basis)

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Feed</th>
<th>Product</th>
<th>% Removal</th>
<th>Test A: Baseline</th>
<th>Feed</th>
<th>Product</th>
<th>% Removal</th>
<th>Test B: High Temperature</th>
<th>Feed</th>
<th>Product</th>
<th>% Removal</th>
<th>Test C: Short Residence Time and High Temp</th>
<th>PRGs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldrin</td>
<td>798</td>
<td>&lt;0.005</td>
<td>&gt;99.999</td>
<td>645</td>
<td>&lt;0.005</td>
<td>&gt;99.999</td>
<td></td>
<td>730</td>
<td>0.005</td>
<td>99.999</td>
<td></td>
<td></td>
<td>0.72</td>
</tr>
<tr>
<td>Chlordane</td>
<td>&lt;6.47</td>
<td>&lt;0.006</td>
<td>NA</td>
<td>&lt;5.69</td>
<td>&lt;0.006</td>
<td>NA</td>
<td></td>
<td>&lt;6.48</td>
<td>&lt;0.006</td>
<td>NA</td>
<td></td>
<td></td>
<td>3.7</td>
</tr>
<tr>
<td>4,4-DDE</td>
<td>&lt;9.00</td>
<td>&lt;0.008</td>
<td>NA</td>
<td>&lt;7.92</td>
<td>&lt;0.008</td>
<td>NA</td>
<td></td>
<td>&lt;9.02</td>
<td>&lt;0.008</td>
<td>NA</td>
<td></td>
<td></td>
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<tr>
<td>4,4-DDT</td>
<td>&lt;10.9</td>
<td>&lt;0.010</td>
<td>NA</td>
<td>&lt;9.59</td>
<td>&lt;0.010</td>
<td>NA</td>
<td></td>
<td>&lt;10.9</td>
<td>&lt;0.010</td>
<td>NA</td>
<td></td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>Dieldrin</td>
<td>423</td>
<td>&lt;0.006</td>
<td>&gt;99.999</td>
<td>340</td>
<td>&lt;0.006</td>
<td>&gt;99.998</td>
<td></td>
<td>355</td>
<td>&lt;0.006</td>
<td>&gt;99.998</td>
<td></td>
<td></td>
<td>0.41</td>
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<tr>
<td>Endrin</td>
<td>312</td>
<td>&lt;0.027</td>
<td>&gt;99.991</td>
<td>300</td>
<td>&lt;0.027</td>
<td>&gt;99.991</td>
<td></td>
<td>284</td>
<td>&lt;0.027</td>
<td>&gt;99.991</td>
<td></td>
<td></td>
<td>230</td>
</tr>
<tr>
<td>Isodrin</td>
<td>51.4</td>
<td>&lt;0.006</td>
<td>&gt;99.988</td>
<td>26.6</td>
<td>&lt;0.006</td>
<td>&gt;99.976</td>
<td></td>
<td>37.9</td>
<td>&lt;0.006</td>
<td>&gt;99.983</td>
<td></td>
<td></td>
<td>52</td>
</tr>
</tbody>
</table>

**Figure 6**

### Horizontal Directional Drilling for Environmental Remediation

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**14 June-July 1996 Soil & Groundwater Cleanup**

**Thermal tests, from page 13**

the research facility kiln limited the fill volume to approximately 6 percent. Fill volume was kept approximately constant for all tests to eliminate one variable. The potential variables were solids temperature, residence time and feed rate. Temperature is of primary concern, and the tests were planned at the baseline value of 355°C and at 440°C in test B. At 440°C, all the pesticide contaminants should be reduced to below their detection levels. Since fill volume is held constant, the increased feed rate test C would also have a shortened residence time.

Actual test conditions are shown in figure three, page 7. The desired baseline temperature for both soils was increased from 355°C to 370°C, based on preliminary results from a shakedown test. The target temperature was held to ±12°C for all six tests. The feed rate for South Plants test C was considerably below the target of 340 kilograms
### South Plants Total Metals
(All concentrations in mg/kg on a dry-weight basis)

<table>
<thead>
<tr>
<th>Metal</th>
<th>Feed</th>
<th>Product</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>249</td>
<td>324</td>
<td>30</td>
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<tr>
<td>Cadmium</td>
<td>0.85</td>
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<tr>
<td>Chromium</td>
<td>13.5</td>
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<tr>
<td>Lead</td>
<td>40</td>
<td>45.5</td>
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<tr>
<td>Mercury</td>
<td>3.52</td>
<td>1.4</td>
<td>-60</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Metal</th>
<th>Feed</th>
<th>Product</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>193</td>
<td>247</td>
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<tr>
<td>Cadmium</td>
<td>1.26</td>
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<tr>
<td>Chromium</td>
<td>14.3</td>
<td>46.7</td>
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<td>Lead</td>
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<tr>
<td>Mercury</td>
<td>4.23</td>
<td>0.33</td>
<td>-92</td>
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</table>

### Basin F Total Metals
(All concentrations in mg/kg on a dry-weight basis)

<table>
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<tr>
<th>Metal</th>
<th>Feed</th>
<th>Product</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>&lt;16.0</td>
<td>23.1</td>
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<tr>
<td>Cadmium</td>
<td>&lt;0.53</td>
<td>&lt;0.50</td>
<td>NA</td>
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<tr>
<td>Chromium</td>
<td>20.7</td>
<td>28.0</td>
<td>36</td>
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<tr>
<td>Lead</td>
<td>27.7</td>
<td>24.8</td>
<td>-10</td>
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<tr>
<td>Mercury</td>
<td>0.564</td>
<td>&lt;0.078</td>
<td>-&gt;86</td>
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</tbody>
</table>

<table>
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<th>Product</th>
<th>% Change</th>
</tr>
</thead>
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<tr>
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<td>&lt;15.8</td>
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<tr>
<td>Cadmium</td>
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<tr>
<td>Chromium</td>
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<td>19.4</td>
<td>-5</td>
</tr>
<tr>
<td>Lead</td>
<td>20.8</td>
<td>25.1</td>
<td>21</td>
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<tr>
<td>Mercury</td>
<td>0.664</td>
<td>&lt;0.079</td>
<td>-&gt;88</td>
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<table>
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<th>Feed</th>
<th>Product</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>4.4</td>
<td>6.3</td>
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<tr>
<td>Cadmium</td>
<td>21.1</td>
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<td>17</td>
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<tr>
<td>Chromium</td>
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<tr>
<td>Lead</td>
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<td>-&gt;89</td>
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</table>

<table>
<thead>
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<th>Avg (3)</th>
<th>% Change</th>
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</thead>
<tbody>
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<td>Arsenic</td>
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<tr>
<td>Cadmium</td>
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</tr>
<tr>
<td>Chromium</td>
<td>182</td>
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<td>Lead</td>
<td>5</td>
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<td>Mercury</td>
<td>-82</td>
</tr>
</tbody>
</table>

### Figure 7

per hour due to the excessive abrasion of the feeder screw auger. Lack of feed material and other project constraints prevented a repeat of the test. For all other tests, the feed rate was maintained at the desired level ±22 kilograms per hour. Residence time is a calculated value, and was held within ±10 percent for all tests.

The primary goal of this study was to determine if all of the organic contaminants can be reduced to below remedial goals. The results of the study indicate that the technology is effective in reducing the concentration of organic contaminants to levels below the remedial goal.

Continues on page 16 →

---

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at reasonable temperatures and residence times as predicted from the earlier bench-scale study. Since the remedial goals for metals are based on their total concentration and not their leachable value, thermal desorption was not expected to reach the goals for metals. However, metals recovery in the treated solids and changes in leachability are addressed.

Since there is always a concern about dioxin and furan formation in thermal processes treating chlorinated organics such as pesticides, this issue is also addressed.

It is necessary to perform a mass balance to assure that all process streams are accounted for and that accurate test data are recorded. In thermal processes, material balances are often difficult to close with respect to both dry solids and ash content. Dry solids represent the solids mass remaining after overnight oven drying at 105°C. When conducting thermal desorption studies at temperatures in the range of 370 to 440°C, the mass balance will not close, because the treated solids mass will be reduced by an amount equal to the mass that volatilizes between 105°C and the temperature of the test. Conversely, if the ash value at 550°C is used, it is possible to recover over 100 percent, since the treated solids never reach that temperature. Figure four, page 13, contains mass balances calculated on a dry solids and ash basis. Since the soil temperatures reached during the tests were between the temperatures used for the dry solids and ash measurement procedures, a mass balance based on the average of the two values was calculated. Mass closure for this average ranged from 96.8 to 99.1 percent. These data indicate that very little material was not accounted for.

Pesticide concentrations in the feed soils, reported on a wet basis are shown in figure five, page 13. For South Plants, Aldrin, Chlordane and Isodrin pesticides are at the same order of magnitude as in the bench-scale study. For South Plants, Aldrin, Chlordane and Isodrin are at the same order of magnitude. DDT and DDE were below 50 mg/kg in both bench and field batches.

Figure six, page 14 shows results for the South Plants tests.

The baseline South Plants test A conducted at 370°C failed to meet the remediation goal for Dieldrin by 0.60 mg/kg, and the Chlordane residual of 1.13 mg/kg was close to the goal of 3.7 mg/kg. Results from test B at 425°C were significantly better. All pesticides except Dieldrin were reduced to below their detection levels. Dieldrin in the treated soil at 0.045 mg/kg was well below the remedial goal of 0.41 mg/kg. Test C was originally planned to be at the baseline temperature with a 50 percent increase in the feed rate and a reduction in residence time from 35 to 25 minutes. Since the preliminary
analytical data from test A indicated residual pesticides in the treated soil, the temperature was elevated to 440°C. Due to mechanical problems with the soil feed system, the feed rate with sampling was 250 kilograms per hour instead of the target 340 kilograms per hour. After test C, a new feed screw had to be constructed due to excessive wear from the South Plants and shakedown tests. For comparison purposes, test C is similar to test B with a 10 percent increase in feed rate and about a 25 percent decrease in residence time. One would expect somewhat higher pesticide residuals from test C compared to test B, and that is what happened. The test C conditions produced measured pesticide residuals for Aldrin and Dieldrin, but both were below their respective remedial goal levels. The pesticide removal efficiencies shown in figure six are excellent. In test A, the poorest percent removal was 98.499 percent for Chlordane. In tests B and C, the percent removal was greater than 99.99 percent for all pesticides that had a measurable concentration in the feed.

Pesticide removal efficiencies for Basin F tests are also shown in figure six. The Basin F soils required ambient air drying from about 14 percent moisture to 6 percent, and were tested after the South Plant soils. The drying was required to accommodate the screw feeder system being used, and did not result in any measurable loss of pesticides. The baseline test A reduced all of the pesticides to below their detection levels. Test B was executed as planned, and also reduced all pesticides to below detection levels. Preliminary analytical results indicated that there were no measurable residual pesticides in the soil from test A or B, so the original planned operating conditions were implemented for test C. The 370°C baseline temperature was used for test C, and the feed rate was increased 50 percent to 340 kilograms per hour, while residence time was decreased from 35 to 25 minutes. It was hoped that the test C conditions would result in detectable levels of one or more pesticides in the treated soil. The data in figure six show a measurable amount of Aldrin, but this can be misleading. The product results are an average of three samples, and the Aldrin analysis produced two results below the detection level of 0.046 mg/kg and one at 0.067 mg/kg. It is difficult to draw valid conclusions with this data set. In any case, it indicates that the baseline temperature with a

Continues on page 18

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reduced residence time and a high feed rate will still produce treated soil that meets the pesticide remedial goals.

Thermal desorption is not generally capable of removing heavy metals from contaminated soils—with the exception of mercury. Arsenic appears to have increased in all three South Plants and Basin F tests, as shown in figure seven, page 15. Since the data are reported on a dry weight basis, varying moisture content does not explain the apparent arsenic increase, which could well be within experimental error. In any case, the data do not indicate that arsenic was volatilized at the temperatures tested. Chromium in the Basin F soils behaved similarly. The increase in chromium in the South Plants samples may be attributed to the excessive wearing of the chrome-plated feed screw. Since the chromium increase from the Basin F tests, where the new feed screw had minimal wear, is much lower, this seems to be a reasonable explanation. For both soil types, cadmium and lead showed no significant change on average, while mercury was reduced by 60 to 93 percent as expected.

It appears that thermal treatment had no effect on leachable cadmium. Leachable lead was found near the detection level in only one of the six treated samples and in none of the untreated samples. The TCLP value for mercury was reduced by approximately the same percentage as the total mercury concentration.

There is always a concern about the formation of PCDDs or PCDFs when using thermal treatment methods on materials containing chlorinated organics such as chlorinated pesticides, certain wood-treating compounds and PCBs. In addition to the feed and treated solids, the scrubber liquid, scrubber solids, baghouse ash and afterburner and baghouse exit flue gases were analyzed for PCDDs and PCDFs. For the South Plants soil the 2,3,7,8-TCDD increased in the treated soil over the feed soil by approximately one order of magnitude at both temperatures. Total PCDD+PCDF increased for all tests, but by a lesser value at the higher temperature. The toxicity equivalency (TEQ) also increased by approximately one order of magnitude, but with the largest increase occurring at the lowest temperature. The ratio of PCDDs to PCDFs was fairly consistent for all three tests.

The pilot-scale direct-fired system testing clearly demonstrated that all the pesticides of concern can be reduced to well below their remedial goals for either soil type. The batch mode bench-scale indirect system testing predicted somewhat lower treatment temperatures than were required by the direct-fired system. Besides differences in the testing procedures and temperatures, the soil samples used for the two testing programs were not from exactly the same source. With these differences between the two studies, the slight difference in the required temperatures is not
surprising. It does, however, support the value from bench-scale treatability studies. Bench-scale testing predicted that thermal desorption could reduce all the pesticides to below their remedial goal levels at temperatures in the 260 to 370°C range with residence times of 25 to 40 minutes. Pilot-scale direct-fired testing required the somewhat higher temperatures of 370 to 440°C with residence times of 25 to 35 minutes.

There were no surprises with regard to total metals. With the exception of mercury, there were no measurable changes in the total metals concentration for either the bench or pilot scale tests. The mercury concentrations in the Basin soils for the two studies were significantly different. The bench-scale Mixed Basins soil contained 164 mg/kg mercury while the pilot scale Basin F soil contained only 0.56 mg/kg. Bench testing showed a direct relationship between temperature and residual mercury, with only 0.89 mg/kg remaining in the Mixed Basins soil after treatment at 360°C—pilot testing results were all below detection level. The Mixed South Plants and South Plants samples had similar mercury contamination levels. Bench-scale tests were inconclusive, since the mercury was reduced to a lower level at 300°C than at 350°C or 400°C. The pilot-scale tests produced a 60 percent reduction at 370°C, 92 percent reduction at 445°C, and 93 percent at 450°C.

The increase of PCDDs and PCDFs in the treated soil is somewhat troubling due to the rather large increase in several of the tests. Total PCDD and PCDF increases of up to almost 650 percent, in South Plant test A, resulting in a TEQ of 1.953 μg/kg in the treated soil were measured. Stack emissions were well within all applicable air regulations. All scrubber water samples contained less than 50 ppq (parts per quintillion) as TEQ, and all scrubber solids were less than 10 ppt (parts per trillion).

Bench scale testing with the indirect heated system produced markedly different results—lower TEQ values in all the treated soils compared to the feed soils. This discrepancy regarding PCDD and PCDF formation can most likely be attributed to the difference in the type of thermal desorber used. The indirectly heated system operated in the batch mode, and consistently produced reductions in the TEQ of up to 97 percent, while the continuously fed, direct-fired system produced increases ranging from zero up to 650 percent. This difference in results should alert investigators to the need for pilot-scale testing for remedy selection. The pilot system used must be of the same type as the system being considered for the full scale. The most important parameter is the heating mechanism. Indirect heating and direct firing cannot be interchanged. Bench-scale testing was more than adequate for remedy screening, and predicted the required times and temperatures well enough to perform budget estimates. It did not, however, warn of the potential for PCDD and PCDF formation.

The next logical step would be to perform a pilot-scale continuous indirect heated system treatability study on the Basin F and South Plants soils. Such a study would determine whether similar temperatures and times would produce similar pesticide removals; whether the difference in heating would affect the metals leachability; and whether the increase in the TEQ was due to the direct heating. No such testing is currently planned.

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By Yue Rong, Ph.D.

An environmental site assessment commonly requires soil matrix and soil gas samples for analysis of volatile organic compounds (VOCs). Commonly, concentrations in soil matrix samples are reported in micrograms per kilogram (µg/kg) and for soil gas samples, in micrograms per liter (µg/L). What is the relationship between the two concentration units?

In the theory of VOC partition and equilibrium in the vadose zone, soil concentration can be related to soil gas concentration by the following equation:

\[ C_T = C_g \cdot (\theta + (n - \theta) \cdot K_H \cdot \rho_b \cdot f_{oc} \cdot K_{oc}) / (\rho_b \cdot K_{fl}) \] (equation one)

Where \( C_T \) is the soil concentration in µg/kg, \( C_g \) is the soil gas concentration in µg/L, \( \theta \) is soil water content by volume (dimensionless), \( n \) is soil porosity (dimensionless), \( \rho_b \) is soil bulk density (g/cm³), \( f_{oc} \) is soil organic carbon content (dimensionless), \( K_H \) is Henry’s Law constant (dimensionless), and \( K_{oc} \) is organic carbon partition coefficient (cm³/g).

Now, let \( CO \) be the coefficient between \( C_T \) and \( C_g \) in equation one, hence, \( CO = (\theta + (n - \theta) \cdot K_H \cdot \rho_b \cdot f_{oc} \cdot K_{oc}) / (\rho_b \cdot K_{fl}) \). Therefore, equation one becomes:

\[ C_T (\mu g/kg) = CO \times C_g (\mu g/L) \] (equation two)

Based on soil physical properties of 55 soil samples obtained in Los Angeles, as summarized in figure one, page 22, we can calculate CO for the average scenario and silt vs. sand scenario.

a) Average CO

Using equation one, and given the median values in figure one (mean is equal to median in the normal distribution) as follows:

\( \rho_b = 1.746 \) (g/cm³), \( \theta = 0.167 \) (—), \( f_{oc} = 0.00138 \) (—), \( n = 0.364 \) (—), the average COs for common VOCs are calculated in figure two, page 22. On one extreme end, highly volatile compounds with a large value of Henry’s Law constant, tend to have low CO values. For instance, vinyl chloride CO = 0.12, which means, by equation two, that if soil gas concentration (\( C_g \)) is detected in 100 µg/L, the soil concentration (\( C_T \)) would be 12 µg/kg. On the other extreme end, for compounds of low

Yue Rong, Ph.D., is an environmental specialist for the California Regional Water Quality Control Board, Los Angeles Region

Continues on page 22→
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### Statistics of Soil Parameters from 55 Samples

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<tr>
<th></th>
<th>$\rho_0$ (g/cm$^3$)</th>
<th>$\theta$ (--)</th>
<th>$f_{oc}$ (--)</th>
<th>$n$ (--)</th>
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### Conversion Coefficient between Soil Concentration in $\mu g$/kg and $\mu g$/L for common VOCs

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<th>CO (silt)</th>
<th>CO (sand)</th>
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<tr>
<td>Methyl Ethyl Ketone (MEK)</td>
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<td>93</td>
<td>82</td>
<td>46</td>
</tr>
<tr>
<td>Chloroethane</td>
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<td>0.6</td>
<td>0.14</td>
</tr>
<tr>
<td>Benzene</td>
<td>65</td>
<td>0.229</td>
<td>0.92</td>
<td>1.13</td>
<td>0.6</td>
</tr>
<tr>
<td>Chloroform</td>
<td>31</td>
<td>0.158</td>
<td>0.99</td>
<td>1.17</td>
<td>0.57</td>
</tr>
<tr>
<td>Cis-1,2-dichloroethylene (c-1,2-DCE)</td>
<td>59</td>
<td>0.274</td>
<td>0.76</td>
<td>0.97</td>
<td>0.48</td>
</tr>
<tr>
<td>Dichlorodifluoromethane (Freon 12)</td>
<td>58</td>
<td>4.158</td>
<td>0.16</td>
<td>0.41</td>
<td>0.05</td>
</tr>
<tr>
<td>1,1-Dichloroethane (1,1-DCA)</td>
<td>30</td>
<td>0.179</td>
<td>0.88</td>
<td>1.1</td>
<td>0.5</td>
</tr>
<tr>
<td>1,2-Dichloroethane (1,2-DCA)</td>
<td>14</td>
<td>0.05</td>
<td>2.41</td>
<td>2.43</td>
<td>1.29</td>
</tr>
<tr>
<td>Dichloromethane (Methylene Chloride)</td>
<td>9</td>
<td>0.11</td>
<td>1.1</td>
<td>1.24</td>
<td>0.53</td>
</tr>
<tr>
<td>1,1,2-Tetrachloroethane</td>
<td>54</td>
<td>0.016</td>
<td>10.8</td>
<td>10.2</td>
<td>7.4</td>
</tr>
<tr>
<td>Trans-1,2-dichloroethylene (t-1,2-DCE)</td>
<td>59</td>
<td>0.274</td>
<td>0.76</td>
<td>0.97</td>
<td>0.48</td>
</tr>
<tr>
<td>1,1,2-Trichloroethane (1,1,2-TCA)</td>
<td>56</td>
<td>0.05</td>
<td>3.6</td>
<td>3.6</td>
<td>2.4</td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td>110</td>
<td>0.998</td>
<td>0.36</td>
<td>0.61</td>
<td>0.22</td>
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<tr>
<td>Chlorobenzene</td>
<td>160</td>
<td>0.146</td>
<td>2.28</td>
<td>2.46</td>
<td>1.84</td>
</tr>
<tr>
<td>1,1-Dichloroethylene (1,1-DCE)</td>
<td>65</td>
<td>6.237</td>
<td>0.14</td>
<td>0.4</td>
<td>0.04</td>
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<tr>
<td>Ethylbenzene</td>
<td>220</td>
<td>0.328</td>
<td>1.33</td>
<td>1.55</td>
<td>1.08</td>
</tr>
<tr>
<td>1,1,2,2-Tetrachloroethane</td>
<td>220</td>
<td>0.021</td>
<td>19.2</td>
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<td>Tetrachloroethylene (PCE)</td>
<td>660</td>
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<tr>
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<td>260</td>
<td>0.274</td>
<td>1.77</td>
<td>1.99</td>
<td>1.49</td>
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<tr>
<td>1,1,1-Trichloroethane (1,1,1-TCA)</td>
<td>150</td>
<td>0.116</td>
<td>2.73</td>
<td>2.88</td>
<td>2.19</td>
</tr>
<tr>
<td>Trichloroethylene (TCE)</td>
<td>130</td>
<td>0.371</td>
<td>0.86</td>
<td>1.08</td>
<td>0.62</td>
</tr>
<tr>
<td>Trichlorofluoromethane (Freon 11)</td>
<td>160</td>
<td>4.03</td>
<td>0.19</td>
<td>0.45</td>
<td>0.08</td>
</tr>
<tr>
<td>1,1,2-Trichloro-trifluoroethane (Freon 113)</td>
<td>160</td>
<td>2.41</td>
<td>0.24</td>
<td>0.5</td>
<td>0.13</td>
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<tr>
<td>Vinyl chloride (VC)</td>
<td>57</td>
<td>29.1</td>
<td>0.12</td>
<td>0.38</td>
<td>0.02</td>
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<tr>
<td>o,m,p - Xylene</td>
<td>240</td>
<td>0.22</td>
<td>2.06</td>
<td>2.26</td>
<td>1.73</td>
</tr>
<tr>
<td>1,2-Dichlorobenzene</td>
<td>1100</td>
<td>0.079</td>
<td>20.6</td>
<td>20.7</td>
<td>19.8</td>
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<tr>
<td>1,3-Dichlorobenzene</td>
<td>1200</td>
<td>0.079</td>
<td>22.3</td>
<td>22.4</td>
<td>21.6</td>
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<tr>
<td>1,4-Dichlorobenzene</td>
<td>1200</td>
<td>0.066</td>
<td>26.7</td>
<td>26.7</td>
<td>25.8</td>
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</tbody>
</table>
volatility (smaller value of Henry’s Law constant) CO values are opposite of those of highly volatile compounds. For example, for acetone CO = 109.5, which implies that if soil gas concentration is detected in 100 µg/L, the soil concentration would be 10,950 µg/kg. In general, given soil type, for highly volatile compounds, soil gas concentration measured in µg/L is higher than soil concentration measured in µg/kg in terms of values. For less volatile compounds, soil concentration in µg/kg is higher than soil gas concentration in µg/L in terms of values.

However, for those compounds at neither extreme end, soil properties and the individual organic carbon partition coefficient Koc may be the influential factors to CO value. For example, the most common VOC soil contaminants tetrachloroethylene (PCE) and trichloroethylene (TCE) have CO equal to 1.17 and 0.86 respectively, as in figure two. These coefficients imply that soil concentration and soil gas concentration are almost a 1:1 ratio in the type of soils represented by the 55 samples.

b) CO for silty and sandy scenario

Using equation one, and given data from the 55 samples, these soil physical property parameter values are used to calculate CO for silt:

\[ \rho_s = 1.2 \text{ (g/cm}^3\text{)}, \ \theta = 0.1 \text{ (—)}, \ f_{oc} = 0.00138 \text{ (—)}, \ n = 0.547 \text{ (—)} \]

and, for sand:

\[ \rho_s = 2.27 \text{ (g/cm}^3\text{)}, \ \theta = 0.1 \text{ (—)}, \ f_{oc} = 0.00138 \text{ (—)}, \ n = 0.143 \text{ (—)} \]

Results of COs under silt and sand scenarios for common VOCs are also presented in figure two. Comparison of the CO values between silt and sand indicates that CO for sand is always smaller than that for silt among the 29 compounds. Therefore, given a certain amount of soil concentration, soil gas concentration would always be higher in sand than in silt.

In summary, CO value is relatively small for highly volatile compounds in coarse material soil. CO value tends to be larger for less volatile compounds in fine-grained soils. Therefore, in a subsurface investigation, when volatile contaminants are in coarse soil such as sand or gravel, soil gas samples should be analyzed. When less volatile contaminants are in fine-grained material such as silt or clay, soil matrix samples could be better. Other situations, such as volatile contaminant in fine-grained soil or contaminant of low volatility in coarse soil may need calculation of particular CO values to assist in making a decision which soil gas or soil matrix samples should be taken. Calculation of CO values can be very site-specific.
How does your water flow?

...Very differently in unsaturated soils than in saturated soil

By Alfred R. Conklin, Jr.

Water movement in water saturated soil is very different from its movement in unsaturated soils. Movement of water in soil saturated with water is relatively straightforward. Factors include water in pores, the attraction of water for soil solids, the effect of gravity and pore geometry. Of these, gravity and pore geometry are most important. In unsaturated conditions, there is the additional influence of the water air interface and the fact that the water must move as a film on the surface of the soil solids. Because of this, the path of water movement is tortuous and consequently the rate of movement is slow. This leads to some surprising differences between saturated and unsaturated flow which dramatically affect pollution control and remediation efforts.

In unsaturated soil, water movement is determined by the thickness of the film of water on the soil particles. The more strongly the water is attracted to the soil surface—the thinner the film—the slower it moves. This attraction is called the matric potential. Water moves from where it is less strongly held—in a thicker film—to where it is more strongly held in a thinner film, as shown in figure one, page 26. In this case, the height of the water—that is, the distance between the top and the bottom of a soil profile—has little effect on the flow rate.

Alfred Conklin, Ph.D. is a professor in the agriculture department of Wilmington College, Wilmington, Ohio

In regions of high to moderate rainfall, the average water movement is from the surface downward to the water table. When a rain event ends, water continues to flow down the profile even though it is unsaturated. Before equilibrium can be established, water begins to evaporate from the soil surface. At this point there is some movement of water back toward the surface of the soil. However, the overall effect is the net downward movement of the water. There is also a net downward movement of salts and any contaminants present.

In dry regions, such as the desert, water can and does move from deep in the profile to the surface. Where the temperature is high and the relative humidity constantly low, water moves from the free water table to the surface. Likewise, irrigation waters move back to the surface of the soil after the irrigation session ends. Usually this results in salts accumulating on the soil surface. And, if the soil is contaminated, contaminants move toward the surface under these conditions.

Although it is surprising, the movement toward the surface can be faster in fine than in coarse textured soil. In fine textured soils—those that have high percentages of clay content—the water films are more continuous and thicker than in coarse textured soils. This leads to faster movement of water. Water can also conceptually move in and out of pores that would normally be closed under saturated conditions.

Continues on page 26→
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How does your water flow? from page 24

However, the path is variously tortuous. The path of water through soil is much longer than one might envision occurring with a straight capillary. It is also longer than the length of flow under saturated conditions. Tortuosity is represented by the following equation: $\tau = \frac{L}{L_c}$

Here, $L_c$ is the column length and $L$ is the water path length. The larger $\tau$, the slower water moves. Unfortunately, $\tau$ can only be evaluated by fitting it to a model or by calibration in the field. As might be expected, $\tau$ changes as the thickness of the water films change. For sandy soils, it may be in the range of 0.01, while in fine textured soils, it may be 0.005. Keep in mind that as tortuosity increases, $\tau$ gets larger.

Using the concept of tortuosity, one understands that the flow of water through soil decreases drastically as soon as unsaturation occurs. That is when large pores drain. Thus, at this point, the whole dynamic of water movement changes. In unsaturated soil, movement of water may be 1/100th or slower than the movement under saturated conditions. Water flows along the surface of both open and closed pores—pores that are open at both ends, and those that are closed at one end. Thus, contaminants have less chance of becoming trapped in closed pores.

The Buckingham-Darcy Law describes water flow under unsaturated conditions. This law is described by a complicated differential calculus equation which is evaluated as a particle derivative under natural conditions. We will not get into this law in depth except to say that the quantity of water moving through a soil under saturated conditions can be evaluated if one knows the water content and matric potential of the soil water. The matric potential is a measure of the tenacity with which water is held to soil particles. It is measured with several different instruments, such as a tensiometer.

A tensiometer is made of a porous cup on the end of a tube filled with water. Normally, the tube of water is attached to a manometer or other gauge which can measure negative pressure. The porous cup is inserted into the soil. As the soil loses water, the water column falls. A negative pressure is observed in the manometer and can be related to the matric potential of the soil’s water. A more common use of the tensiometer is to follow water content of soil for irrigation purposes.

The Buckingham-Darcy Law describes unsaturated water flow in uniform soil. However, all soils contain horizons. The horizons frequently have different textures and structures, and thus have different water contents, different matric potential and conduct water at different rates. A soil with a loam topsoil, underlain by a sandy soil layer which is in turn underlain by a clay soil does not conduct water uniformly in a downward direction.

To understand what happens, one must remember that water does not naturally move into soil as a saturated front. For water to move into soil, air must move out. This can only occur under unsaturated conditions.

What happens when water is applied to a soil of varying horizons, as described above? What does one observe when a steady supply of water is applied, and its downward movement is followed? Water wets the top silt loam soil completely before entering the sand layer. It moves rapidly through the sandy layer and begins to wet the lower clay layer. In a soil with sandy-clayey-sandy textural layers, water moves continuously downward.

The reason for this is that in the upper soil, water is held more strongly than it is in the sandy soil. Thus, it
cannot move into the sandy layer. Soil can easily take water from the sandy soil because it holds water more strongly. Water moves easily from a sandy soil to a clayey soil. Once the clay layer is saturated, water again moves downward in a uniform front, as shown in figure two, page 26.

In describing water loss from soils, soil scientists often refer to evapotranspiration. This is the water lost from soil under unsaturated conditions. The loss is by both evaporation and by transpiration. That is evaporation from the soil surface, and transpiration from the leaves of the plants growing in the soil. These two are combined because it is virtually impossible to separate them under field conditions. Plant roots effectively increase what might be called the evaporative surface of the soil.

Under all conditions, plants tend to retard the downward movement of water in soil. In moderate and high rainfall conditions, this effect may not be noticeable. Under low rainfall conditions, it may be dramatic. Plants tend to inhibit the downward movement of pollutants which move with water. Under conditions of limited rainfall and high evapotranspiration, water and pollutants tend to move to the surface of the soil.

On the other hand, it is important to remember that plants increase movement of water into soils. Plants increase the roughness of the soil surface, thus reducing the flow of water across it. This increases the time available for infiltration. Also, pores created by roots increase infiltration. The area around the stems of plants when they emerge from soil also allow increased infiltration of water into the soil.

Thus, plants have both a detrimental and a beneficial effect on the remediation of contaminated soil. Plants and their roots increase movement into soil. However, they also limit the downward movement. Which of these effects is most important depends on the soil type, rainfall pattern, evapotranspiration, depth to the water table, and other site specific conditions. The effect considered here is physical, and quite apart from any rhizosphere or uptake phenomenon.

The role of unsaturated movement of water in soil in remediation efforts should not be overlooked. Under most natural conditions, it tends to limit the downward movement of contaminants. This is especially true if the surface of soil is kept dry and exposed to intense drying conditions. Plants growing on contaminated soil can also help limit the downward movement of contaminants, helping to prevent groundwater contamination.
The Russians are coming

Powerful bugs from Siberia may revolutionize bioremediation

It is common knowledge that bacteria adapt efficiently to soil conditions. When a spill occurs, the microbial population quickly learns to metabolize and degrade the pollutant. As time passes, the bacteria become more and more efficient in their abilities. So, why not find the nastiest possible spill, that has been in place for the longest possible time, and cultivate those bacteria—who must have become the leanest, meanest possible degrading machines? That's what William Weinstein and Ken Garrett asked themselves back in 1991.

The two men met on opposite sides of the cleanup effort following the Exxon Valdez oil spill disaster in Alaska's Prince William Sound. Garret was equipment manager for VECO International, the prime cleanup contractor of the spill, and Weinstein was city manager of the city of Cordova, Alaska, and responsible for the
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breakthrough was to successfully extract these multi-enzyme complexes intact from the mass-produced bacteria. This was achieved by dissolving the cell wall and the cytoplasmic membrane through a process known as autolysis. The result is a new generation of bioremediation technology that cuts remediation time by more than 90 percent over conventional methods, say Weinstein and Garrett.

In conventional bioremediation, the initial step in the breakdown process of hydrocarbons involves molecular oxygen as a reactant in which one of the oxygen atoms is incorporated into the oxidized hydrocarbon. This reaction is carried out by enzymes called oxygenases which activate oxygen and convert it to a form in which the oxygen atom can be incorporated directly into a biochemical compound. This process repeated, quickly breaks the hydrocarbon compound down to the corresponding alcohol, aldehyde and finally to the monobasic fatty acids.

Metabolism of both aliphatic and aromatic hydrocarbons must go through the same difficult stage formation of fatty acid. This critical step of oxidation requires specific enzymes which are produced by relatively few kinds of microorganisms known as hydrocarbon oxidizers. As the hydrocarbons are transformed upon contact to the fatty acid stage, they become what are known as easy hydrocarbons, and can readily be assimilated by the indigenous bacterial population.

As the enzyme process accounts for approximately 90 percent of the remedial breakdown, by instituting these products directly into the soil and groundwater at the inception of the treatment, ETEC developed a method of accelerating the breakdown process by more than tenfold. This method also eliminates the past problems facing biological remediation by removing critical factors such as temperature windows, moisture content, toxic shock and so forth.

Recently, ETEC completed testing for the Oregon Department of Environmental Quality (ODEQ) and EPA Region 10 at the McCormick and Baxter Creosoting Site, which was placed on the Superfund National Priorities List by EPA on May 31, 1994. The objective was to prove the capability of applied bioremediation to sites highly contaminated with creosote and other polycyclic aromatic hydrocarbons (PAHs).

McCormick & Baxter operated a wood treatment plant at the site from 1944 to 1991. Wood treatment processes used at the site included creosote in oil and pentachlorophenol (PCP). For years, waste oil containing creosote was reportedly applied to site soil.

In August 1995, ETEC received some of the contaminated soil from the site. Initial concentration of PAH compounds by EPA 8310 analysis was 1862 ppm. Sixteen different PAH constituents were analyzed. The cleanup goal is 100 ppm total for these contaminants.

Due to the high concentration of toxic compounds, a biosurfactant compound was applied first to reduce the total system toxicity. Due to the specific chemical structure of PAH compounds, PAH constituents will affect the three-dimensional structure of enzyme molecules, as well as simply killing bacteria through toxic shock.

After 72 days of treatment with the biosurfactant and multi-enzyme complex products, PAH
was reduced by 55.8 percent. Up to this time, a realistic performance of bioremediation was that it could break down 95 percent of two, three or four-ring PAHs, but only about 60 percent of five and six-ring compounds over a two or three year time. Although ETEC's results are somewhat impressive, most of the degradation occurred in the two through four ring PAHs.

Presently, ETEC scientists have completed development of a new product based on co-metabolism which integrates four separate strains of bacteria. Two of the strains work together to begin the process of breaking down the ring structure. Then the third and fourth strains are added to complete the breakdown. The combination of the strains has a synergistic effect.

The new co-metabolism product was applied to the previously treated sample and the degradation levels were significantly reduced in 16 days. Total PAH levels dropped from 823 to 146, which is close to the target level of 100 ppm. Most dramatic was the drop in the five and six ring compounds. One of the most difficult compounds to bioremediate, benzo(a)Pyrene, dropped nearly 90 percent in 16 days. The remaining 15 PAH constituents degraded to between 90 and 100 percent. Applying similar principles, ETEC has isolated and cultured two additional strains of bacteria that they believe will result in even more efficient degradation. ETEC has completed the next step in their research and development program which separates the enzymatic compounds from the bacterial strains—as they do now for their hydrocarbon products—which will make the bioremediation of PAHs faster and more cost effective.

ETEC has worked with the U.S. Department of Defense, Southern Pacific Transportation Co., Portland Terminal Railroad, Portland Development Commission, Chevron and a number of environmental consulting and engineering firms in the northwest. Also, ETEC has licensed its technology as distributorships as far away as Venezuela, and is currently negotiating with several Japanese companies for distribution. The company continues to improve its technology through an extensive research and development program with leading Russian scientists, the Russian Academy of Sciences and various Russian universities. As a result, ETEC also serves as a clearinghouse for the transfer of environmental technologies and products into Russia.

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It's not the heat, it's the humidity

Combined technologies address sorption problem

By Troy T. DuGuay and Arthur J. Pyron, P.G.

After many years of operation, remediation systems at some sites reach the point where contamination levels are no longer declining. This should be cause for celebration, but instead, interested parties are often uneasy about the specter of site rebound—when the system is turned off, contamination levels start to climb. Sometimes rebound is evident within days, other times it occurs well into the final rounds of closure sampling. Understanding the dynamics of contaminant rebound, the operational merits and limits of treatment systems and the dogma of infrastructure design are

Troy DuGuay is the principal, and Arthur Pyron P.G., is an associate for IETC, International Environmental Trading Corp., Shillington, Pa. Information for this article was obtained from "An Introduction to Biosparging for the Environmental Professional," © 1996, by Michael Hobby.
fundamental to solve the rebound problem.

When soils are contaminated with a hydrocarbon based compound, the material is dispersed by capillary action, percolation of rain water and seasonal variations of groundwater elevations. The individual grains of soil become sorbed with hydrocarbons. Sorption is the coating of sand, silt and clay particles with a hydrocarbon film or sheen. Desorption is the stripping or removal of sorbed hydrocarbon which will not readily dissolve into the groundwater otherwise, and is how remediation of hydrocarbon contaminated soils occurs. Sorption is a difficult property to analyze because so many variables are involved.

Typically, during a site investigation, soil samples are collected at varying depths below the surface until groundwater is encountered, at which time a groundwater sample is also collected. The concentration of the contaminants detected in the groundwater sample is routinely accepted as the concentration of the contamination below the groundwater surface, but does not accurately reflect the total mass of the contaminants, because the static sorbed phase below the surface of the groundwater cannot be measured until it is desorbed and becomes mobile. In addition, a portion of the contaminant which impacts the soils is locked into the matrix by clays, micro fractures and surface tension. Soil vapor extraction promotes the formation of a low pressure envelope in the vadose zone by use of a vacuum. In an air sparging system, a second, nearby injection point introduces heated air into this low pressure envelope to assist venting. Both techniques are limited by the natural permeability of the media. If the sorption factor of the soil is higher than its permeability, then a portion of the contaminant remains locked on the grains and will not be remediared by vapor extraction or sparging.

An analog to this situation is the application of pump and treat technology to contaminated groundwater. By pulling down the surface of the groundwater into a cone of depression within a given wellbore, much, if not most of the sorbed phase becomes suspended where no water flows through the former capillary fringe, which may be the most heavily contaminated level of the soil. In cases where free product is present when the extraction well begins operations, it will systematically sorb into all of the newly exposed soil as the groundwater elevation drops. If the system is turned off, the groundwater returns to its former level, again submerging the sorbed phase. This results in rebound, which is actually recharge of the groundwater with newly leached contamination. Rebound can also occur when venting or sparging systems are shut off, when a portion of the contamination is inaccessible simply because of the properties of the media. Rebound is the most detrimental factor associated with application of these remediation systems because it extends the time of remediation and increases the costs—especially for operations and maintenance.

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problem by inducing desorption within the vadose zone by recirculating rather than discharging the air extracted from the contaminated zone. It involves the injection of a heated mixture of oxygen-enriched air, water, nutrients and bacteria into an injection port. A second, downgradient port recovers and recycles the air through the surface unit. During transport across the contaminated zone, bacteria and nutrients are introduced into the interstitial spaces between soil grains. Once recovered, the air is directed toward a biocell, which scrubs the volatiles from the airstream. The volatiles are destroyed by the bacteria in the cell while the air is prepared for re-injection. Since the system is a closed loop, no release to the environment occurs, so no air permitting is necessary. Re-injection

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Figure A

of the moist air system causes a uniform elevated subsurface temperature, which promotes year-round bioremediation, and prevents desiccation. From an operations and maintenance perspective, no activated carbon is used, so weekly visits to replace or recharge carbon filters is eliminated.

The injected material creates three instantaneous remediation activities. Venting of easily volatilized materials accompanies the injection and recovery of the warmed, moist air. Sparging of impacted soils also accompanies injection of the warmed air into the soils, and can also volatilize floating product. It also assists in the desorption of sorbed hydrocarbons. Finally, bacteria, upon injection, begin to seek hydrocarbon food sources. Since the venting function removes the easily volatilized contaminants, the sorbed contaminants are the only remaining food source. As the bacteria are introduced into the media, they work their way into the interstices of the contaminated soil and expedite the process.

The combination of heat and bacteria causes the sorbed phase column to begin to collapse. Collapse is defined as the process by which the sorbed material releases from its physical soil bond and is remobilized into the active area of biodegradation and collection. Once desorbed, the hydrocarbon is rapidly degraded by acclimated bacteria in both in situ and in the biocell until a non-detectable concentration is reached. The degradation curve of the contaminant does not level off as it approaches zero due to the use of codegradation products, which buffer the degradation rate as the concentration falls. Maximum remediation time is measured in
months to a year or two for most sites, as compared to several years, even decades for comparative technologies.

The Bio-Sparge system consists of a relatively small, mobile, self-contained treatment unit, including an absorption system filled with gilsonite-coated spheres, a bio-inoculant, nutrients and water. An air compressor/blower injects the mixture of heated air, water inoculant and nutrients into the injection well. The heated mixture is drawn across the contaminated zone by the same or a second air compressor/blower which recovers impacted air via the recovery port. This air is bubbled through the absorption tank under pressure. Water from the absorption system is circulated through an onboard bioreactor, where the contaminants absorbed into the liquid by pressure are destroyed by bacteria as a continuous process. The water then re-enters the absorption system. This process allows for removal and destruction of virtually 100 percent of the contaminants within the impacted air prior to reinjection.

The system is connected to a subsurface infrastructure of wells and connecting lines which are installed for the duration of the project. The remedial design plan for physical layout of the system can incorporate existing monitoring wellbores or interceptor or recovery trenches as injection and recovery ports. The Bio-Sparge system can be used on organic compounds of either high or low volatility. With an ozone amendment, it can be used on semi-volatile compounds, including chlorinated solvents. The system is adaptable to a wide range of site conditions.

**Case studies**

A Bio-Sparge system, consisting of a closed loop vapor extraction and recirculation system with four vapor extraction wells and a

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Humidity, from page 35

vadose return (vapor injection) well was installed at a contaminated site in Utah. Soils at the site consisted of heavy clay with a small silt fraction. Average permeability of the soils ranged from 10-6 to 10-5 cm/sec². Contamination at the site was the result of unleaded gasoline leaking from underground storage tanks. The site investigation indicated that only the soil was contaminated.

The remediation system for this site required heated air to continuously move through a mobile Bio-Sparg system. The design provided for injection and maintenance of hot water vapor, acclimated organisms, heated oxygen and nutrients to control subsurface conditions for bioremediation. The system circulated 14 liters per second. Vacuum pressure necessary to withdraw this amount of soil gas was approximately 125 millimeters (water). The extracted vapor immediately jumped from a temperature of 10°C to over 100°C, which fully expanded both the withdrawn water vapor and the BTEX gases. This created a pressure between the blower and the sparge tank of 55 kPa. The superheated pressurized vapor enters the base of the absorption system tank where both the water vapor and 60 to 90 percent of the BTEX and TPH immediately collapsed into solution in the tank liquid bio agent. The pressure between the top of the sparge tank and the vadose return well was only that pressure necessary to overcome formation resistance to reinjection and measured an average of 29 kPa.

Subsurface VOC vapors were maintained within the area of venting well influence, based on the monitoring well pressure readings. Injected air moved to the area of extraction, and not into uncontaminated areas. Rising
temperatures and dissolved oxygen concentrations proved biological degradation was taking place. Monitoring of the site during remediation showed that bioactivity increased during the biosparging step, accompanied by an increasing pH level and decreasing benzene level. The acclimated organisms appeared to be well distributed throughout the subsurface, as based on the plate counts and the universal decline in benzene concentration. Upon analysis of the data, it was noted that there was no increase in BTEX concentration, even following a significant rise in the groundwater level, which brought groundwater to within 600 millimeters of the bottom of the vadose zone. The site met its cleanup goals within 18 months, with no evidence of rebound six months after shutdown.

At a site in Nevada, a Bio-Sparge system was installed at a site where lower permeability clays and silts were cut by a remnant meander channel of an old stream which contained higher permeability sands. The area was contaminated by a release of diesel fuel from old fuel islands. This resulted in the entire soil column becoming saturated down to groundwater. Further, the presence of the meander channel changed the size of the contamination plume by preferentially diverting product through the more permeable sands, across gradient.

The mobile unit used an infrastructure incorporating 23 previously installed monitoring wells. The area under the fuel islands received hot oxygenated air at 55°C and 7.5 cubic meters per hour of oxygen which was generated by the unit. The formation temperature dropped due to a reduction in groundwater elevation across the site between mid-November and mid-December, but retain enough heat to allow for active bioremediation. The heat introduced beneath the fuel islands where the sorbed phase of the diesel was located reduced the effective viscosity of the diesel, and allowed the sorbed column to begin collapsing. The collapsing sorbed phase increased the amount of free product to the north, west and south of the fuel island. In the downgradient direction, to the east, active biodegradation kept pace with the increase in the amount and further reduced the free product elevation.

As the formation temperature continued to increase over time at the elevation of the free product, replacement of the withdrawn fuel column occurred more rapidly. A unique wellhead design, which incorporated the vacuum and pressure forces of the biopurge unit, removed free product without the use of submersible pumps. This process helped reduce the total volume of free product and to expedite remediation. After several months of operation, the free product plume contracted by approximately one-third.

Further general reduction in free product occurred site-wide, due to biological activity, which exceeded product recovery as the primary mechanism for site remediation some six to eight months after the initiation of remediation activity. This was due to an unusually high biological destruction to free product recovery ratio. Biological destruction of hydrocarbons exceeded product recovery in several areas of the site, and allowed completion of remediation to be achieved within two years due to accelerating remediation efficiency.

Site rebound forces the design of a treatment system upon completion of a remediation project. Traditionally, the emphasis has been on initiating remediation at the lowest cost to prevent further migration of contaminants via dispersal. But, as each system is turned off, the problem of site rebound emerges, confirming that it should be addressed during initial design. Instead of reinventing the wheel, remediation designers should learn from available data on proven technologies. New technologies are not needed as much as new designs which increase the efficiency of treatment. Understanding the limiting factors of traditional, in situ groundwater and soil treatment technologies is critical to the advancement of more effective treatment systems.
EPA teams with Air Force to offer cleanup software

**TANK RACER gives cost estimates for LUST sites**

Generating fast, accurate and comprehensive cost estimates for leaking underground storage tank cleanups can be complicated and challenging. Just ask Michael Piotrowski, president of Matrix Remedial Technologies in Monument, Colo. “There are many unforeseen or hidden costs that are difficult to predict at the beginning of a cleanup. Generating comprehensive cost estimates can be a slow, tedious process, which is especially frustrating when clients need estimates quickly,” he says. Piotrowski’s complaint is well placed. The average cleanup includes more than a hundred cost components—from vapor extraction wells to lab fees to decontamination equipment. And, billing often takes place over numerous phases of a cleanup that can span time frames of several years.

Reviewing reimbursement claims isn’t simple either. Lori Cessna, a cost reviewer with the Kentucky assurance fund, points out, “There are no standardized cost reports. Each party has different billing statements.” Robert Hastings, with Shell Development Co., says, “The lack of consistency in presentation of cost estimates is a big problem. In addition, it’s difficult to determine if a consultant has designed the remediation system to maximize cost savings while still meeting cleanup goals.”

While each of these issues is a separate problem, taken together, they can lead to inflated or unnecessary cleanup costs. To improve cost estimation for both the private and public sector, responsible party and consultant, the U.S. EPA Office of Underground Storage Tanks (OUST) formed a partnership with the U.S. Air Force to develop TANK RACER software. TANK RACER is a Windows-based PC program that provides fast, accurate and comprehensive cost estimates for LUST site assessments and corrective actions on a site-specific basis. The software is designed to enable all parties to avoid charging or paying inflated cleanup costs.

TANK RACER supports OUST’s efforts to promote faster, more effective and less costly cleanups. The software is customized for UST sites, and estimates costs for all phases of remediation including: tank closure, remedial design, operations and maintenance, site assessment, remedial action, site work and utilities.

To ensure that the software would meet the needs of state funds and the private sector, OUST developed a test group to provide input on all aspects of the software design and utility. The test group included representatives from eight state funds, three major oil companies and three consulting firms. Their input helped OUST design the program to answer these questions with confidence:

- Could a less expensive technology achieve the same results?
- Are reimbursement claims reasonable?
- Does this estimate include all costs?
- Is this piece of equipment necessary?

To generate a cost estimate, users are prompted to enter site-specific information regarding the technologies that will be used at the site, the conditions and geology of the site, and the nature and extent of the contamination. TANK RACER calculates site-

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Continues on next page→
Uncle Sam needs you
To use processed harbor sediments

America’s waterways need to be dredged to maintain strong national commerce. Yet, environmental regulations restrict much port and waterway dredging practices because dredging stirs up over a century of pollution to be dealt with. One common, existing sediment cleanup technology is chemical destruction, another is stabilization and solidification. Emerging technologies often have end products, which vary from soils, to fillers and aggregates, to bricks and blocks, to vitrified material.

M&S Associates of Beverly, Mass., is conducting a study for the U.S. Army Corps of Engineers to find ways America can use cleaned, processed sediment. Some potential uses include: concrete-like product for use as tennis courts; bike paths; breakwaters; retaining walls; floats; pilings; docks; highway roadbeds; soil erosion control; landfill cover; wetlands and mine reclamation. Sediment could even be used to create “fast” land to build islands for docks in deep water so that tankers do not have to enter ports, which reduces harbor maintenance problems.

Clearly, the eventual uses of cleaned sediments will be driven by many factors, such as the ability to process the material into the necessary particle size, its strength and adaptability, cost competitiveness with alternative materials, available supplies and the integration of research and marketing.

The research for the Corps focuses on finding and defining potential uses and users for cleaned sediment. Sediment recycling will likely be used in applications that lead to the prevention of environmental problems. M&S Associates is trying to reach real estate developers, contractors, highway construction specifiers, marketing organizations for recycled construction materials, manufacturers of concrete products and others willing to consider the potential of these materials.

Write in 701

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TANK RACER, from page 38

Specific costs that can be downloaded into a variety of cost reports to provide various levels of detail.

TANK RACER can produce cost estimates that are preliminary or final. The level of specificity depends on the user’s needs and the nature of the data input into the program. The user controls the levels of parameters and quantities used within the system, including default quantities and unit costs.

State fund staff can easily load their desired unit costs into the TANK RACER database. Major oil companies and consulting firms can do the same. The software also contains default cost data from the U.S. Army Corps of Engineers. These data are updated every year. The data include costs for alternative site assessment and remediation options such as: thermal desorption, bioremediation, soil vapor extraction, dual phase extraction, air sparging, natural attenuation, bioventing, and immunoassay testing.

EPA strongly recommends that users take a two-day TANK RACER training workshop prior to using the software. The total cost of the workshop and software is $495 per person for regulators, and $740 per person for non-regulators—in workshops of 15 participants. Lower rates can be negotiated for larger workshops.

To learn more about TANK RACER, order free brochures and demonstration disks by contacting Mick Edgar or Scott Henson at Delta Research Corp., phone 904-897-5380.

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Write in 333

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N.J. gives nod to compost plants

Plant construction begins later this year

A new company plans to build and operate merchant composting facilities. Compost America Holding Co. Inc., of Doylestown, Pa., is looking at facilities, located in urban settings, that can separate organic waste from a waste stream.

A subsidiary of Compost America, Newark Recycling and Composting Co. Inc., has been issued state and local permits to begin construction of a $60 million plant near the N.J. Turnpike. Company president, Roger Tuttle, says the fully enclosed, in-vessel, 20,000 square meter composting facility can handle over 300 metric tons of biosolids and 270 metric tons of source-separated waste such as supermarket and restaurant food and soiled paper wastes each day. The full scale facility will be built by VRH Construction Corp. of Englewood, N.J., on over 4.5 hectares near the Newark Airport.

City officials in Gloucester City, N.J. have given their approval for a composting demonstration project to serve as a prelude to the construction of another facility, similar to the Newark project, that will have “the potential to generate up to $500,000 a year in revenue and create 20 jobs for the city,” notes Gloucester mayor Charles Billingham. “We hope to provide some workable solutions to communities nationwide seeking to reduce trash flow and avoid ever increasing solid waste tipping fees,” he says.

As part of the demonstration project, the organic waste is composted within 14 to 24 days. No waste is handled or stored outside, and when the raw compost reaches maturity in a curing area, it is assessed for value through analysis and plant growth studies. After its quality is confirmed, the finished compost is available for use in the community. The project, scheduled for completion by this fall, will be built on the grounds of the former Gloucester City wastewater treatment facility. Compost America is working with the New Jersey Department of Environmental Protection to amend their existing demonstration permit to reflect this new location.

Among others, the assembled Compost America team consists of Professional Services Group of Houston, Texas, the nation’s largest private operator of wastewater treatment and composting facilities, and PaineWebber, the company’s bond underwriter.

Firms prosper in difficult market

Remediation construction leads environmental growth

Farkas Berkowitz & Co., Washington DC, presents its 8th annual State-of-the-Industry report at the Environmental Business ’96 convention. Publicly traded environmental firms, with the exception of the hazardous waste management sector, showed strong growth in revenue and increased operating margins in 1995. Joan Berkowitz, Ph.D., and principal of the firm, says “Higher growth rates for all indices were due largely to continuing merger and acquisition activity.”

Alan Farkas, also a principal, reports that the U.S. market for environmental consulting and remediation services climbed five percent to $12.5 billion in 1995. “Nearly all the growth in this sector can be accounted for by remediation construction,” he says.

Survey results show a strong consensus among environmental firm CEOs that by 2000, the industry will consist of less than ten very large firms, a large number of firms with revenues less than $50 million, and very few firms in between. The CEO survey also projected lackluster growth in consulting and remediation, predicting on average a decline of one percent in 1996, and annual increases of only three percent in 1997 and 1998. Farkas predicts, “We think the environmental consulting market is at the beginning of a gradual decline, but we see growth in remediation construction until around 1998. If the trend toward design-build-operate continues, we will see an increasing premium on scale and diversity, and this will fundamentally change the structure of this sector. However, we see good continuing opportunities for environmental specialty firms.”

Berkowitz notes, “Industrial by-product processing represents a newly emerging segment for on-site as well as off-site services. A great deal of environmental work is being subsumed under process engineering plant construction or real estate development. Industrial development is being rediscovered as a key market driver.” She believes the hot markets are in providing environmental goods and services to high growth, profitable industries and plants, and to growing population centers.

The full report is available from Farkas Berkowitz & Co., 1220 Nineteenth St., NW, Suite 300, Washington DC 20036. Enclose a check for $300, and mark the envelope to the attention of Danny Collier.
Innovative technology clearinghouse

Groundwater center seeks vendor information for database

The EPA asked the National Environmental Technology Applications Center (NETAC), of Pittsburgh, Pa., to establish and operate a national center to promote innovative technologies to clean up contaminated groundwater. Known as the Groundwater Remediation Technologies Analysis Center (GWRTAC), the center is located in the University of Pittsburgh Applied Research Center in Harmarville, Pa., where it operates in association with the environmental engineering program at the University.

Edgar Berkey, Ph.D., president of NETAC, serves as director of the center, while Frederick Pohland, Ph.D., the Edward Weidlein Chair of environmental engineering at Pitt, is associate director. The center’s activities are coordinated with the Technology Innovation Office of the EPA, directed by Walter Kovalick, Jr., Ph.D.

“The center serves as a principal voice for describing and promoting the application of the latest groundwater technologies throughout the country,” Kovalick says.

Center reports are prepared by technical teams drawn from NETAC, Pitt, and other supporting institutions, including Carnegie-Mellon University.

GWRTAC is currently compiling a Vendor Information database that will eventually be placed on the world wide web at http://www.gwrtac.org. The databases will be interactive and will include information on in-process and completed case studies. The interactive databases will also allow vendors to enter general information and a detailed description of their services.

“We expect to become an important focal point for transfer of technical information between technology developers and users. In collaboration with the University of Pittsburgh and others, we will work to improve the understanding and coordination of research, development and application activities in the field of groundwater cleanup,” says Berkey.

For more information, mail your inquiry to NETAC at 615 William Pitt Way, Pittsburgh, Pa. 15238. Fax 412-826-5552 or e-mail gwrtac@chmr.org.
Drills offer thrills and chills

Foremost Drills/Mobile Drilling Co. Inc., of Michigan, Ind., offers the Minuteman® rotary drive drill rig, which weighs only 120 kilograms. Available in gasoline or electric power models, the unit uses solid stem and hollow stem augers. In auger drilling applications, the unit reaches diameters up to 300 millimeters to depths of over 9 meters. In core drilling applications, the unit reaches depths over 15 meters.

The company also offers a truck or trailer mounted hydraulic model B-31 which can drill down 1.7 meters with one stroke before stopping to add tools. A conversion kit for concrete and asphalt coring is available as optional equipment. The model B-59 can reach depths over 300 meters in rotary drilling applications. The company also offers the B-61 HDX, environmental geotechnical drill that combines rotary system with torque converter to a maximum of 26,001 Nm. with available mast height to 10.4 meters. The system is also equipped with an emergency shutdown system. The company also offers a complete line of auger drive components, continuous flight augers, bits, hollow stem augers, cutterheads, drill rods, hoisting and driving tools, swivels, hoses, soil sampling tools, continuous sampling systems and drill modules.

Dry vinyl™ polymer controls fluid loss

SlurryPro CDP, from K3 Technologies Ltd., Chattanooga, Tenn., is a water soluble vinyl polymer in a dry granular form. It is designed for preparation of viscous earth-stabilizing fluids or slurries for a variety of drilling, trenching and walling applications. It controls fluid loss in sands and gravels, stabilizes excavations, reduces chipping and cleaning of poured concrete. Since it is environmentally safe, it reduces or eliminates disposal costs, says the company.

ATV carries probe to all terrains

Simco Drilling Equipment Co., Osceola, Iowa, now offers a 4x4 all-terrain vehicle for use with its Earthprobe direct push rigs. The ATV has a gas engine, four-speed transission, automotive drive train, a certified roll protection system, and can carry two passengers and a full load of tools. Articulated steering keeps all four tires in contact with the ground. The Earthprobe is easily removed from the ATV and transferred to another carrier.
Leave it to powerful, yet small-size drill

Little Beaver Inc., Houston, Texas, introduces a new earth drilling tool (right, top) for use in environmental drilling, test wells, as well as foundation repair. The portable, hydraulic Big Beaver can be operated and moved by one or two people and drills large holes comparable in size to truck mounted units. It can be adapted to a variety of carriers. The unit can deliver over 530 J of torque which is enough to drive 150 mm diameter augers to 30 meters deep, and 400 mm diameter augers to 8.5 meters deep in typical applications. On the 1.5 meter tall mast are two hydraulic control levers which allow the operator to feather the drill feed from slow to fast. An adjustable back stay pushes the weight of the machine forward onto the base to provide three-point stability, and a torque tube prevents rotation of the mast in case the auger binds.

The company also offers an ultra light hollow stem auger for soil testing (right, bottom). It comes in 1.2 meter sections which can be linked for deeper drilling, sampling and testing. Available in auger sizes of either 150 mm outside diameter with 60 mm inside or 200 mm outside with 90 mm inside, the larger unit can go as deep as 15 meters in sandy soils. Auger barrels can be opened while in the ground so tools can be inserted for sampling or soil testing.

Write in 706

Drilling people associate to share and learn

The International Association of Foundation Drilling (ADSC), serves its members with news and technological developments in foundation drilling and anchored earth retention practices. The association offers members training, and other educational opportunities, OSHA updates, and news through Foundation Drilling magazine. To receive a membership information package, fax your request to ADSC at 214-343-2384.

Drilling newsletter for the horizontal

The Horizontal Well Market Report is a monthly newsletter focusing on market news about directionally drilled environmental horizontal wells. The report is targeted to anyone who "makes a living in, wants to enter, sells to or wants to monitor the horizontal well marketplace."

Cost of the report is $149 per year. Mail a check or request for information to EMS, 431 S. Dearborn, Suite 509, Chicago, Ill. 60605.

Compact unit fits in tight spaces

McLaughlin Manufacturing Co., Greenville, S.C., offers the Mighty Mole II, a compact and fast unit that produces holes to 112 mm in diameter in dry media, or to 200 mm in slurry boring at speeds approaching 2.5 meters per minute. The unit can drill to distances up to 60 meters in certain soil conditions. At only 850 mm wide, the unit can fit into tight spaces. It uses Flex-Alloy™ drill rods with snap-button connectors.

Write in 707
Piston pumps have many features

Bennett Sample Pumps Inc., of Amarillo, Texas, offers a line of pumps with reciprocating piston motors operated by compressed air, that generate power for a double acting piston fluid pump. Models for lifts up to 150 meters have one motor piston. Models for lifts up to 300 meters have two motor pistons. The pumps can be operated in any position from horizontal to vertical. They can operate submerged to great depths, or above the water with a drop tube attached. All models dis-assemble in the field for cleaning and maintenance using ordinary tools. Model 180 and 1800 have a 25 mm diameter pump piston, and model 140 and 1400 have a 19 mm diameter.

Ins and outs for pipe

Fluid Controls Inc., of Huntsville, Ala., offers field locatable containment access ports and low point drains for smaller diameter dual containment systems. The company says that field location of the access ports and low point drains with electrofusion fittings from Central™ Fittings and Fluid Controls Inc. can cost less than butt-fused access port and low point drain fittings. Systems are available to 1.2 meter carrier pipe.

Pump runs on inert gas

Geotech Environmental Equipment Inc., of Denver, Colo., offers a line of environmental products, including small diameter well pumps for 50 mm wells. Made of Teflon™ and stainless steel, it can operate entirely on inert gas, and is operated at the wellhead by either the Electronic Pneumatic logic unit or pneumatic logic unit. The company also offers peristatic pumps designed for single and multi stage pressure or vacuum pumping for liquids or gases in or out of the laboratory. Because they operate to a depth of 8.5 meters at sea level, they are suited for sample removal from shallow wells and all surface water sources. These units can pump up to 1000 milliliters per minute. The power source can either be 115 VAC or 12 VDC. They are variable speed, reversible and equipped with a 5 amp circuit breaker.

Collect free product

P.J. Products Co., Scituate, Mass., offers a new liquid hydrocarbon recovery system to collect free product floating on groundwater. The PetroPore floats, so it is not affected by groundwater fluctuations. It features passive operation, with no moving parts in the basic system. It reduces hydrocarbon smearing. Model 250 collects more than 2 ml per minute per 2.5 mm of product.
Measure the pressure

Keller PSI Inc., a Pressure Systems Inc. subsidiary, of Oceanside, Calif., announces a small bore, low range Series 310 submersible pressure transducer/transmitter for groundwater monitoring (above left). The device has a 16 mm diameter static accuracy of ±25 percent and features on-board electronics that provide optional 3 wire 1-5 VDC or 2 wire 4-20 mA output. KPSI also offers a new small bore Series 300 HD submersible pressure transducer/transmitter designed for groundwater and oceanographic monitoring to depths exceeding 900 meters (above center). It has a diameter of less than 20 mm, static accuracy of ± 0.5 percent, and also has on board electronics. The company also offers a new Series 27 low range, all purpose, all media pressure transducer for process control, industrial, oceanographic, geophysical and liquid level measurements (above right). Approximately 25 mm in diameter, this model also features on board electronics that provide optional 0-5, 0-10 VCDE or 2 wire 4-20 mA output, as well as surge and reverse polarity protection. Housed in a welded stainless steel case, the unit is made to function in hostile environments.

Watch pump and dredge on video

Soli-Flo LLC, of Oceanside, Calif., offers dredging and material handling services as a joint venture of Fluor Daniel and Xetex Corp. The heart of the system is the patented Eddy Pump®, so powerful, it can extract imbedded solids without the use of mechanical agitation devices. The Eddy Pump creates and harnesses a dynamic eddy effect via a spiral column of immense energy which passes through the housing and down the center of the intake pipe where it agitates the material to be pumped. With the nozzle of the inlet pipe imbedded in the sediments, the dynamics of the high suction pump transfer high solids fraction material while producing virtually no turbidity to the surrounding area. The spiral water column also creates a peripheral eddy effect, causing the agitated material, such as sediments, sludge or mineral slurries, to travel up the sides of the intake pipe and chamber directly to the discharge. The system uses a cable suspension system to support and guide the intake apparatus. Depths up to 30 meters can be reached with no decrease in dredging efficiency, says the company. The systems are modular, truck-transportable and set up in less than four days. Computer controls enable operators to monitor location, turbidity levels against background, flow rate and material density. An underwater video system allows the operating team to maintain constant visual surveillance of the pump and dredge intake.

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Write in 714

Write in 715

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**Brochure covers ordnance**

A new brochure from National Technical Systems, Camden, Ark., details the company's ordnance, munitions and environmental testing services. Their remote test site enables safe testing of a variety of hazardous materials. Write in 718

**Mixer uses Venturi principle for blending**

New from Flo Trend Systems Inc., Houston, Texas, is the Spiral Jet Mixer for blending without moving parts. Pressurized fluid flow creates all the energy to mix, suspend solid particulates in a liquid phase. It can also be used to emulsify one liquid with another. The unit uses the Venturi principle of converting static pressure into velocity. The velocity of the jet stream issuing from the motive nozzle develops a low pressure region across the radial inductors, drawing the liquid into the mixing chamber. The helical passage through the inductors promotes a spiral, turbulent flow that emerges from the diffuser section in an oscillating plume, entraining more of the surrounding liquid. Write in 717

**Grout machine for direct push applications**

Geoprobe Systems of Salina, Kan., announces the GS-1000 series grout machine, the first grouting system designed specifically for direct push applications. With powerful reciprocating piston pump, the machine can deliver standard ASTM grout through standard 25 mm Geoprobe probe rods or through 10 mm polyethylene tubing. The pump has flow rates up to 8.7 liters per minute. No carrier vehicle or outside power source is necessary. Write in 716

**Find TPH without Freon**

FCI Environmental Inc., Las Vegas, Nev., offers an alternative to EPA Method 418 for TPH analysis. The PetroSense® PHA-100W offers rapid, in situ analysis of TPH dissolved in water and as free product. The unit does not need Freon 113, as required in Method 418. The unit uses fiber optic technology in a handheld probe, and gives direct digital readout of TPH in ppm, without sample preparation or use of solvents. Write in 719

Continues on page 48→
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Soil & Groundwater Cleanup June-July 1996
It screens, it shreds

The Dimminutor™ from Franklin Miller Inc., Livingston, N.J., screens and shreds oversized wastewater particles in open channels with no need for secondary devices for solids removal or transfer. The one meter model handles up to 95 million liters per day in continuous service. It is made of high strength ground steel plate and uses oversized tapered roller bearings for accurate rotation with low deflection. A patented clear slot screen allows the three rotary cutters to penetrate the screen openings to positively clear them of debris. The screen is made of stainless steel bar, which provide open areas to wastewater flow. The Dimminutor is made for channels from 300 mm to just over one meter wide, and is available with several options.

Write in 723

Reagent conquers metals

Geo-Chem Technologies of Olathe, Kan., introduces Cad-Con 1000™ magnesia-based reagent formula to stabilize heavy metals in contaminated groundwater and soils. It precipitates and chemically combines cadmium, lead, zinc and other metals to an insoluble mineral form that tests non-hazardous by standard TCLP method. After treatment, clarified wastewater is suitable for disposal to sewer or stream, and soils are able to be backfilled.

Write in 724

Logger module is a snap

Campbell Monoflex, Largo, Florida offers the HydroTrack™ as an automated well level data logging system for water level measurement in wells, tanks, surface waters and mines. The unit fits inside a 50 mm well and requires no external power source or connecting cable. A snap-in logger module removes without disturbing the installation.

Write in 722

Measure degradation of plastics, oils, creosote

Columbus Instruments, of Columbus, Ohio, offers a new compost respirometer to determine the aerobic biodegradation of plastic materials under controlled composting conditions in the laboratory. Measurements conform to ASTM D 5338-92. The unit does not trap CO2, so no chemical agents are involved in measurements. It can monitor up to 80 samples at once and measures gas exchanges during slow biodegradation of plastics, detergents, oils, creosote, explosives and others.

Write in 721

Continues on page 50→
Remtech Engineers Bubble Lance Low-Profile Diffused Air Stripper

- Remtech Engineers, of Marietta, Ga., introduces the first diffused air, shallow channel, low-profile air stripper that can reduce maintenance and life cycle costs compared to deep diffused air strippers or plate strippers. The patent pending Bubble Lance system consists of lightweight stackable chambers that may be added to increase treatment efficiencies. Water enters the top chamber where the water depth is hydrostatically balanced with diffusers to create a frothing aeration action that removes volatile organic compounds and prevents solid settling. No metals pretreatment is required. Enhanced VOC treatment efficiency is achieved by routing the water through a series of baffled channels on each level before it cascades through an overflow weir to the next level. Exhaust gases exit the system through ventilation ports on the unit side which may be vented to the atmosphere or connected to an off-gas treatment system, such as activated carbon. The water depth in each channel is designed to maximize air to water ratios using smaller blowers for treatment efficiencies comparable to conventional diffused air strippers. The diffusers, stripper shell, air injection and exhaust manifolds are all constructed of polyvinyl chloride (PVC) which offers a wide range of chemical compatibility, corrosion protection and easy cleaning. Structural PVC channel reinforcement enables the system to handle over 380 liters per minute. A 266 liter per minute, three chamber stripper with a sump is 600 mm wide, 1800 mm long and 1200 mm high, and can reach treatment efficiencies of 99.9 percent. Gravity feed eliminates the need for an interprocess transfer pump between the separator and the stripper. Observation ports are provided to observe aeration and clean system diffusers in each channel.

Write in 699
What's New

Free pollution guide
Safety-Kleen Corp., of Elgin, Ill., offers a brochure to help businesses assess waste handling costs and services. "Buyer's Guide to Pollution Control" is available by calling John Fitzgerald at 847-468-2490.

Measure deep water
Solinst Canada Ltd., Georgetown, Ontario, offers a water level meter and conductivity profiler that provides repeatable measurements of static water in wells. Probes are designed to give accurate signals even in cascading water. Depths range to 900 meters. Model 101 can be converted to a downhole conductivity profiler.

Detect toxic gases
International Sensor Technology, Irvine, Calif., introduces the Model 4-20 IQ Intelligent Gas Detection Transmitter, which monitors ambient air and detects leaks of over 150 toxic or flammable gases.

Sensor measures oxygen on line
Terriss Consolidated Industries Inc., Asbury Park, N.J., offers the LS/QA SmarTester to measure dissolved oxygen on line. The sensor never touches the liquid to prevent fouling, interferences and temperature problems. The sensor is calibrated automatically in place. Sensor accuracy and repeatability is ±.01 mg/liter.

Book deals with in situ matters
Geraghty & Miller Inc., Denver, Colo., releases the fifth volume in their Environmental Science and Engineering series, "In Situ Treatment Technology," by Evan Nyer, vice president and senior project advisor for the firm. Seven engineers co-authored the 400 page volume. Cost is $69.95. To order, call 800-425-6127. For more information, call 303-294-1200.

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ETUS CPU MOD/T Heavy Metals Remover

The ETUS Inc. CPU MOD/T Heavy Metals Remover is a continuous-batch treatment system that removes heavy metals from process wastewater streams, says the Sanford, Florida-based company. The unit is nominally capable of processing 3800 liters per hour and uses chemical precipitation technology to balance pH, convert metallic ions to insoluble particles, and separate solids from liquid.

Treatment begins as waste solution is transferred from a holding tank to the system reaction tank. An in-line electrode continuously senses the pH of the incoming stream. A controller monitors the signal and, as required, activates a reagent pump which adds pH balancing reagent until the pH set point is reached.

To convert the metallic ions, a proprietary precipitant, SP-90X, is injected into the stream. An in-line electrode monitors the stream for excess precipitant, and activates the reagent pump to add precipitant until the precipitation endpoint is reached. A slurry of diatomaceous earth is injected into the incoming wastewater stream. As the wastewater is circulated in multiple passes through the system filter bags, the filtering media helps capture the precipitate and suspended solids.

Filter bags are periodically replaced and allowed to drain, yielding a sludge with a solids content of 40 percent or higher. No filter press is required to further dewater the solids. Treated water is automatically discharged. The system uses programmable controllers to control the sequence of operations. No operator interaction is needed to add chemicals, time reactions or monitor results. Major components of the mainframe unit include reaction tank, system pump with piping and valves, filter bag manifold, control panel, reagent pumps, air regulator and filter.

Write in 700
What's New

from page 50

Separator removes free product

Carbtrol Corp., Westport, Conn., expands their line of oil water separators to remove free product from contaminated groundwater. Modular units to 190 liters per minute provide free oil removal to less than 10 ppm.

Meter measures oil on groundwater

GeoGuard of Medina, N.Y., offers an electronic oil/water interface meter to measure the thickness of floating product above the water table. It also measures DNAPLs with stainless steel tape conductors up to 60 meters long.

Sensors never sleep

Mil-Ram Technology Inc., San Jose, Calif., offers chemically selective sensors that do not react with air, are insensitive to changes in temperature, humidity or pressure, and stay awake even in the absence of gas. Recovery is less than 15 seconds even when exposed to high gas levels. Each factory battery charge offers over two years of maintenance free life, says the company.

Measure liquids with ultrasound

Flowline, of Seal Beach, Calif., offers a new alphasonic contact level transmitter that uses ultrasonic technology to measure relatively clean, non-coating or scaling liquids up to 3 meters. Compact size is suited for small tanks or restricted environments.

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New vitrification method makes glass

Developers plan to apply vitrification to solid wastes

A new waste conversion technology for treating solid wastes will soon be available commercially through a startup company, Integrated Environmental Technologies, which has established a technology research center in Richland, Wash.

The new technology, known as the controlled plasma glassification process, differs significantly from any plasma technology on the market. The process was developed jointly by Jeffrey Surma, a Pacific Northwest National Laboratory researcher and two independent consultants—Daniel Cohn, a research scientist at the Massachusetts Institute of Technology, and Charles Titus, a private consultant and electrical engineer. The Pacific Northwest National Laboratory is operated by Battelle, of Columbus, Ohio, for the U.S. Department of Energy.

The process uses electrically conductive gas, or plasma, to vitrify waste to the point that it becomes molten. The resulting material—a solid glass or metal material—prevents any contaminants from leaching into the environment.

The technology is well-suited to tackle most solid waste streams, including hazardous, medical, radioactive, mixed industrial and municipal solid waste. The controlled plasma glassification can reliably process higher volumes of waste in a relatively small unit while reducing environmental impacts. The process virtually eliminates the hazardous emissions associated with incineration. Because all solid byproducts are converted to a glass-like product or a usable metal, the process does not have a secondary disposal problem. The byproduct is very durable and possibly could be recycled for other uses, such as construction materials. The process recovers energy from treated waste material. A commercial prototype to demonstrate the technology is expected in the spring of 1997. Larry Dinkin, president of IET, indicates that the company is exploring alliances and partnerships with companies in the waste treatment field.

Write in 720

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