METCO ENVIRONMENTAL, INC.

PROVIDING REMEDIATION OF CONTAMINATED SOIL AND DEVELOPING SAFE, ECONOMICAL ANSWERS TO TODAY'S ENVIRONMENTAL PROBLEMS

The METCO Group, building on twenty years of experience, can offer the professional services you need to deal with your environmental problems. METCO's soil remediation equipment employs patented technology, using its radiant thermal process, to remove hydrocarbons and destroy many other organic pollutants from soil. We can remediate your soil on site with portable plants capable of production up to 150 tons per hour, or your soil can be treated at our stationary facilities in Maryland.

Specializing in remediation of petroleum contaminated soil, METCO can offer a reasonable alternative to accepting the financial liability which can continue to exist after landfiling your contaminated soils. We can safely accept your soil at our enclosed and permitted facilities for thermal remediation. Our price can compete with other less desirable methods of disposal and eliminate the associated risks. METCO's performance can be bonded and certificates of destruction are available from our process. For information and pricing of our services contact us at (301) 729 - 6922 or FAX (301) 729 - 0118.

Write in 193
A PROBLEM SOIL?
GRR! HAS
THE SOLUTION.

Recycle Your Soil!
as a raw material in the manufacture of
GIANT CEMENT

Through our patented Tigrr! process, GIANT Resource Recovery has removed the contaminants from and recycled over 60,000 tons of soil. All of the solid siliceous residue from the process was then used as part of the raw material for GIANT's cement production in a facility that meets RCRA standards.

- Improved waste management with NO LIABILITY
- Positive public perception of recycling
- No more dependence on landfills
- Protection of the environment

We turn a liability — waste — into an asset that replaces sand in our manufacturing process. Call us today at 1-800-786-0477 for an information packet.

Giant Resource Recovery Company
Highway 453 / Post Office Box 352
Harleyville, South Carolina 29448
(803) 496-7676 / (800) 786-0477

Giant Cement Company
Highway 453 / Post Office Box 218
Harleyville, South Carolina 29448
(803) 496-7880 / (800) 845-1174

GIANT GROUP, LTD.
Post Office Box 218
Harleyville, South Carolina 29448
(803) 496-7880

Keystone Cement Company
7311 Airport Road / Drawer A
Bath, Pennsylvania 18014-0058
(215) 837-1881 / (800) 255-5736

Write in 130
Features

6 What happened to the consulting market?
Sales were up, but it was the smallest increase in a decade

8 Save test dollars using TCLP alternative
Total constituent analysis can reduce testing expenses
By Dwayne L. Conrad and W.R. Deever, Ph.D.

14 Concrete solution to solidify soil problems
How petroleum contaminated soil performs in concrete
By A. Samer Ezeldin, David Vaccari, Lauren Bradford, Samuel Dilcer, Emad Farouz and Robert Mueller

20 How to predict biodegradation rates
It is possible to use bench-scale results to predict rates
By H.F. Stroo, Ph.D., H.K. Anderson and J.R. Smith, Ph.D.

26 Tank closure: the players and their roles
How to draw a winning hand
By Cheryl A. Kehres-Dietrich and Brian F. Burke

30 Firm powers thermal unit with landfill waste methane gas
Thermal unit reaches 1800°F to convert contaminants
By Douglas E. Lierle

Departments
39 What's new
46 Advertiser Index

Here's How It Works page 42

Here's How It Works
41 IS Robotics T-I Robot
42 MDA Scientific Sensor
44 Solvent Extraction

Cover: This issue features articles about consulting and engineering in the industry as well as the popular feature, Here's How It Works. Cover design by Keith Kavanaugh.

Soils magazine is published nine times per year by Group III Communications, Inc., 10229 E. Independence Ave., Independence, Missouri, 64053. Phone: 816-254-8735; FAX: 816-254-2128. Entire contents copyright 1992 by Group III Communications, Inc. All rights reserved. Opinions expressed by writers in Soils magazine are not necessarily those held by the publisher. SUBSCRIPTIONS: Soils magazine is mailed to companies with hydrocarbon storage liabilities and regulatory people. U.S. subscriptions: $24 a year. Outside U.S.: $40 a year. U.S. funds only.
It's 11:00 p.m.

Do You Know Where Your Contaminated Soil Is?

You'd better — because even after it's hauled off, you're still responsible (regardless of how much you paid). When your soil was removed, did you solve your problem or just transfer it? Was it processed to State Clean Fill Standards or was it mixed into other products? Did you entrust it to someone that might not be in business tomorrow?

If you can't answer these questions, it could be later than you think.

We're TPS Technologies Inc., the nation's leader in thermal recycling of petroleum-contaminated soils. We'll virtually eliminate your liability by remediating your soil at one of our state-of-the-art Soil Recycling Centers. In fact, we guarantee your recycled soil will meet or exceed State regulatory cleanup standards.

So don't stay up late worrying about your petroleum-contaminated soil (or when it might come back to haunt you!). Call or write today.

Our Soil Recycling Centers located throughout the U.S. ensure contaminants never reach the surrounding environment.

TPS Technologies Inc.

2070 South Orange Blossom Trail
Apopka, Florida 32703
(407) 886-2000  Toll free: (800) 940-2666
Fax: (407) 886-8300

A subsidiary of Thermo Process Systems Inc. and Thermo Electron Corporation

Write in 199
In 1991, environmental consulting firms finally began to feel the crunch of the recession. According to a survey of 20 leading national firms, environmental billings increased a mere 15 percent last year, compared to rates of more than 25 percent for most of the previous decade.

Consultants are expected to feel further repercussions in 1992 as growth remains at 1991 levels or possibly falls further toward single digits, according to Farkas, Berkowitz & Co., a Washington, D.C. based management consulting firm.

The bright side of the coin, however, is that in the midst of substantial decline for many industries, the environmental consulting and engineering arena remains a vibrant, growing marketplace with estimated billings last year at just over $8 billion.

“I’ve never believed environmental consulting is a recession proof business, but it is a recession resistant one,” says Alan L. Farkas, director of the consulting company and a recognized expert on environmental markets.

Consulting firms have retained an economic edge, Farkas asserts, because the federal government has offset recessional decline in the industrial and municipal sectors.

For instance, in the Northeast and California, where economic troubles have caused the most damage, environmental consulting firms were not affected as adversely as their industrial counterparts. When industrial firms delayed major environmental expenditures to stay afloat and tight city budgets constrained spending on wastewater and water supply projects, many consulting firms found relief in abundant federal contracts. Of particular increase were jobs relating to assessment and engineering studies for cleanup of contaminated department of defense sites.

In order to better understand the big picture for 1991, Farkas, Berkowitz estimated individual market sizes and growth rates for environmental consulting and engineering firms.

Consulting related to hazardous waste, for example, grew 20 percent, while water quality consulting and engineering revenues grew at less than five percent. Air quality consulting and monitoring was the fastest growing market with a 30 percent increase.

The firms that prospered the most from growth in the air quality market were those that maintained a strong air quality practice over the years. Firms venturing into the market in 1991 with new programs had a more difficult time, according to Farkas.

The leading firms in the field, he noted, envision continued and accelerated growth in 1992 and in subsequent years as industries apply for permits under the new Clean Air Act Amendments of 1990. Additionally, the Environmental Protection Agency (EPA) is expected to spend $100 million in 1992 on consulting assistance to develop new regulatory programs in this area.

Farkas predicts that new regulations under the Resource Conservation and Recovery Act (RCRA) Subtitle D which were promulgated last September, should drive the solid waste market over the next few years. More specifically, landfill upgrade and closure work should accelerate. As in 1991, however, tight municipal budgets may again constrain the growth of this consulting market. Spending cuts at the city level pulled growth levels down to ten to 15
percent last year, from a rate of over 35 percent in 1990. RCRA regulations for corrective actions also are expected to create continued strong demand for contaminant site assessment and feasibility studies in 1992.

Overall, however, environmental consulting firms should prepare for another slow growth year. As in 1991, profitability may again be depressed, explains Farkas.

<table>
<thead>
<tr>
<th>FIELD</th>
<th>MARKETS</th>
<th>1991 MARKET SIZE ($ MILLIONS)</th>
<th>1991 GROWTH RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous Waste</td>
<td>Federal and Industrial</td>
<td>4,000</td>
<td>20%</td>
</tr>
<tr>
<td>Water Quality</td>
<td>Primarily Municipal</td>
<td>3,000</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>Air</td>
<td>Industrial and EPA</td>
<td>600</td>
<td>30%</td>
</tr>
<tr>
<td>Solid Waste</td>
<td>Municipal and Industrial</td>
<td>600</td>
<td>10-15%</td>
</tr>
<tr>
<td>Analytical Services</td>
<td>Diverse</td>
<td>850</td>
<td>5-10%</td>
</tr>
</tbody>
</table>


"Only the best managed firms were able to realize operating margins above 12 percent in 1991," he asserts. The Farkas, Berkowitz index of 11 publicly-traded environmental consulting firms shows a composite operating profit margin of only 2 percent for the second and third quarter of 1991. Three firms in that index reported substantial losses for the period.

Farkas foresees that profitability will increasingly require a more thoughtful approach to strategy, better focused marketing and sales and greater attention to cost control. "The industrial buyer has become more sophisticated by selecting the best firms for national contracts, and by using volume procurements to drive hard bargains in terms of billing rates and terms and conditions," he explains. "In addition to industrial pricing pressures, the growing importance of the federal market and its historic price sensitivity places a premium on strong project management and cost control," he says.

Among industry trends for 1991, Farkas observed a reduction in the pace of diversification among engineering firms. He attributes this slowdown to losses incurred in the 1980s when consulting firms diversified into analytical lab services. This market has been very poor in recent years, Farkas explains. In 1991, analytical services grew 5 to 10 percent to approximately an $850 million market.

Another trend, Farkas points out, is the increased move of American firms into markets abroad. Foreign enterprises, he claims, have not been profitable for U.S. consulting firms, at least not yet. The central target for expansion, Europe, has some vibrant markets but overall is in the throes of its own recession.

To beat the recession, Farkas says environmental consulting firms may begin to position themselves to consult in areas outside the environmental arena.

Write in 532 for more information
Save test dollars using TCLP alternative

Total constituent analysis can reduce testing expenses

By Dwayne L. Conrad and W.R. Deever, Ph.D.

Getting the most information about a site or a waste material at the least cost, while still satisfying regulatory constraints, is the primary objective of essentially all environmental project sampling plans. The extent of a problem and, therefore, the appropriate disposal or remediation options are defined by the results of test performed on those samples. Analytical costs are frequently a significant portion of the project budget. Anyone who has had samples tested for the Toxicity Characteristic Leaching Procedure (TCLP) constituents knows that the cost for this complex analysis can exceed $1,000 per sample. However, the total constituent analysis can be used to screen samples less expensively.

The TCLP is one of the Resource Conservation and Recovery Act (RCRA) hazardous characteristics analyses designated by the U.S. Environmental Protection Agency (EPA) to determine if a waste material is hazardous. If any of the 39 regulated constituents are detected in the waste extract at concentrations which exceed the limits specified by the EPA, the waste material is considered to be a hazardous waste. The TCLP is published in 40 CFR 261.24, Appendix II—Method 1311 Toxicity Characteristic Leaching Procedure.

In paragraph 1.0, Scope and Application, it states that, “If a total analysis of the waste demonstrates that individual contaminants are not present in the waste, or that they are present, but at such low concentrations that the appropriate regulatory thresholds could not possibly be exceeded, the TCLP need not be run.” It is this paragraph that allows the analysis of the total constituent content to be used as an indicator for the TCLP. It can therefore save time and money to understand the theoretical relationship between total and TCLP constituent analyses.

A waste that is to be analyzed by the TCLP must first be subjected to a preliminary evaluation in the laboratory. During this evaluation, the analyst determines, among other parameters, the percent solids of the sample. Two types of percent solids are calculated: the percent dry solids and percent wet solids. In the published TCLP procedure, the percent wet solids is actually referred to simply as the percent solids. For clarity in this discussion, the terms percent dry and percent wet solids will be used.

The percent dry solids content is calculated from the mass of the filtered, oven-dried residue of the sample. It is used to determine whether the solid phase of the sample must be extracted or not. The percent wet solids content is based on the mass of the solid residue remaining after the sample is filtered under pressure. The residue is not oven-dried. The percent wet solids content is used to calculate the mass of extraction fluid to be used in the TCLP. The mass ratio of extraction fluid to the wet solids is 20 to one by weight.

Once the preliminary evaluation of the waste is completed, a subsample of the waste is subjected to the TCLP. The extraction equipment required to handle a sample to be analyzed for volatile organics is different from that used for metals, semivolatile organics, pesticides and herbicides. However, the mass ratio of extraction fluid to the wet solids is the same for each type of extraction.

If the sample is a liquid containing less than .5 percent dry solids, then the TCLP consists of filtering the sample and the filtrate is the TCLP extract. If a waste is a liquid/solid mixture containing greater than or equal to .5 percent dry solids, the solid and liquid phases must be separated by filtration. The solid phase is extracted with the appropriate extraction fluid. The initial filtrate and the final extract are combined to create the TCLP extract. A sample which yields no free liquid when subjected to the filtration step is consickered to consist of 100 percent wet solids for the purpose of the analysis. Therefore, the entire sample is extracted with the appropriate extraction fluid. After extraction, the fluid phase is filtered to provide the TCLP extract. The TCLP extract is then analyzed for the required inorganic or organic constituents.

In theory, there is a minimum total concentration which must be present in a waste if that waste is to exceed the TCLP concentration for a given constituent. For this to apply, it is assumed that all of the constituent will go into solution when the sample is subjected to the TCLP analysis. In reality, this is a conservative assumption. It is highly unlikely that the conditions of the TCLP are severe enough to extract 100 percent of the TCLP components from the waste. Also, some losses of volatile compounds may occur during the TCLP analysis in spite of the use of the Zero Headspace Extractor.

While in the planning stage of an environmental investigation, it may be feasible to minimize the quantity of TCLP analyses by substituting a total analysis for the appropriate compounds. If the total analysis results in constituent concentrations which are below the theoretical minimum levels, then the waste would not fail the TCLP. To take advantage of this, it is

Dwayne L. Conrad is senior project chemical engineer and W. R. Deever, Ph.D. is senior staff chemist for Texaco, Inc. Research & Development, Port Arthur, Texas.

8 April 1992 Soils
also necessary to obtain analyses for the percent wet solids and the percent dry solids of the waste. These tests can be provided by any laboratory capable of performing the TCLP analysis. The relationship between the total constituent analysis, the TCLP extract concentration and the percent wet solids is illustrated graphically for benzene in Figure 1, above. This relationship takes into account the various dilutions of the target compounds which will occur for a given waste consistency.

To understand how this relationship can be applied, consider these three samples of waste material:

Sample A is an aqueous liquid containing no significant suspended solids. Sample A has less than .5 percent dry solids as determined in the preliminary evaluation. As a result, Sample A is simply filtered through the appropriate filtration apparatus to provide the TCLP extract. It is only necessary to filter enough of the extract to perform the desired analyses.

Sample B is a relatively dry solid. In the preliminary waste evaluation, Sample B yielded no free liquid. Sample B is extracted for approximately 18 hours with the appropriate extraction fluid and then filtered to provide the TCLP extract. The volume of extraction fluid needed for the extraction is calculated from the percent wet solids determined in the preliminary evaluation of the waste. For Sample B, this would be 100 percent wet solids. If 25 grams of Sample B is extracted, then 500 grams of

Continues on page 10

What is it, and where did it come from?

Someday you may be asked to clean up someone else’s spill.

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

Friedman & Bruya, Inc. are experts in the identification and fingerprinting of petroleum products. There are simple, inexpensive tests that can be run to provide information that can be used next year or the year after to figure out just what was present and where it came from.

Call 1 - (800) 487-8231 for more information.

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Petroleum Product Identifications
Expert Witnesses • Soil and Water Testing

Write in 055

April 1992 Soils 9
Save test dollars, from page 9

extraction fluid was used. The solids are separated from the extract by filtration. As with Sample A, it is necessary to only filter enough of the extract to perform the desired analyses.

Sample C is a liquid/solid mixture. Sample C contains much more than .5 percent dry solids. The percent wet solids was determined to be 50 percent by weight. The TCLP would begin with the separation of the liquid phase from the solid phase by pressure filtration. To provide 25 grams of wet solids for the extraction, it is necessary to filter 50 grams of the waste sample. The liquid phase is then stored for later use. The 25 grams of the solid phase must be extracted with 500 grams of extraction fluid. After the extraction, the extracted solids are separated from the extract by filtration. The entire volume of extract, approximately 500 grams, is then combined with the 25 gram liquid phase which has been stored during the test. This yields 525 grams of TCLP extract.

In the case of Sample A, the theoretical total benzene concentration present in the original waste which would equal or exceed the TCLP limit would have to be at least .5 mg/L, since no dilution by the extraction fluid occurred. It is assumed here that the fluid specific gravity is 1.0. Therefore, a concentration of .5 mg/L is equivalent to .5 mg/kg of the waste. Note that the position of Sample A on Figure 1 would be at the left end of the line at the coordinates equal to .5 mg/kg and zero percent wet solids content.

In Figure 1, Sample B would be located at the right end of the line. To yield a TCLP extract concentration of at least .5 mg/L, the benzene content in the original waste sample would theoretically have to be 10 mg/kg. A 25 gram sample of B would contain .025 kg by 10 mg/kg, or .25 mg of benzene. If all this benzene were extracted by 500 mg of extraction fluid, the final TCLP extract concentration would indeed be .5 mg/L.

To exceed the TCLP benzene limit of .5 mg/L, Sample C must contain at least .5 mg/L by .525 L extract per .05 kg waste, or 5.2 mg/kg. The position of Sample C is also shown on Figure 1.

The linear relationship between total constituent concentration in mg/kg and the percent wet solids exists for all 39 of the TCLP compounds. This relationship can be reduced to a simple formula which can be used to calculate one of the two factors if the other is known or assumed. That formula is:

\[
TCC = \left(19 \times LIM \times \%WS + LIM\right) \times C \times 100
\]

where TCC=total constituent concentration, mg/kg of waste, LIM=the TCLP limit for the compound of interest, mg/L, %WS=percent wet solids determined in the TCLP preliminary evaluation of the waste, percent by weight, C=conversion factor to change concentration in mg/L to weight fraction, one L/kg of extract.

The data listed in Figure 2, page 11, was calculated for
### Fig. 2: THEORETICAL RELATIONSHIP BETWEEN TCLP AND TOTAL CONCENTRATIONS

<table>
<thead>
<tr>
<th>TCLP CONSTITUENT</th>
<th>TCLP LIMIT (MG/L)</th>
<th>TOTAL CONCENTRATION, MG/KG (WHICH COULD YIELD HAZARDOUS TCLP CONCENTRATION)</th>
<th>(LIQUID)</th>
<th>% WET SOLIDS</th>
<th>(SOLID)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100%</td>
</tr>
<tr>
<td>ARSENIC</td>
<td>5.0</td>
<td>5.0</td>
<td>28.8</td>
<td>55.5</td>
<td>76.3</td>
</tr>
<tr>
<td>BARIUM</td>
<td>100.0</td>
<td>100.0</td>
<td>575.0</td>
<td>1060.0</td>
<td>1525.0</td>
</tr>
<tr>
<td>BENZENE</td>
<td>0.5</td>
<td>0.5</td>
<td>2.9</td>
<td>5.3</td>
<td>7.6</td>
</tr>
<tr>
<td>CADMIUM</td>
<td>1.0</td>
<td>1.0</td>
<td>5.8</td>
<td>10.5</td>
<td>15.3</td>
</tr>
<tr>
<td>CARBON TETRACHLORIDE</td>
<td>0.5</td>
<td>0.5</td>
<td>2.9</td>
<td>5.3</td>
<td>7.6</td>
</tr>
<tr>
<td>CHLORODANE</td>
<td>0.03</td>
<td>0.03</td>
<td>0.17</td>
<td>0.31</td>
<td>0.46</td>
</tr>
<tr>
<td>CHLOROBENZENE</td>
<td>100.0</td>
<td>100.0</td>
<td>575.0</td>
<td>1060.0</td>
<td>1525.0</td>
</tr>
<tr>
<td>CHLOROFORM</td>
<td>6.0</td>
<td>6.0</td>
<td>34.5</td>
<td>63.0</td>
<td>91.5</td>
</tr>
<tr>
<td>CHROMIUM</td>
<td>5.0</td>
<td>5.0</td>
<td>28.8</td>
<td>57.5</td>
<td>76.3</td>
</tr>
<tr>
<td>o,m-p CRESOL</td>
<td>2000.0</td>
<td>2000.0</td>
<td>1150.0</td>
<td>2100.0</td>
<td>3050.0</td>
</tr>
<tr>
<td>2,4-D</td>
<td>10.0</td>
<td>10.0</td>
<td>57.5</td>
<td>105.0</td>
<td>152.5</td>
</tr>
<tr>
<td>1,4-DICHLOROBENZENE</td>
<td>7.5</td>
<td>7.5</td>
<td>43.1</td>
<td>78.6</td>
<td>114.4</td>
</tr>
<tr>
<td>1,2-DICHLOROETHANE</td>
<td>0.5</td>
<td>0.5</td>
<td>2.9</td>
<td>5.3</td>
<td>7.6</td>
</tr>
<tr>
<td>1,1-DICHLOROETHYLENE</td>
<td>0.7</td>
<td>0.7</td>
<td>4.0</td>
<td>7.4</td>
<td>10.7</td>
</tr>
<tr>
<td>2,4-DINITROTOUENE</td>
<td>0.13</td>
<td>0.13</td>
<td>0.75</td>
<td>1.37</td>
<td>1.98</td>
</tr>
<tr>
<td>ENDRIN</td>
<td>0.02</td>
<td>0.02</td>
<td>0.12</td>
<td>0.21</td>
<td>0.31</td>
</tr>
<tr>
<td>HEPTACHLOR</td>
<td>0.006</td>
<td>0.006</td>
<td>0.045</td>
<td>0.084</td>
<td>0.122</td>
</tr>
<tr>
<td>HEXACHLOROBENZENE</td>
<td>0.13</td>
<td>0.13</td>
<td>0.75</td>
<td>1.37</td>
<td>1.98</td>
</tr>
<tr>
<td>HEXACHLORODIENE</td>
<td>0.5</td>
<td>0.5</td>
<td>2.9</td>
<td>5.3</td>
<td>7.6</td>
</tr>
<tr>
<td>HEXACHLOROTHANE</td>
<td>3.0</td>
<td>3.0</td>
<td>17.3</td>
<td>31.5</td>
<td>45.8</td>
</tr>
<tr>
<td>LEAD</td>
<td>5.0</td>
<td>5.0</td>
<td>28.8</td>
<td>56.5</td>
<td>76.3</td>
</tr>
<tr>
<td>MERCURY</td>
<td>0.2</td>
<td>0.2</td>
<td>1.2</td>
<td>2.1</td>
<td>3.1</td>
</tr>
<tr>
<td>METHYL ETHYL KETONE</td>
<td>200.0</td>
<td>200.0</td>
<td>1150.0</td>
<td>2100.0</td>
<td>3050.0</td>
</tr>
<tr>
<td>NITROBENZENE</td>
<td>2.0</td>
<td>2.0</td>
<td>11.5</td>
<td>21.0</td>
<td>30.5</td>
</tr>
<tr>
<td>PENTACHLOROPHENOL</td>
<td>100.0</td>
<td>100.0</td>
<td>575.0</td>
<td>1060.0</td>
<td>1525.0</td>
</tr>
<tr>
<td>SELENIUM</td>
<td>1.0</td>
<td>1.0</td>
<td>5.8</td>
<td>10.5</td>
<td>15.3</td>
</tr>
<tr>
<td>SILVER</td>
<td>5.0</td>
<td>5.0</td>
<td>28.8</td>
<td>56.5</td>
<td>76.3</td>
</tr>
<tr>
<td>TETRACHLOROETHYLENE</td>
<td>0.7</td>
<td>0.7</td>
<td>4.0</td>
<td>7.4</td>
<td>10.7</td>
</tr>
<tr>
<td>TOXAPHENE</td>
<td>0.5</td>
<td>0.5</td>
<td>2.9</td>
<td>5.3</td>
<td>7.6</td>
</tr>
<tr>
<td>TRICHLOROETHYLENE</td>
<td>0.5</td>
<td>0.5</td>
<td>2.9</td>
<td>5.3</td>
<td>7.6</td>
</tr>
<tr>
<td>2,4,5-TRICHLOROPHENOL</td>
<td>400.0</td>
<td>400.0</td>
<td>2300.0</td>
<td>4200.0</td>
<td>6100.0</td>
</tr>
<tr>
<td>2,4,6-TRICHLOROPHENOL</td>
<td>2.0</td>
<td>2.0</td>
<td>11.5</td>
<td>21.0</td>
<td>30.5</td>
</tr>
<tr>
<td>VINYL CHLORIDE</td>
<td>0.2</td>
<td>0.2</td>
<td>1.2</td>
<td>2.1</td>
<td>3.1</td>
</tr>
</tbody>
</table>

---

**Soil Reclamation—safe and economical with Midland Portable Cold Mix Plant**

**FAST ON THE JOB...**

- Contaminated Soils
- Cold Mix Asphalt
- Cold Recycling
- Blend 2 Aggregates
- Soil Stabilization

**Featuring**
- All Hydrostatic Drives
- Rugged Tubular Frame
- 200-700 Tons Per Hour

**FAST TO THE JOB...**

Making both large jobs and small jobs more profitable!

Call Today 1-800-2 GET-MMC
(800)243-8662

"The most portable pugmill available anywhere."

MIDLAND MACHINERY CO., INC.
101 Cranbrook Ext., Tonawanda, NY, USA 14150

Write in 081

April 1992 Soils 11
O2/CO2 Respirometer for Measuring Bacteria and Fungus Growth

The micro-Oxymax O2/CO2 Respirometer is equipped with O2 and CO2 sensors which monitor "head space" gas exchange produced by bacterial or fungal contamination in solids or liquids. Operates with 1 to 20 measuring chambers (supplied or user's own chambers) with volumes ranging from 50mL to 50L. Max. sensitivity is 0.2μL/hr. Fully automatic 24 hr. operation with periodic printouts under IBM-PC computer control. Applications are in monitoring aflatoxin contamination in grains, bacterial contamination in food, biodegradation of pollutants in water and soil, fermentation, etc.

Columbus Instruments
POST OFFICE BOX 44049
PH: (614) 276-0861 Toll Free: 1-800-669-5011
Fax: (614) 276-0529 TLX: 246514

Save test dollars, from page 11

TCLP constituents using the formula and assuming five different concentrations for percent wet solids. This formula could also be used to construct a plot similar to Figure 1 for any of the constituents.

The cost savings realized by using a total analysis rather than a TCLP depend on the constituents for which the waste samples are to be analyzed. The difference in costs between the two analyses is associated with the TCLP extraction step. Several commercial laboratories were surveyed to

Fig. 3 AVERAGE ANALYTICAL COSTS FOR TCLP AND TOTAL CONSTITUENT TEST

<table>
<thead>
<tr>
<th>ANALYSIS (EPA TEST METHOD)</th>
<th>AQUEOUS MATRIX</th>
<th>SOLID MATRIX</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCLP EXTRATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1311 FOR VOL.ORG.)</td>
<td>$88</td>
<td>$162</td>
</tr>
<tr>
<td>(1311 FOR SEMIVOL.)</td>
<td>$55</td>
<td>$129</td>
</tr>
<tr>
<td>TCLP VOLATILE ORGANICS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8240)</td>
<td>$263</td>
<td>NA</td>
</tr>
<tr>
<td>TCLP SEMIVOLATILES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8270)</td>
<td>$479</td>
<td>NA</td>
</tr>
<tr>
<td>TCLP PESTICIDES/HERBICIDES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6080 / 8150)</td>
<td>$415</td>
<td>NA</td>
</tr>
<tr>
<td>TCLP METALS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6010 / 7040 / 7471)</td>
<td>$173</td>
<td>NA</td>
</tr>
<tr>
<td>% WET SOLIDS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1311)</td>
<td>$15</td>
<td>$16</td>
</tr>
<tr>
<td>% DRY SOLIDS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1311)</td>
<td>$24</td>
<td>$24</td>
</tr>
<tr>
<td>VOLATILE ORGANICS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8200)</td>
<td>$131</td>
<td>$146</td>
</tr>
<tr>
<td>(8240)</td>
<td>$269</td>
<td>$301</td>
</tr>
<tr>
<td>BTEX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8020)</td>
<td>$103</td>
<td>$106</td>
</tr>
<tr>
<td>ICP DIGESTION FOR METALS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3050)</td>
<td>$14</td>
<td>$16</td>
</tr>
<tr>
<td>INDIVIDUAL METALS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(200.7 / 6010)</td>
<td>$12</td>
<td>$13</td>
</tr>
<tr>
<td>MERCURY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(245.1 / 7471)</td>
<td>$32</td>
<td>$35</td>
</tr>
</tbody>
</table>

determine average costs for each of the analyses. These costs are shown in Figure 3, above. Since the metals analyses are less expensive in comparison to the volatile and semivolatile organics species, the relative savings are greater. It is likely that the percent dry solids and percent wet solids determinations for a relatively dry solid waste or soil sample could be eliminated, enhancing the cost savings. Liquid samples which do not require extraction in the TCLP would not lower the cost of the environmental investigation. Of course, the laboratory must be able to provide analytical detection limits for all the compounds of interest at or below the theoretically hazardous total concentrations.

The objective of the project sampling plan can influence the decision to use the total constituent analysis for screening samples. For example, assume that a refinery is in the process of closing a former oily waste impoundment area. It is necessary to collect a large number of sludge samples to delineate potential benzene and lead hot spots. If 50 samples are collected and each analyzed for total benzene, total lead and percent wet solids (assuming percent
<table>
<thead>
<tr>
<th>TEST</th>
<th>UNIT COST</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCLP ZHE EXTRACTION FOR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VOLATILES, SOLID MATRIX</td>
<td>$162</td>
<td>$8,088</td>
</tr>
<tr>
<td>TCLP EXTRACTION FOR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>METALS, SOLID MATRIX</td>
<td>$129</td>
<td>$6,438</td>
</tr>
<tr>
<td>TCLP VOLATILES ANALYSIS</td>
<td>$263</td>
<td>$13,150</td>
</tr>
<tr>
<td>TCLP METALS ANALYSIS</td>
<td>$173</td>
<td>$8,650</td>
</tr>
</tbody>
</table>

**TOTAL COST, NOT DISCOUNTED FOR VOLUME**  $36,325

**TOTAL COST, DISCOUNT 10% FOR VOLUME**  $32,693

| % WET SOLIDS                              | $15       | $763       |
| TOTAL BENZENE (BTEX ANALYSIS),            |           |            |
| SOLID MATRIX                              | $106      | $5,300     |
| ICP DIGESTION FOR METALS,                 |           |            |
| SOLID MATRIX                              | $16       | $813       |
| LEAD ANALYSIS                             | $13       | $650       |

**TOTAL COST, NOT DISCOUNTED FOR VOLUME**  $7,525

**TOTAL COST, DISCOUNT 10% FOR VOLUME**  $6,773

| SAVINGS, BASED ON LIST PRICES             | $28,800   |
| SAVINGS, BASED ON DISCOUNTED PRICES       | $25,920   |

dry solids is greater than .5), rather than the respective TCLP concentrations, a savings of $26,000 to $29,000 would result. That savings could be applied to additional sampling and TCLP analyses in the hot spots that theoretically exceed the TCLP limit. A worksheet for such a case is shown in Figure 4, above.

Given the sample loads that many commercial laboratories must handle, it may not be feasible to piggyback the total and TCLP analyses using the same samples. The EPA recommended sample holding times for volatile and semivolatile organics analyses, from collection to total analysis or TCLP extraction, is 14 days. Getting the results of total constituent analyses in time to follow up with TCLP analyses, if necessary, may not be practical. On the other hand, rush handling by the laboratory adds to the cost of a project. Therefore, the sampling plan should be flexible enough to allow for the collection of more samples when the need is indicated by the total constituent results. A sampling plan which is developed primarily for metals contamination will not be hampered due to the longer recommended sample holding times. The sample holding time for metals analyses, excluding mercury, is 180 days. The holding time for mercury analysis is 28 days.

In conclusion, the cost of conducting an environmental investigation can be reduced by minimizing or eliminating the TCLP test in the sampling plan. In many cases, the sampling plan can be structured to use a more cost-effective total analysis for screening samples. A total constituent analysis provides sufficient information to indicate if the waste being sampled can theoretically exceed the limits for the TCLP.
Concrete solution to solidify soil problems

How petroleum contaminated soil performs in concrete mixtures

By A. Samer Ezeldin, David Vaccari, Lauren Bradford, Samuel Dilcer, Emad Farouz, and Robert Mueller

With the projected volumes of contaminated soils, researchers are exploring re-use options such as stabilization and solidification in concrete. But it is important to determine how the addition of petroleum contaminated soil (PCS) affects the performance of concrete.

Traditional soil remediation programs such as incineration, bioremediation and chemical treatments usually leave contaminant residues in soils. Current final disposal of petroleum contaminated soils with low concentration or residue contaminants is usually by means of secure, shallow land burial.

Even a trace indication of subsurface VOC contamination can be the tip of a liability or groundwater contamination iceberg. That makes Enviroscan's unique soil gas testing service critical to you and your clients.

Get to more places.
Enviroscan's 4-wheel drive van is equipped with a specially designed probe driving unit. A one-man crew can take 15 to 20 gas samples a day - many more than is possible with manual probes. That means better quality samples, more samples per field day, and more quality data per project dollar. Analytical results can be available in as little as 48 hours.

Get to lower detection.
Enviroscan soil gas analysis is carried out to lower levels of detection than is offered by field-based instrumentation. Samples are collected in adsorption tubes and processed through a special thermal desorption/gas chromatograph system. It's done under controlled laboratory conditions by qualified chemists following stringent QC procedures for the most accurate, sensitive and reliable analysis available.

Get to more VOCs.
In addition to an analysis that detects contaminants down to sub-parts per billion, Enviroscan can also check for a much broader range of sub-surface VOCs. Something most portable or field units just can't do.

No one can afford the potential cost of undetected sub-surface contamination. So if you want to get the most from your preliminary site investigation dollar, ask about our soil gas testing services. Just call 1/800-338-7226 (SCAN) or FAX 715/355-3221.

ENVIRONMENTAL AND ANALYTICAL SERVICES
Enviroscan
303 West Military Road
Rothschild, WI 54474

Write in 086
Research shows that large amounts of industrial wastes could be recycled in concrete as a substitute for cement materials or aggregates. Waste stabilization by adding cement or fly ash is an emerging solution.

Stabilization is functionally described in terms of three properties of the final product, namely: mechanical stabilization, immobilization by fixation and immobilization by isolation. These three characteristics are usually

<table>
<thead>
<tr>
<th>Soil Classification</th>
<th>Moisture Content %</th>
<th>Type of Contaminant</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well graded sand</td>
<td>7.3</td>
<td>Heating oil</td>
<td>0.11% by weight</td>
</tr>
<tr>
<td>Clay-silt</td>
<td>14.3</td>
<td>Heating oil</td>
<td>0.12% by weight</td>
</tr>
<tr>
<td>Silty sand</td>
<td>24.7</td>
<td>Heating oil</td>
<td>0.60% by weight</td>
</tr>
<tr>
<td>Poorly graded sand</td>
<td>14.4</td>
<td>Gasoline</td>
<td>25ppm</td>
</tr>
<tr>
<td>Silty clay</td>
<td>19.6</td>
<td>Gasoline</td>
<td>150ppm</td>
</tr>
</tbody>
</table>

Figure 1: Soils description

obtained with a well-designed hydraulic cement and/or fly ash stabilization process. The hardening binds and strengthens the mass, coats and incorporates some contaminant molecules in the siliceous solids and blocks channels between pores.

Experiments were conducted using Type III portland cement meeting ASTM C-150 standard specifications, fine aggregate of natural sand and coarse aggregate of 3/8-inch crushed stones. Five petroleum contaminated soil types, provided by the New Jersey Department of Environmental Protection (NJDEP) were used in the study. The soil classification, moisture content, contaminant type and contamination concentration are shown in Figure 1, above.

Soils were sieved through a #4 sieve to disregard any debris or large, unwanted particles. The Soxhlet oil and grease extraction method was used to determine the degree of oil contamination. Gasoline in the liquid and vapor phase was extracted by carbon disulfide and the sample injected into a gas chromatograph (GC). Based on the fluid content of the contaminated soil sample and the total areas of all the peaks from the GC, total gasoline content was determined.

A concrete control mixture with no petroleum contamination was used as a reference and had a compressive


tinue on page 16 ➔
Concrete solution, from page 15

After mixing, 3" x 6" and 4" x 8" cylindrical specimens were cast for compression tests.

For flexural tests, four- by 14-inch prisms were cast and two-inch prisms were made for durability tests. In order to conduct leachability tests, two-inch square cubes were cast. All the specimens were left at room temperature for 24 hours and demolded. Then they were immersed in water until testing—except the leachability cube specimens, which were left uncovered at room temperature.

Compression and flexural tests were conducted using a 250 kips capacity universal testing machine. The three- by six-inch compression cylinders were tested in duplicate at the early age of two days. The four- by eight-inch compression cylinders were tested in duplicate at age seven days. Tests were conducted in accordance with ASTM C-39. The four- by 14-inch prisms were tested after seven days according to ASTM C-78. (See Figure 2, left).

The durability tests consisted of freeze-thaw and wet-dry testing. Wet-dry testing was performed in accordance with ASTM D-559. It involved putting a two- by 10-inch prism through 12 wet-dry cycles. Each cycle was 48 hours long with six hours submerged in a water tank followed by 42 hours in an oven at 71°C. After each cycle, the prism was wire-brushed 25 times on all four sides. The freeze-thaw testing, performed according to ASTM D-560, put a two-by 10-inch prism through 12 freeze-thaw cycles. Each cycle was 48 hours—24 hours in a freezer at -10°C followed by 24 hours at 20°C room temperature. After each cycle, the prism was wire-brushed 25 times on all four sides. The durability tests started approximately 30 days after the concrete casting. The weights of all concrete prisms were taken before and after the completion of all 12 cycles.

After curing for 24 hours, to test leachability, the two-inch cubes were placed in 473 milliliter (mL) jars. The jars were filled with tap water which had been boiled and cooled to remove any volatile organics. The jars were

Figure 2: Experimental test results

Because the soils were obtained from disposal sites, some initial moisture could not be avoided. The initial moisture content for each soil was accounted for when adding water to the mixture. To achieve uniformity for all mixes, water was added to each mixture until a slump value of six inches, plus/minus one inch, was reached. This was more practical than drying the soil at room temperature or high temperature as this would have affected the contaminants concentration originally existing in each soil.

Soil and sand were dry mixed for one minute. Cement and two-thirds of control mix water were added and mixed for two minutes. Aggregate and water were added in increments and mixed for three minutes. Then the slump test was performed. More water was added (as needed) and mixed for three minutes before performing the slump test.

Figure 3: Effect of PCS/Sand ratio on setting time

MONITORING PIPE & ACCESSORIES FOR THE PETROLEUM, ENVIRONMENTAL & WATER WELL INDUSTRIES

<table>
<thead>
<tr>
<th>Mix</th>
<th>Design</th>
<th>Compressive Strength, psi</th>
<th>2 days</th>
<th>7 days</th>
<th>Flexural Strength, psi</th>
<th>7 days</th>
<th>Unit Weight (lb/ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>4950</td>
<td>6160</td>
<td>975</td>
<td>151.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1C1</td>
<td>4950</td>
<td>5669</td>
<td>975</td>
<td>152.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1C2</td>
<td>4950</td>
<td>5171</td>
<td>956</td>
<td>148.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1C3</td>
<td>4450</td>
<td>5370</td>
<td>843</td>
<td>146.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2C1</td>
<td>3258</td>
<td>5708</td>
<td>750</td>
<td>143.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2C2</td>
<td>2591</td>
<td>5171</td>
<td>731</td>
<td>141.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2C3</td>
<td>2124</td>
<td>3302</td>
<td>656</td>
<td>137.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3C1</td>
<td>3336</td>
<td>4579</td>
<td>693</td>
<td>144.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3C2</td>
<td>2404</td>
<td>3941</td>
<td>675</td>
<td>142.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3C3</td>
<td>2263</td>
<td>3503</td>
<td>687</td>
<td>138.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4C1</td>
<td>3395</td>
<td>4656</td>
<td>881</td>
<td>148.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4C2</td>
<td>3395</td>
<td>4419</td>
<td>788</td>
<td>149.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4C3</td>
<td>3283</td>
<td>4140</td>
<td>788</td>
<td>154.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5C1</td>
<td>2666</td>
<td>4628</td>
<td>693</td>
<td>151.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5C2</td>
<td>2826</td>
<td>4805</td>
<td>656</td>
<td>149.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5C3</td>
<td>2826</td>
<td>3819</td>
<td>637</td>
<td>148.6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Continues on page 18
SOIL REMEDIATION EQUIPMENT

TARMAC offers
customized plants and plant components

- Highly portable...Hercules plane transportable.
- 33 Ton/hr. Two-load portable plants...light oil remediation.
- 33 Ton/hr. Three-load portable plants...heavy oil remediation.
- 50-70 Ton/hr. Three-load portable plants...light oil remediation.
- 50-70 Ton/hr. Four-load portable plants...heavy oil remediation.
- 100-120 Ton/hr. Stationary plants...light oil remediation.
- 100-120 Ton/hr. Stationary plants...heavy oil remediation.

FAX to 816-228-0888

COMPONENTS & SERVICES
Check your requirements:

- Screening/Shredding/Crushing
- Material Feed
- Dryers/Kilns
- Oxidizers
- Baghouses
- Burners
- Heat Exchangers
- Controls
- Soil Conditioners
- Permit Compliance

NAME ________________________________
TITLE ________________________________
COMPANY ____________________________
ADDRESS ____________________________
CITY __________________ STATE ____ ZIP __
PHONE __________ FAX ________________

Original Equipment Manufacturer

TARMAC EQUIPMENT CO., INC. Soils Division

219 N. 7 Highway • Blue Springs, MO 64014

Write in 158

800-833-4383
Concrete solution, from page 16

capped with a Teflon lined closure. A small airspace remained in the jars. By keeping the volume of airspace less than five percent of the total water volume, the amount of required to cause a needle to penetrate one inch into the mortar. The initial and final setting times are defined as times at which the penetration resistances are 500 psi and 4,000 psi, respectively. It should be noted that these are arbitrary chosen values and do not indicate the strength of the initial and final setting times of concrete. The initial setting times appear to increase with the increase of PCS/sand ratio. The final setting time is found to be less affected by the increase of PCS/sand replacement ratio. For instance, at a PCS/sand replacement ratio of 40 percent, initial setting time increases by about 30 percent as compared to the control mix—while the final setting time increases by only 20 percent. A similar trend was observed for all five soil types in this investigation. It must be emphasized that during this experimental program, all concrete mixtures reached their final setting time well before removal of the specimens from the molds—usually within nine hours.

The effect of contaminant concentration can be seen in Figure 4, left. When comparing the setting time of Soil I (.11 percent contaminant concentration) to Soil III (.66 percent contaminant concentration) both the initial and final setting times are consistently greater for the soil with higher contamination concentration. This indicates that the inclusion of PCS and the contamination concentration affect the setting time of concrete. However, for the soil types included in this investigation and for the contamination levels used, this effect is not major. With a .66 percent contaminant concentration and a PCS/sand replacement ratio of 40

![Figure 4: Effect of contamination concentration on setting times](image)

volatilization could be detected. The jars were placed on an orbital shaker table at 75 revolutions per minute. At testing time, duplicate 10 mL samples were immediately drawn from each jar and placed in 40 mL vials with Teflon lined septa for immediate benzene analysis.

Tests were performed at 24 hours after mixing with a test duration of 96 hours, and at 10 days after mixing with a test duration of 24 hours. Between leaching tests, the cubes were kept in the jars with the caps off and covered with water. The samples were analyzed for benzene by a headspace method. The vials were placed in a 90°C water bath for one hour. An 80 mL sample was taken from each vial and injected into a GC at injection port temperatures of 100°C with an isothermal temperature program of 170°C.

The reactions between cement and water cause the setting of concrete. Setting time may be affected by the addition of admixtures or by-products to the concrete. The initial and final setting times of the concrete are commonly defined by the ASTM C-403 method. Essentially, the test consists of measuring the force

![Figure 5: Effect of contaminant concentration on concrete strength](image)
percent, only 50 percent and 30 percent are recorded for initial time and final setting time respectively.

Compressive and flexural results are shown in Figure 2. Test results indicated that, irrespective of soil type, concrete containing higher PCS/sand replacement ratio develops lower compressive and flexural strengths at early and late stages. The presence of contaminants seems to interfere with the water-cement binding reactions and delays or prevents the full hydration of the cement particles. The increase of PCS content (increase of the PCS/sand replacement ratio) yields to the presence of more petroleum contaminants that separate the cement particles from water. So for the same total content of cement, a lesser amount is actually reacting with water to produce the hardened binder. This resulted in concrete weaker than the control mix.

The strength reduction at each PCS/sand replacement ratio level depends on contamination concentration, contaminant type and soil type. The increase in contaminant concentration has an adverse effect on the concrete strength. Figure 5, page 18, presents a comparison between the strength results of concrete containing Soil I (sandy, with .11 percent oil contamination) and Soil III (sandy, with .66 percent oil contamination.) While the presence of Soil I at PCS/sand ratio of 40 percent reduces concrete strength by 10 percent for the two days compressive strength and 13 percent for the seven days compressive strength, the presence of Soil III with the same PCS/sand ratio yields concretes 54 percent and 43 percent weaker than the control after two and seven days, respectively.

The effect of soil type on the strength of concrete containing PCS is shown in Figure 7, page 38. The presence of fine contaminated soil particles as in Soil II yields a lower strength than concrete mixed with sandy contaminated soil particles as in Soil I. While for Soil I, an average of 13 percent strength reduction is observed at PCS/sand replacement ratio of 40 percent when compared to the control mix, the inclusion of Soil II results in a strength reduction of about 45 percent. In addition to the strength reduction, preparing clay-silty soils for usage in concrete was time consuming. The use of very fine soils to replace sand in concrete is not recommended for practical (mixing and soil preparation) difficulties and technical (excessive loss of strength; about 50 percent of control) reasons. The results of the wet-dry and freeze/thaw tests show percentage weight losses of less than two percent for all tested specimens. No visible cracking or surface deterioration was observed on any specimen. This indicates that up to 40 percent of PCS/sand replacement ratio could be used without seriously affecting the integrity of concrete members. But, such a conclusion certainly requires more testing.

Benzene was non-detectable in the leaching test results. The detection limit was .01 ppm. The amount of benzene leaching from concrete was not sufficient to produce a measurable

Continues on page 38

Rotron blowers provide soil solutions.

EG&G Rotron regenerative blowers have proven themselves in years of environmental service to be quiet, compact, and reliable. These direct-drive low-maintenance blowers require no lubrication.

They have explosion-proof motors, spark-resistant construction, and adaptable vacuum performance curves. Environmental applications include:  ■ Soil remediation.
   ■ Landfill cegassing.  ■ Aeration.

Rotron also has accessories such as moisture separators available. Call or fax for a copy of A Consultant’s Guide to Environmental Applications.
How to predict biodegradation rates

It is possible to use bench-scale results to predict biodegradation rates

By H.F. Stroo, Ph.D., H.K. Anderson and J.R. Smith, Ph.D.

How reliable is laboratory testing as a predictor of biodegradation rates of petroleum hydrocarbons? Predicting the rate and extent of biodegradation of petroleum hydrocarbons is nearly impossible without site-specific laboratory treatability studies. But, there is very little information available regarding the confidence with which we can estimate biodegradation rates in the field based on treatability tests. There are theoretical reasons for the variations in the rates and extents of biodegradation observed at different sites.

Biodegradation of hydrocarbons can be stimulated by measures commonly taken to enhance biological activity. However, the rates and extent of loss measured under optimized conditions still vary widely between different materials and sites. A recent summary of data on oil biodegradation, which used only studies with sufficient time points and replicates to allow valid kinetic analysis of polycyclic aromatic hydrocarbons (PAHs) half lives, shows this variability and illustrates the relative biodegradability of different PAHs (See Figure 1, below). Typically, PAH biodegradability decreases with increasing molecular weight,

---

95 Percent Confidence Intervals for Half Life Estimates for Individual PAH Compounds

Figure 1: Data on oil biodegradation with sufficient time points to allow valid kinetic analysis of PAH half lives.
which appears to be related to the fact that solubility in water also decreases with size.

The nature of the waste matrix is one of the factors affecting degradation rates. Potentially toxic compounds often found with PAHs can apparently decrease degradation rates. Anthracene appears to degrade more rapidly in oily sludges than in creosote sites. The effect of waste type on the biodegradability of specific compounds has been examined more closely by comparison of results from different treatability tests performed under similar conditions. (See Figure 2, right).

The simpler PAHs (less than four rings) had the greatest removal over a two-month period—roughly 75 percent on average. The moderately degradable four-ring PAHs had losses of roughly 50 percent. The five- and six-ring compounds exhibited low removals (30 percent on average).

Significantly, the losses were very low in materials such as coal tars which had high relative abundances of these compounds so that overall PAH removal was reduced in such wastes.

In extreme cases, compounds which are normally biodegradable may not be removed in a given site sample for reasons which are not well understood. For example, we have recently tested two sites contaminated with No. 2 fuel oil and diesel, petroleum products considered biodegradable. In this case, however, only very slight removal of the total petroleum hydrocarbons was observed and the concentrations plateaued at levels exceeding the cleanup criteria. The failure of bioremediation in these soils was not due to any obvious toxicity, since high numbers of total microorganisms and oil degraders were observed. Further, 

Continues on page 22→
DON'T BE A VICTIM OF UNIT COST DIG & HAUL REMEDIAL RAPE!

America's fastest growing environmental crime against owners of UST installations is the unscrupulous practice of persuading the responsible party to blindly proceed with a unit cost Dig & Haul remediation program prior to clearly defining the extent of the contaminant plume's migration and the applicability of other remedial action technologies.

It is a costly con game whereby the property owner is duped into allowing the contractor to embark on a contaminated soil hunt with a backhoe and dump truck without first examining the superior benefits of treatment based corrective action options.

Contact BioVac Environmental Services for an objective evaluation of your on-site & in-place treatment alternatives.

VAPOR EXTRACTION BISOVENTING LAND FARMING BIOPILE TREATMENT

566 First Capitol Dr., P.O. Box 938, St.Charles, MO 63302
314 - 947 - 9917

How to predict, from page 21

an added model compound (14C-labelled hexadecane) was rapidly mineralized, suggesting that the lack of apparent loss was due to other factors, such as poor bioavailability of the petroleum compounds.

Despite the fact that reasonable predictions can be made for compounds and specific waste types, on average, there is a great deal of site-specific variability that cannot be immediately explained by waste characterization data. The level of variability in the extent and rate of hydrocarbon degradation is such that it is difficult to use the average values in a meaningful predictive manner. The rate and extent of removal is sufficiently dependent of site-specific factors that it is generally necessary to perform bench-scale tests for each new site.

Although we do not fully understand the reasons for site-specific variability in biodegradation, several factors besides PAH distribution and waste type are obviously involved.

One of the most critical appears to be the degree of sorption of hydrocarbons to soil. Soil texture and organic matter content are therefore important parameters to assess at a given site. The particle size distribution has such a pronounced impact that we routinely include this analysis in initial characterization of sites and can often predict that land treatment will not be successful if slowly-degraded wastes are present in very fine-textured soils. The extent of partitioning of contaminants from solids to water is also routinely measured to assess relative biodegradability.

Figure 3: No mineralization of phenanthrene was detected until the glucose was consumed.

The presence of other inorganic and organic compounds at a site can also affect the rate of degradation. The impacts of salts or toxic metals on biological activities are well known to slow rates and account for slow rate of activity at many sites.

However, interactions among organic compounds may also
A. Losses of PAH Compounds by Ring Number During Land Treatment

<table>
<thead>
<tr>
<th>RING NUMBER</th>
<th>LAB 1</th>
<th>PILOT 2</th>
<th>FULL SCALE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 rings</td>
<td>32</td>
<td>30</td>
<td>&lt;45</td>
</tr>
<tr>
<td>3 rings</td>
<td>38</td>
<td>43</td>
<td>45</td>
</tr>
<tr>
<td>4+5 rings</td>
<td>204</td>
<td>173</td>
<td>115</td>
</tr>
</tbody>
</table>

1. Average of 5 plots; Duration=120 days
2. Average of 5 plots; Duration=126 days
3. Duration=193 days

B. Losses of Specific PAH Compounds During Land Treatment

<table>
<thead>
<tr>
<th>COMPOUND</th>
<th>LAB</th>
<th>HALF LIFE (DAYS)</th>
<th>FIELD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenanthrene</td>
<td>32</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>46</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Pyrene</td>
<td>47</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>Chrysene</td>
<td>42</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>Benzo(a)pyrene</td>
<td>208</td>
<td>228</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4: Excellent agreement was found among all three systems.

be important and may be very complex. For example, we recently tested the effect of adding glucose to soil slurries containing PAH-contaminated soil on the mineralization (i.e., production of labelled carbon dioxide) of 14C-labelled phenanthrene or 14C-labelled glucose in separate flasks which were otherwise identical. (See Figure 3, left). Although a readily-degraded carbon source might be expected to increase biomass and activity, in fact, no mineralization of the phenanthrene was detected until the glucose was consumed.

In a separate test with no glucose added, phenanthrene mineralization occurred with virtually no lag period. This testing also showed that adding glucose can interfere with the accurate measurement of hydrocarbons, causing apparent increases in total petroleum hydrocarbons through the production of microbial biomass.

Finally, the concentrations of the waste can impact the rate and extent of biodegradation. For example, when oily sludges were added to soil at oil and grease concentrations ranging from 2.5 to 10 percent, the apparent rate and extent of oil and grease loss decreased with increasing oil concentrations. Reasons may include direct inhibition of biological activity by the oil or its associated inorganic metals or salts, saturation of the soil's sorptive capacity—since some oil and grease loss is certainly due to sorption to the soil—or saturation of the degradative capacity (i.e., a shift from first-order to zero-order kinetics due to limitations on the number or activity of degradative organisms).

Thus, the feasibility of biodegradation for reaching specific cleanup goals at a given site and the time required for cleanup are difficult to predict without site-specific testing. Reasons for this lack of predictability are not fully understood, but include the chemical characteristics of the organic waste, soil texture, site-specific sorption/desorption kinetics, contaminant concentrations and the influence of other organic compounds present at the site.

Given such variability and the necessity for lab testing, as well as the artificial nature of the laboratory microcosm and the recognized difficulties in scale-up from lab to field, it is

Continues on page 34→

EnviroTech

WE CAN TEST IT. WE CAN CLEAN IT. WE CAN PROVE IT!

Turning petroleum contaminated soils into clean product is a challenge EnviroTech Mid-Atlantic always welcomes. We begin with thorough laboratory evaluation of the hydrocarbon contaminated soils. While awaiting treatment, your soil is stored in our covered buildings for protection from the elements. Our rotary kiln thermal destruction units process an average of 720 tons per day. Constant emissions monitoring and extensive air pollution control equipment ensure complete protection of the environment while eliminating soil contaminants. And when decontamination is complete, EnviroTech Mid-Atlantic will provide you with written verification of cleanup that's backed by our extensive liability coverage. Turning contaminated soil into a reclaimed product is what we do best and we can prove it!
There's a lot of important information buried in this ad.

These days, the environment is no longer a hidden issue. Which is why O/C TANKS make more sense than ever.

And in environmentally sensitive areas why our double-walled Fiberglas* tanks are the best choice yet.

Fiberglas* tanks: rust-proof and rust-proof proven

When steel tanks rust — inside or out — they can leak. Fiberglas* tanks never rust. So they never leak from corrosion. And O/C TANKS have proven that in use. In fact, we're now the world's most experienced manufacturer of underground tanks with over 185,000 installed nationwide.

Protecting our precious underground water supplies

No one wants polluted drinking water. Or polluted well water. Or farms with tainted irrigation systems. That's why the American Petroleum Institute guidelines recommend secondary containment for underground tanks when potable water wells or sole-source aquifers are within 300 feet of the tank. In environmentally sensitive areas, our double-walled HydroGuard™ System is the perfect solution.

The system is activated at our factory and goes right to work. HydroGuard™ checks the tank's condition during transportation...
and through installation. After that, the system operates continuously underground. And that’s not all.

**The Leak Detection System that’s unique to HydroGuard™**

HydroGuard™ provides 360 degree secondary containment 24 hours a day for the life of the tank. Its built-in leak monitor is actually sensitive enough to detect leaks as tiny as 0.10 gallons per hour, not coincidentally the EPA standard for precision-testing. And if that’s not enough reassurance, HydroGuard™ comes with a 30-year structural and corrosion warranty.

If you’re looking for a new tank that will protect the environment from pollution and your business from liability risks, choose the HydroGuard™ System. Don’t bury a mistake.

A SUBSIDIARY OF OWENS/CORNING FIBERGLAS

{} Send me your HydroGuard™ System Brochure
{} Have a salesman call me (or call 1-800-OC-TANKS)

Name__________________________
Company__________________________
Address__________________________
City__________________________State__________________________
Zip__________________________Phone__________________________

Send to C.M.X. Meeks, O/C TANKS Corp., P.O. Box 10025, Toledo, OH 43699-0025

© O/C TANKS Corp. 1992

Write in 195
Tank closure: the players and their roles

How to draw a winning hand

By Cheryl A. Kehres-Dietrich and Brian F. Burke

Who are the players in the game of removing an underground storage tank (UST)? Tank owners, working to comply with their state’s regulations, often find themselves among a variety of unfamiliar people with a variety of roles and responsibilities. “Who’s doing what around here?” can be a familiar cry at UST sites.

Since the mid-1980s, state regulations have imposed strict closure requirements on USTs. If a tank has not leaked, closure of the site may be a simple process. It may be “pulled” or removed from the ground and taken to a secure area in accordance with applicable state regulations. If it has leaked, a remediation plan must be immediately developed to clean up contamination of the soil and groundwater.

Owners who do not comply with their state’s regulations face the possibility of costly fines until compliance is accomplished. Closing a UST site means an owner must prove that the tank has never leaked or that the effects of a release have been adequately defined and remediated.

The UST owner or, by default, the property owner is ultimately responsible for the closure of the UST site. The owner works to satisfy the regulator who has the power to approve or disapprove the site’s compliance status. Until closure approval is achieved, the owner may not be able to sell or develop the property, and it generally remains under the scrutiny of the regulator.

The owner is also responsible for all registration fees and is the one who receives noncompliance notifications from the regulator. It is the owner who must sign all disposal manifests and is responsible for the disposal of contaminated soil and groundwater for all eternity. The cost of compliance is the owner’s obligation.

Understandably, because owners pay directly for the services of an environmental consultant and a qualified contractor—and pay indirectly for the services of the regulator—they want results. Results, however, often take time. Owners typically have a business to run and disruptions to their property, compounded by slow progress of investigation and remediation activities may be costly to accept. Owners want to know how long it is going to take and how much is it going to cost.

Owners, who must make all the decisions, in most cases, must rely on the expertise of the regulator, the consultant and the contractor. With all the responsibility, it is little wonder the owner is the unhappiest participant in UST closure.

The regulator is responsible for implementing state level environmental regulations dictated by the federal government. The representative of the state must consider how the regulations apply to the unique conditions of each individual site. Some states have a list of approved contractors and consultants considered capable of performing UST closures. It is the regulator that usually approves their credentials. Corrective and remedial action plans undertaken by the owner must be reviewed and approved by the regulator, who also reviews and
approves the final closure. If the state has public funding available for remedial actions, the regulator must approve the reimbursement to the owner. It is wise to keep in mind that short of litigation, the regulator has the final word on all activities involving a UST closure.

With the proliferation of leaking UST sites, the regulator can sometimes take months to produce reviews, revisions and approvals. Furthermore, the overworked regulator may not be able to observe activities firsthand and sometimes depends on the expertise of the consultant to accurately document corrective actions.

Some regulators may evaluate the cost-effectiveness of a corrective action plan, however, cost is not their primary concern. Their mission is to protect public health, welfare and safety and preserve the natural resources of the state. Therefore, the participants in UST closure must recognize the regulator is often very cautious, and sometimes slow, about making decisions.

With the regulator telling the owner to, “clean up your site—or else,” the owner’s next step is to ask if the state has a list of approved contractors and consultants for UST closures. If not, recommendations from others who have successfully closed a site are appropriate. Hiring a good consultant can save the owner headaches and financial pain in the end.

The consultant normally works for the owner. Sometimes, however, the contractor hires a consultant for expert advice. It is the consultant who must interface with the owner, regulator and possibly the contractor at the owner’s request. The consultant interprets existing regulations and should be knowledgeable about proposed regulations to advise the owner on possible courses of action. The consultant designs site investigations and corrective actions, collects soil and groundwater samples to determine the extent of contamination or the effectiveness of remediation. The consultant interprets analytical results and prepares all documentation of the event. The consultant also monitors the contractor’s work, including soil removal and volume of disposed materials. Advising the owner on reporting requirements and assisting the owner in meeting reporting deadlines is also the consultant’s job—along with evaluating eligibility for reimbursement for public funding.

The consultant must be able to estimate the cost of remediation in terms of money and time for each course of action and often represents the owner to the regulator. Therefore, the consultant needs to anticipate regulatory concerns and proceed with both the owner’s and the regulator’s interests in mind.

The consultant must also submit all necessary paperwork to the owner or regulator, at the owner’s request. This includes results of site investigation, proposed corrective action designs and completed corrective action documentation. The consultant does not actually remove the tanks. It is the contractor who usually does the actual physical work at the site. In

Continues on page 28++

---

Low-Temperature Thermal Desorption

---

Williams Environmental Services is the Final Solution for Hazardous Waste

Williams Environmental Services’ Mobile Thermal Processing Units are specifically designed and built to provide the most efficient and cost effective remediation of hazardous and non-hazardous materials. Williams has units designed for soil processing, low-temperature thermal desorption and high temperature incineration. We are one of the nation’s leading designers and operators of mobile thermal processing systems. We have one of the best compliance records and have completed projects in states requiring thorough permitting and operating requirements. Please call for more information.

WILLIAMS ENVIRONMENTAL SERVICES

1-800-247-4030

2076 West Park Place • Stone Mountain, GA 30087 • 404/498-2020

A Williams Service Group Company ©1992 Williams Environmental Services, Inc.

Write in 223

April 1992 Soils 27
many states, the contractor must be approved by the regulator. The owner should check with the state or the consultant to see if this is a requirement.

Since the contractor’s services are generally the most expensive in a closure, the work usually goes out on bid. The consultant can assist in writing bid specifications and help with the selection process. Though everyone should be concerned with cost effectiveness, the owner should not look at price alone. Experience with similar projects and a good reputation in the industry should also be considered when selecting the project team.

The contractor’s responsibilities include activities necessary to execute the work. The contractor brings the equipment to the job and should conduct all work according to Occupation Safety and Health Administration (OSHA) and other safety regulations. The tank removal and excavation, including hauling of contaminated soil, pumping contaminated groundwater and backfilling the UST excavation falls to the contractor. Arranging for disposal of contaminated materials and facilitating the manifest process, along with the installation, operation and maintenance of the remediation system are also duties of the contractor.

Even when contractors are proficient and experienced, they may not necessarily be completely up-to-date on UST regulations and must rely on the owner and consultant to provide appropriate guidance. Since contractors are typically anxious to proceed with the work at hand, delays due to the regulatory process are usually not appreciated and “down times” can cause them distress—particularly when their equipment has been transported and is tied up at the site. Equipment sitting idle at one site is equipment that could be making money at another. Consequently, the contractor may appear hurried and feel justified to charge for time incurred if the consultant has to stop to collect additional samples and contact the owner and regulator for decisions about unanticipated site conditions.

Many times at a UST site closure, the work crew wonders why work is not proceeding according to plan. The owner, of course, is also anxious to have the work completed. That is why a good consultant must also be a good communicator, keeping everyone informed about the status of the project. Often, everyone is waiting for the regulator to review and approve the recommended course of action. It would be risky to continue any work without this approval.

Unfortunately, UST sites rarely reach closure without expense, frustration and time delays. Therefore, care must be taken at the time the project team is assembled to make sure the various team members clearly recognize their roles and responsibilities. An understanding of the closure process and roles of the various players involved can help owners know what to expect and be able to make informed decisions about their site.

Write in 536 for more information

The Association for the Environmental Health of Soils presents...

Hydrocarbon Contaminated Soils 1992 Technical Seminar
June 2 & 3, 1992
Hyatt Regency Hotel, Houston, Texas

Purpose:
To serve as a technical training function for environmental scientists in petroleum, chemical and petro-chemical industries, both in the private and public sectors.

Presenters:
Selected experts in the areas of analytical chemistry, site assessment, environmental fate, field screening methodologies and remediation.

For further information, please call Martha Barrett at (413) 549-5170

Advisory Board/Sponsors
Amoco
City of Houston
Dupont Environ. Rem. Services
ENSR Consulting Engineers
Exxon Co. U.S.A.
HNU-Hanby
Koch Industries, Inc.
K.W. Brown Envir. Services
Louisiana DEQ
Monsanto
Shell
Texas Water Commission
Woodward Clyde Consultants
Union Carbide/Agri-Diagnostics
University of Texas at Austin
U.S. EPA Region 6
"Today's Solution to Yesterday's Pollution"

DISPOSAL TECHNOLOGIES, INC.

In today's times, it has become increasingly essential that contaminated soil generators and contractors protect themselves from liability regarding the disposal of their waste materials. At Disposal Technologies, Inc. we pride ourselves in our ability to assure our customers the utmost in protection by eliminating liability through the implementation of our innovative qualification program, waste tracking and security system.

WHY NOT TRY THE BEST!

DISPOSAL TECHNOLOGIES

FEATURING

- petroleum contaminated soil
- non-hazardous wastes
- hazardous wastes
- municipal solid waste
- demolition debris

CALL 1-800-428-SOIL (7645)

Thermal Treatment • Recycling • Landfilling
Enhanced Evaporation decontamination equipment thermally separates hydrocarbons from soil.

Firm powers thermal unit with landfill waste methane gas

_Thermal unit reaches 1800°F to convert contaminants._

By Douglas E. Lierle

Officials at Greenville County, S.C. are using the methane gas from decaying landfill waste to power thermal soil remediation equipment.

"Methane is a very clean burning fuel, and our estimates of the lifetime for methane production from the Greenville landfill run as high as 10 years," says Don Babb, president of Soil Remediation Co. (SRC), the Columbia, S.C. based firm providing the equipment to the site.

"To our knowledge, SRC is the second company in the country to use methane to power equipment for environmental cleanup purposes," Babb says. "It's very much a 'win/win' situation between private industry and government."

SRC is using over 35 million BTUs of energy from 24 methane wells to operate their patent-pending Enhanced Evaporation (E2) thermal processing technique. The heart of the E2 equipment is the primary treatment unit, a rotary dryer that thermally separates hydrocarbon contaminants from soil. The contaminants are converted to carbon dioxide and water in the turbulent 1100 to 1800°F atmosphere of the secondary treatment unit. (See Figure 1, next page).

_Douglas E. Lierle is president of Lierle Public Relations of Aurora, Colo._

Soil is processed at Soil Remediation Co.'s Columbia, S.C. recycling site.
To control particulate emissions and to meet or exceed environmental regulations, process air is filtered by high efficiency cyclones and a baghouse.

The process has successfully remediates gasoline, diesel fuel, heating fuels, aviation fuels and crude oil in projects ranging in size from a single barrel of contaminated material to sites with several thousand tons of petroleum contaminated soil.

One recent project remediated over 2,200 tons of petroleum contaminated soil at a former training facility for area fire departments in New Hanover County, N.C. The site included a 60 by 120 foot “burn pit” and a large tank used to store waste gas, kerosene and other flammable products. Old truck and car bodies, as well as abandoned train cars were set on fire in the burn pit for training purposes by city and county fire departments and the Army Corps of Engineers.

“The soil at this old burn site is very sandy, and several tons of soil were contaminated over a period of time,” says a spokesperson for Ensite Corp., an environmental site restoration firm in Tucker, Ga., prime contractors on the project. Ensite felt that SRC’s Enhanced Evaporation technology was a cost-effective alternative to landfilling the soil.

Another recent project dealt with 1,300 tons of petroleum contaminated soil at the Columbia Mills building in Columbia, S.C. The site, formerly an abandoned cotton mill built in 1896, was converted to an office building and state museum about five years ago by the state government.

Continues on page 33 →

The Enhanced Evaporation process is based on proven techniques whereby volatile hydrocarbons and water are driven from the soil and the volatiles reduced to carbon dioxide and water vapor. Exhaust gas is cooled, then sent through a baghouse to control particulate emissions.

EXHAUSTING POTENTIAL

If vapor extraction is the remediation method of choice to remove VOC's from your site, consider the potential of using a Lamson exhauster.

Lamson Multistage Centrifugal for varying flow/constant pressure performance: preferred for consistent soil composition. Volume to 350 CFM; vacuum to 10^2 HG.

Lamson Turbodion for varying pressure/constant flow for dense or inconsistent soil. Volume to 1000 CFM; vacuum to 15^2 HG.

- Both feature non-ferrous, aluminum casing and impeller for spark and rust resistance.
- Both offer quiet operation to meet OSHA standards.
- Both have low maintenance requirements; the impeller is the only moving part.
- Both offer a wide variety of performance characteristics from a single machine. (When belt driven)
- Both have externally mounted, grease lubricated bearings to assure clean, pulse-free air flow.
- Both have been specified extensively for this application; on package modules and custom designs alike.
- Both are completely custom manufactured to meet your specification at the Lamson factory in Syracuse, New York.
- Both can be supplied as bare units or complete packages, including motor.
- Both are very competitively priced.

To tap the potential Lamson exhausters can supply for your remediation project call tollfree @ 1-800-543-7736

LAMSON CORPORATION
Through soil recycling, the beauty and value of a virgin forest will not be destroyed by clearing for a new landfill. Soil Safe’s unique stabilization process recycles 100% of incoming material, thereby not contributing to landfill growth.

We offer turnkey services for petroleum contaminated soil removal needs. Professionally managed from start to finish, we perform site audits, collect soil samples, complete required analytical tests, schedule trucking and loading, supervise soil removal, and finally, accept material at our facility where it’s recycled into high quality construction materials and paving products.

Our comprehensive Materials Management Program provides a complete audit trail for every truckload and/or drum of material that enters the facility. All incoming soil and outgoing recycled products are closely managed to monitor our constantly changing inventory of material.

Another advantage we offer our clients is the volume of material we are capable of recycling relative to other disposal alternatives. The plants at our Baltimore facility are capable of producing 650 tons of paving products each hour. Because of these significant production capabilities, we have recycled in excess of 330,000 tons of soil in the two year period we have been in business.

The market for our recycled products is ever expanding. We have completed over 50 construction projects to date, and our Construction Sales Division consistently has an inventory of 50 potential projects under evaluation. Many of our clients who bring soil to our facility enjoy significant savings by utilizing our recycled products in their paving projects.

Having the capability to manage both incoming and outgoing material in a cost effective and efficient manner is one of the key competitive advantages we offer our valued clients. For more information on our services and how we can help you solve your soil problems, call DAN NIESER, Marketing Director.
The equipment is portable so the process can be applied to a variety of remote locations.

The equipment is portable so the process can be applied to a variety of remote locations.

state is credited with taking the initiative to clean up the pre-existing condition caused by the apparent use of heavy petroleum products prior to the renovation of the building.

An official with the state museum explains that the old spinning cotton mill was one of the first such facilities powered by electricity. Originally steam powered, the plant was converted to electricity upon completion of a power plant built at the turn of the century on the Columbia Canal near the Congaree River, which is adjacent to the mill.

Since the equipment is portable, the process is also applicable to transportation and industrial accidents, as well as leaking underground storage tank sites.

"Transportation and industrial accidents come in varying degrees of severity and in numerous forms," explains SRC customer service representative, Stan Warner. "Trucking and railroad accidents, for example, do not always entail a ruptured tanker or tank car, but more likely spilled diesel fuel from the truck’s saddle tanks or the locomotive’s damaged fuel tanks. Accidents can also occur during the loading and unloading of fuel at gas stations and bulk plants—or something as simple as driving away from a gas pump with the fuel hose still in your tank."

George Chedsey, vice president of SRC says the company plans to expand the use of methane power and sites to handle additional recyclables.  

Write in 537 for more information

<table>
<thead>
<tr>
<th>CANAAN RENTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Express &amp; U.P.S Next-Day</td>
</tr>
<tr>
<td>FOXBORO • O.V.A.</td>
</tr>
<tr>
<td>T.E.C.O. • P.I.D.</td>
</tr>
<tr>
<td>H.N.U. • P.I.D.</td>
</tr>
<tr>
<td>PHOTOVAC • P.I.D.</td>
</tr>
<tr>
<td>A.I.M. • L.E.L.</td>
</tr>
<tr>
<td>SAMPLING PUMPS</td>
</tr>
</tbody>
</table>

[Image of a truck]

<table>
<thead>
<tr>
<th>CANAAN RENTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canaan Scientific Rentals</td>
</tr>
<tr>
<td>4037 Darling Court</td>
</tr>
<tr>
<td>Lilburn (Atlanta) GA 30047</td>
</tr>
<tr>
<td>404-929-2855 FAX: 404-929-2811</td>
</tr>
<tr>
<td>(800) 842-1088</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>United Retek Corp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1562 Washington St. Box 6037 Holliston, MA 01746, 508-429-6220</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soils Remediation</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Problems</td>
</tr>
<tr>
<td>Petroleum Hydrocarbons</td>
</tr>
<tr>
<td>Acetone/MIBK</td>
</tr>
<tr>
<td>PAHs</td>
</tr>
<tr>
<td>PCBs</td>
</tr>
<tr>
<td>Halogenated VOCs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The WRIGHT Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioremediation</td>
</tr>
<tr>
<td>Vapor Extraction</td>
</tr>
<tr>
<td>Treatability Studies</td>
</tr>
<tr>
<td>The &quot;Bug Blanket&quot; (Patent Pending)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>r.e. wright associates, inc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete Soil Analyses, Monitoring and Remediation</td>
</tr>
<tr>
<td>Middletown, PA (717) 944-5501</td>
</tr>
<tr>
<td>Westminster, MD (301) 878-0280</td>
</tr>
<tr>
<td>Irving, TX (214) 556-1864</td>
</tr>
<tr>
<td>King of Prussia, PA (215) 971-9348</td>
</tr>
</tbody>
</table>

April 1992 Soils 33
reasonable to speculate how well lab results actually predict the performance of bioremediation in the field.

It is difficult to find sites for which data are available for valid comparison of field- and bench-scale results for similar materials. However, we have adequate data from three such land treatment sites, all of which suggest that bench-scale testing provides a remarkably accurate assessment of full-scale performance. Two of these sites are Superfund sites contaminated with creosote, at which full-scale bioremediation is underway and the third is a site receiving highly asphaltic oily sludge.

At the first site, data are available from lab-, pilot- and full-scale treatment of the same material. Figure 4, page 23, summarizes these results. For the two- and three-ring PAHs, excellent agreement was found between the half-lives calculated for all three systems—30 to 45 days in all cases. For the relatively low concentrations of four- and five-ring PAHs present in the soils, the lab and pilot studies yielded very similar estimates of near 200 days, while the full-scale estimate was much lower at 115 days.

The field data were considered somewhat suspect because less sampling times were used and detection levels changed over time, so that several compounds were not detected at later times. The lab and field data were therefore compared for the most prevalent compounds which resulted in much closer agreement with the lab data.

At the second site, also a creosote-contaminated Superfund site, lab testing was done in liquid/solid

---

**WE SOLVE ENVIRONMENTAL CONCERNS FOR THE MOST COST CONSCIOUS COMPANIES IN THE WORLD.**

The list of those who utilize our cost effective environmental solutions reads like a who’s who of industrial companies, small and large, including other subsidiaries of The Coastal Corporation.

In fact, Coastal Remediation Company has earned its reputation by satisfying the most cost-conscious clients—other Coastal subsidiary companies who demand cost-effective, fast-track solutions to a wide variety of complex environmental concerns including UST Management, Environmental Site Assessments, soil and groundwater remediation, wastewater treatment and design, and air modelling and permitting.

If you, too, want practical, permanent remediation tailored to your needs, call us at 1-800-776-5733.

---

**Coastal Remediation Company**

**A SUBSIDIARY OF THE COASTAL CORPORATION**

The Energy People

Roanoke, VA  Norman, OK  Philadelphia, PA  Tampa, FL

---

**Comparison of PAH Losses During Bench- and Field-Scale Land Treatment of Creosote-Contaminated Soil**

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>FIELD</th>
<th>LAB</th>
<th>DIFFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL PAH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td>859±233</td>
<td>595</td>
<td>264</td>
</tr>
<tr>
<td>Final</td>
<td>195±121</td>
<td>204</td>
<td>9</td>
</tr>
<tr>
<td>% Loss</td>
<td>77</td>
<td>65</td>
<td>12</td>
</tr>
<tr>
<td>Half-life (days)</td>
<td>84</td>
<td>92</td>
<td>8</td>
</tr>
</tbody>
</table>

**BENZ(a)PYRENE**

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>FIELD</th>
<th>LAB</th>
<th>DIFFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>22.1±5.7</td>
<td>38</td>
<td>15.9</td>
</tr>
<tr>
<td>Final</td>
<td>6.9±5.6</td>
<td>12</td>
<td>4.7</td>
</tr>
<tr>
<td>% Loss</td>
<td>71</td>
<td>68</td>
<td>3</td>
</tr>
<tr>
<td>Half-life (days)</td>
<td>102</td>
<td>108</td>
<td>6</td>
</tr>
</tbody>
</table>

1. Based on results from loading of land treatment plots in December 1989 to sampling in September 1990. Six months of active biodegradation assumed.
2. Based on 20 weeks of bench-scale testing.
3. Means and standard deviations from 18 samples.
4. Means based on results from replicate samples.
5. Means and standard deviations from 12 samples.

---

**Figure 5: Bench-scale simulation produced estimations almost identical to field results.**

---

reactors and simulated land treatment. These results have been compared to the full-scale land treatment results in Figure 5, below. In this case, the cleanup criteria were based on total PAH and benzo(a)pyrene concentrations. For lab-scale land treatment simulation over five months, the results are very close to the results from the field over one treatment season—assuming active
biodegradation lasts for over six months. Thus, the bench-scale simulation produced estimated half-lives almost identical to those observed in the field for both benzo(a)pyrene and total PAHs.

More importantly, the results accurately predicted attainment of the cleanup criteria of 14 parts per million (ppm) benzopyrene and 200 ppm total PAH within six months of active treatment.

At the final land treatment site, highly asphalitic oil sludge was added to soil and a bench-scale test was performed at the same time as a field pilot study, using similar materials and loading rates. The results, Figure 6, page 36, show an initial equilibration period in which concentrations appeared to decline rapidly and then increase to the starting levels after four months. The rate of loss after the 20 week point was virtually identical in the bench and field tests. And, if this value is used as the starting point, both had oil and grease half life values of approximately seven months. However, the loss was apparently greater in the field, largely because roughly a fourth of the oil and grease had been removed after 20 weeks. The discrepancy suggested that movement of oil below the zone of incorporation had occurred and once this fraction was included in the results, the agreement between lab and field was very close. In this case, disagreement between lab and field was valuable data for understanding the fate of waste in the environment.

Liquid/solids treatment, or treatment of soils and sludges in a slurry form, has been used increasingly because it offers rapid treatment and remediation in an enclosed environment, thereby limiting potential emissions or off-site migration of contaminants. Because liquid/solids treatment is an innovative approach, there are few full-scale systems with adequate databases for comparison to lab testing. However, we do have good data for two large pilot-scale tests with oily sludges, along with concurrent lab tests with the same materials.

Continues on page 36→
The first site for which we have both field and lab data is an oil refinery sludge which was treated in a million-gallon pilot test. A five-gallon bench-scale reactor was also operated with the same material and the rate of degradation of oil and grease was slightly faster in the bench scale reactor. Both reactors had linear (zero-order) degradation rates with losses of 85 and 69.5 milligrams of oil and grease per kilogram of solids per day for the bench- and pilot-scale reactors, respectively. The linear degradation rate is important, since it indicates that even with adequate nutrients and oxygen, the mass of organics exceeded the degradative ability of the biomass which could be sustained. The measured kinetic constants in the bench- and pilot-scale bioreactors were very close—18 percent faster in the bench-scale bioreactor. The slight discrepancy was, in fact, useful evidence that the pilot reactor was not operating at maximal efficiency because its geometry was limiting complete mixing and aeration of the solids. Subsequent designs have been improved as a result of this observation.

At the second site studied, enclosed tanks were retrofitted to serve as pilot-scale liquid/solids reactors—one with a 17,000 gallon capacity and the other with 70,000 gallon capacity. Both were operated at the same time as a series of one-gallon bench-scale reactors. Two different materials were tested, identified as sludge pond and sludge pit wastes. Similar half-lives for oil and grease were measured in the pilot test at 65 and 57 days, respectively. The bench-scale reactors which simulated the identical waste loadings and operating conditions had similar average oil and grease half-lives of 55 days for pit sludge and 85 days for the pond sludge.

The biodegradation of PAHs during treatment was of particular concern and the lab testing was also accurate in estimating the success of treatment for this parameter. Over 90 percent of the total PAHs were lost from both wastes in 60 days of treatment in both lab and pilot tests. In comparing field and lab results, there were no significant differences in the losses observed for either waste and the lab results also predicted the faster PAH losses observed with the sludge pit material. Because biodegradation rates are markedly faster in slurries than in land treatment, slurry tests have been used as a rapid screening test to assess biodegradability and it would be helpful to be able to use such testing to predict land treatment performance.

Extended bench-scale testing of land treatment of oil sludges has shown that virtually complete disappearance of PAHs is observed, but six months or more may be required to reach an end point. For example, testing of soil #7 in Figure 2 was extended for 20 weeks and first-order removal continued during the entire time until total PAH concentrations had been reduced from 650 to below five milligrams per kilogram. In many cases, however, removal slows dramatically at a much higher endpoint, and it is critical to determine what endpoint is achievable.

We KNOW Tanks!

- 25 Years Experience
- OSHA Trained Crews
- State Certified for work in NJ & PA
- Specialist in UST Removal & Installation
- Site Restoration & Remediation
- Joint Ventures with Consultants & Engineers

Get Your Project ON TRACK!

Contact:
LATTIMORE CONSTRUCTION
Box 1325 Milford, PA 18337
717 296-5369

Write in 240
36 April 1992 Soils
Thus, it is necessary in many situations to combine slurry testing with simulated land treatment to estimate rates and endpoints for land treatment in a reasonable time. The ability to predict the success of bioremediation is crucial to the selection and design of a remedial action. However, absolute hydrocarbon removal rates are highly variable. Although many of the reasons for this variability are known, at present the complex interactions of factors at any given sites prevents predictability of the rate or extent of loss without laboratory testing. Carefully designed laboratory testing can, in fact, provide excellent predictions of performance under field conditions for either land treatment or biological treatment of soils and sludges in slurry form—liquid/solids treatment. Bench-scale studies have been shown to accurately predict, in most cases, both the extent of loss achievable and the rate of contaminant removal. Discrepancies between lab and field data have even been useful clues to improving field performance.

Figure 7: Slurry testing can be combined with simulated land treatment to estimate rates.

An important finding is that in land treatment, long time periods may be required to attain endpoints, and endpoints can often not be measured in the times generally allotted for treatability testing. However, laboratory testing in bench-scale slurry reactors appears to provide an excellent rapid prediction of both the rates and extents of hydrocarbon loss during land treatment—at least for oily sludges. A combination of slurry treatment to predict endpoints in a reasonable time and simulated land treatment to estimate kinetics in the field has proven to be a useful approach with excellent predictive ability.
Concrete solution, from page 19

response.

To increase the sensitivity of the leaching test, a soil was artificially contaminated with neat benzene. Samples from Soils I and III were left in an oven at 105°C for four hours to drive off VOCs. The samples were left uncovered overnight to allow rehydration. Contamination levels of .5 percent and three percent benzene were added on a weight basis. Soil replacement ratio of 40 percent by weight was incorporated in a concrete mixture. Loose soil was used as a control. Concrete cubes specimens were made and tested for leachability.

The results after 24 hours showed that the fraction of benzene in the cubes which leached ranged from .11 to 1.27 percent. These levels are about 99 percent lower than the values for loose soil in the case of .5 percent contamination and about 95 percent lower for the case of three percent contamination.

Based on all these results, the inclusion of PCS does affect the setting times of fresh concrete. The final setting time is found to be less affected than the initial setting time by the increase of PCS/sand replacement ratio. For the soil types included in this investigation and for the contaminants level used, this effect is not major. With a .66 percent contamination concentration and a PCS/sand ratio of 40 percent, only 50 percent and 30 percent increases are recorded for initial and final setting times, respectively.

The addition of PCS yields concrete with lower compressive and flexural strengths at early and late stages. However, sandy soil contaminated with up to .66 percent oil and used with a PCS/sand replacement ratio of 40 percent can produce concrete with 3,500 psi compressive strength and 500 psi flexural strength which is 60 percent of the control strength.

Leachability of hydrocarbons to water at different time periods needs more extensive evaluation. Durability of concrete containing PCS is acceptable but needs more research.

Figure 7: Effect of soil type on concrete strength

Write in 534 for more information

SOIL PROCESSING
USED AND NEW EQUIPMENT

KILNS    DRYERS    BAGHOUSES    SCRUBBERS    CONTROL SYSTEMS    FEEDERS

We offer the nation's largest selection of soil processing equipment... new, used, rebuilt, standard or custom designed. Call us for immediate quotes on parts, major components or complete systems.

GenTec Environmental 12611 Townepark Way, Louisville, KY 40243

CALL TOLL FREE 1-800-826-0223
(Outside the U.S. And in Kentucky call 1-502-245-1977)

Write in 001
What's new

Hirt's oxidizer processes vapors

Hirt Combustion Engineers of Montebello, Calif., introduces a new thermal oxidizer that processes vapors resulting from remediation of gasoline contaminated sites. Gasoline is evaporated by forced ventilation of the soil. The thermal oxidizer accepts the fume stream, removes the hydrocarbon contamination and discharges into the atmosphere a clean, non-contaminating stream.

Write in 540 for more information

Analyzer monitors hydrocarbons

Eagle Monitoring Systems, Inc. of Irvine, Calif., announces two new model hydrocarbon analyzers designed for continuous monitoring of hydrocarbons in gaseous samples. The EM 700 model has a flame ionization detector to monitor inlet and exhaust of carbon adsorption systems, vapor extraction systems, drying ovens and ambient air.

The model EM 7000 can also monitor various types of applications from high exhaust stacks and high moisture content sources to ambient air. Both units are available in stationary or portable packages.

Write in 541 for more information

Knock out liquids from samples

Round One Knockout of Richmond, Texas offers the TKO Model 180, a membrane separator that removes liquid entrained in gas samples without altering the gas/vapor phase composition. Gas/vapor flows through its membrane but entrained liquid is separated and drained off.

It is designed specifically for protection of stack and flue gas sample pumps and analyzers.

Write in 542 for more information.

• Hertz Equipment Rental, Park Ridge, N.J., names Richard A. Brown division vice president of the Northwest Region in Sacramento, Calif. Brown previously served as western region manager in Irvine.

• Waste-Tech Services, Inc., Golden, Colo., a subsidiary of Amoco Oil Holding Co., has acquired Ecova Corp., a bioremediation company based in Redmond, Wash.

• Xerxes Corp., Minneapolis, Minn., promotes Greg Cirangle of Toms River, N.J., to eastern regional sales manager and Mark Mays of Cincinnati, Ohio, to central regional sales manager.

• AERS, Inc., Salem, Mass., has commercialized their portable recycling process that recycles hydrocarbon contaminated soils averaging 50,000 ppm total petroleum hydrocarbon into asphalt concrete and allows non detectable to less than one ppm.

Call 816-254-8735 to find out soils magazine's affordable advertising rates. What could it hurt? You'll be surprised at the rates — amazed at the results!

Begin with the end in mind.

As an environmental manager, even if you know where you want to go, you may need help getting there.

Barr Engineering Company can help. We have three decades of experience in investigation, permitting, design, and implementation assistance. We address the effects of waste and remediation on soils, and can help you make the right choices. Call us for more information about our waste-related services.

Barr Engineering Company
8300 Norman Center Drive
Minneapolis, MN 55437
612/832-2600

Write in 206

CONTAMINATED SOIL SOLUTION

THERMAL REMEDIATION TECHNOLOGY Can Clean Hydrocarbon Contaminated Soil

- On-site operation
- No future liability
- Cost effective
- No unnecessary use of landfill space

Contact us or your environmental consultant for further information regarding use of our equipment on your site. MDNR and MUSTA have approved this technology.

We can offer you a better solution to contamination cleanups.

KALCON
616/258-9134
Fax 616/258-6113
Kalkaska Construction Services, Inc. 418 S. Maple, Kalkaska, MI 49646

Write in 237

April 1992 Soils 39
Join your colleagues

More than 6,000 environmental professionals will attend the Air & Waste Management Association’s 85th Annual Meeting & Exhibition, June 21-26, 1992, in Kansas City, Missouri.

The technical program will include more than 800 papers arranged into 200-plus sessions. The three-day exhibition will feature the world’s foremost suppliers of environmental products and services. Continuing education courses will help professionals brush up on or learn the latest about selected environmental topics. Finally, ancillary events, technical tours and social events will provide even more networking and educational opportunities.

The technical sessions are organized into three areas: air issues, environmental management issues and waste issues. These areas of technical exchange are further subdivided into these categories:

**Waste Issues**
- management
- municipal solid waste
- treatment technologies
- incineration
- waste handling
- source reduction/pollution prevention

**Air Issues**
- atmospheric science & measurements
- indoor air quality
- ozone & air toxics/VOCs
- modeling/emissions

**Environmental Management Issues**
- control, operations, & strategies
- management
- global management
- effects
- toxic chemicals
- legal, regulatory & public issues

Attendees will discuss these topics in depth: pollution prevention, contaminated soil and water, combustion/incineration, implementing the Clean Air Act Amendments, air toxics and operating permits.

Kansas City is located at the geographic center of the U.S. and is an inexpensive city for conference attendees.

A preliminary program containing brief descriptions and schedules of the sessions and information about registration fees, hotel rates, committees, the exhibition and ancillary and social events is available.

To receive the program or for more information call or write:

**Air & Waste Management Association**

P.O. Box 2861
Pittsburgh, Pennsylvania 15230
412/232-3444
IS Robotics' T-I robot packs a payload of custom sensors, a tilt/pan color video camera and a microprocessor that can be pre-programmed from a computer or controlled by a data-link radio system. In fact, an operator can control several of these units simultaneously. Each robot can report its position, second-by-second, coordinated with a single base station.

Ringed by infrared proximity sensors and by pressure-sensitive bumpers, the T-I snake around tall obstacles and treads knowledgeably through stone-littered terrain, mud and snow, and even fords one inch deep water. It climbs grades up to 45°, side slopes of 30°; and surmounts four” high obstacles on track-type treads.

Only 16" long, 13" wide, and 8" high, it's surprisingly fast on its treads, the manufacturer says, moving at up to three miles per hour (walking speed).

The T-I is built first as a basic platform, incorporating partially-completed chassis system with motors, certain sensors and processor boards assembled into the main chassis. Then, it's completed according to customer sensor specifications.

The basic system includes independent right and left tread speed controls; infrared proximity sensors; an open bus architecture control system that accommodates up to six microprocessors; subsumption reactive control; and work station-operator support.

The manufacturer says the unit offers many emergency response and site survey capabilities. It can place sensors without operator risk, collect samples, record sensor signals, and offer a first quick look and assessment in hazardous situations and potentially in fire department seek and rescue missions. To date, its customers have included NASA and industrial companies.

Write in 538 for more information.
The FTIR remote sensor from MDA Scientific, Inc., of Lincolnshire, Ill., measures the absorption caused by various infrared active gases. It transmits an infrared beam along a path to a retroreflector which returns it to the receiver. The interferogram is recorded and after the Fourier transform is performed, the absorption spectrum as a function of wavenumber is used for analysis. The instrument can make measurements from about 700 to about 4500 wavenumbers (a wavenumber is the inverse of the wavelength in centimeters) so that any gas that absorbs in that region is measurable against a library that contains about 120 compound standards. Multiple compatibility studies have been completed to show quantitative equivalents of remote sensing techniques to traditional point sampling methods, such as Summa Canisters, analyzed by GC/MS. The FTIR requires a clear line of sight between the retroreflector and the transmit-receive optics to a maximum distance of 650 meters. This should allow measurement along one boundary of most sites, sufficient to obtain emission rates of various gases. The FTIR can make measurements along several lines of sight quite rapidly, says the company. The unit weighs 150 pounds, can be set up and on line at the site in half an hour and provides computerized documentation of emissions.

Write in 539 for more information.
At last there is an answer to all the times you have said, “I only wish we had...”

The Association for the Environmental Health of Soils now offers the first, annual bibliography, “Hydrocarbon Contamination Soils Remediation: Current References 1990”

- Over 200 entries
- “Key words” provide easy review and search
- Complete author index with reference numbers
- Comments section for additional information
- Subject index for detailed access and cross references
- “Availability” field for acquiring materials
- Compiled and expanded every year

AEHS Members $45.00
Regulatory Non-Members $65.00
Non-Members $95.00

2 Easy Ways to Subscribe:
1.) Mail this portion with check or credit card number.
2.) Call (413) 549-5170 (Mon.-Fri.) or FAX Order (413) 549-0579.

If you are not a Member this is a great opportunity to receive the benefits now, including a 50% reduction in your cost for the bibliography next year!

☐ Please send information on AEHS Membership.

AEHS
P.O. Box 312, Amherst, MA 01004

Name

Company

Street

City/State/Zip

Telephone

ALL ORDERS MUST BE SIGNED
☐ Check enclosed in the amount of $_____
☐ Credit Card: ☐ Mastercard ☐ Visa

Account No. (all digits)

Exp. Date ______ Signature__________
In solvent extraction, contaminants are removed from soils or sludges by mixing them with a solvent into which the contaminants preferentially partition. Which solvent is used for a particular treatment depends on the type of contaminant present. Solvents commonly used include water with surfactant additives, which can be used to remove many salts from soil. Low levels of organic contamination may be removed. Acidified water removes soluble metals from soil. Chelating agents, such as ethylenediaminetetraacetic acid, have been used to extract metals, such as lead, from soils. Organic solvents extract organic contaminants from soils. Supercritical fluids or liquified gases such as propane and carbon dioxide at supercritical conditions (high pressures, elevated temperatures) exist as a fluid phase that is neither a gas or a liquid. In this state, the supercritical solvent possesses the good solvent characteristics of a liquid and the diffusive characteristics of a gas. After mixing with soil, the supercritical fluid containing organic wastes is separated and pressure is reduced. At this point, the solvent becomes a gas, while the extracted organics remain liquids, and they separate. The solvent is compressed and recycled. Any solvent chosen must have a high affinity for contaminant(s) of interest and must leave an extract that is amenable to further treatment. In all cases, contaminants transferred to the water phase must be treated by other technologies. Solvent extraction is most economically applied to soils and sludges contaminated with large amounts of organics and soil types that do not strongly bind contaminants (sandy soil). This information taken with permission from the Shell Oil Co., Soil Remediation Workshop Handbook, Houston, Texas. For more information, write in 543.
HAZMAT 92
10th Anniversary
International

Hazardous Materials and Environmental Management Conference & Exhibition/International
June 10-12, 1992 • Atlantic City Convention Center • Atlantic City, New Jersey

North America's Largest and Most Authoritative Conference and Exhibition in the Hazardous Materials and Environmental Management Industry

The Exhibition
See, compare and evaluate the industry's newest products and services for Hazardous Materials Management, Pollution Abatement, Environmental Remediation, Emergency Response and much more ... on display in over 700 exhibit booths.

The Conference Program
Wide-ranging Conference Program covers current industry issues, new technology and the latest regulations. More than 150 papers in 22 sessions PLUS Tutorials, hands-on Workshops, Certification Exams - and more!

BONUS - Visit the International Environmental Pavilion - Featuring Global Participation

Plan NOW to Attend!
Simply complete and mail the coupon, or contact the organizer, for full details including pre-registration form for reduced admission fee to the exhibits.

Sponsored by:

Organized by:

Co-Sponsored by:
National Environmental Training Association • New Jersey Institute of Technology • World Safety Organization • Chemical Equipment magazine • Hazardous Waste Treatment Council • Environmental Hazards Management Institute • National Environmental Health Association • Business & Legal Reports • Industrial Safety and Hygiene News • Chemical Marketing Reporter • Environmental Protection magazine • World Waste magazine • Environmental Liability Report • Environmental Software Report • Journal of Environmental Health • University of Findlay • University of Illinois, Institute of Labor and Industrial Relations • Hazardous Materials Intelligence Report • ECON: Environmental Contractor • Water & Waste Water International • Environmental Careers • AHW Reporter • EPI, Environmental Products Index • Environmental Labs • Circuit News • Waste Tech News • Soils magazine • National Employment Review • Environmental Compliance Reporter • Environmental Business Journal • Pollution Prevention (Europe) • National Association of Environmental Professionals • Golab Oil Pollution Bulletin

TO: Tower Conference Management Co.
800 Roosevelt Rd., Bldg. E - Ste. 408
Glen Ellyn, IL 60137-5835
(708) 469-3373 • FAX: (708) 469-7477

[] I am interested in ATTENDING HazMat/International '92. Please send full conference details and pre-registration form.

[] My company is interested in EXHIBITING. Please contact me with additional information.

Name ________________________________
Title ________________________________
Company ______________________________
Address ______________________________
City ________________________________
State __________ Zip __________
Phone (______) ________________________
FAX (______) ________________________
D'APPOLINA

ENVIROMENTAL ENGINEERING
- Site Assessments
- Underpinning
- Tank Removal
- Dewatering
- Remediation
- Excavation Support
- Ground Water
- Monitoring

412-856-9440 FAX 412-856-9535

Write in 242

ANNOUNCING THE OPENING OF OUR CUMBERLAND COUNTY N.C. FACILITY TO TREAT PETROLEUM CONTAMINATED SOIL & WATER

- Conveniently located on 195 in Fayetteville, NC
- Low Temperature Thermal Desorption
- Fully permitted & insured
- Large storage & treatment capacity
- Tight acceptance protocols for your protection

WE DO IT THE RIGHT WAY!

TERRADYNE Environmental Services, Inc.
1-919-774-3478
P.O. Box 1225, Sanford, NC 27331-1225

Write in 235

Your company name can appear on this page in the next issue. It is easy to call for soils advertising rates. 816-254-8735

Comprehensive Analytical & Sampling Services related to:
Contaminated Soils • Groundwater • Wastes Wastewater • Air

General Testing Corporation
Rochester, NY (716)464-3706
Hacketson, NJ (201)988-6342
Patterson, NY (716)834-0344

A Full Service Environmental Laboratory Since 1971

Write in 190

Environmental Instrument Sales

Hands-on product manager required for technically superior line of environmental analyzers. Exciting growth opportunity for an energetic self starter willing to travel.

Requires practical experience in environmental instrumentation, government regulation and sales. Involves researching potential markets, developing a strong relationship with EPA and other government agencies, selling to end users and engineering/consulting firms.

Relevant degree and at least five years successful selling in this market are essential qualifications.

Please mail resume and salary requirements to:

Byron Instruments
25776 Simpatica Circle
El Toro, CA 92630

CANAAN PRODUCTS

Federal Express & U.P.S. Next-Day
Gas Standards
Chemicals
Instrument Sales
Instrument Leasing
Lab Supplies
G.C. Supplies
Training

Canaan Scientific Rentals
4037 Darlings Court
Lilburn (Atlanta) GA 30024
(404) 925-2853 FAX: (404)-925-2811
(800) 842-1088

Write in 207

C.T.S. Central Testing Service
Wis. Mich. Ill.

- Tank Testing—Upgrading—Removal
- Tank Site Closures/ Audits
- On Site Hydrocarbon Recovery
- Soil/water Remediation Systems
- Monitor Well Design/Installation
- Site Assessments/Investigations

1-800-542-9392
Fax: 715-266-3109

Write in 113

CANAAN PRODUCTS

Write in 207

Geraghty & Miller, Inc.
Environmental Services

- Hydrocarbon Recovery
- Environmental Engineering
- Underground Storage Tank Services
- Soil/Ground-Water Investigation and Remediation
- Environmental Site Assessments
- Pollution Prevention Services
125 E. Bethpage Rd.,
Plainview, NY 11803-1-800-225-8419

Write in 014
The only solution you should consider for your petroleum contaminated soil problems.

State of the art technology allows you to recycle on-site at an extremely reduced rate and maintain a rapid quantity of material processed daily.

The mobile emulsion unit has been specifically designed for the recycling of contaminated soils. This is the only system of its kind which screens, classifies, weighs, and through computer supervision, thoroughly mixes soils with custom liquid asphalt emulsions. Available in portable or stationary models, with process rates up to 300 tons per hour. Configurations available for additive feed and special features.

The Proven Solution: Valuable construction products are manufactured, while costly environmental liability is avoided. Please direct inquiries concerning:

- Regional Recycling Centers
- Mobile Remediation Services
- Joint Venture Opportunities
- Engineering for Recycling
to our office at (516) 264-2215.

Please feel free to contact us for price quotes on all your remediation problems.
The new **SPILL KILLER™** is here...

...turning oil-contaminated soil and sand into clean fill ON SITE!

- **SAFE** for the environment and the operators! Uses our InProve Colloidal™ Oil Spill Cleanup Agent — non-toxic, 100% biodegradable, EPA-accepted.
- **EFFECTIVE** on oil, gasoline, jet and distillate fuel, and other hydrocarbon spills — new or old!
- **FAST** — clean 11 tons/hour with model shown. Other SPILL KILLERS offer 40, 100, 200 tons/hour capacity.
- **PORTABLE** and self-contained, from its own power supply to its separation tanks.
- **COST-EFFECTIVE** — with only the separated contaminant to remove from site, and no need to haul in clean fill. Contractors make more money on lower bids — customers save time and money, too. Everybody wins with the SPILL KILLER!
- **FAX** (415) 358-9902 on your letterhead for free SPILL KILLER demonstration video tape!

---

**InProve™**

**INDUSTRY-PROVEN PRODUCTS**

**UNIQUE PRODUCTS, INC. 1-800-325-6747**

SALES OFFICE: 2228 So. El Camino Real, #175 • San Mateo, CA 94403 USA • Tel: (415) 358-1930 • Fax: (415) 358-9902

Write in 222