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BIOREMEDIATION CASE STUDIES:

AN ANALYSIS OF VENDOR SUPPLIED DATA

by

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NOTICE

This report has been prepared as a part of the activities of the Data Identification and Collection Subcommittee of the Bioremediation Action Committee (BAC). The BAC is an affiliation of academia, government and industry representatives who share a common goal of working collectively to expand the responsible use of biotechnology for the prevention and remediation of environmental contamination. All data contained within are based on vendor-supplied information. The data contains much variation in details and has not been verified by the compilers. Due to the developing nature of the bioremediation industry and the lack of standardized testing protocols, the report has not been formally peer reviewed by the Agency; hence, the contents do not necessarily represent the views and policies of the U.S. Environmental Protection Agency or of other Federal agencies.

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FOREWORD

The purpose of this report and its companion report, **Bioremediation Case Studies: Abstracts, EPA/600/R-92/044**, is to provide users with reference information about 132 on-going and/or completed field applications and studies from 10 different biotechnology companies. About two-thirds of the cases were at full-scale clean-up level with the remainder at pilot or laboratory scale. The information contained in these reports was voluntarily submitted and was not the result of a formal survey. The report does not contain information from all companies involved in bioremediation, only those companies who responded to a request for voluntary submissions.

These reports were prepared in conjunction with the **Data Identification and Collection Subcommittee** of the **EPA-Industry Bioremediation Action Committee (BAC)**. One of the objectives of the **BAC** is to promote the full potential of bioremediation to treat hazardous waste and clean-up leaks, spills, and abandoned sites through research, demonstrations, and technology transfer. Due to the relative newness of bioremediation for hazardous waste clean-up, there is, in comparison to other more widely used treatment technologies, little information currently available.

These reports were prepared to compile bioremediation studies in a variety of locations and treating diverse contaminants, most of which were previously undocumented. All data contained in this report are based on vendor-supplied information and there was no opportunity to independently confirm its accuracy.

To assist the user in identifying the most useful sources of information, abstracts of the 132 case studies have been entered into the **Alternative Treatment Technology Information Center (ATTIC)** data base to augment the already existing bioremediation information it contains. ATTIC is an on-line, key word searchable, automated data system which provides, with out charge, information on innovative treatment technologies for hazardous waste clean-up. Another source of bioremediation case studies (focused primarily on Federal and State managed clean-up) is contained in **Bioremediation in the Field**, a bulletin published by the U.S. Environmental Protection Agency (EPA).

For more information about these reports, contact Dr. Curtis Harlin, RD-681, U.S. EPA, Office of Research and Development, 401 M Street, S.W., Washington, D.C. For information about ATTIC contact Ms. Joyce Perdek, U.S. EPA, Risk Reduction Engineering Laboratory, 2890 Woodbridge Ave., Edison, NJ.

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I. Purpose and Goal of the Case Study Collection

A. Purpose

The major goal of the Bioremediation Action Committee's (BAC) Data Identification/Collection Subcommittee is to collect bioremediation information that exhibits the technology's benefits and costs and make this information available to the public and private sectors. *(See Appendix A for more information on the origin, purpose, and structure of the BAC.)* One means of exhibiting such information is through an existing U.S. Environmental Protection Agency (EPA) Office of Research and Development (ORD) Office of Environmental Engineering and Technology Demonstration (OEETD) database, the Alternative Treatment Technology Information Center (ATTIC).

ATTIC is an information retrieval network that provides technical information on innovative treatment methods for hazardous wastes and other contaminants. ATTIC provides site remediation managers with information that can assist them in making effective decisions on cleanup alternatives. The technologies in ATTIC are classified as: thermal, biological, solidification/stabilization, chemical, and physical.

ATTIC information is provided in the form of an abstract of a report or case study. The abstract can include information on: location (EPA region and state) where the technology was used, the target waste(s), the media treated, the initial concentration(s) of contaminant(s), a short description of the use of the technology, the cost of the technology, and the final contamination concentration after use of the technology. Copies of the reports from which abstracts are derived are available on request. Currently, more than 1000 users access the system each month. *(See Appendix B for more information on ATTIC and an example of an ATTIC abstract.)*

B. Goal

The general goal of the 1991 ATTIC Bioremediation Case Study Augmentation Project was to increase the number of bioremediation case studies available in ATTIC. Prior to the project, there were approximately 250 cases in the biological treatment portion of the database. For purposes of the project, bioremediation was defined as the process in which soil, sludge, water, or an air stream is managed to encourage optimal activity of microorganisms in order to biodegrade or biotransform target contaminants. Based on resources dedicated to the project, it was estimated that the number of bioremediation abstracts in ATTIC would be increased by 50–100 cases.

II. Methodology

A. Call for Data

1. Telephone Communication

In order to guarantee a certain level of participation, a few companies, who were known to have field-level experience and known to have the resources necessary to participate in the project, were contacted by telephone and questioned as to their interest in participation. A follow-up letter was issued to these companies. *(See Appendix C for follow-up letter.)*

2. In-person Communication

In June 1991, a meeting was held at which the BAC delivered a progress report to EPA Administrator William K. Reilly. More than 100 representatives of industry, government, and academia attended this meeting, which provided the opportunity for industry representatives to comment to the Administrator on EPA's activities concerning bioremediation.

Prior to the Administrator briefing, a poster session was held at which the BAC subcommittees displayed information concerning their activities. For this data collection effort, information on ATTIC and a list of bioremediation information that would be of value to ATTIC users was distributed to potential participants. Because the list of information which would be of value to ATTIC users was fairly extensive, it was stressed that this list was for orientation purposes only. Companies were urged to provide such information, or information of a similar nature, that was readily available. *(See Appendix D for information handout.)*

3. Written Communication

a. Federal Register Notice

On August 7, 1991, "Expansion of Bioremediation Data in the Alternative Treatment Technology Information Center," appeared in the Federal Register, alerting readers to the ATTIC bioremediation case study augmentation project. *(Appendix E contains the Federal Register notice.)*

b. Industry News

A story, "EPA Calls for Bioremediation Case History Information," was published in the July 1991 issue of the industry newspaper, Biotreatment News.

B. Review information submitted

1. Extent and quality of information received

The amount and quality of information initially received from the call for data was highly variable. Case study information ranged from one to two sentences to technical reports of more than 30 pages. Sources of information included corporate statements of qualifications, papers either presented at conferences or submitted for journal publication, abstracts of papers presented, and descriptions of cleanup activities that were not sourced to a specific publication.

More than 240 cases were received. However, based on established ATTIC database acceptance criteria, many of these had too little pertinent information to warrant further investigation and were dropped from the study at the outset. For the remaining cases, companies were contacted with questions on every case in order to ensure that as many cases as possible were suitable for inclusion in ATTIC.

2. Quality Assurance Fields

There are five fields in ATTIC that address quality assurance: site characterization, representative samples taken, data quality objectives met, QA/QC objectives met, and peer review of report. The EPA definition of each is:

site characterization – the contaminated site was characterized for the extent and nature of contaminants present;
representative sampling – a sampling strategy was designed that provided a statistical basis for estimating the contamination before and after the remediation activity;
data quality objective process – the objectives for data quality were established prior to the onset of the study or remediation;
QA/QC conducted – QA/QC steps, such as audits, replicate analysis, calibration of instruments, and training of personnel, were used in sampling and analysis; and
peer review – the report or the data were sent out to be reviewed by knowledgeable peers.

If definitive information is lacking, the field can be entered as "not reported."

In many cases, it was not possible for reviewers of the submitted bioremediation case study information to ascertain the status of the data quality assurance parameters. Therefore, when information on each case was incorporated into the ATTIC format and sent back to the participating companies for a final review, each company was asked at that time to provide information (in a Y/N format) for the data quality assurance fields. *(See Appendix F for cover letter sent to participants concerning final review of cases.)*

III. Results of Information Collection

A total of 132 cases concerning bioremediation resulted from this project. A hard copy of all 132 cases submitted through the 1991 ATTIC Bioremediation Case Study Augmentation Project, in the ATTIC abstract format, is available in a separate publication, "1991 Alternative Treatment Technology Information Center (ATTIC) Augmentation: Bioremediation Case Studies." A copy of this publication is available by calling Dr. Curtis Harlin of OEETD/ORD/EPA at (202) 260-9642; faxing (202) 260-3861; or writing Dr. Harlin at OEETD (RD-681), Office of Research and Development, U.S. EPA, 401 M Street S.W., Washington, D.C. 20460.

Information from these collected case studies has been extracted and loaded into a database. The following are statistics derived from this information.

A. Companies Participating and Number of Cases

There were a total of 10 companies who submitted information that was suitable for ATTIC. From these companies, as stated above, a total of 132 abstracts were prepared for the ATTIC database. These 132 cases increase the number of biological treatment cases in ATTIC by more than 50 percent. Table 1 lists the participating companies by name, the location of the coordinating office for the project, the number of cases for each participating company, and percentage of total number of cases contributed by each company.

Table 1
1991 ATTIC Bioremediation Case Study Augmentation Project: Participating Companies and Number of Cases for ATTIC

Company	Location of Coordinating Office	Number of Cases	Percent of Total
ABB Environmental	Wakefield, MA	7	5.3
CET Environmental Services	Long Beach, CA	5	3.8
ECOVA Corporation	Redmond, WA	17	12.9
Environmental Remediation	Baton Rouge, LA	20	15.2
Groundwater Technology	Concord, CA	33	25.0
IT Corporation	Knoxville, TN	10	7.6
OHM Corporation	Walnut Creek, CA	12	9.1
Remediation Technologies	Chapel Hill, NC	15	11.4
Roy F. Weston	West Chester, PA	6	4.5
Woodward-Clyde	San Diego, CA	7	5.3
Total		132	100.0%[a]

[a]Does not add to 100% due to rounding.

B. Stage of Cleanup

About two-thirds of the cases reported (86 cases) were at full field-scale cleanup level. Fifteen percent of the cases (20 cases) were reported at the field pilot stage while the remaining 20 percent (26 cases) were laboratory studies. Therefore, more than 80 percent of the cases were either at field pilot level or full scale *(Table 2)*.

Table 2
1991 ATTIC Bioremediation Case Study Augmentation Project: Cases by Stage of Cleanup [a]

Stage of Cleanup	Number of Cases	Percent of Total
Full Scale	86	65.2
Pilot (Field) Scale	20	15.2
Laboratory Study	26	19.7
Total	132	100.0%[b]

[a]In instances where more than one level of effort may have been reported in the same case study, the highest level of effort was recorded.
[b]Does not add to 100% due to rounding.

C. Additional Non-Bioremediation Treatments

For 29 percent of the cases reported (38 cases), it was stated that there were treatment technologies used on a particular media in addition to bioremediation *(Table 3)*. However, it should be noted that a case study may not necessarily have listed treatments performed in addition to bioremediation.

Table 3
1991 ATTIC Bioremediation Case Study Augmentation Project: Cases Reporting Treatment in Addition to Bioremediation

Additional Treatment	Number of Cases	Percent of Total
Yes	38	28.8
No	94	71.2
Total	132	100.0%

D. Date Bioremediation Treatment Started

One-quarter of the cases (33 cases) reported bioremediation activity commencing earlier than 1989, 12 percent (16 cases) commenced in 1989, 24 percent (32 cases) commenced in 1990, and 4.5 percent (6 cases) were started in 1991. More than one-third of the cases (45 cases) did not specify when treatment started *(Table 4)*.

Table 4
1991 ATTIC Bioremediation Case Study Augmentation Project: Cases by Date of Treatment Commencement

Start Date of Bioremediation Treatment[a]	Number of Cases	Percent of Total
1988 or Earlier	33	25.0
1989	16	12.1
1990	32	24.2
1991	6	4.5
Not Provided	45	34.1
Total	132	100.0%[b]

[a]Year that bioremediation activities commenced, including installation of bioremediation-related equipment.
[b]Does not add to 100% due to rounding.

E. Status of Completion

About 68 percent of the cases (90 cases) reported that bioremediation activities were completed as of the end of 1991, with about 24 percent (31 cases) still in progress. Another 5 percent (7 cases) are on-going and have no completion date as they are intended to treat a continual flow of contaminants *(Table 5)*.

Table 5
1991 ATTIC Bioremediation Case Study Augmentation Project: Cases by Status of Completion

Status of Completion[a]	Number of Cases	Percent of Total
Project Completed as of 1992	90	68.2
Project In-Progress as of 1992	31	23.5
On-Going Project[b]	7	5.3
Not Provided	4	3.0
Total	132	100.0%

[a]Completion of bioremediation activities.
[b]No completion date; intended to treat continued flow of contaminant.

F. Location of Cleanup Activity

The cases reported media that were the focus of bioremediation activities in 31 states. Almost half of the cleanup activities reported involved media from only five states: California, Louisiana, Massachusetts, New Jersey, and Texas accounted for 44.8 percent of the total number of cases *(Table 6)*.

Table 6
1991 ATTIC Bioremediation Case Study Augmentation Project: Cases by State [a]

State	Number of Cases	Percent of Total
Alabama	1	0.8
Alaska	3	2.3
Arizona	1	0.8
Arkansas	2	1.5
California	22	16.7
Colorado	2	1.5
Connecticut	3	2.3
Florida	4	3.0
Indiana	1	0.8
Louisiana	12	9.1
Massachusetts	8	6.1
Michigan	2	1.5
Minnesota	3	2.3
Missouri	3	2.3
Montana	4	3.0
New Hampshire	3	2.3
New Jersey	9	6.8
New York	4	3.0
North Dakota	1	0.8
Ohio	1	0.8
Oklahoma	1	0.8
Oregon	2	1.5
Pennsylvania	3	2.3
Rhode Island	2	1.5
Tennessee	1	0.8
Texas	8	6.1
Vermont	1	0.8
Virginia	1	0.8
Washington	3	2.3
West Virginia	1	0.8
Wyoming	1	0.8
Non-U.S.	4	3.0
Not Applicable/ Not Provided	15	11.4
Total	132	100.0%[b]

[a]Laboratory studies were included in these statistics if the location of the media used in the study was identified.
[b]Does not add to 100% due to rounding.

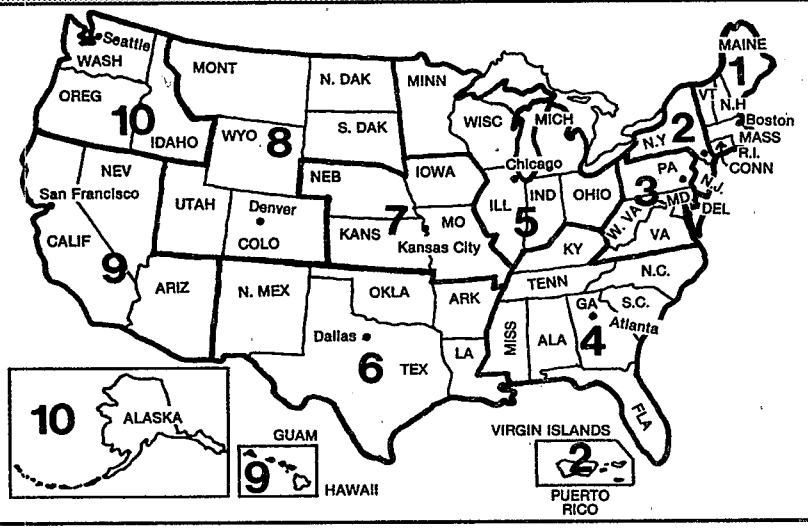
The corresponding EPA Regions for these states are Region 1 (Massachusetts), Region 2 (New Jersey), Region 6 (Texas and Louisiana), and Region 9 (California) *(Table 7)*. Figure 1 shows the U.S. by EPA Regions.

Table 7
1991 ATTIC Bioremediation Case Study Augmentation Project: Cases by EPA Region [a]

EPA Region[b]	Number of Cases	Percent of Total
1	18	13.6
2	14	10.6
3	4	3.0
4	6	4.6
5	7	5.3
6	24	18.2
7	4	3.0
8	8	6.1
9	23	17.4
10	8	6.1
Non-U.S.	4	3.0
Not Applicable/Not Provided	12	9.1
Total	132	100.0%[c]

[a]Laboratory studies were included in these statistics if the location of the media used in the study was identified.
[b]Some cases provided the EPA Region without providing the state.
[c]Does not add to 100% due to rounding.

Figure 1
The EPA Regions



G. Contaminants Treated

Of the 132 cases, more than 62 percent (82 cases) reported treatment of a petroleum–related waste. In seven of these cases, petroleum–related contaminants were treated in addition to other contaminants. Twenty–five cases, 19 percent of the total 132 cases and 31 percent of the petroleum–related cases, were reported as underground storage tank (UST) sites. Almost 9 percent (11 cases) involved treatment of solvents. Agricultural (pesticides) and wood–preserving chemicals constituted 5.3 percent (7 cases) and 9.8 percent (13 cases), respectively, of the total 132 cases. Munitions and coal tar/tar each comprised 4 percent (5 cases). Other contaminants were reported in 7 percent of the cases (9 cases) *(Table 8)*.

Table 8
1991 ATTIC Bioremediation Case Study Augmentation Project: Cases by Contaminants Treated

Contaminant/ Contaminant Use	Number of Cases	Percent of Total
Petroleum–Related[a]	75	56.8
Wood Preservatives[b]	13	9.8
Solvents	10	7.6
Other	9	6.8
Agricultural Chemicals	7	5.3
Coal Tar/Tar	5	3.8
Munitions	4	3.0
Petroleum–Related/Other	3	2.3
Petroleum–Related/ Wood Preservatives	2	1.5
Petroleum/Solvents	2	1.5
Munitions/Agricultural Chemicals	1	0.8
Solvents/Other	1	0.8
Total	132	100.0%[c]

[a]Twenty–five cases (19 percent of the total and 31 percent of the petroleum–related cases) were reported as UST sites.
[b]Creosote and pentachlorophenol.
[c]Does not add to 100% due to rounding.

H. Media Treated

The predominant media treated was soil. In more than 74 percent of the cases reported (98 cases), soil was at least one of the media that was bioremediated. Treatment of soil alone constituted 46 percent of the cases reported (61 cases), while soil and groundwater bioremediation at a single site accounted for 23 percent of the total number of cases (30 cases). Almost 5 percent of the cases (6 cases) involved soil and sludge bioremediation at a single site.

Cases involving bioremediation of only groundwater/water made up 16 percent of the sites reported (21 cases) while bioremediation of groundwater/water in addition to other media comprised 39 percent (52 cases).

Treatment of sludge constituted more than 14 percent of total cases (19 cases) *(Table 9)*.

Table 9
1991 ATTIC Bioremediation Case Study Augmentation Project: Cases by Media Treated

Media	Number of Cases	Percent of Total
Soil	61	46.2
Soil/Groundwater	30	22.7
Groundwater/Water	21	15.9
Sludge	11	8.3
Soil/Sludge	6	4.5
Sludge/Water	1	0.8
Soil/Sludge/Groundwater	1	0.8
Vapor	1	0.8
Total	132	100.0%[a]

I. Method of Treatment Used by Media

More than 60 percent of the cases (48 cases) that involved soil at field pilot or full scale involved solely the use of solid phase/land treatment while in more than 25 percent (21 cases), soil was treated *in situ*. Four percent (3 cases) reported bioreactor/bioslurry usage for soil treatment and another 5 percent (4 cases) utilized both *in situ* and some type of above-ground treatment.

Table 10
1991 ATTIC Bioremediation Case Study Augmentation Project: Cases by Treatment Method Used for Soil

Method	Number of Cases	Percent of Total
In Situ[a]	21	26.6
Above-Ground		
Solid Phase/Land Treatment[b]	48	60.8
Bioreactor/Bioslurry[c]	3	3.8
Solid Phase/Land Treatment And Bioreactor/Bioslurry	3	3.8
In Situ And Above-Ground	4	5.1
Total	79[d]	100.0%[e]

[a]Contaminated medium is treated in place usually through the delivery of oxygen and other nutrients.
[b]Contaminated medium is spread over a prepared area and treated through optimization of microbial requirements for biodegradation. Includes composting.
[c]Contained systems, typically used for treatment of aqueous and slurry media.
[d]Percentages based upon total number of full-scale and field pilot-scale cases involving soil treatment.
[e]Does not add to 100% due to rounding.

Of the 36 cases that registered the treatment of groundwater/water at field pilot or full scale, in 53 percent (19 cases), treatment included bringing the water to the surface and reinjecting without the use of a bioreactor. Forty-seven percent (17 cases) indicated the use of a bioreactor for treatment. Twelve percent (5 cases) involved treatment of groundwater totally below the surface.

Table 11
1991 ATTIC Bioremediation Case Study Augmentation Project: Cases by Treatment Method Used for Groundwater [a]

Treatment Method	Number of Cases	Percent of Total
No Bioreactor/Recirculation[b]	19	46.3
Bioreactor/Bioslurry[c]	17	41.5
Other[d]	5	12.2
Total	41[e]	100.0%

[a]Includes water
[b]Treatment includes bringing groundwater to the surface and making amendments prior to reinjection.
[c]Contained systems typically used for treatment of aqueous and slurry media. Water treated can be reinjected.
[d]Water fully treated in place, below the surface.
[e]Percentages based upon total number of full-scale and field pilot-scale cases involving groundwater treatment.

Almost two-thirds of the cases (10 cases) that dealt with sludge reported bioreactor/bioslurry-type treatment. The remainder (6 cases) were treated by either slurry followed by land treatment or land treatment alone.

Table 12
1991 ATTIC Bioremediation Case Study Augmentation Project: Cases by Treatment Method Used for Sludge

Treatment Method	Number of Cases	Percent of Total
Solid Phase/Land Treatment[a]	3	18.8
Bioreactor/Bioslurry[b]	10	62.5
Bioreactor/Bioslurry And Solid Phase/Land Treatment	3	18.8
Total	16[c]	100.0%[d]

[a]Contaminated medium is placed in a prepared area and treated through optimization of microbial requirements for biodegradation. Includes composting.
[b]Contained systems, typically used for treatment of aqueous and slurry media.
[c]Percentages based upon total number of full-scale and field pilot-scale cases involving sludge treatment.

J. Treatment Method for Soil by Year of Commencement of Treatment

Due to the large number of cases involving soil treatment, the treatment method for soil was assessed by the year that treatment commenced. Only those cases for which a starting year was reported are listed *(Table 13)*.

Table 13
1991 ATTIC Bioremediation Case Study Augmentation Project:
Cases by Treatment Method for Soil by Year of Treatment Commencement

Treatment Method	Years							
	pre–1989		1989		1990		1991	
In Situ[a]	7	33.3	1	8.3	5	22.7	2	66.7
Above–Ground Solid Phase/ Land Treatment[b]	11	52.4	9	75.0	16	72.7	1	33.3
Bioreactor/Bioslurry[c]	0	0.0	0	0.0	1	4.5	0	0.0
Solid Phase/Land Treatment And Bioreactor/Bioslurry	2	9.5	0	0.0	0	0.0	0	0.0
In Situ And Above–Ground	1	4.8	2	16.7	0	0.0	0	0.0
Total	21[d]	100.0%	12[d]	100.0%	22[d]	100.0%[e]	3[d]	100.0%

[a]Contaminated medium is treated in place usually through the delivery of oxygen and other nutrients.
[b]Contaminated medium is spread over a prepared area and treated through optimization of microbial requirements for biodegradation. Includes composting.
[c]Contained systems, typically used for treatment of aqueous and slurry media.
[d]Percentages based upon total number of full–scale and field pilot–scale cases involving soil treatment.
[e]Does not add to 100% due to rounding.

K. Company Specific Information

It is interesting to note that of the cases reported, there were contrasting statistics, on a company basis, concerning parameters such as contaminant treated, method of treatment, and location.

It should be stressed, however, that the information presented below is based solely on the 132 cases described above. Therefore, these cases do not necessarily reflect the total range of capabilities of any participating company and should not be construed as totally representative of company services.

1. Contaminants Treated

Of the cases described above, all companies except for one (Roy F. Weston, Inc.) reported activity involving petroleum–related waste. For six companies (ECOVA Corporation; Environmental Remediation, Inc.; Groundwater Technology, Inc.; IT Corporation; OHM Corporation; and Woodward–Clyde), petroleum–related contaminants constituted the majority of work reported. The remaining companies (ABB Environmental, CET Environmental Services, and Remediation Technologies, Inc.), had activity more dispersed among the various contaminants *(Table 14)*.

2. Media Treated

Of the cases described above, treatment of soil alone or soil and groundwater/water comprised the majority of media for all companies except for one (Environmental Remediation, Inc.), in which case sludge and soil/sludge were the predominant media treated *(Table 15)*.

3. Location of Treatment

Most company activity was concentrated in one region or section of the country. However, one company (Groundwater Technology, Inc.) registered activity in eight out of ten regions *(Table 16)*.

IV. Limitations of the Project

Terminology was not consistent among companies, and thus in some cases, assumptions were made concerning the parameters reported.

These cases do not necessarily reflect all cleanup efforts of any one company. These cases are, instead, only those cases on which information existed and was readily available. Consequently, individual company profiles may be skewed.

Table 14

1991 ATTIC Bioremediation Case Study Augmentation Project: Cases by Contaminants Treated by Company

Contaminant/ Contaminant Use	ABB[a]		CET		ECO		ERI		GTI		IT		OHM		RET		RFW		WCC	
Petroleum-Related	2	28.6	2	40.0	9	52.9	11	55.0	25	75.8	8	80.0	6	50.0	7	46.7	0	0.0	5	71.4
Solvents	2	28.6	0	0.0	1	5.9	0	0.0	3	9.1	1	10.0	2	16.7	0	0.0	1	16.7	0	0.0
Other	1	14.3	1	20.0	1	5.9	2	10.0	0	0.0	0	0.0	3	25.0	0	0.0	1	16.7	0	0.0
Wood Preservatives[b]	0	0.0	0	0.0	3	17.6	3	15.0	0	0.0	0	0.0	1	8.3	5	33.3	0	0.0	1	14.3
Agricultural Chemicals	0	0.0	1	20.0	3	17.6	1	5.0	1	3.0	0	0.0	0	0.0	1	6.7	0	0.0	0	0.0
Coal Tar/Tar	2	28.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	13.3	0	0.0	1	14.3
Munitions	0	0.0	1	20.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	50.0	0	0.0
Petroleum-Related/ Other	0	0.0	0	0.0	0	0.0	2	10.0	1	3.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Petroleum-Related/ Wood Preservatives	0	0.0	0	0.0	0	0.0	0	0.0	2	6.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Petroleum/Solvents	0	0.0	0	0.0	0	0.0	0	0.0	1	3.0	1	10.0	0	0.0	0	0.0	0	0.0	0	0.0
Munitions/Agricultural Chemicals	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	16.7	0	0.0
Solvents/ Other	0	0.0	0	0.0	0	0.0	1	5.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	7	100.0%[b]	5	100.0%	17	100.0%[b]	20	100.0%	33	100.0%	10	100.0%	12	100.0%	15	100.0%	6	100.0%[b]	7	100.0%

[a]ABB- ABB Environmental
CET-CET Environmental Services
ECO-ECOVA Corporation
ERI-Environmental Remediation, Inc.
GTI-Groundwater Technology, Inc.
IT-IT Corporation
OHM-OHM Corporation
RET-Remediation Techologies Inc.
RFW-Roy F. Weston, Inc.
WCC-Woodward-Clyde

[b]Creosote and pentachlorophenol

[c]Does not add to 100% due to rounding.

Table 15

1991 ATTIC Bioremediation Case Study Augmentation Project: Cases by Media Treated by Company

Method of Treatment	ABB[a]		CET		ECO		ERI		GTI		IT		OHM		RET		RFW		WCC	
Soil	4	57.1	4	80.0	7	41.2	6	30.0	13	39.4	5	50.0	5	41.7	9	60.0	4	66.7	4	57.1
Soil/Groundwater	2	28.6	0	0.0	4	23.5	1	5.0	15	45.5	4	40.0	3	25.0	0	0.0	0	0.0	1	14.3
Groundwater/Water	1	14.3	1	20.0	5	29.4	3	15.0	5	15.2	1	10.0	1	8.3	1	6.7	1	16.7	2	28.6
Sludge	0	0.0	0	0.0	1	5.9	7	35.0	0	0.0	0	0.0	0	0.0	3	20.0	0	0.0	0	0.0
Soil/Sludge	0	0.0	0	0.0	0	0.0	3	15.0	0	0.0	0	0.0	1	8.3	2	13.3	0	0.0	0	0.0
Sludge/Water	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	8.3	0	0.0	0	0.0	0	0.0
Soil/Sludge/Groundwater	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	8.3	0	0.0	0	0.0	0	0.0
Vapor	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	16.7	0	0.0
Total	7	100.0%	5	100.0%	17	100.0%	20	100.0%	33	100.0%[b]	10	100.0%	12	100.0%[b]	15	100.0%	6	100.0%[b]	7	100.0%

[a]ABB- ABB Environmental
CET-CET Environmental Services
ECO-ECOVA Corporation
ERI-Environmental Remediation, Inc.
GTI-Groundwater Technology, Inc.
IT-IT Corporation
OHM-OHM Corporation
RET-Remediation Techologies Inc.
RFW-Roy F. Weston, Inc.
WCC-Woodward-Clyde

[b]Does not add to 100% due to rounding.

Table 16
1991 ATTIC Bioremediation Case Study Augmentation Project: Cases by EPA Region by Company

Region	ABB[a]		CET		ECO		ERI		GTI		IT		OHM		RET		RFW		WCC	
1	4	57.1	0	0.0	0	0.0	1	5.0	9	27.3	0	0.0	1	8.3	2	13.3	1	16.7	0	0.0
2	0	0.0	0	0.0	0	0.0	0	0.0	6	18.2	3	30.0	3	25.0	1	6.7	0	0.0	1	14.3
3	0	0.0	0	0.0	0	0.0	0	0.0	2	6.1	1	10.0	1	8.3	0	0.0	0	0.0	0	0.0
4	0	0.0	0	0.0	0	0.0	1	5.0	2	6.1	2	20.0	1	8.3	0	0.0	0	0.0	0	0.0
5	1	14.3	0	0.0	1	5.9	0	0.0	1	3.0	1	10.0	1	8.3	2	13.3	0	0.0	0	0.0
6	0	0.0	0	0.0	1	5.9	14	70.0	3	9.1	2	20.0	1	8.3	1	6.7	1	16.7	1	14.3
7	0	0.0	0	0.0	0	0.0	1	5.0	0	0.0	1	10.0	0	0.0	2	13.3	0	0.0	0	0.0
8	0	0.0	0	0.0	4	23.5	0	0.0	1	3.0	0	0.0	0	0.0	1	6.7	1	16.7	1	14.3
9	1	14.3	5	100.0	6	35.3	2	10.0	6	18.2	0	0.0	3	25.0	0	0.0	0	0.0	0	0.0
10	0	0.0	0	0.0	4	23.5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	16.7	3	42.9
Non-U.S.	0	0.0	0	0.0	0	0.0	0	0.0	3	9.1	0	0.0	0	0.0	0	0.0	0	0.0	1	14.3
Not Applicable/ Not Provided	1	14.3	0	0.0	1	5.9	1	5.0	0	0.0	0	0.0	1	8.3	6	40.0	2	33.3	0	0.0
Total	7	100.0%	5	100.0%	17	100.0%	20	100.0%	33	100.0%[a]	10	100.0%	12	100.0%[a]	15	100.0%	6	100.0%[a]	7	100.0%[a]

[a]ABB- ABB Environmental
CET-CET Environmental Services
ECO-ECOVA Corporation
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[b]Does not add to 100% due to rounding.

List of Appendices

Appendix A

The Bioremediation Action Committee (BAC): Origin, Purpose, and Structure

BAC's Origin and Purpose

In February 1990, U.S. Environmental Protection Agency (EPA) Administrator William K. Reilly and the Assistant Administrators of the Offices of Water, Pesticides and Toxic Substances, Solid Waste and Emergency Response, and Research and Development met with representatives of industry, government, and academia. The purpose of this meeting was to prepare an agenda for the 1990s that identified roles of the public and private sectors and specific actions for each sector to increase environmental applications of biotechnology. As a result of this meeting, the Bioremediation Action Committee (BAC) was formed to evaluate progress on implementation of meeting participants' suggested actions to facilitate the usage of bioremediation and to provide a coordinated forum for continuing dialogue and action.

BAC Structure

The BAC is chaired by Dr. John H. Skinner, Deputy Assistant Administrator of EPA's Office of Research and Development (ORD).

Stephen A. Lingle, Deputy Office Director of the Office of Environmental Engineering and Technology Demonstration, oversees the Committee's progress. Currently, there are six BAC subcommittees, each consisting of several representatives from industry, government, and academia and a chair who reports to the full committee.

The current subcommittees and their respective functions are listed in Table A–1.

Table A-1
The BAC's Subcommittees and Functions

Subcommittee	Function
Data Identification/ Collection	Identify and collect case study information which exhibits the benefits and costs of bioremediation for public and private sector usage.
Education	Propose solutions to the need for technically-trained people.
National Spill Response Plan	Investigate the potential for bioremediation to be utilized as a spill response technique.
Pollution Prevention	Identify applications of biotechnology to industrial processes, resulting in reduced waste streams.
Protocols	Provide technical input for the development of protocols for testing the applicability and effectiveness of bioremediation as a cleanup technology at specific sites.
Research	Review Federal, state, and university research on bioremediation to determine consistency, overlap, and needs.

The Alternative Treatment Technology Information Center (ATTIC)

ATTIC is an information retrieval network providing up–to–date information on innovative treatment technologies. ATTIC provides site remediation managers with the information necessary to make effective decisions on hazardous waste cleanup alternatives. It can be accessed with a PC and modem 24 hours a day and there are no user fees.

How ATTIC Helps Its Users

ATTIC helps users

* Find innovative solutions for permanent remedies at hazardous waste sites.
* Save time and resources by providing a single source for information on alternative treatment options.
* Streamline searches for information by providing searchable abstracts that allow users to quickly screen hundreds of source documents.
* Communicate with peers and learn from their experiences in applying innovative technologies.
* Identify technical experts who can assist them in selecting appropriate technologies and vendors who can help implement the remediation.

How ATTIC Provides Information

Information contained in ATTIC is available from four types of sources:

On–line databases – Using a PC equipped with communications software and a modem, users can access the ATTIC databases which include the ATTIC Database, the Risk Reduction Engineering Laboratory Treatability Database, the Technical Assistance Database, and a Calendar of Events.

Electronic bulletin boards – PC–equipped users can also access a message center, retrieve bulletins containing the latest news on alternative treatment technologies, and participate in on–line special interest groups.

Hotline – Users who do not have access to a PC and modem can request searches be run for them by contacting the ATTIC System Operator.

Repository – Full–text copies of the source documents abstracted in the ATTIC Database are available.

Source: EPA/600/M–91/049, November 1991

SAMPLE ATTIC ABSTRACT

ATTIC CONTROL NUMBER : EH00052
DATE ENTERED : 03/30/89
LAST UPDATED : 12/14/91
LAST REVIEWED : 12/15/91
TITLE : In Situ Biological Degradation Test at Kelly Air Force Base: Vol. I Site Characterization
PUBLICATION DATE : 04/01/86
NTIS NUMBER :
GOVT. PUB. NUMBER :
GOVT. CONTACT : Edward Heyse (904) 283-4628
GOVT. ORGANIZATION : Tyndall Air Force Base, FL
DEVELOPER CONTACT :
ORGANIZATION :
REGION/STATE : 06TX

QUALITY ASSURANCE DATA :
The site was characterized.
Representative samples were taken.
Data quality objectives were met.
QA/QC objectives were met.
The report was not peer reviewe

SITE NAME(S)/LOCATION(S):
Kelly AFB, San Antonio, TX

SUMMARY:
This is a report of in situ pilot-scale bioremediation at a site contaminated with electroplating wastes and solvents. Contaminants were found at varying concentrations: hydrocarbons--220-880 ppm, ketones--1-26 ppm, benzene and chlorobenzene--0.5-116 ppm. Chromium was also present. Soil samples were taken and mixed with groundwater. Microcosm and nutrients were added and incubated for 100 days. Tests were done under aerobic and anaerobic conditions. Microbial degradation took place in both the aerobic alkane, aromatic, and polar hydrocarbon fractions. Chromatographic profiles for the anaerobic microcosm and anaerobic sterile control show similar chromatographic profiles with very little or no evidence of any hydrocarbon degradation. Purge and trap GC/MS were used to monitor anaerobic microbial degradation of chlorinated solvents. Tests revealed that tetrachloroethylene (PCE) and trichloroethylene (TCE) degraded rapidly under anaerobic conditions. Laboratory studies indicate in situ biological degradation of the Kelly Air Force Base

site is feasible. It should be noted that direct comparison cannot be made between total hydrocarbons before treatment and total hydrocarbons after treatment. Pre-treatment samples were analyzed using oil and grease extractions. Post-treatment samples were analyzed by gas chromatography. Oil and grease analysis quantify a larger category of organic compounds present in the soil, and therefore, concentrations should be higher than those resulting from GC/FIA analysis.

CONTAMINANT(S): non-volatile/volatile organic compounds (VOCs), non-volatile metals (electroplating wastes, sediments)

MEDIA: soil, groundwater

TECHNOLOGY: biological treatment, aerobic/anaerobic biodegradation, white rot fungus controls

REPORTED CONCENTRATIONS: hydrocarbons--220-880 ppm; ketones--1-26 ppm; benzene and chlorobenzene--0.5-116 ppm

REPORTED % REDUCTION: One sample contained 0.071 ppm total hydrocarbons. Remaining samples had no detectable quantities.

ADDITIONAL INFORMATION: Engineering and Services Laboratory, Tyndall AFB, FL, (904) 238-4628

COST DATA: Total cost of demonstration site: $281,850, includes system construction, sampling, analysis, chemicals, other direct costs and labor

HISTORY:
This is an electroplating waste disposal site; early-mid 1960's as chemical evaporation pit for waste solvents and other organic compounds.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
RESEARCH AND DEVELOPMENT

Stephen A. Svendsen
Environmental Remediation, Inc.
PO Box 45212-210
Baton Rouge, LA 70895

Dear Mr. Svendsen:

As environmental pollution continues to escalate in our nation, the U.S. Environmental Protection Agency's mission to identify cost effective solutions becomes increasingly important. To fulfill this mission, the Agency actively encourages the use of promising innovative technologies through the dissemination of benefits and cost information on such technologies.

Two years ago, the EPA Office of Research and Development created an information system on alternative innovative technologies designed to increase communication among all parties involved in site remediation. This system is the Alternative Treatment Technology Information Center, ATTIC (see enclosed "Information Sheet on EPA's ATTIC").

Because bioremediation is increasingly being used for addressing pollution problems, the Office of Research and Development is making a special effort to augment the bioremediation information that currently exists in ATTIC with case study information voluntarily submitted by companies such as yours. The EPA would be pleased to include information on any clean-up activities in which your company has been involved. See enclosure, "Bioremediation Case History Information of Value for ATTIC".

By registering with the ATTIC system, you provide site remediation managers with information that promotes effective clean-up decisions. Additionally, your organization's contributions to site clean-ups and other pertinent company information becomes internationally available to the average 680 monthly users of the system.

Should you choose to participate, we suggest several information transfer methods:

* **written response:** information for each case study can be drafted and faxed or mailed.

* **telephone communication:** information of interest can be discussed with a telephone interviewer.

* **transmittal of hard copy text:** a copy of a paper or presentation on a clean-up activity that may have been given in a conference or seminar, or published in a trade journal, can be mailed. Relevant information will be extracted by the project staff.

* **on-line information transmittal:** specifics of this method can be discussed with EPA representatives.

* **any combination of these suggested data transfer options.**

If information is incomplete for any given clean-up, please keep in mind that even partial data can be of value. Additionally, information from clean-ups that may not have yielded expected results are also of value. If arrangements of a proprietary nature seemingly preclude participation, we recommend that you consider either de-sensitizing the information of concern or leaving certain elements of the case study undiscussed, so that you will not have to forego this opportunity for inclusion in ATTIC.

If you would like to participate in this bioremediation information collection, please call the EPA contractor representative, Katherine Devine, of DEVO Enterprises, Inc., at (202) 543-2752. Arrangements for information transfer will be made.

Sincerely yours,

Gregory Ondich
Director, Program Development Staff

Enclosure

This letter was mailed with a copy of the information handout on ATTIC which is included in this report as Appendix D.

Appendix D

Information Sheet on EPA's ATTIC

What is ATTIC?

ATTIC is an acronym for Alternative Treatment Technology Information Center. The ATTIC is an information retrieval network that provides up-to-date technical information on innovative treatment methods for hazardous wastes and other contaminants. ATTIC provides site remediation managers with the information necessary to make effective decisions on clean-up alternatives. The technologies in ATTIC are classified as: thermal, biological, solidification/stabilization, and chemical/physical.

Who uses ATTIC?

The ATTIC user community includes

* EPA:
  on-site coordinators,
  remedial project managers,
  RCRA corrective action permit writers,
  EPA contractors -- ARCS (alternative remedial contracts strategy), REMs (remedial engineering management), ERCS (emergency response cleanup services);
* Other federal agencies;
* State agencies;
* Academia;
* Private sector;
* International agencies.

Currently, an average of 300 users access ATTIC information each month.

What are the information transfer mechanisms employed by ATTIC?

* **Hotline/system operator** -- provides a telephone link to the ATTIC system for all users without access to a PC or Macintosh.
* **On-line system** -- electronic link to the ATTIC system databases and document ordering. It is accessible by any PC or Macintosh equipped with communications software and a modem.
* **Reference library** -- hard copy collection of all technical documents and reports in the ATTIC system containing the most up-to-date information on alternative treatments.
* **Outreach efforts** -- general and specific information on alternative treatment methods, conferences and workshops, user bulletins, fact sheets, and updates.

Bioremediation Case History Information of Value For ATTIC

* Status of clean–up (field, pilot, or treatability study)
* Principal treatment for clean–up (bioremediation or other)
* Remediation system employed (e.g. above–ground, in situ saturated, in situ unsaturated, bioreactor)
* Bioaugmentation or biostimulation
* Genera/species
* Location of clean–up
* Media in which contaminants found
* Type of soil or geologic setting
* Contaminants
* Initial conditions: initial contaminants, number of samples taken, technique used for initial sampling
* Final results: final level of contaminants, number of samples taken, and technique used for final sampling
* Number of interim samples taken
* Action level
* Oxygen source
* Water disposal method
* Time period of cleanup
* Estimated volume of contaminated material
* Government involvement (e.g. Superfund, RCRA, or UST site)
* Clean–up cost
* Cause of contamination
* Brief description of clean–up
* Company information: range of services provided, availability of supporting material, company contact's name and phone number

If you would be interested in having your company's bioremediation information included in ATTIC, contact Katherine Devine at (202) 543–2752.

Side 2

ENVIRONMENTAL PROTECTION AGENCY

[FRL-3982-2]

Expansion of Bioremediation Data in the Alternative Treatment Technology Information Center

AGENCY: Environmental Protection Agency.

ACTION: Notice.

SUMMARY: EPA's Office of Environmental Engineering and Technology Demonstration (OEETD) of the Office of Research and Development (ORD) is expanding the bioremediation data in the Alternative Treatment Technology Information Center (ATTIC). Bioremediation, for this purpose, is defined as the process in which soil, sludge, water, or an air stream is managed to encourage optimal activity of microorganisms in order to biodegrade or biotransform target contaminants. ATTIC is a computerized, on-line, information network that provides up-to-date technical information on innovative treatment methods for hazardous wastes to all members of the Federal, State, and private sector involved in site remediation. The information contained in ATTIC consists of a wide variety of data obtained from Federal, State, and private sector sources.

ADDRESSES: All interested parties may submit information on bioremediation to the following address: Katherine Devine, DEVO Enterprises, Inc., 704 9th Street SE., Washington, DC 20003-2804, (202) 543-2752, FAX (202) 547-2909.

FOR FURTHER INFORMATION CONTACT: Dr. Curtis C. Harlin, OEETD RD-681, U.S. Environmental Protection Agency, 401 M Street SW., Washington, DC 20460, (202) 479-9642.

SUPPLEMENTARY INFORMATION: As environmental pollution continues to escalate in our nation, the U.S. Environmental Protection Agency's mission to identify cost effective solutions becomes increasingly important. To fulfill this mission, the Agency actively encourages the use of promising innovative technologies through the dissemination of benefits and cost information on such technologies.

Two years ago, the EPA Office of Research and Development created an information system on alternative innovative technologies designed to increase communication among all parties involved in site remediation. This system is the Alternative Treatment Technology Information Center.

Because bioremediation is increasingly being used for addressing pollution problems, ORD is making a special effort to augment the bioremediation information that currently exists in ATTIC with case study information voluntarily submitted by the public and private sector involved in bioremediation efforts. Interested parties, including bioremediation companies, may submit information, such as case studies, on technologies used for site clean-up for transfer to ATTIC by: (1) Mailing or faxing written material; (2) providing the information by telephone; (3) sending a copy of a report or a paper or presentation, on a clean-up activity, that may have been given at a conference or seminar, or published in a trade journal, and relevant information will be extracted by ATTIC staff; (4) entering information on-line (contact Katherine Devine or Curtis Harlin for method); or (5) a combination of the above.

At the present time, the ATTIC database contains over 1,600 technical documents and reports collected into a keyboard searchable format. Documentation includes Records of Decisions (RODs) from the Superfund program, SITE project summaries, reports from other Federal agencies, State agency reports, and industry studies. ATTIC is available through both the ATTIC System Operator and an easy-to-use online computer system and will provide technical assistance, conduct searches, and assist in document retrieval at no charge to the user. Currently, there is an average of over 600 monthly users of the system.

Dated: August 1, 1991.

Alfred W. Lindsey,

Director, Office of Environmental Engineering and Technology Demonstration.

[FR Doc. 91-18735 Filed 8-6-91; 8:45 am]

BILLING CODE 6560-50-M

DEVO Enterprises, Inc.
704 9th Street, S.E.
Washington, D.C. 20003-2804
(202) 543-2752 • FAX (202) 547-2909

November 14, 1991

Dr. William R. Mahaffey
ECOVA Corporation
3820 159th Avenue NE
Redmond, WA 98052

Dear Bill:

Thank you for participating in the EPA's ATTIC bioremediation information augmentation project. Enclosed you will find the final draft hard copy version of your company's bioremediation case study information, that is slated for inclusion in ATTIC. Do not be concerned if most of the initial 10 fields are blank, as such fields are either for the system operator's use or do not apply to your particular case(s). Please review this material to ensure that there is no proprietary, or incorrect information, included in these abstracts.

Additionally, we would like to draw your attention to the abstract fields under "quality assurance data" and the EPA definition for each:
site characterization - the contaminated site was characterized for the extent and nature of contaminants present;
representative sampling - a sampling strategy was designed that provided a statistical basis for estimating the contamination before and after the remediation activity;
data quality objective process - the objectives for data quality were established prior to the onset of the study or remediation;
QA/QC conducted - QA/QC steps, such as audits, replicate analysis, calibration of instruments, and training of personnel, were used in sampling and analysis; and
peer review - the report or the data were sent out to be reviewed by knowledgeable peers.
These fields have been entered as "Y/N" (yes/no) on your abstract. In order to ensure maximum accuracy for the database, these have been intentionally left blank. If applicable and, if known, please circle either "Y" or "N". Otherwise, "not reported" will be submitted.

We would like to receive your comments by December 13. After that time, we will assume that there is no additional input on the enclosed cases. If you find that you will require more time to

review the enclosed, please contact us at the number above.

Again, your interest in increasing the amount of publicly-accessible bioremediation information is appreciated. Please do not hesitate to contact us in the future as pertains to submission of more bioremediation case study information to the ATTIC system.

Sincerely,

Katherine Devine and Mari Hotchkiss, Consultants
ATTIC Bioremediation Information Augmentation Project

Enclosure(s)

☆U.S. GOVERNMENT PRINTING OFFICE: 1993 - 750-002/60137