EPA/625/K-97/002
June 1997

Seminar Series on Wood Preserving Site Remediation

June 24-25, 1997—Milwaukee, WI
June 26-27, 1997—Atlanta, GA
July 8-9, 1997—Tacoma, WA

U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory
Center for Environmental Research Information

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Notice

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Overview of Wood Preserving Site Remediation

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Douglas Grosse has a B.A. in English literature from Ohio University and an M.S. in environmental science (engineering) from the University of Cincinnati. He has worked as an environmental engineer at the U.S. Environmental Protection Agency (EPA) in Cincinnati, Ohio, for the past 18 years. He obtained a Certified Electroplater-Finisher certification from the American Electroplaters and Surface Finishers Society in 1988.

Mr. Grosse is currently working in EPA's National Risk Management Research Laboratory. His past experience includes in-house wastewater and hazardous waste research at EPA's pilot plant facilities; serving as a pilot facility manager and project officer (Center Hill Laboratory); working on the Superfund innovative technology evaluation program; serving as a Resource Conservation and Recovery Act (RCRA) corrective action coordinator; and providing technical assistance in Superfund, RCRA, and treatability studies as an aqueous treatment specialist. Currently, Mr. Grosse is working in technology transfer, serving as a specialist in site remediation and industrial wastewater treatment.

Overview of Wood Preserving Site Remediation

by

Douglas W. Grosse

US Environmental Protection Agency

National Risk Management Research Laboratory

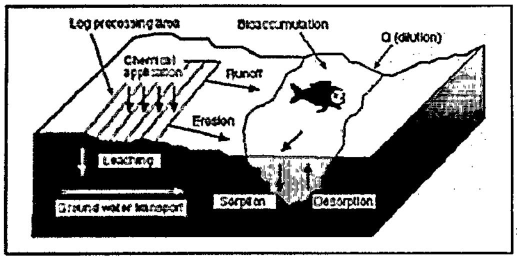
Outline

- Site Description
- Treatability Studies
- Technology Applications

Background

- Wood Preserving Sites
- Contaminants of Concern
- Analytical Methods
- Presumptive Remedies

Contaminant Migration from Modeled Wood Preserving Site



Antrazo, E. Modeling the Transport and Fate of Wood Preserving Wastes in Surface Waters. Proceedings of the Forum on Wood Preserving Wastes, San Francisco, CA (1988).

Distribution of Wood Preserving Sites by EPA Region

EPA Region	No. of Sites
I	17
II	12
III	78
IV	301
V	83
VI	109
VII	28
VIII	31
IX	32
X	58
Total	749

SITE Characterization Leach Tests (SPLP)

Site	Dioxin (1)	PCP (2)	PAH (3)
American Creosote	320	8.2	2.8
Texarkana Wood (TX)	6,200	7.2	11
McCormick Baxter (CA)	9,800	13	14

(2) TEQ - ppq
(3) BAP TEQ - ppb

Treatability Studies

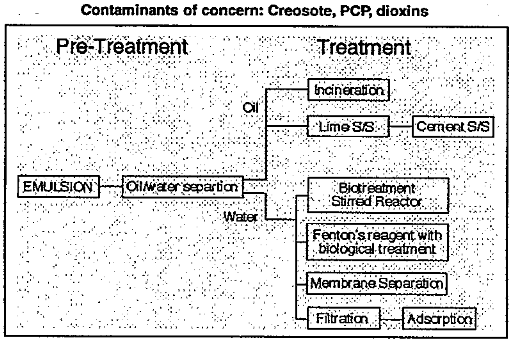
- Start/TSAP
- NPL Sites:
  - RAB
  - ACW
  - MCB

Remedial Action Technology Description

- Pretreatment
- Soil Treatment
- Groundwater Treatment

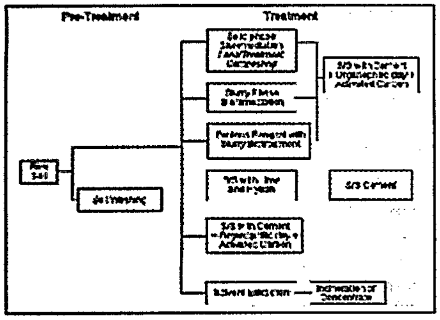
Remedial Options For Creosote Emulsions

Contaminants of concern: Creosote, PCP, dioxins



Remedial Options For Creosote Contaminated Soil

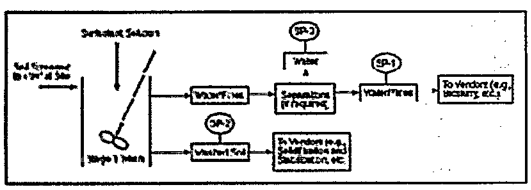
Contaminants of concern: Creosote, Pentachlorophenol, Inorganics, Dioxins



Pretreatment: Soil Washing

- Objectives
- Wet Screening And Sieving
- Results

Soil Washing Test Procedure



Ref. Unpublished report (IT, Corp.)

Soil Treatment Technology

- Bioremediation
- Immobilization
- Physical Separation

Bioremediation

- Description
- Slurry-Phase
- Fenton's Reagent
- Land Farming

Solidification/stabilization

- Description
- Formulations
- Analytical Procedures
- Treatability Study

Thermal Treatment

- Description
- Thermal Desorption
- Incineration
- Case Study

Solvent Extraction

- Description
- Advantages
- Limitations
- Case Study

Base-Catalyzed Decomposition

- Description
- Advantages
- Limitations
- Treatability Study

Groundwater Technologies

- **Photolytic Oxidation**
- **Carbon Adsorption**
- **Membrane Separation**

Cost Estimate for Water Treatment Technologies

Technology	Cost ($/1,000Gal)	Cost Factors	Ref.
Photo Ox	3.90-14.22	Electricity	EPA, 1993b
Carbon	1.38	Conc.	IT, 1996a
Hydraulic	3-75	Depth	EPA, 1992a
Biotreat	2.94-14.56	Location	EPA, 1991a

Cost Estimate for Soil Treatment Technologies

Technology	Cost ($/Ton)	Cost Factors	Ref.
Soil Wash	30-200	Residuals	Biogenesis 1993b
S/S	98-250	Heterogeneity	IT, 1996a
TD	100-600	Moisture	EPA,1994b
SE	94-112	Residuals	EPA, 1993f
BCD	200-500	Residuals	EPA, 1990b
Biotreat	44-105	Method	EPA, 1993d

The Wood Preserving Industry From the Perspective of RCRA and CERCLA

George E. Parris

George E. Parris

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Dr. George E. Parris holds a Ph.D. in organic chemistry from the Georgia Institute of Technology, and pursued a post-doctoral appointment at the National Bureau of Standards in analytical and environmental chemistry, where he focused on the environmental chemistry of arsenic. Dr. Parris has worked in the Environmental Protection Agency's (EPA's) Office of Toxic Substances, served as a research chemist and policy analyst for the Food and Drug Administration, and acted as a consultant to EPA regarding the Toxic Substances Control Act (TSCA) and Resource Conservation and Recovery Act (RCRA) programs. He has also worked at a private engineering firm, where he managed remediations of Superfund sites and underground storage tanks. Dr. Parris further coordinated the Department of Energy's (DOE's) Environmental Restoration Programmatic Environmental Impact Analysis and managed a Corps of Engineers' project to conduct an installation-wide assessment for Fort Riley, Kansas.

In 1996, he joined the American Wood Preservers Institute as the Director of Environmental and Regulatory Affairs, and has since visited approximately 30 treating plants and related facilities. He has been especially active in RCRA; Federal Insecticide, Fungicide, and Rodenticide Act; Comprehensive Environmental Response, Compensation, and Liability Act; and Clean Air Act issues that affect the industry. Dr. Parris has published approximately 20 peer-reviewed basic research papers, a variety of magazine articles, and a long list of government technical support documents.

The Wood Preserving Industry from the Perspective of RCRA and CERCLA

Presented By

George E. Parris, Ph.D.

Director of Environmental and Regulatory Affairs
American Wood Preservers Institute

For The

US EPA Wood Preserving Site Remediation and Technology Transfer Seminar Series

History of Modern Wood Preservation and Environmental Regulation

- **1400-1850 Wooden ships and archaic wood preserving efforts**
  - 1767 Copper sulfate recommended for wood preservation in Europe
  - 1832 Patent for preservation of wood with mercury chloride (Kyanizing)
  - 1836 Coal-tar creosote patented as wood preservative in Europe
  - 1837-9 Patents for copper wood preservatives issued in Europe
- **1840-1950 Railroad Expansion**
  - 1840 Pressure-Treatment Preserving
  - 1850-1900: Zinc chloride sometimes with tannic acid widely used to treat railroad ties and timbers
  - 1875 First major creosote treating plant (West Pascagoula, Mississippi)
  - 1881 Boulton process for treating unseasoned timber introduced

- **1950-1975 Affluent Suburban Lifestyle Expansion**
  - 1950s Pentachlorophenol enters wood treatment
  - 1965 Production:

Pressure-treated Wood Production (1965)

441 Treating Plants
159 million gallons of creosote
60 million gallons of petroleum (no zinc)
20 million pounds of pentachlorophenol

  - 1967 CCA first used in utility poles
  - 1970s Wooden decks popular
  - 1970 US EPA established

- **1975-2000 Era of Environmental Regulation**

    1976 Toxic Substances Control Act (TSCA)

    1977 Resources Conservation and Recovery Act (RCRA)

    1980 Comprehensive Environmental Response, Compensation, and Liability Act

    1980 RCRA Mixture and Derived-from rules

    1985 RCRA Land Disposal Restrictions

    1986 RCRA Contained-in policy

    1986 CERCLA Applicable or Relevant and Appropriate Requirements

    1987 FIFRA Rebuttable Presumption Against Registration agreement on wood preservatives

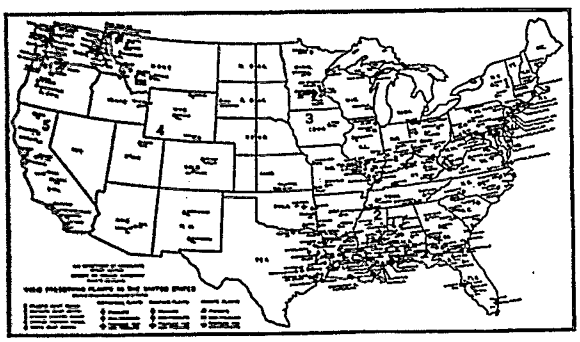
    1987-92 RCRA Listings (K001, F027, F032, F034, F035)

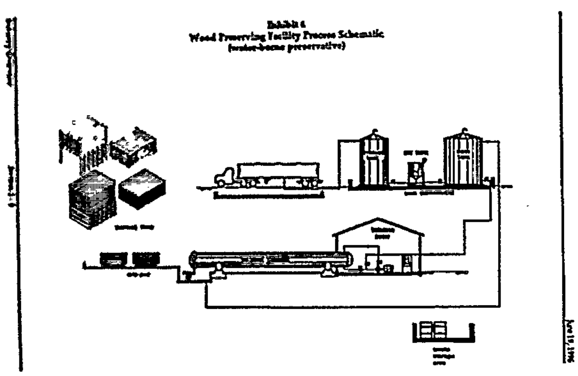
    1988 RCRA Sub-part W Drip Pads

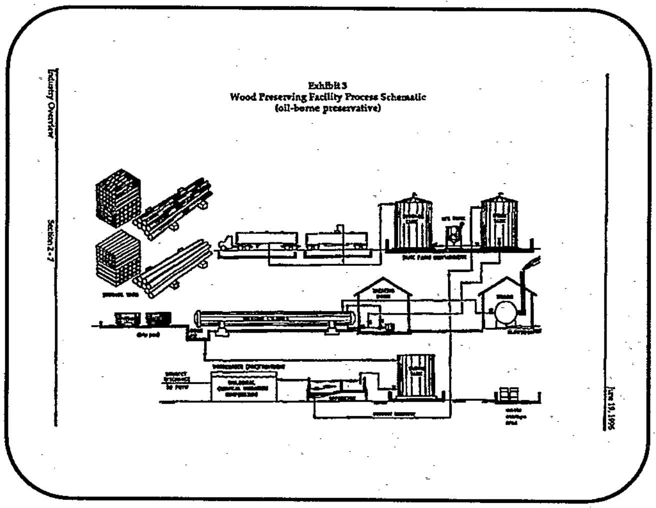
    1997 RCRA LDR Phase IV (F032, F034, F035)

Pressure-treated Wood Production (1996)

Over 451 plants
634 million cubic feet (14% creosote, 5% pentachlorophenol, 71% CCA, ACZA, etc.)






Industry Overview
Exhibit 3
Wood Preserving Facility Process Schematic
(oil-borne preservative)
Section 2-7
June 19, 1996

Remediation of Wood Treating Sites: Solidification/Stabilization

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Edward Bates holds a B.S. and an M.S. in geology from Michigan State University. He has 25 years of experience in environmental investigation and reclamation. For the past 20 years, Mr. Bates has been working at the U.S. Environmental Protection Agency where he is a specialist in remedial design/remedial action, solidification/stabilization, and the remediation of battery recycling and wood preserving sites. He has also worked on the characterization and remediation of 12 wood treating sites and over 40 Superfund sites.

REMEDIATION OF WOOD TREATING SITES
SOLIDIFICATION/STABILIZATION

By

Edward R. Bates
NRMRL/USEPA

Solidification/Stabilization

Purpose: To reduce the mobility of contaminants

Treated Product Properties

- Chemical - SPLP Leachate
  - PAH's - BaP Potency Equivalents
  - PCP
  - Dioxins - TCDD TEQ
- Physical
  - UCS - Unconfined Compressive Strength
  - Permeability
  - Volume Expansion

Dioxin Leach Tests
Untreated Soil (ppq-TEQ)

Site	Totals (1)	TCLP (2)	SPLP (2)
American Creosote (TN)	50,000,000	9.8	320
Texarkana Wood (TX)	8,750,000	14	6,200
McCormick Baxter (CA)	14,000,000	110	9,800
Selma (Area C) (CA)	12,000,000	27.9	144

(1) MTD 8,280
(2) MTD 8,290

PCP Leach Tests
Untreated Soil (ppm) (1)

Site	Totals	TCLP	SPLP
American Creosote (TN)	200	1.0	8.2
Texarkana Wood(TX)	305	0.7	7.2
McCormick Baxter (CA)	347	0.36	13
Selma (Area C)(CA)	1,100	3.13	8.5

(1) MTD 8270

PAH Leach Tests
Untreated Soil (BaP TEQ - ppb) (1)

Site	Totals	TCLP	SPLP
American Creosote (TN)	29,000	ND (2.8)	2.8
Texarkana Wood (TX)	43,500	ND (0.9)	11
McCormick Baxter (CA)	54,000	ND (2.8)	14

(1) MTD 8,270

Relative Potency Factors for Benzo (a) pyrene (BaP) Potency Estimates [1]

PAH Name	BaP Potency Factor [1]
Benz (a) anthracene	0.1
Benzo (a) pyrene	1.0
Benzo (b) fluoranthene	0.1
Benzo (k) fluoranthene	0.01
Chrysene	0.001
Dibenz (a,h) anthracene	1.0
Indeno (1,2,3-cd) pyrene	0.1

1. Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons. EPA/600/R-93. July 1993.

Solidification/Stabilization

Treatability Test Results for 3 sites

Selma Pressure Treating
Selma, California

Contaminants: PCP, CCA

Remediated 1993

Selma Performance Samples
PCP (ppm)

Untreated	Treated	
Total	1,100	—
TCLP	3.1	<0.1
SPLP	39	<0.1

Selma Performance Samples
Dioxins (TEQ - ppq)

	Untreated	Treated
Total	12,000,000	—
TCLP	28	0.025
SPLP	144	<0.01

Selma Performance Samples
Arsenic (ppm)

	Untreated	Treated
Total	204	—
TCLP	1.32	0.11
SPLP	0.5	<0.01

Selma Performance Samples
Chromium (ppm)

	Untreated	Treated
Total	223	—
TCLP	0.04	0.20
SPLP	0.01	0.10

Selma Performance Samples
Physical Properties

UCS	>100 psi
Permeability	$<1 \times 10^{-7}$ cm/sec
Volume Increase	≈ 35%

McCormick/Baxter Site
Stockton, California
Treatability Study

Contaminants: PCP, PAHs, Dioxins

Reagent Cost ≈ $50/Ton Raw Soil

McCormick/Baxter
PCP (ppm)

	Untreated	Treated
Total	347	—
TCLP	0.36	ND (0.001)
SPLP	13.0	ND (0.001)

McCormick/Baxter
Dioxins (TEQ - ppq)

	Untreated	Treated
Total	14,000,000	—
TCLP	110	26
SPLP	9,800	11

McCormick/Baxter
PAHs (BaP TEQ - ppb)

	Untreated	Treated
Total	54,000	—
TCLP	ND (2.8)	ND (2.8)
SPLP	14	ND (2.8)

McCormick/Baxter
Arsenic (ppb)

	Untreated	Treated
Total	80,000	—
TCLP	191	64.4
SPLP	189	ND (20.0)

American Creosote Site
Jackson, Tennessee
Treatability Study

Contaminants: PCP, Dioxins, PAHs

American Creosote
PCP (ppm)

	Target	Untreated	Treated $20*	Treated $62*
Total	—	200	—	—
TCLP	—	1.000	2.500	—
SPLP	0.200	8.200	1.900	0.012

*Formula Cost Only

American Creosote
Dioxins (TEQ - ppq)

	Target	Untreated	Treated $20	Treated $62
Total	—	50,000,000	—	—
TCLP	—	9.8	14	—
SPLP	30	320	9.6	14

American Creosote
PAHs (BaP TEQ - ppb)

	Target	Untreated	Treated $20	Treated $62
Total	—	29,000	—	—
TCLP	—	ND (2.8)	ND (2.8)	—
SPLP	10	2.8	ND (2.8)	ND (2.8)

American Creosote
Physical Properties

	Target	Treated $20	Treated $62
UCS (psi)	100	1,071	1,240
Permeability (Cm/sec)	$1X10^{-6}$	$1.1X10^{-6}$	$4.1X10^{-7}$

Texarkana Wood Site
Texarkana, Texas
Treatability Study

Contaminants: PCP, Dioxins, PAHs

Texarkana Wood Site
PCP (ppm)

	Target	Untreated	Treated $54*	Treated $66*
Total	—	305	—	—
TCLP	—	0.69	0.077	0.005
SPLP	0.20	7.2	0.15	0.07

*Formula Reagent Cost Only

Texarkana Wood Site
Dioxins (TEQ - ppq)

	Target	Untreated	Treated $54*	Treated $66*
Total	—	8,750,000	—	—
TCLP	—	14	17	17
SPLP	30	6,200	12	29

*Cost of Reagents Only

Texarkana
PAHs (BaP TEQ-ppb)

	Target	Untreated	Treated $54*	Treated $66*
Total	—	43,500	—	—
TCLP	—	ND (0.9)	4.1	ND (3.6)
SPLP	10	11	ND (0.8)	<0.98

*Reagent Cost Only

Texarkana Wood Site
Physical Properties

	Target	Treated $54*	Treated $66*
UCS (psi)	100	620	340
Permeability (cm/sec)	$1X10^{-6}$	$5.6X10^{-7}$	$1.4X10^{-7}$

*Reagent Cost Only

Typical Achievable Results

SPLP PCP	<0.2 ppm
SPLP Dioxins	<30 ppq TEQ
SPLP PAHs	<10 ppb as BaP TEQ
UCS	>100 psi
Permeability	<1X10-6 cm/sec
Reagent Formula Cost	$40-70/Ton Soil

Wood Preserving Site Remediation Using Solvent Extraction

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John Markiewicz

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John Markiewicz earned his B.S. in chemical engineering from the University of Pittsburgh. He has 17 years of technical experience developing chemical processes and process improvements for commercialization. During the course of his association with CF Systems Corporation, Mr. Markiewicz accumulated over 9 years' experience working with an innovative solvent extraction technology using liquefied gases and supercritical fluids. In his role as Development Manager, he designed, conducted, and managed laboratory and pilot-scale studies used to develop and optimize the technology for specific chemical and environmental applications in industry and government. He then assumed technical responsibility for the start-up and safe operation of CF Systems' first commercial unit—an extraction process using liquefied propane in a resource recovery/waste minimization application for a major U.S. Gulf coast refinery.

Mr. Markiewicz is the founder of C3 Engineering, which provides high quality process engineering services to industry and government. He recently contracted with CF Environmental Corporation to provide engineering services in support of a commercial extraction and remediation process at a former wood treating site contaminated with polyaromatic hydrocarbons, pentachlorophenol, furans, and dioxin. Mr. Markiewicz has presented and published numerous papers and is a member of the American Institute of Chemical Engineers.

Wood Preserving Site Remediation using Solvent Extraction

John Markiewicz

Introduction

- More Than 50 Wood Treating Sites In U.S. Requiring Remedial Action
- Contaminamts of Concern Include:
  - Polyaromatic Hydrocarbons
  - Pentachlorophenol
  - Furans
  - Dioxin

Introduction (continued)

- Bench and Pilot Scale Treatability Studies Demonstrated Solvent Extraction as a Viable Technology
- CF Environmental Corporation Currently in Commercial Start-Up of a Solvent Extraction Facility in Conroe, TX

Advantages of Solvent Extraction

- Accept Variety/Levels of Organic Contaminants in Soils, Sludges, Sediments
- Removes Organic Contaminants One to Several Orders of Magnitude
- Environmentally Friendly - no combustion, pyrolysis, etc.
- Commercially Proven and Available

Limitations of Solvent Extraction

- Solvents Are Flammable, Toxic or Both
- May Not Be Cost Effective for Small Quantities
- Potential for Emulsion Formation
- Technology Does Not Destroy Organic Contaminants
- Technology Typically Is Limited to 99.5% or Less Reduction of Organics

Solvent Extraction Variables

- Contactor Type (Mixer, Packed Bed, Etc.)
- Solvent Type
- Solvent to Feed Ratio
- Extraction Stages
- Contact Time
- Extraction Temperature
- Feed Pretreatment Requirements

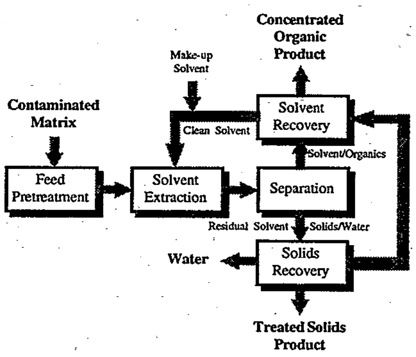
Criteria for Solvent Selection

- Effectiveness in Extracting the Contaminants from the Waste Matrix
- Economical Separation of Solvent from the Contaminants for Recovery and Reuse
- Low Solvent Cost and Toxicity

Solvent Types

- Liquefied Gases
  - propane, butane, dimethyl ether
- Supercritical Fluids
  - carbon dioxide
- Critical Solution Temperature Solvents
  - triethylamine, diethylamine
- Conventional Hydrocarbon Solvents
  - alkanes, alcohols, ketones

Solvent Extraction Process Schematic



Solvent Extraction Vendors

- CF Environmental Corporation
  - liquefied gas solvents, supercritical fluids
- Terra-Kleen Corporation
  - conventional hydrocarbon solvents
- Biotherm, LLC
  - conventional hydrocarbon solvents
- Resources Conservation Company
  - critical solution temperature solvents

CF Systems' Performance Data (Pilot Scale)
United Creosoting Superfund Site
Non-Carcinogenic PAHs

Compound	Feed (mg/kg)	Treated (mg/kg)	Reduction (%)
Napthalene	590	1.5	99.7
Acenaphthylene	15	3.0	80.0
Acenaphthene	360	3.4	99.1
Fluorene	380	3.8	99.0
Phenanthrene	590	13	97.8
Anthracene	330	8.9	97.3
Fluoranthene	360	11	96.9
Pyrene	360	11	96.9
Total nc-PAHs	2985	55.6	98.1

CF Systems' Performance Data (Pilot Scale)
United Creosoting Superfund Site
Carcinogenic PAHs

Compound	Feed (mg/kg)	Treated (mg/kg)	Reduction (%)
Chrysene	110	9.1	91.7
Benzo(a)anthracene	100	7.9	92.1
Benzo(k)fluoranthene	50	17	66.0
Benzo(b)fluoranthene	51	9.7	81.0
Benzo(a)pyrene	48	12	75.0
Indeno(1,2,3-cd)pyrene	19	11	42.1
Dibenzo(a,h)anthracene	ND	4.3	NA
Benzo(g,h,i)perylene	20	12	40.0
Total c-PAHs	398	83	79.1
c-PAHs (BAP equiv.)	54.3	16.2	70.1

CF Systems' Performance Data (Pilot Scale)
United Creosoting Superfund Site
Pentachlorophenol

Compound	Feed (mg/kg)	Treated (mg/kg)	Reduction (%)
Pentachlorophenol	380	58	84.7

Factors Impacting Cost

- Quantity of Material Requiring Treatment
- Project Duration
- Required Treatment Levels

Reference

- EPA's Engineering Bulletin on Solvent Extraction
  - Document # EPA/540/S-94/503

Chemical Dechlorination of Wood Preserving Waste Components Using the Base-Catalyzed Dechlorination (BCD) Process

Thomas O. Tiernan

Thomas O. Tiernan

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Thomas Tiernan holds a B.S. in chemistry from the University of Windsor and M.S. and Ph.D. degrees in chemistry from Carnegie-Mellon University. For the past 22 years, he has directed an extensive environmental research program at Wright State University, developing and implementing complex analytical methods to characterize toxic organic chemicals in numerous media. This has helped develop several analytical protocols that have been applied in the conduct of numerous environmental assessments and remedial action programs. Dr. Tiernan's laboratory has also conducted studies in connection with the assessment and cleanup of hazardous products resulting from fires involving polychlorinated biphenyl (PCB) dielectric fluid- transformers; related studies have been aimed at evaluating the risks posed by toxic organics generated by municipal and hazardous waste incinerators. Prior to joining the faculty of Wright State University, Dr. Tiernan was a U.S. Air Force civilian research scientist and laboratory director for 15 years at Wright-Patterson Air Force Base, where he was the scientific and administrative director of a large research group that encompassed both in-house and external contract research programs in physical, analytical, and environmental chemistry. These programs involved studies of radiation chemistry of fundamental electron, ion and free radical processes, as well as development of specialized mass spectrometric and related instrumentation. The latter phases of this work involved studies to assess the environmental impact and to achieve ultimate disposal of the inventory of Agent Orange.

Dr. Tiernan is currently a professor of chemistry and the director of the Brehm Laboratory at Wright State University. Recent research and development work by Dr. Tiernan's laboratory is concerned with alternative chemical treatment technologies for remediation of hazardous waste sites, particularly for dehalogenation of PCBs, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, various chlorinated pesticides and solvents, and contaminated soils. These studies are currently focused on the Base-Catalyzed Decomposition Process. Dr. Tiernan has authored more than 200 publications; presented invited lectures through the United States, Canada, Europe, and Japan; and organized and chaired symposia at both national and international scientific conferences. Dr. Tiernan has served as a critical reviewer of EPA reports and documents, including several recent Health Assessment, Chemical Criteria, and Remedial Technology documents, as well as reports relating to specific environmental assessments conducted by EPA and its contractors. Dr. Tiernan has also served on many peer review panels to review and evaluate EPA, U.S. Department Of Energy, U.S. Air Force, and U.S. Army research programs. Dr. Tiernan is a member of the National Academy of Sciences - National Research Council Committee on Alternative Chemical Demilitarization Technologies.

CHEMICAL DECHLORINATION OF WOOD PRESERVING WASTE COMPONENTS USING THE BASE-CATALYZED DECHLORINATION (BCD) PROCESS

THOMAS O. TIERNAN, PH.D.

WRIGHT STATE UNIVERSITY
BREHM LABORATORY
DAYTON, OH 45435

MAJOR TOXIC CONTAMINANTS IN PENTACHLOROPHENOL WOOD PRESERVING MATERIALS

CHLOROPHENOLS
(PENTA-, TETRA-, TRICHLORINATED)

POLYCHLORINATED DIBENZO-p- DIOXINS AND POLYCHLORINATED DIBENZOFURANS (PRINCIPALLY HEXA-, HEPTA- AND OCTACHLORINATED)

POLYCYCLIC AROMATIC HYDROCARBONS (ACENAPHTHENE, ANTHRACENE, BENZ(a)ANTHRACENE, CHRYSENE, FLUORANTHENE, PHENANTHRENE, PYRENE)

POLYCHLORINATED DIBENZO-p-DIOXINS (PCDDs) AND POLYCHLORINATED DIBENZOFURANS (PCDFs)

75 PCDD ISOMERS AND 135 PCDF ISOMERS RANGING FROM MONO- THROUGH OCTACHLORINATED

2,3,7,8-SUBSTITUTED ISOMERS ARE CONSIDERED TO BE MORE TOXIC

2,3,7,8-TETRACHOLORDIBENZO-p-DIOXIN (TCDD) MOST TOXIC SINGLE ISOMER

BASE-CATALYZED DECHLORINATION (BCD) PROCESS

A CATALYTIC HYDROGENATION PROCESS IN WHICH CHLORINE ATOMS ARE REMOVED FROM CHLORINATED MOLECULES AND REPLACED BY HYDROGEN ATOMS

$$\underset{[\text{Chlorinated Molecule}]}{R-Cl} + \underset{[\text{Sodium Hydroxide}]}{NaOH} + \underset{[\text{Hydrogen Donor}]}{R'-H} \xrightarrow[320^\circ\text{-}360^\circ]{\text{Catalyst}} R' + R-H + NaCl + H_2O$$

IT HAS BEEN SHOWN THAT BCD OF POLYCHLORINATED MOLECULES SUCH AS PCDDs, PCDFs, PCBs OCCURS BY STEPWISE REMOVAL OF CHLORINE ATOMS BEGINNING WITH THE HIGHER CHLORINATED ISOMERS AND CONTINUING TO THE LOWER CHLORINATED ISOMERS UNTIL DECHLORINATION IS COMPLETE

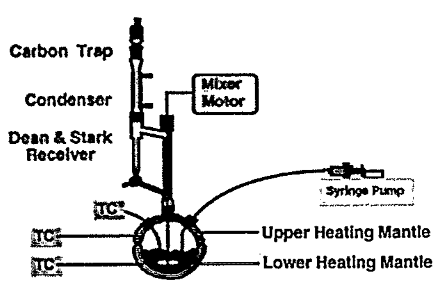
MATERIALS SUBJECTED TO BCD IN THE PRESENT BENCH-SCALE STUDY

WASTE CHEMICAL SOLUTIONS CONTAINING CHOLOROPHENOLS, PCDDs, PCDFs AND PAHs WERE EXTRACTED FROM CONTAMINATED WOOD PRESERVING SITE SOILS BY:

1) THERMAL DESORPTION
2) SOLVENT EXTRACTION

THE ORGANIC PHASE OF THESE EXTRACTS WAS SUBJECTED TO BCD TREATMENT

LABORATORY SCALE REACTOR FOR BCD TREATMENT STUDIES



TC=Thermocouple

Experimental Parameters for BCD Treatability Tests

Test Parameter	Preliminary Test #1	Preliminary Test #2	Preliminary Test #3	Final Test
Mass of Organic Treated	2.16 g	2.15 g	2.00 g	2.15 g
Initial Additives	63.0 g LW-110 oil 22.00 g LW-104 oil 30.0 g NaOH 2.00 g catalyst C2	100.0 g No. 6 fuel oil 10.0 g NaOH 2.00 g catalyst C2	40.0 g LW-110 oil 40.0 g LW-104 oil 20.0 g NaOH 4.00 g CaO 2.00, g catalyst SS1	40.0 g LW-110 oil 40.0 g LW-104 oil 20.0 g NaOH 4.00 g CaO 2.00 g catalyst SS1
Mass of LW-110 oil added (to rinse syringe)	4.87 g	4.76 g	0	0
Total Mass of material (organic and additives)	124.03 g	118.91 g	108 g	108.15 g
Reaction temperature	322°C to 333°C	329°C to 344°C	311°C to 325°C	310°C to 312°C
Elapsed heating time before reaction temperature was reached	1 hour	1 hour	1 hour, 20 minutes	1 hour, 20 minutes
Time at reaction temperature	5 hours	2 hours	1 hour	1 hour
Physical description of reaction product	Two phases: a light oil phase with the color and consistency of motor oil; and a black, solid material	One phase, black in color with the consistency of honey	One phase, dark brown in color with the consistency of molasses	One phase, dark brown in color with the consistency of molasses

Analytical Procedures Utilized to Characterize Untreated and Treated Wastes

Matrix	Analytical Parameter	Method Number	Method Reference
Organic Extract	SVOCs	3580A/8270B	SW-846[a]
	Dioxins/Furans	8290	SW-846[a]
BCD Reaction Product from Preliminary Tests	SVOCs (PCP only)	3580A/8270B	SW-846[a]
BCD Reaction Product from Final Test	SVOCs	3580A/8270B	SW-846[a]
	Dioxins/Furans	8290	SW-846[a]

a. Test Methods for Evaluating Solid Waste, USEPA 1987, SW-846, 3rd Edition

Analytical Results from Preliminary BCD Treatability Studies

Target Chemical	Organic Extract µg/g	Reaction Product from Preliminary Test No. 1 µg/g	No. 2 µg/g	No. 3 µg/g
Pentachlorophenol	12,900	ND (0.045)	ND (0.175)	ND (0.025)

ND - Not detected at the reporting limit. Reporting limit stated in parentheses.

Analytical Results from Final BCD Treatability Test

Compound Name	Concentration in Organic Extract	Concentrations in Reaction Product
Dioxins and Furans, in ng/g (ppb)		
2378-TCDD	3.80	ND (0.0033)
2378-TCDF	5.47	ND (0.0019)
12378-PeCDF	21.4	ND (0.0031)
12378-PeCDD	18.1	ND (0.0034)
23478-PeCDF	26.8	ND (0.0024)
123478-HxCDF	178	ND (0.0030)
123678-HxCDF	86.4	ND (0.0053)
123478-HxCDD	45.9	ND (0.0060)
123678-HxCDD	441	ND (0.0056)
123789-HxCDD	104	ND (0.0049)
234678-HxCDF	33.5	ND (0.0034)
123789-HxCDF	5.53	ND (0.0040)
1234678-HpCDF	2,280	ND (0.0043)
1234678-HpCDD	12,600	ND (0.0054)
1234789-HpCDF	ND (354)	ND (0.0073)
OCDD	183,000	ND (0.0014)
OCDF	16,900	ND (0.0064)

ND : Not detected at the reporting limit. Reporting limit stated in parentheses.

Results of Final BCD Treatability Test - Dioxin/Furan Concentrations Expressed as Toxic Equivalents (TEQ)

		Organic Extract		Reaction Product	
Compound Name	TEF*	ng/g (ppb)	TCDD - TEQ*	ng/g (ppb))	TCDD - TEQ*
2378-TCDD	1	3.80	3.80	ND (0.0033)	0.00330
2378-TCDF	0.1	5.47	0.547	ND (0.0019)	0.00019
12378-PeCDF	0.05	21.4	1.07	ND (0.0031)	0.00016
12378-PeCDD	0.5	18.1	9.05	ND (0.0034)	0.00170
23478-PeCDF	0.5	18.1	13.4	ND (0.0024)	0.00120
123478-HxCDF	0.1	178	17.8	ND (0.0030)	0.00030
123678-HxCDF	0.1	86.4	8.64	ND (0.0053)	0.00053
123478-HxCDD	0.1	45.9	4.59	ND (0.0060)	0.00060
123678-HxCDD	0.1	441	44.1	ND (0.0056)	0.00056
123789-HxCDD	0.1	104	10.4	ND (0.0049)	0.00049
234678-HxCDF	0.1	33.5	3.35	ND (0.0034)	0.00034
123789-HxCDF	0.1	5.53	0.553	ND (0.0040)	0.00040
1234678-HpCDF	0.01	2,280	22.8	ND (0.0043)	0.000043
1234678-HpCDD	0.01	12,600	126	ND (0.0054)	0.000054
1234789-HpCDF	0.01	ND(354)	3.54	ND (0.0073)	0.000073
OCDD	0.001	183,000	183	ND (0.0142)	0.000014
OCDF	0.001	16,900	16.9	ND (0.0064)	0.000006
TCDD - TEQ*			<470		ND (0.00606)

ND : Not detected at the reporting limit. Reporting limit stated in parentheses.

* TEF is the Toxicity Equivalency Factor from the I-TEF/89 scheme; TCDD-TEQ is the toxicity equivalency from the I-TEF/89 scheme.

Analytical Results from Final BCD Treatability Test (continued)

Compound Name	Concentration in Organic Extract	Concentration in Reaction Product
Dioxins and Furans, in ng/g (ppb)		
Total TCDD	27.4	ND (0.0033)
Total PeCDD	117	ND (0.0034)
Total HxCDD	1,750	ND (0.0054)
Total HpCDD	24,700	ND (0.0054)
Total TCDF	41.4	ND (0.0019)
Total PeCDF	528	ND (0.0027)
Total HxCDF	2,920	ND (0.0039)
Total HpCDF	12,400	ND (0.0054)

ND - Not detected at the reporting limit. Reporting limit stated in parentheses.

Analytical Results from Final BCD Treatability Test (continued)

Compound Name	Concentration in Organic Extract	Concentration in Reaction Product
Chlorophenols, in µg/g (ppm)		
Pentachlorophenol	12,900	ND (0.020)
2,3,4,6 - Tetrachlorophenol	197	ND (0.010)
2,4,5 - Trichlorophenol	ND (0.1)	ND (0.010)
2,4,6 - Trichlorophenol	ND (0.1)	ND (0.010)

ND - Not detected at the reporting limit. Reporting limit stated in parentheses.

Analytical Results from Final BCD Treatability Test (continued)

Compound Name	Concentration in Organic Extract	Concentration in Reaction Product
SVOCs, in µg/g (ppm)		
Acenaphthene	2,330	56 J
Anthracene	1,920	46 J
Benz(a)anthracene	2,000	36 J
Benzo(b)fluoranthene	1,780	24 J
Benzo(k)fluoranthene	1,350	12 J
Benzo(a)pyrene	847	16 J
Chrysene	2,210	50 J
Fluoranthene	6,910	150
Fluorene	580	16 J
Phenanthrene	2,870	48 J
Pyrene	9,300	130
Total detected PAHs	32,500	680

J = Estimated value; detected above method detection limit but below reporting limit.

Percent Reductions in Contaminant Concentrations in Organic Extract Achieved by BCD Treatment

Compound Name	Concentration in Organic Extract	Concentration in Reaction Product		Percent Reduction in Contaminant Concentration Between Extract and Reaction Product	
		As Analyzed	Adjusted for Dilution	As Analyzed	Adjusted for Dilution
Dioxins and Furans in ng/g (ppb)					
2378-TCDD	3.80	ND (0.0033)	ND (0.17)	>99.9	>95.6
2378-TCDF	5.47	ND (0.0019)	ND (0.01)	>99.9	>98.3
12378-PeCDF	21.4	ND (0.0031)	ND (0.16)	>99.9	>99.3
12378-PeCDD	18.1	ND (0.0034)	ND (0.17)	>99.9	>99.1
23478-PeCDF	26.8	ND (0.0024)	ND (0.12)	>99.9	>99.5
123478-HxCDF	178	ND (0.0030)	ND (0.15)	>99.9	>99.9
123678-HxCDF	86.4	ND (0.0053)	ND (0.27)	>99.9	>99.7
123478-HxCDD	45.9	ND (0.0060)	ND (0.30)	>99.9	>99.3
123678-HxCDD	441	ND (0.0056)	ND (0.28)	>99.9	>99.9
123789-HxCDD	104	ND (0.0049)	ND (0.25)	>99.9	>99.8
234678-HxCDF	33.5	ND (0.0034)	ND (0.17)	>99.9	>99.5
123789-HxCDF	5.53	ND (0.0040)	ND (0.20)	>99.9	>99.4
1234678-HpCDF	2,280	ND (0.0043)	ND (0.22)	>99.9	>99.9
1234678-HpCDD	12,600	ND (0.0054)	ND (0.27)	>99.9	>99.9
1234789-HpCDF					
OCDD	183,000	ND (0.0142)	ND (0.71)	>99.9	>99.9
OCDF	16,900	ND (0.0064)	ND (0.32)	>99.9	>99.9

ND - Not detected at the reporting limit. Reporting limit stated in parentheses.

Percent Reductions in Contaminant Concentrations in Organic Extract Achieved by BCD Treatment (continued)

Compound Name	Concentration in Organic Extract	Concentration in Reaction Product		Percent Reduction in Contaminant Concentration Between Extract and Reaction Product	
		As Analyzed	Adjusted for Dilution	As Analyzed	Adjusted for Dilution
Dioxins and Furans, in ng/g (ppb)					
Total TCDD	27.4	ND (0.0009)	ND (0.17)	>99.9	>99.4
Total PeCDD	117	ND (0.0004)	ND (0.17)	>99.9	>99.9
Total HxCDD	1,750	ND (0.0064)	ND (0.27)	>99.9	>99.9
Total HpCDD	24,700	ND (0.0064)	ND (0.27)	>99.9	>99.9
Total TCDF	41.4	ND (0.0019)	ND (0.10)	>99.9	>99.8
Total PeCDF	826	ND (0.0027)	ND (0.14)	>99.9	>99.9
Total HxCDF	2,300	ND (0.0009)	ND (0.19)	>99.9	>99.9
Total HpCDF	12,400	ND (0.0064)	ND (0.27)	>99.9	>99.9

ND : Not detected at the reporting limit. Reporting limit stated in parentheses.

Percent Reductions in Contaminant Concentrations in Organic Extract Achieved by BCD Treatment (continued)

Compound Name	Concentration in Organic Extract	Concentration in Reaction Product		Percent Reduction in Contaminant Concentration Between Extract and Reaction Product	
		As Analyzed	Adjusted for Dilution	As Analyzed	Adjusted for Dilution
Chlorophenols, in µg/g (ppm)					
4-Nitrophenol	4,610	ND (100)	ND (5,000)	>97.8	NC
Pentachlorophenol	12,900	ND (0.020)	ND (1.0)	>99.9	>99.9
2,3,4,6-Tetrachlorophenol	197	ND (0.010)	ND (0.05)	>99.9	>99.7

NC = Not calculated.

QA Analyses - Duplicate Results for Organic Extract

Compound Name Dioxins and Furans	Sample Result ng/g (ppb)	Duplicate Result ng/g (ppb)	Average ng/g (ppb)	RPD
2378-TCDD	3.80	4.59	4.20	18.8
2378-TCDF	5.47	5.34	5.41	2.41
12378-PeCDF	21.4	21.6	21.5	0.93
12378-PeCDD	18.1	17.6	17.9	2.80
23478-PeCDF	26.8	26.8	26.8	0
123478-HxCDF	178	176	177	1.13
123678-HxCDF	86.4	89.9	88.2	3.97
123478-HxCDD	45.9	46.8	46.4	1.94
123678-HxCDD	441	448	445	1.57
123789-HxCDD	104	102	103	1.94
234678-HxCDF	33.5	32.6	33.1	2.72
123789-HxCDF	5.53	ND(6.46)	NC	NC
1234678-HpCDF	2,280	2,260	2,270	0.88
1234678-HpCDD	12,600	12,400	12,500	1.60
1234789-HpCDF	ND (354)	ND (385)	NC	NC
OCDD	183,000	198,000	190,000	7.87
OCDF	16,900	16,800	16,900	0.59

NC : Not calculated.
ND : Not detected at the reporting limit. Reporting limit stated in parentheses.

QA Analyses - Duplicate Results for Organic Extract (continued)

Compound Name Dioxins and Furans	Sample Result ng/g (ppb)	Duplicate Result ng/g (ppb)	Average ng/g (ppb)	RPD
Total TCDD	27.4	33.7	30.6	20.6
Total PeCDD	117	122	120	4.18
Total HxCDD	1,750	1,790	1,770	2.26
Total HpCDD	24,700	23,500	24,100	4.98
Total TCDF	41.4	42.0	41.7	1.44
Total PeCDF	526	535	531	1.70
Total HxCDF	2,920	3,110	3,020	6.30
Total HpCDF	12,400	12,500	12,500	0.803
Total CDFs	32,900	33,100	33,000	0.606
Total CDDs	209,000	223,000	216,000	6.48
Total CDFs/CDDs	242,000	256,000	249,000	5.62

QA Analyses Duplicate Results for Organic Extract (continued)

Compound Name	Sample Result	Duplicate Result	Average	RPD
Pentachlorophenol	12,900	10,700	11,800	18.6
2,3,4,6 - Tetrachlorophenol	197	234	216	17.2

QA Analyses - Duplicate Results for Organic Extract (continued)

Compound Name	Sample Result	Duplicate Result	Average	%RPD
SVOCs, in µg/g (ppm)				
Acenaphthene	2,330	2,260	2,300	3.05
Anthracene	1,920	2,070	1,990	7.52
Benz(a)anthracene	2,000	2,100	2,050	4.88
Benzo(b)fluoranthene	1,780	1,520	1,650	15.8
Benzo(k)fluoranthene	1,350	1,150	1,250	16.0
Benzo(a)pyrene	847	813	830	4.10
Chrysene	2,210	2,350	2,280	6.14
Fluoranthene	6,910	7,090	7,000	2.57
Fluorene	580	580	580	0
Phenanthrene	2,870	2,730	2,800	5.00
Pyrene	9,300	9,230	9,270	0.76

QA Analyses - MS/MSD Results for Treated Soils

Compound Name Dioxins and Furans	Sample Result ng/g	Spiked Added ng/g	Spike Result ng/g	% Recovery	Duplicate Spike Added ng/g	Duplicate Spike Result ng/g	% Recovery	RPD
2378-TCDD	ND	1.00	1.21	121	1.00	1.21	121	0
2378-TCDF	ND	1.00	1.00	99.7	1.00	0.976	97.6	2.13
12378-PeCDF	ND	1.00	0.81	80.7	1.00	0.797	79.7	1.25
12378-PeCDD	ND	1.00	1.08	108	1.00	1.05	105	2.82
23478-PeCDF	ND	1.00	1.35	135	1.00	1.16	116	15.1
123478-HxCDF	ND	2.50	2.56	102	2.50	2.50	100	2.37
123678-HxCDF	ND	2.50	2.04	81.6	2.50	2.08	83.2	1.94
123478-HxCDD	ND	2.50	2.45	98.0	2.50	2.06	82.4	17.3
123678-HxCDD	ND	2.50	2.46	98.4	2.50	2.48	99.2	0.81
123789-HxCDD	ND	2.50	3.07	123	2.50	2.81	112	8.84
234678-HxCDF	ND	2.50	2.70	108	2.50	2.64	106	2.25
123789-HxCDF	ND	2.50	2.78	111	2.50	2.66	106	4.41
1234678-HpCDF	ND	2.50	2.57	103	2.50	2.48	99.2	3.56
1234678-HpCDD	ND	2.50	2.44	97.6	2.50	2.30	92.0	5.91
1234789-HpCDF	ND	2.50	2.86	115	2.50	2.87	115	0.35
OCDD	ND	5.00	5.45	109	5.00	5.40	108	0.92
OCDF	ND	5.00	4.63	92.6	5.00	4.73	94.6	2.14

ND - Not detected at the reporting limit. Reporting limit stated in parentheses.

QA Analyses - MS/MSD Results for Treated Soil

Compound Name	Sample Result µg/g (ppm)	Spike Added µg/g (ppm)	Spike Result µg/g (ppm)	% Recovery	Duplicate Spike Added µg/g (ppm)	Duplicate Spike Result µg/g (ppm)	% Recovery	RPD
SVOCs								
Anthracene	46 J	1,000	812	76.6	1,000	722	67.6	11.7
Chrysene	93 J	1,000	1,120	107	1,000	986	93.6	12.7
Naphthalene	8.0 J	1,000	782	77.4	1,000	694	68.6	11.9
Pyrene	138	1,000	860	72.0	1,000	796	65.8	7.45
Chlorophenols								
Pentachlorophenol	ND	2,500	1,900	76.0	2,500	2,030	81.2	6.67
2,3,4,6-Tetrachlorophenol	ND	2,500	2,710	108	2,500	2,870	115	5.73
2,4,5-Trichlorophenol	ND	2,500	2,900	120	2,500	3,340	134	11.1

J - Estimated value, detected above method detection limit but below reporting limit.
ND - Not detected at the reporting limit. Reporting limit stated in parentheses.

Surrogate Recoveries Achieved in Method 8270 Analyses

Sample	Phenol-d5	Nitrobenzene-d5	2,4,6-Tribromophenol	Terphenyl-d14	2-Fluorobiphenyl	$^{13}C_6$-Pentachlorophenol
Organic Extract	137*	81	219*	131	NA	73
Organic Extract (Duplicate)	110	73	198*	133	NA	91
Reaction Product from Final Test	35.8	77.9	23.4	73.4	64.6	93

* Outside acceptance criteria

Conclusions

The BCD process effectively and rapidly dechlorinates all chlorophenols, PCDD's and PCDF's present in wood preserving waste solutions extracted from contaminated soil.

BCD treatment has no significant effect on most of the PAHs found in wood preserving waste solutions extracted from contaminated soil.

Application of Thermal Desorption to Wood Preserving Sites

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APPLICATION OF THERMAL DESORPTION TO WOOD PRESERVING SITES

Presentation

- Thermal Desorption Types
- Wood Preserving Site Characteristics And Issues
- Case Studies

Thermal Desorption Definition

An ex-situ process for physically separating organic contaminants from solids by heating to temperatures high enough to volatilize the contaminants.

Thermal Desorption
TD Types

- Type 1 - "True" Thermal Desorber Separation Process
- Type 2 - Incinerator Destruction Process

Thermal Desorption
Laws / Regulations

- Type 1 for Hazardous Waste Federal - CERCLA Subpart X ; Miscellaneous
- Type 2 for Non-Hazardous Waste; UST State Regulations Primarily Air Pollution Limitations; No Federal Regulations

Thermal Desorption
Type 1 - "True" TD

- Recovery or Non-Destructive Air Pollution Control System
- No Flame in the Primary Heating Unit
- Residuals Disposal Required

Thermal Desorption Type 2 TD

- An Incinerator
- Afterburner Part of Air Pollution Control System
- Flame Destruction in Primary Unit
- Few Residuals Requiring Disposal

Thermal Desorption Guidance / Policies

- USEPA Presumptive Remedy
  EPA/540/R-95/128 12/1995
- Engineering Forum Issue Paper
  EPA/540/F-95/031 11/1996
- ITRC Technical Requirements

Wood Preserving Chemical Components

- PAHs, Creosote, BNAs, Diesel Fuel,Semivolatile Organics
- PCP - Pentachlorophenol
- CAC - Chromium, Arsenic and Copper

Wood Preserving Sites
PAHs Treatment

- Type 1 TD - Proven Effective up To 50,000 ppm Residual Contamination in Soils
- Type 2 TD - Proven Effective Little Contamination in Soil

Wood Preserving Sites
Type 1 PAHs Treatment Issues

- PAHs not highly toxic PPM Residuals Okay
- Air Emissions of Non-Condensable Organics

Wood Preserving Sites
Type 2 PAHs Treatment Issues

- Incineration of PAHs is Effective, Safe and Less Expensive than Type 1 TD
- Formation of Dioxins/Furans Cannot Occur (no chlorine)

Wood Preserving Sites
PCP Treatment

- Type 1 TD - Proven by Treatability Studies
- Type 2 TD - Proven by Hazardous Waste Incineration Studies

Wood Preserving Sites
Type 1 PCP Treatment Issues

- PCP Air Emissions Will Occur, But Very Limited
- Dioxins / Furans in Soil will be Removed and Concentrated in Air Pollution Control Residuals

Wood Preserving Sites
Type 2 PCP Treatment Issues

- Dioxin / Furan and PIC Formation And Emissions
- Hazardous Waste Incinerator

Wood Preserving Sites
CAC Treatment

- Type 1 Ineffective
  No Air Emission Problems
- Type 2 Ineffective
  Air Emission Problems

Wood Preserving Sites
Case Study #1 - SMWT

	Soil Concentration (ppb) Initial	Final
PCP	18,000	<1700
TCDD TEQ	74.7	1.6
Phenanthrene	39,000	18
Naphthalene	27,000	ND (40)

Type 1 TD at 900oF at 10 minutes residence time

Wood Preserving Sites
Case Study #1 - SMWT

Air Emission Concentrations

CO - 928.7 ppmv

THC - 251.1 ppmv

Wood Preserving Sites
Case Study #2 - PP

	Soil Concentration (ppb)	
	Initial	Final
PCP	9,000	<300
PAHs	3,428,000	2,250

Type 1 TD at 900oF at 85 minutes residence time

Wood Preserving Sites
Case Study # 3 - PP

	Soil Concentration (ppb)	
	Initial	Final
Oil & Grease	1,180,000	21
TCDD TEQ	566	5

Type 1 TD at 980oF

Wood Preserving Sites
Case Study #4 - NMPC

- Type 2 TD - Incinerator Afterburner Included in APC
- MPG - Manufactured Gas Plant
- Four Heavy Organic Wastes

Wood Preserving Sites
Case Study #4 - NMPC

PAH Waste Concentrations (ppm)

	Initial	Final
Coke Plant	320	13
Purifier Bed	1040	5.1
Harbor Sediments	1624	5.5
Water Gas Plant	4420	26

600 - 900oF Type 2 TD

Wood Treating Sites
Case Study #4 - NMPC

Arsenic Concentrations

	Feed Soil ppm	Treated Soil ppm	Air Emissions lb/hr
Coke Plant	35	35	0.0007
Purifier Bed	59	59	0.0024
Harbor Sediments	27	35	0.0004
Water Gas Plant	61	140	0.0004

Wood Treating Sites
Case Study #4 - NMPC

Cyanide Concentrations (ppm)

	Feed Soil	Treated Soil
Coke Plant	730	21
Purifier Bed	1120	0.24
Harbor Sediments	9.3	0.23
Water Gas Plant	4.3	0.2

Wood Treating Sites
Case Study #4 - NMPC

Destruction and Removal Efficiency (DRE)

Naphthalene	99.97 - 99.9998 %
Total Xylenes	99.990 - 99.9992 %

Wood Preserving Sites
TD Summary and Conclusions

- Thermal Desorption is Proven Effective and a Presumptive Remedy
- Air Emissions and Control are Major Concerns and Focus of Regulatory Agencies
- Site Contaminants Control Type of Thermal Desorber and Process Conditions that can be Used

Treatment of Wood Preservative Contaminated Ground Water

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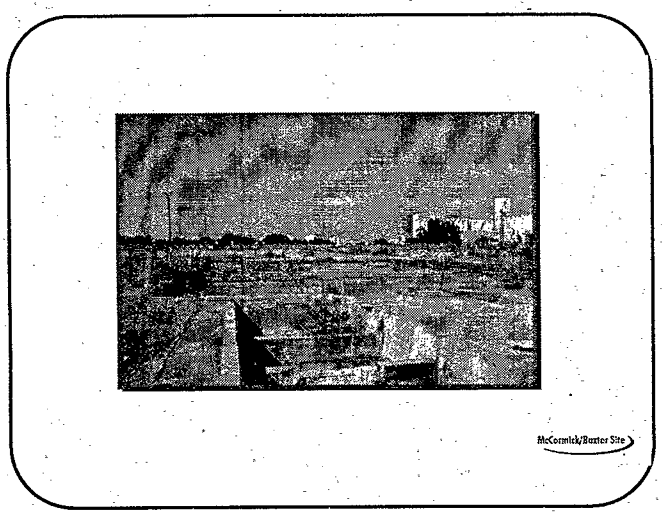
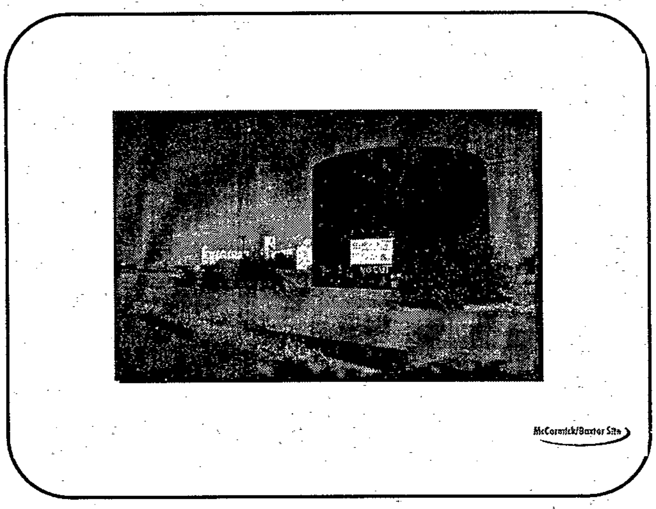
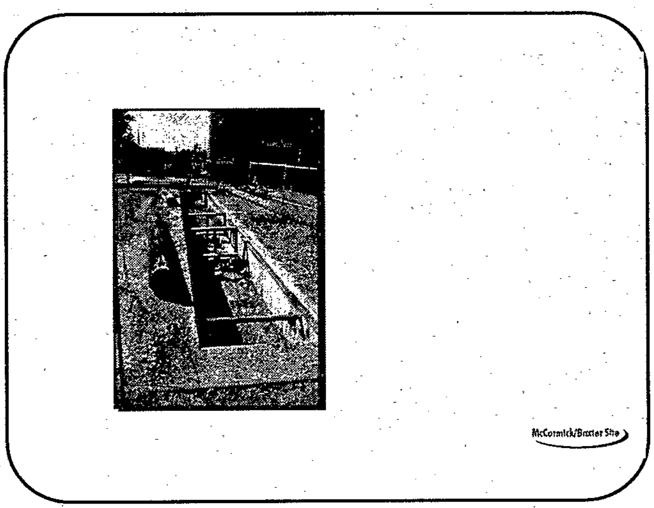
Paul C. Kefauver earned his B.S. and M.S. from the University of Cincinnati. Mr. Kefauver is a certified hazardous materials manager with 21 years of experience in environmental sciences, including 15 years of experience in hazardous waste management and related areas. He is IT Corporation's Operations Manager for the U.S. Environmental Protection Agency's Test and Evaluation Facility in Cincinnati, Ohio, where he is responsible for all aspects of on-site operations at the 24,000 square foot treatability study facility. He has conducted or coordinated treatability studies on contaminated soils, surface water, and ground water.

In addition, Mr. Kefauver has conducted numerous environmental compliance assessments for commercial and industrial waste transportation and disposal activities at numerous Resource Conservation and Recovery Act facilities; Comprehensive Environmental Response, Compensation, and Liability Act/Superfund sites; and Department of Defense sites. He has also prepared Superfund Amendments and Reauthorization Act of 1986 Title III Form Rs and Canadian National Pollutants Release Inventory reports, and developed pollution prevention baseline inventories, pollution prevention program management plans, and pollution prevention opportunity assessments.


McCormick/Baxter Site

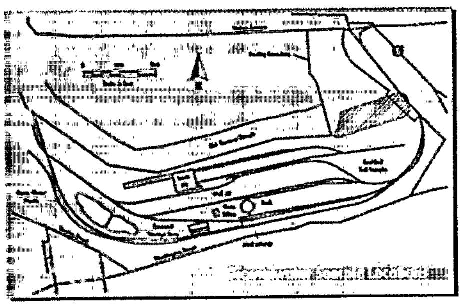

McCormick/Baxter Site

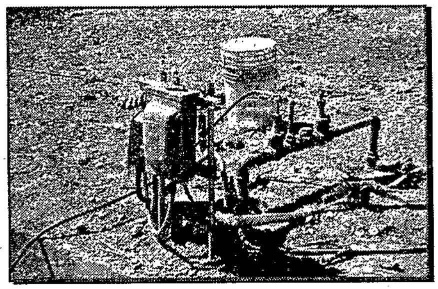

McCormick/Baxter Site

• McCormick/Baxter Site

- Historical Wood Preserving Operations (1942 to 1991)
  - Ammoniacal Copper Arsenate (ACA or Chemonite)
  - Ammoniacal Copper-Zinc Arsenate (ACZA)
  - Creosote
  - Pentachlorophenol (PCP) in Diesel
  - PCP in Liquefied Petroleum Gas (CELLON)
  - Chromated Copper Arsenate (CCA)

• McCormick/Baxter Site



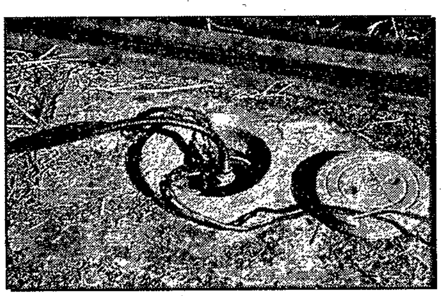


McCormick/Baxter Site

- **McCormick/Baxter Site**

- **Two Main Aquifers:**
  - 20 feet below ground surface
  - 175 feet below ground surface

McCormick/Baxter Site



McCormick/Baxter Site

• McCormick/Baxter Site

- Groundwater Treatability Studies:
  - Granular Activated Carbon using an Accelerated Column Test (ACT) – conducted by Calgon Carbon, Inc.
  - UV Oxidation/Peroxidation conducted by Vulcan Peroxidation Systems, Inc. (now Calgon Carbon Oxidation Technologies)

McCormick/Baxter Site

• Groundwater Treatment Target Levels for McCormick/Baxter Groundwater Contaminants

Contaminant	MCL* (ppb)
Benzo(a)pyrene (BAP)	0.2
Pentachlorophenol (PCP)	1.0
2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD)	3×10^{-5}

*Maximum Contaminant Levels

McCormick/Baxter Site

• Groundwater Carbon Treatment Simulation using Accelerated Column Test (ACT)

	Simulated Operating Parameters		
ACT Sample Day	Days of Operation	Water Treated (10^4 gal)	Carbon Used (lb/1000 gal)
0	0 (filtered water)	0	–
1	35.7	4.198	1.19
2	75.0	8.815	0.57
3	114.3	13.432	0.37
4	153.6	18.050	0.28
5	196.5	23.087	0.22
6	235.8	27.704	0.18

McCormick/Baxter Site

• McCormick/Baxter Carbon-Treated Water
Measured Concentrations and Calculated Equivalency Factors

		10-μm Filtered Influent	ACT Sample Day 1	ACT Sample Day 2	ACT Sample Day 3	ACT Sample Day 6
Simulated Day		0	35.7	75.0	114.3	235.8
Simulated amount treated (10^6 gal)		0	4.198	8.815	13.432	27.704
Simulated carbon use (lb/1000 gal)		0	1.19	0.57	0.37	0.18
Contaminant	MCL					
Benzo(a)pyrene	0.2	ND[a]	ND	ND	ND	ND
BAP equivalence	0.2	0	0	0	0	0
PCP	1.0	7400	3900	11,000	NA[b]	8000
2,3,7,8-TCDD	3×10^{-5}	ND$\geq 3 \times 10^{-6}$	ND$\geq 3 \times 10^{-6}$	ND$\geq 3 \times 10^{-7}$	NA	ND$\geq 3 \times 10^{-6}$
TCDD-TEF	3×10^{-5}	5.1×10^{-5}	2.1×10^{-5}	2.6×10^{-5}	NA	2.4×10^{-5}

[a]ND = Not Detected at detection limit
[b]NA = Not analyzed

McCormick/Baxter Site

• UV Oxidation/Peroxidation
Groundwater Treatment Conditions

Test No.	Treatment Time (min)	Prefilter	Hydrogen Peroxide Concentration (mg/L)	Initial pH	UV Lamp Type	Catalyst Added (mg/L
1	0 (influent) 0.5 2.0	none	200	7.5	S	none
2	0.5 2.0	none	200	4.5	S	none
3	0 (influent) 0.5 2.0	none	200	4.5	S	3
4	0.5 2.0	none	200	7.5	SX	none
5	0.5 2.0	5-μm	200	7.5	S	none
6	0 (influent) 0.5 2.0	5-μm	100	7.5	S	none
7	0.5 2.0	5-μm	100	5.0	S	none
8	0.5 2.0	none	300	7.5	F	none
9	0.5 2.0	5-μm	200	7.5	F	none

McCormick/Baxter Site

• McCormick/Baxter UV Oxidation/Peroxidation Treated Water
Measured Concentrations and Calculated Equivalency Factors

Test No.			1	2	3	4	5	6	7	8	9
Treatment Time (min)			2.0	2.0	2.0	1.0	2.0	2.0	2.0	1.0	1.0
Contaminant	MCL	Influent									
Benzo(a)pyrene	0.2	ND-37	24	26	36	28	ND[a]	ND	ND	29	1
BAP Equivalence	0.2	0-66	36.6-42.3	38.5-44.2	52.3-60.2	42.1-48.7	0	0	0	44.3-51.6	1.9-2.5
PCP	1.0	7500-8000	120	980	570	51	40	38	180	39	7

[a]ND = Not Detected at detection limit

McCormick/Baxter Site

• Comparison of McCormick/Baxter Water Treatment System Designs and Costs

	Cost	
Treatment Time	Capital ($)	Operation/Maintenance ($/1000 gal)
Carbon Treatment	80,000	1.19
UV Oxidation/Peroxidation*	312195 – 385,000	7.53 – 8.08

*Designed for PCP destruction only

McCormick/Baxter Site

• Oil/Water Separation

- Belt Skimmer
- Air Lift Pump
- Oil/Water Separator

McCormick/Baxter Site

• Emulsified Oil Treatment

- Acidify Water
- Heat to 200°F

McCormick/Baxter Site

• Groundwater Treatment

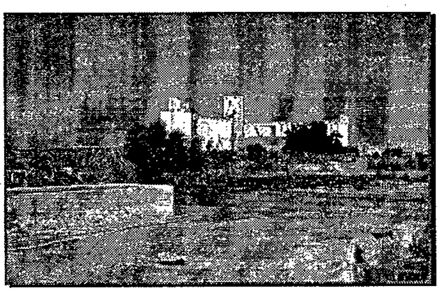
- Oil/Water Separation
- Oil Treatment
  - Recycle/Reuse
  - Incineration
- Water Treatment
  - Emulsified Oil Removal
  - Prefiltration
  - Final Treatment

McCormick/Baxter Site

• Final Water Treatment Alternatives

- Membrane Technology
  - Reverse Osmosis
  - Nanofiltration
- Advanced Oxidation
- Carbon Treatment

McCormick/Baxter Site



McCormick/Baxter Site

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