SOIL TREATABILITY STUDIES FOR POLY-CARB SITE, WELLS, NEVADA

by

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I. SUMMARY

The objective of this study was to explore various bench-scale treatment options to remediate soil from the Poly Carb site in Wells, Nevada, contaminated with three major contaminants: phenol, ortho-cresol and meta- and para-cresol. The three treatment methods explored were: passive evaporation, soil washing, and biological degradation (land farming).

Passive evaporation of the contaminants was explored because of favorable site conditions: dry; windy; hot (in summer); open, and outside of town. This treatment offers the advantages of design simplicity and low cost. East trench soils placed in petri plates without mixing showed phenol, ortho-cresol, and meta- and para-cresol reductions of 58, 55, and 43 percent, respectively. North trench soils showed 66, 80, and 36 percent after three week evaporation. The half-lives of these contaminants are 1.5, 2.0-2.5, and 4.2-4.8 weeks, respectively. Half-life plots from initial evaporation rate data indicate a first order decay within the following relationship. The relation of relative vapor pressure of these components of phenol to reciprocal half-life show a direct relationship between a component's vapor pressure and its half-life.

The significant environmental factors identified for passive evaporation treatment are component vapor pressure; temperature; velocity; soil depth, and soil mixing.

Soil washing reduced contamination by 82 to 98%. Of the aqueous extractants used, plain water showed the most promise. Adjusting the pH of water to 11.5 increased efficiency. Decontamination of the extractants was not explored. The biological degradation (land farming) is in progress.

The results of the two experiments passive evaporation and soil washing showed that:

- o Passive evaporation is a viable treatment easily implemented and low in cost;
- o Soil washing is also a viable treatment. However, the EPA Countercurrent Soil Washing Unit would have to be modified to allow proper residence time for the Wells, Nevada soil site.

II. GENERAL INTRODUCTION

The Poly Carb site, a former waste recycling pilot plant, contains approximately 850 cubic yards of phenol- and cresol- contaminated soil in two PVC-lined trenches. In addition, several upright tanks and one gutted building remain on-site. The location and dimensions of these items are shown on the site diagram (Figure 1).

Located 0.5 mile outside of Wells, Nevada and 75 yards from a local highway, the Poly Carb site is in the arid high chaparrel desert (elevation 5,500 ft). The area is the source of the Humbolt River, which is the major source of drinking water for the region. Consequently this soil remediation effort explored methods of on-site soil decontamination to eliminate liability from water pollution.

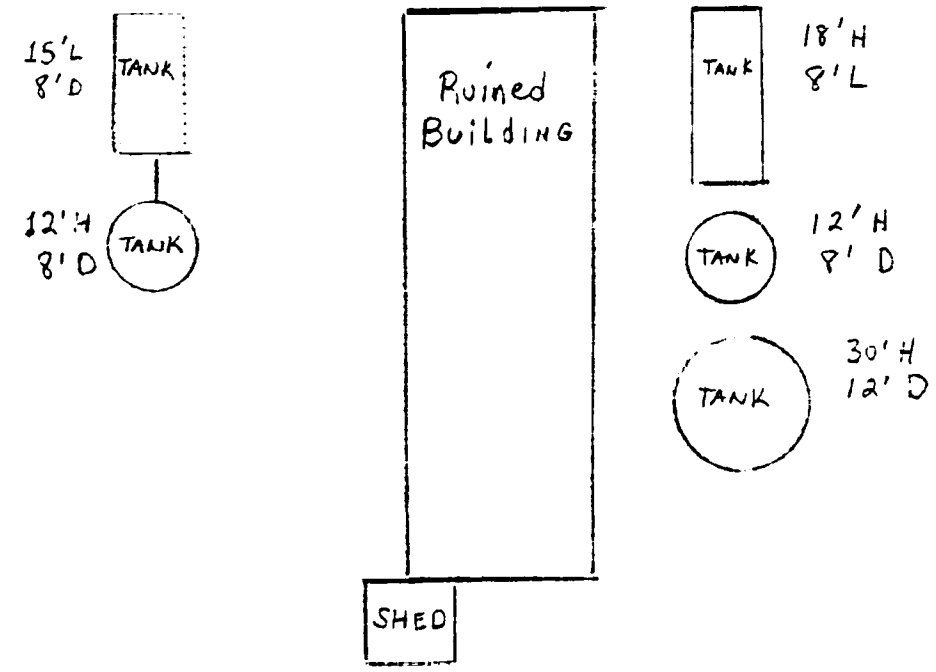
Site sampling and assessment was the first step in this project. The type, amount, and extent of contamination was investigated by soil borings, using a 4X4 sampling matrix. Four vertical holes were bored, both by hand and with a Vibra-Cor soil sampler, in each lined trench. Samples were taken at each of four boring depths.

Each sample was packed in a glass jar, shipped to the EERU facility in Edison, and stored at ambient temperature. This soil was composited and used for treatability studies.

Bench scale treatability studies were performed to determine the most effective on-site treatment method. Three treatment technologies were explored: passive evaporation; soils washing; and biological degradation (land farming). Treatment effectiveness was determined by the reduction of the three major contaminants; phenol, orth-cresol, and para- and meta-cresol.

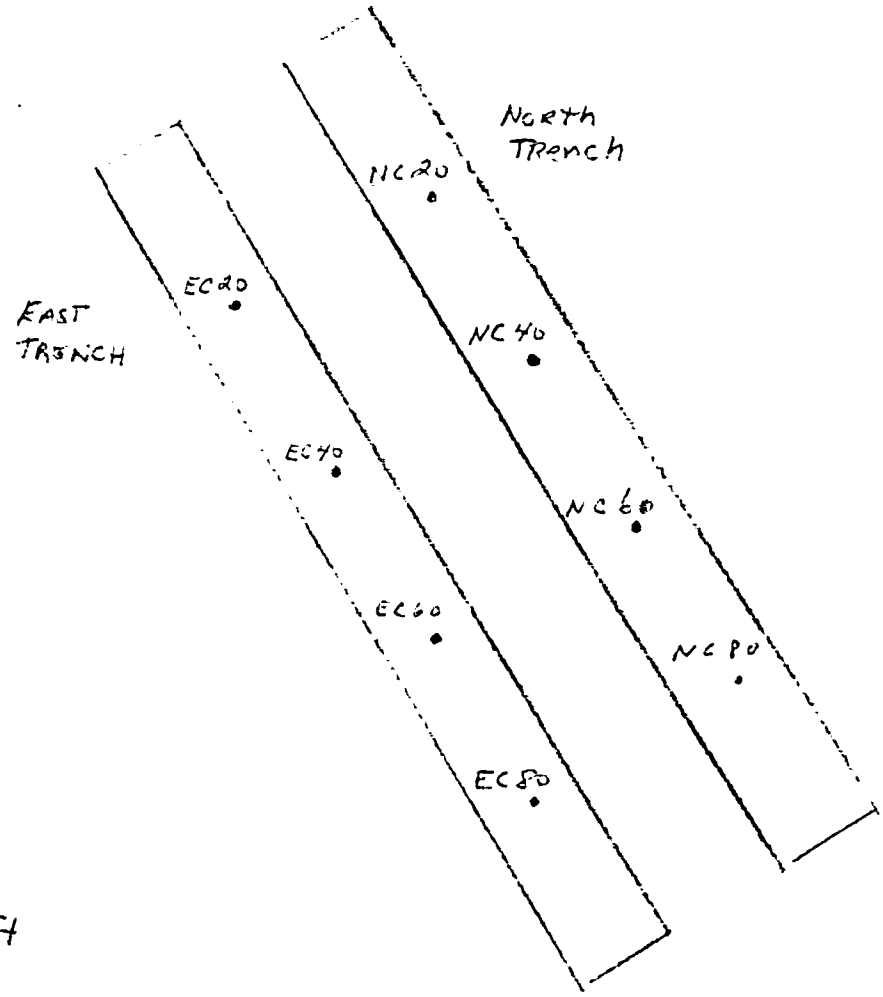
Contaminant concentrations were determined by gas chromatography Method 8040, SW846 (EPA test method for solid waste, 1982).

FIGURE 1 POLY CARB SITE DIAGRAM



Wells, Nev
0.5 mi

Interstate #80
0.6 mi



SCALE 10'

ELEVATION 5,500 ft

III. SOIL COMPOSITING

Discrete soil samples were composited to obtain representative soil samples for treatability studies. Soil compositing averages the soil contaminant concentrations, thus eliminating the range of levels found in discrete samples.

An explanation of the sample plan provides a clear understanding of the compositing scheme. Twenty-five bore holes were drilled at distances of 20, 40, 60, and 80 feet from the end of the trench nearest the ruined building. The following four discrete samples were taken from each bore hole:

1. "Clean" fill sample - soil above upper PVC liner, 2-6 inches below soil surface;
2. Shallow contaminated sample - approximately 6 inches to 2 feet below upper liner;
3. Middle contaminated sample - approximately 2-4 feet below upper liner;
4. Deep contaminated sample - just above the lower liner.

The labeling scheme gave compositors the exact location where each sample was taken.

- The first letter of the sample's label designated the trench (i.e., E for east and N for north).
- The second letter designated location in the trench from the sides (i.e., C for centerline).
- The first number designated the distance of the bore hole from the trench's end closest to the ruined building.
- The last number designated the average depth from which the soil was taken. For example, sample #EC-60-1.5 indicates that this discrete sample was taken from the centerline of the east pit, 60 feet from the end of the trench closest to the ruined building, and 1.5 feet (average) in depth.

Five soil composites were made at the east trench (a vertical and diagonal composite from each trench plus a composite of the remaining soil). These were respectively labeled the east trench vertical and diagonal composites (ECV and ECD). The same procedure was followed for the north trench (samples were labeled NCV and NCD). Samples contained in each composite are listed in Table 1.

Soil washing and biological degradation studies used composites ECD, ECV, NCD, and NCV; the total soil in each composite was divided for the two studies. Passive evaporation used the Remaining composite.

TABLE 1. DISCRETE SAMPLES CONTAINED IN INDIVIDUAL COMPONENTS

Composite Designation	Sample Number	
ECD	EC-20-0.5	EC-60-2.5
	EC-40-1.0	EC-80-4.5
ECV	EC-60-1	EC-60-4
	EC-60-2.5	EC-60-4.7
NCD	NC-80-0.5	NC-40-3.5
	NC-60-2.5	NC-20-4.5
NCV	NC-40-0.6	NC-40-3.5
	NC-40-2.5	NC-40-4.5
Remaining	EC-20-2	NC-20-1
	EC-20-3	NC-20-2
	EC-20-4	NC-60-0.7
	EC-40-0.2	NC-60-4
	EC-40-4.5	NC-60-4.7
	EC-40-4.7	NC-80-2
	EC-80-1	NC-80-4
	EC-80-2.5	
	EC-80-4	

IV. PASSIVE EVAPORATION

INTRODUCTION

Passive evaporation entails the conversion of soil-bound contaminants into air-bound vapor through the use of natural forces such as ambient temperature, wind velocity, and contaminant vapor pressure. Passive evaporation was explored because meteorological and geographical conditions at the Nevada site are favorable for this treatment method: dry, windy, hot (in summer), open, and outside of town. The major advantages of this technique are design simplicity and low treatment cost.

For passive evaporation treatment, contaminated soil is excavated and thinly spread on a PVC liner. To increase contact with air, the soil can be periodically stirred. If vapor containment is required, an inflatable PVC liner can cover the soil-laden liner in a dome-fashion. Carbon adsorption can filter the dome's air to eliminate air pollution or odor problems.

METHODOLOGY

A canopy-covered table was designed and constructed to support and protect soil samples from dust during passive evaporation (see photographs, Appendix 1). A circular chart temperature recorder and a relative humidity indicator measured environmental conditions. The apparatus was in a warehouse where temperature and humidity were relatively constant (see Appendix 2).

For proper mixing, the Remaining composite soil was placed in 1-gallon paint cans and hand-shaken for 30 minutes. The soil was spooned into plastic petri plates (88mm diameter X 18mm high), poured into plates on the table, and arranged by trench and evaporation duration. Neither heating elements nor fans were used to expediate evaporation. In addition, experimenters did not mix the soil during the evaporation period.

For each trench, a 4X4 experimental matrix was used. Four evaporation durations were used: (1) 0 days (no evaporation); (2) 7 days; (3) 14 days; and (4) 21 days. Four soil samples per duration yielded 16 samples per trench. At the end of each duration, the soil was spooned from plate to sample jar for analysis. The experimental control was soil that remained in the sealed paint can for the experiment's duration (21 days).

RESULTS

Table 2 shows the concentration of phenol, ortho-cresol, and para- and meta-cresol in the soil samples, sample means, and sample standard deviation. These sample means, standard deviations, and contaminant half-lives are plotted for each compound tested in Figures 2, 3, and 4(Summary of Analyses in Appendix 3).

TABLE 2. SAMPLE RESULTS FOR PHENOL AND CRESOLS

Sample Number	Phenol	Ortho-Cresol	Para+Meta-Cresol
E-0-1	951	84.6	365
E-0-2	993	89.4	385
E-0-3	1020	100	409
E-0-4	1000	94.9	394
	$\bar{X}$ = 991	$\bar{X}$ = 92.2	$\bar{X}$ = 388
	σ = 29.0	σ = 6.7	σ = 18.4
N-0-1	594	[41.4]	175
N-0-2	543	[39.4]	162
N-0-3	544	[38.2]	161
N-0-4	559	[38.4]	165
	$\bar{X}$ = 560	$\bar{X}$ = 39.4	$\bar{X}$ = 166
	σ = 23.8	σ = 1.5	σ = 6.4
E-7-1	555	[58.3]	259
E-7-2(1)	607	[64.0]	274
E-7-3	645	[69.3]	287
E-7-4	639	[68.5]	291
	$\bar{X}$ = 612	$\bar{X}$ = 65.0	$\bar{X}$ = 278
	σ = 41.2	σ = 5.1	σ = 14.8

ND denotes not detected.

(1) answer based on the average of the original and duplicate runs.

[ ] denotes that values are approximate due to the response being below that of the lower limit of quantification (LOQ) of 10 ug/g.

$\bar{X}$= sample mean.
σ = sample standard deviation.

Sample number - designation: first letter signifies trench, E = east and N = north; next number(s) gives days soil subjected to evaporation; and last numeral is sample number.

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TABLE 2 (CONT'D). SAMPLE RESULTS FOR PHENOL AND CRESOLS

Sample Number	Phenol	Ortho-Cresol	Para+Meta-Cresol
N-7-1	256	11.0	94.8
N-7-2	279	12.2	105
N-7-3	239	11.0	91.1
N-7-4	264	11.2	100
	$\bar{X}$ = 260	$\bar{X}$ = 11.4	$\bar{X}$ = 97.7
	σ = 16.7	σ = 0.6	σ = 6.1
E-14-1	460	[44.7]	238
E-14-2(1)	441	[49.4]	236
E-14-3	458	[43.0]	234
E-14-4	436	[44.8]	221
	$\bar{X}$ = 449	$\bar{X}$ = 44.5	$\bar{X}$ = 232
	σ = 12.0	σ = 2.7	σ = 7.7
N-14-1	189	10.1	124
N-14-2	164	[8.88]	117
N-14-3	187	[9.75]	124
N-14-4	214	10.4	133
	$\bar{X}$ = 189	$\bar{X}$ = 9.8	$\bar{X}$ = 125
	σ = 20.4	σ = 0.7	σ = 6.6

ND denotes not detected.

(1) answer based on the average of the original and duplicate runs.

[ ] denotes that values are approximate due to the response being below that of the lower limit of quantification (LOQ) of 10 ug/g.

$\bar{X}$= sample mean.
σ = sample standard deviation.

Sample number - designation: first letter signifies trench, E = east and N = north; next number(s) gives days soil subjected to evaporation; and last numeral is sample number.

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TABLE 2 (CONT'D). SAMPLE RESULTS FOR PHENOL AND CRESOLS

Sample Number	Phenol	Ortho-Cresol	Para+Meta-Cresol
E-21-1	375	[37.5]	197
E-21-2(1)	449	[44.8]	240
E-21-3	412	[39.9]	222
E-21-4	424	[44.3]	228
	$\bar{X}$ = 415	$\bar{X}$ = 41.6	$\bar{X}$ = 222
	σ = 30.8	σ = 3.5	σ = 18.1
N-21-1	188	[7.94]	103
N-21-2	201	[8.32]	112
N-21-3	182	[7.97]	106
N-21-4	195	[8.25]	108
	$\bar{X}$ = 192	$\bar{X}$ = 8.1	$\bar{X}$ = 107
	σ = 8.3	σ = 0.2	σ = 3.8
E-C-1	867	[71.8]	315
E-C-2(1)	902	[79.4]	338
E-C-3	785	[71.8]	297
E-C-4	938	[82.4]	347
	$\bar{X}$ = 873	$\bar{X}$ = 76.4	$\bar{X}$ = 342
	σ = 65.4	σ = 5.4	σ = 22.6
N-C-1	506	[36.7]	141
N-C-2	514	[36.9]	144
N-C-3	488	[32.0]	131
N-C-4	512	[37.8]	142
	$\bar{X}$ = 505	$\bar{X}$ = 35.8	$\bar{X}$ = 140
	σ = 11.8	σ = 2.6	= 5.8

ND denotes not detected.

(1) answer based on the average of the original and duplicate runs.

[ ] denotes that values are approximate due to the response being below that of the lower limit of quantification (LOQ) of 10 ug/g.

$\bar{X}$= sample mean.
σ = sample standard deviation.

Sample number - designation: first letter signifies trench, E = east and N = north; next number(s) gives days soil subjected to evaporation; and last numeral is sample number.

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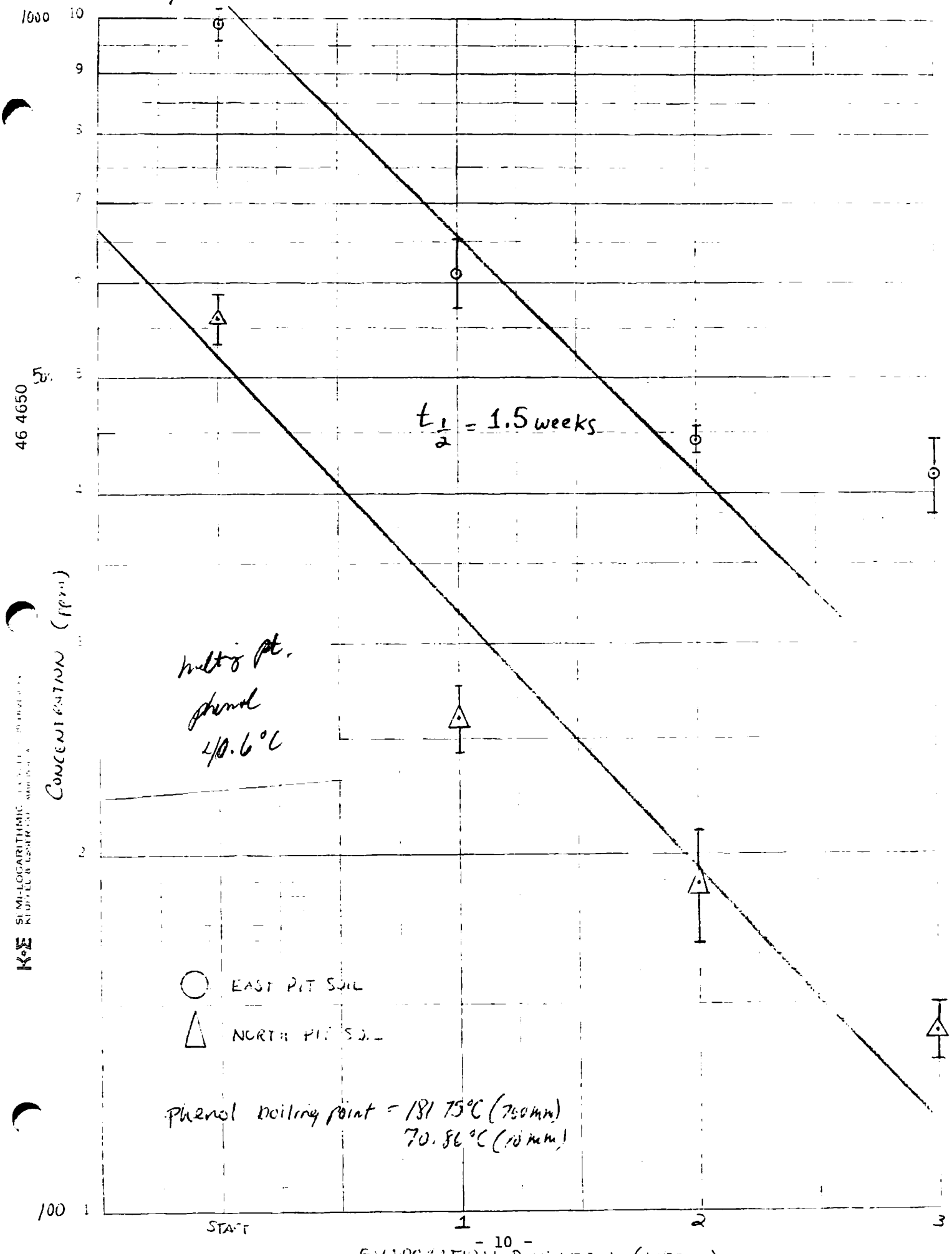
FIGURE 2 PHENOL EVAPORATION

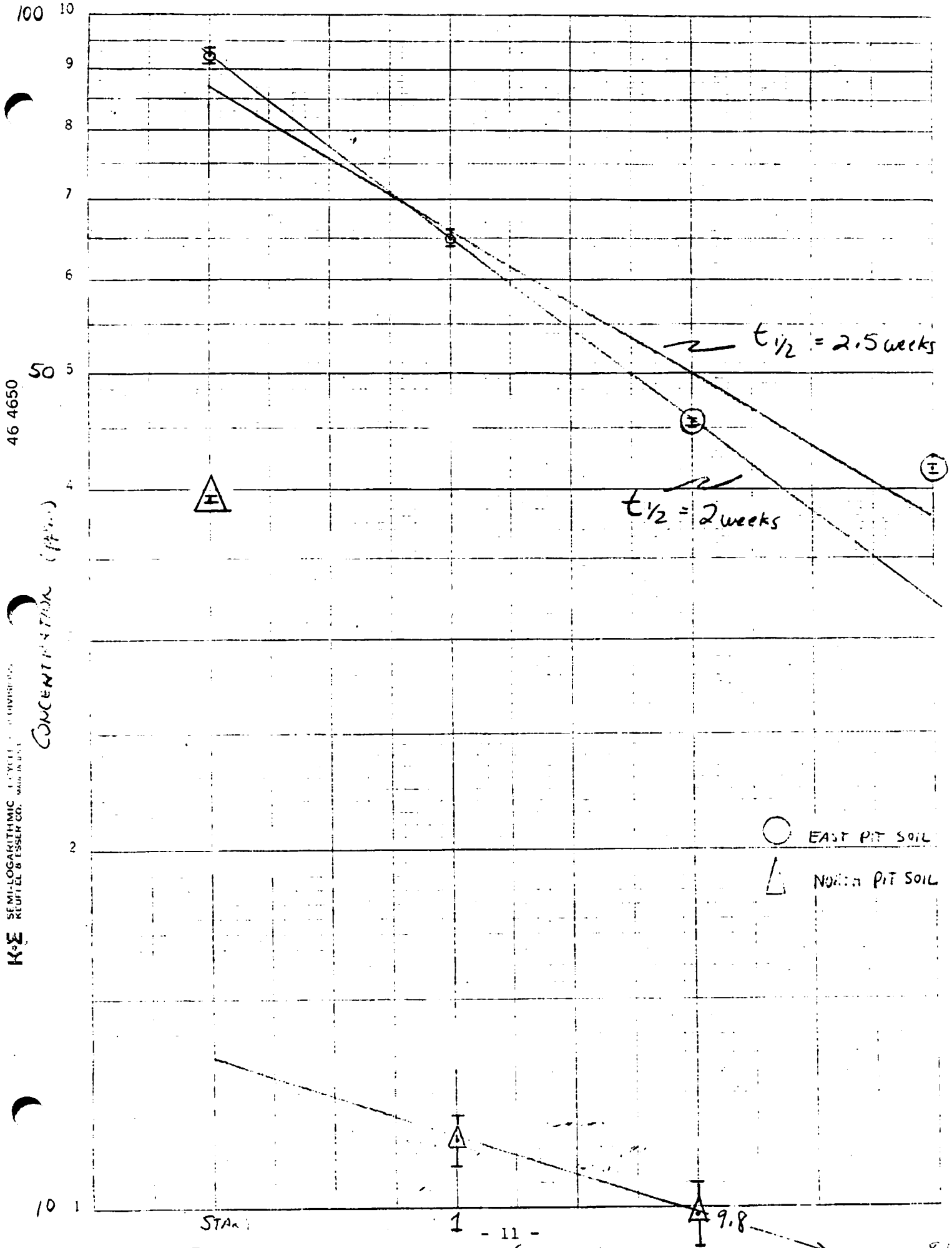


Phenol boiling point = 181.75°C (760mm)
70.86°C (10 mm)

46 4650 50

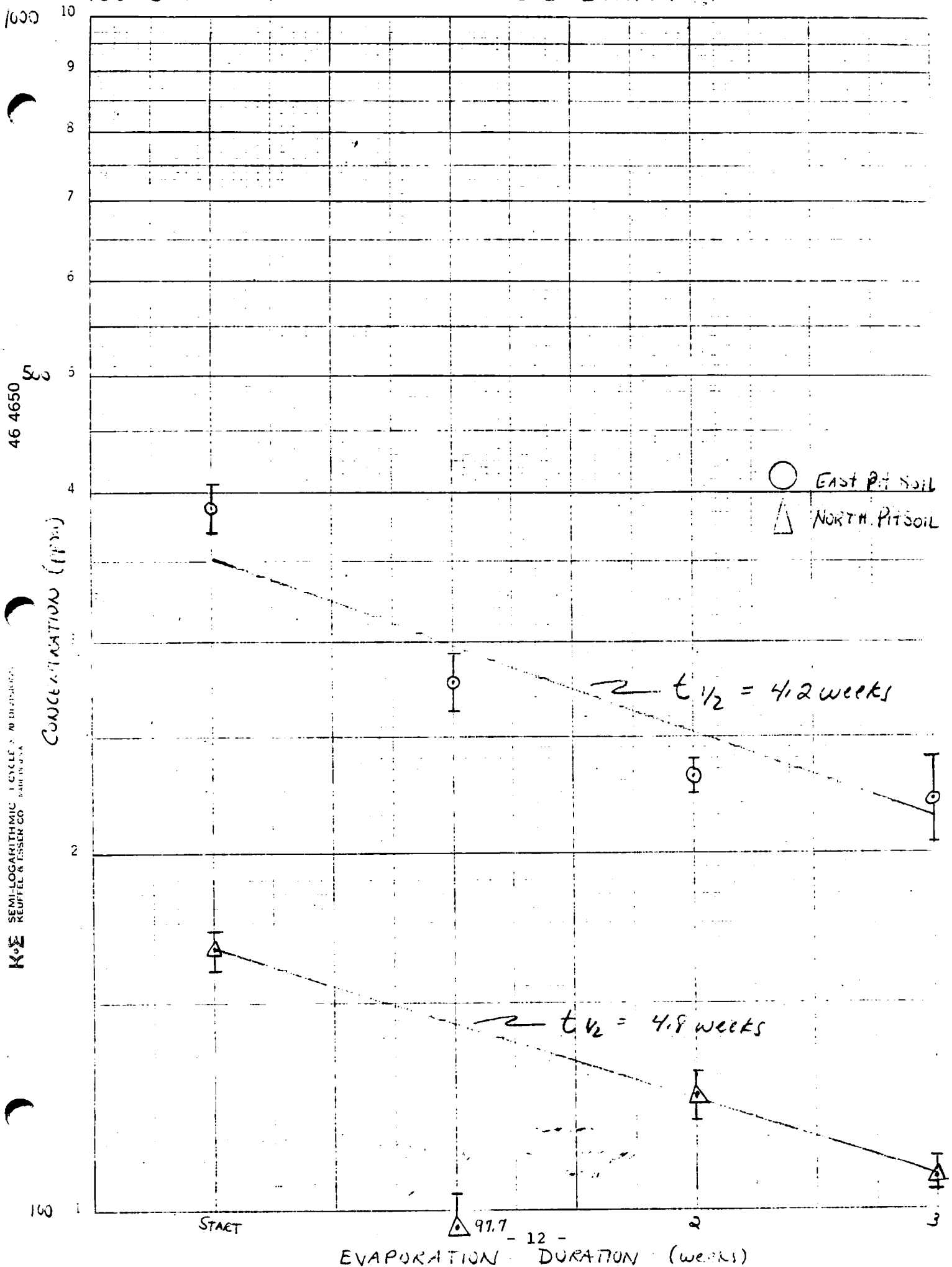
KE SEMI-LOGARITHMIC KEUFFEL & ESSER CO.

FIGURE 3 ORTHO CRESOL EVAPORATION



8.1

FIGURE 1 PARA & META CRESOL EVAPORATION



For east trench soil, the reduction of phenol, ortho-cresol, and meta- and para-cresol after 3 weeks evaporation was 58, 55, and 43 percent, respectively; for north trench soil, the reduction was 66, 80, and 36 percent.

The data show, that while there is greater reduction of contaminants in north trench soil due to passive evaporation, there is little difference in the contaminant decay characteristics between trenches. Phenol, ortho-cresol and meta- and para-cresol concentration were higher in the east trench than in the north trench.

Contaminant evaporation is a decay process. To show this, we plotted component half-lives. The half-lives of phenol, ortho-cresol, and para- and meta-cresol are 1.5-2.0, 2.5, and 4.2-4.8 weeks, respectively. The rate of evaporation is equal to component half-life; phenol with the shortest half-life has the greatest evaporation rate. The linear half-life plots indicate first order decay; thus, even though the initial concentration of phenol is higher than meta- and para-cresol, lower levels of phenol can be expected in soil after time due to its higher evaporation rate throughout the evaporative durations.

The relation of relative vapor pressures to reciprocol half-life is plotted in Figure 5. Vapor pressures of phenol, ortho-cresol, and meta- and para-cresol were set relative to phenol. Therefore, phenol has a relative vapor pressure of 1.0, ortho-cresol, 0.74, and meta- and para-cresol, 0.54. The plot shows a linear relationship between the relative vapor pressure and reciprocal half-life. In other words, a direct relationship exists between component's increased vapor pressure and its decreased half-life.

Figure 6 is a plot of component vapor pressures vs. temperatures. This plot shows that as temperature increases, component vapor pressure correspondingly increases. Therefore, if the treatment temperature increases, we can expect a shorter component half-life.

FIGURE 5 RELATION OF RELATIVE VAPOR PRESSURES

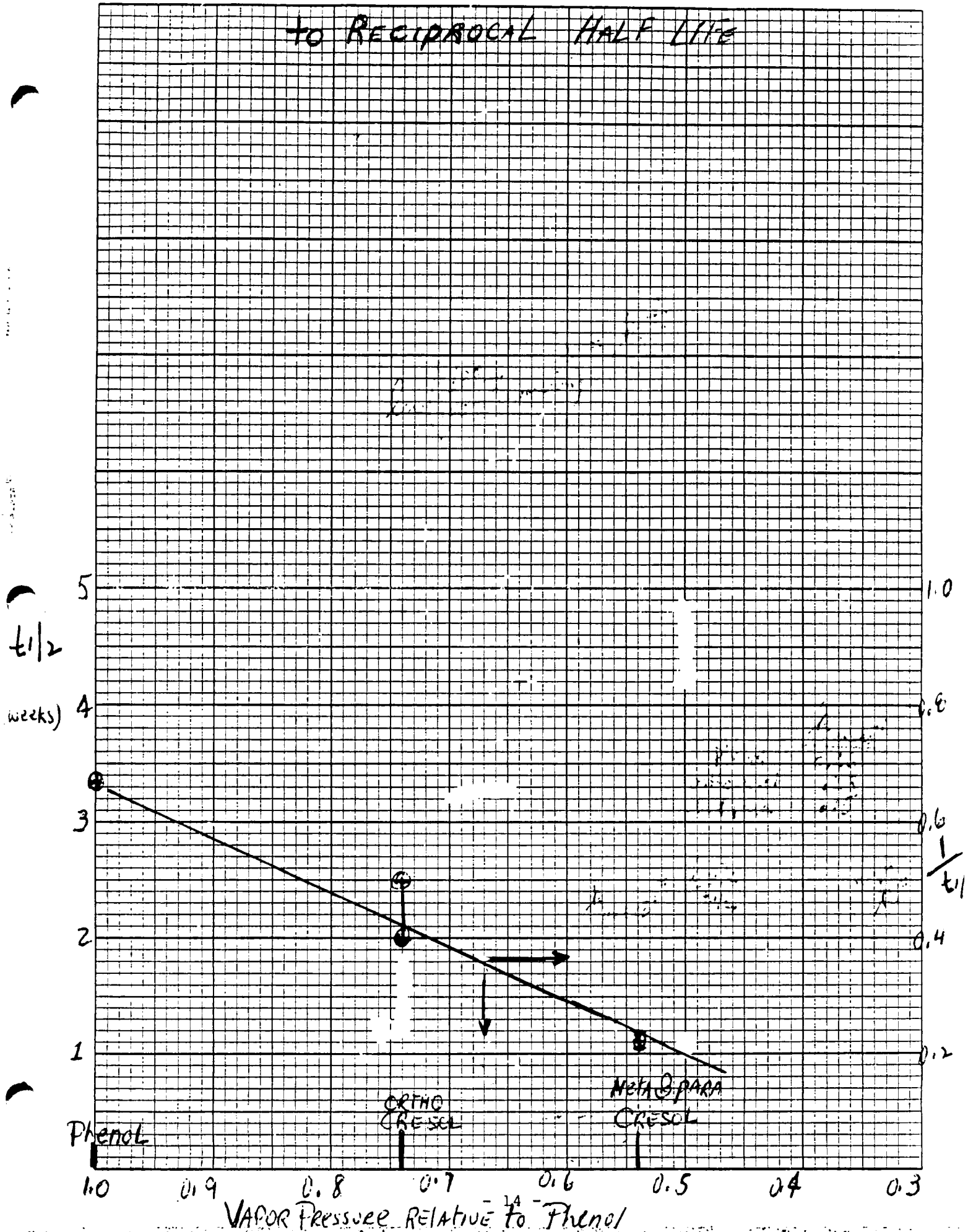


FIGURE 6

Rel of $\bar{T}$ to R_{wp}

DISCUSSION

This experiment showed a reduction in soil contaminants due to passive evaporation. The rate of component reduction in soil is a function of the rate of evaporation. The rate of evaporation is plotted as the component half-life. The contaminants, in order of increasing half-life, are phenol, ortho-cresol, and meta- and para-cresol. This corresponds to the overall percentage reduction of these components in the soil.

The initial slopes of the component concentration vs. time curves were used for the half-life plots. In the absence of soil mixing, evaporation occurs at the soil surface. When the components at the surface have evaporated, internal diffusion is the limiting factor. In order to obtain evaporation rate plots over the length of the experiment, the soil must be mixed several times a day. Soil mixing allows unevaporated components contact time with the air. This is an important factor since only the soil surface experiences evaporation. Subsurface contaminants in the soil must internally diffuse through the interstitial space or evaporate; recondense on solid particles above it, re-evaporate, and so on until reaching the surface. In both mechanisms, it is a tortuous path to the surface.

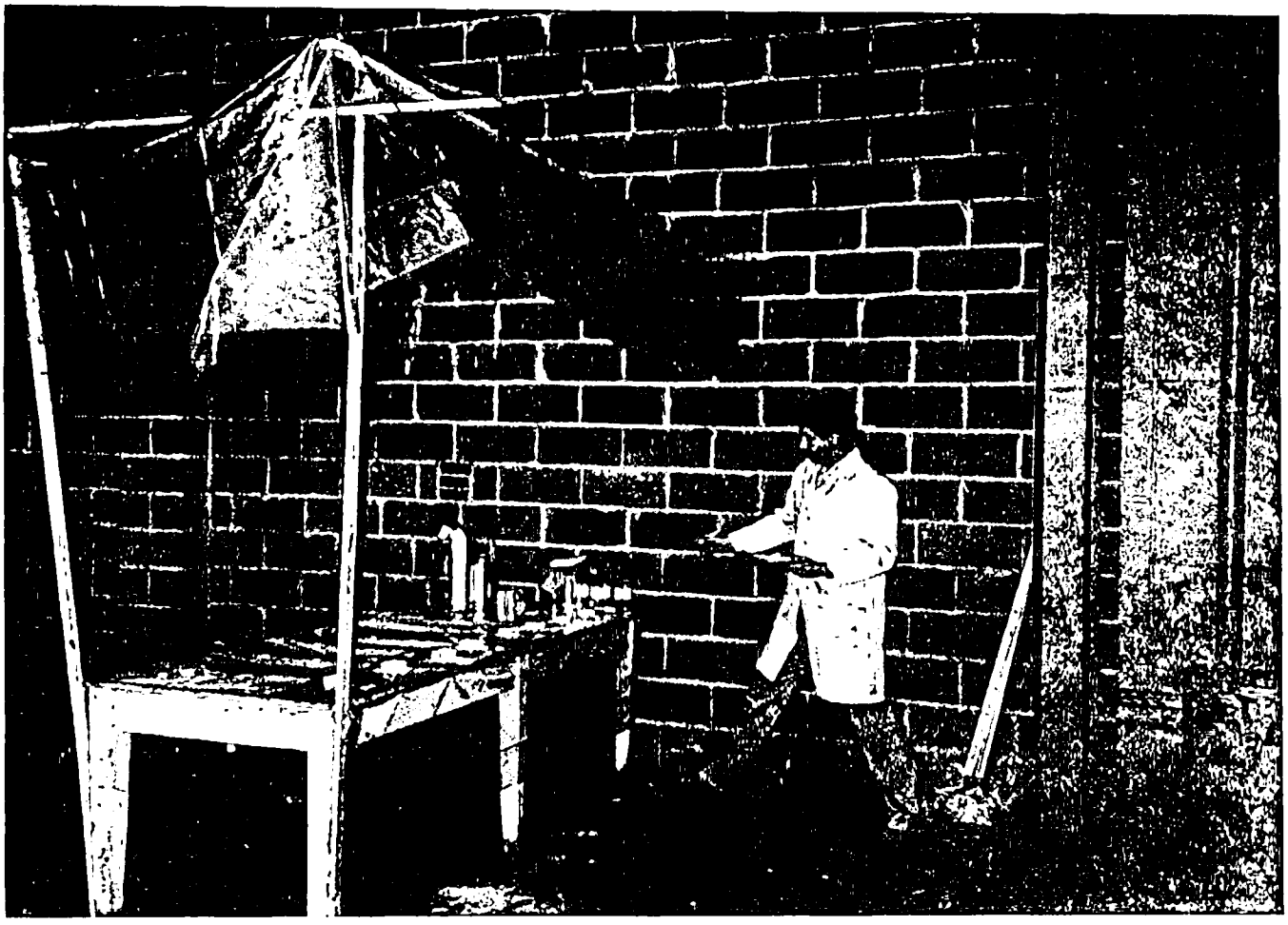
Important environmental variables that can affect passive evaporation are component vapor pressure, temperature, wind velocity, soil depth, and soil mixing. Vapor pressure determines the evaporation duration of an unbound component. An increase in temperature decreases the treatment duration; therefore, a favorable time of year for this program should be chosen. Wind velocity, although an uncontrollable environmental factor, increases evaporation by removing the component-laden air above the evaporating soil. Furthermore, as wind velocity increases, so does the connection of air through the soil, thereby increasing the depth of the soil surface exposed to air where components can freely evaporate. Since evaporation occurs at the surface, a decrease in soil depth shortens the evaporation duration; likewise, frequent soil mixing reduces treatment time.

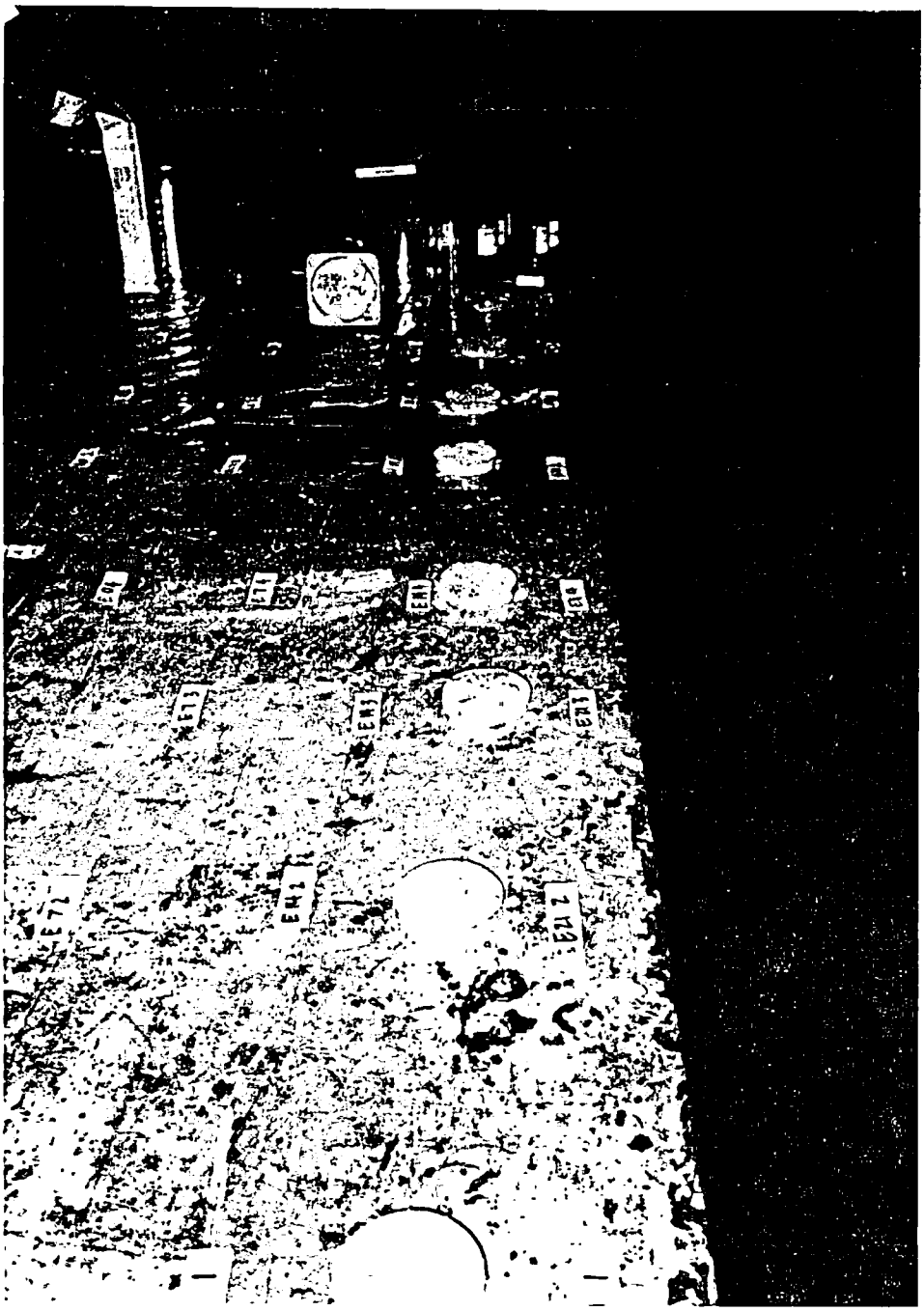
V. SOIL WASHING

The soil washings investigations were performed by Mason and Hangar Corporation, the OHMSETT operating contractor at Leonardo, NJ. Their report of March 31, 1987 is reproduced in its entirety.

APPENDIX 1

Pictures of Experimental Appartus





APPENDIX 2

Passive Evaporation Temperature and Relative Humidity Data

WELLS, NEVADA PASSIVE EVAPORATION

Day	Time	Temperature	Relative Humidity	Comments
3/23/87	1445	54°F	80%	Begin study; collect time zero samples noticed much less phenol odor today vs. 2/23
3/25/87	0900	51°F	76%	
3/26/87	1230	54°F	80%	
3/27/87	1440	58°F	71%	
3/30/87	1530	57°F	77%	Took 7-days samples
4/1/87	1400	52°F	66%	
4/2/87	1400	53°F	68%	
4/3/87	1300	54°F	72%	
4/6/87	1700	52°F	82%	Took 14-day samples
4/7/87	1400	52°F	76%	
4/10/87	1400	56°F	77%	
4/13/87	1430	59°F	76%	Took 21-day samples

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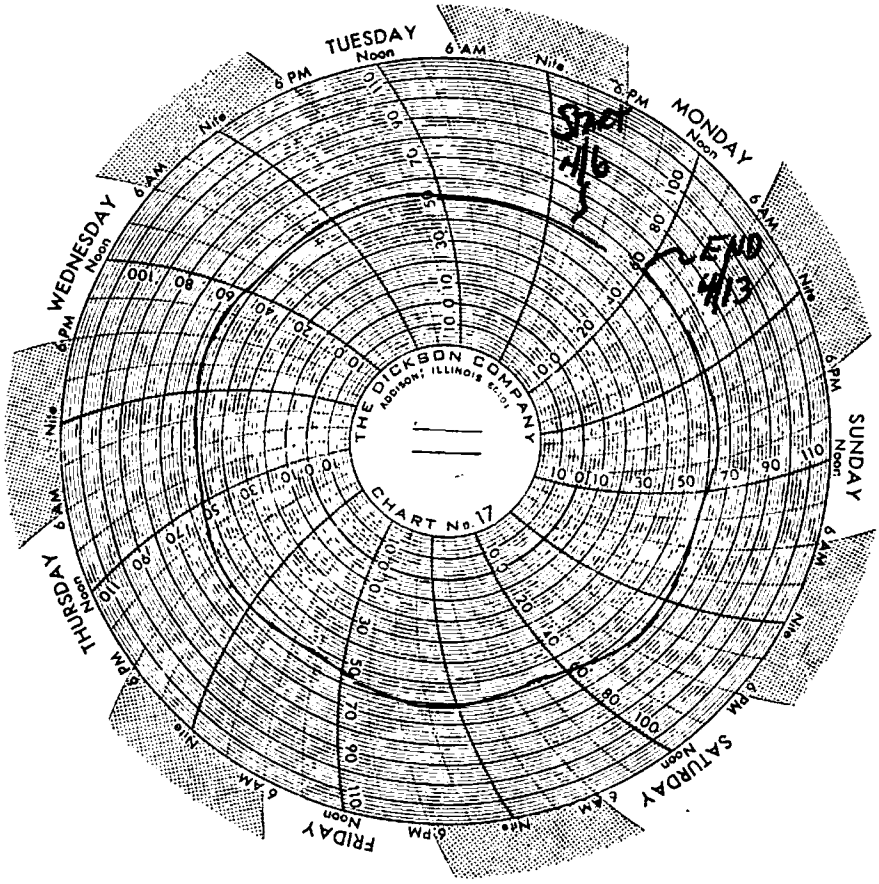
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MONDAY
SUNDAY
SATURDAY
FRIDAY
THURSDAY
WEDNESDAY
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6 AM
6 PM
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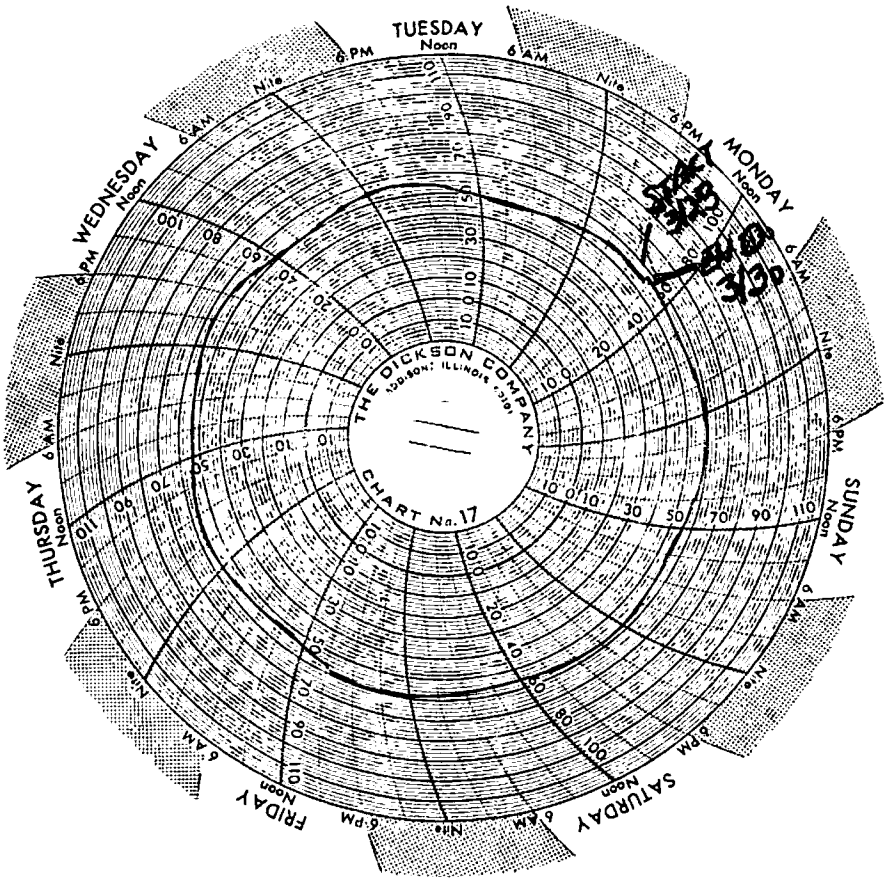
Spot 4/6
End 4/13
THE DICKSON COMPANY
CHART No. 17


TUESDAY
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MONDAY
WEDNESDAY
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SUNDAY
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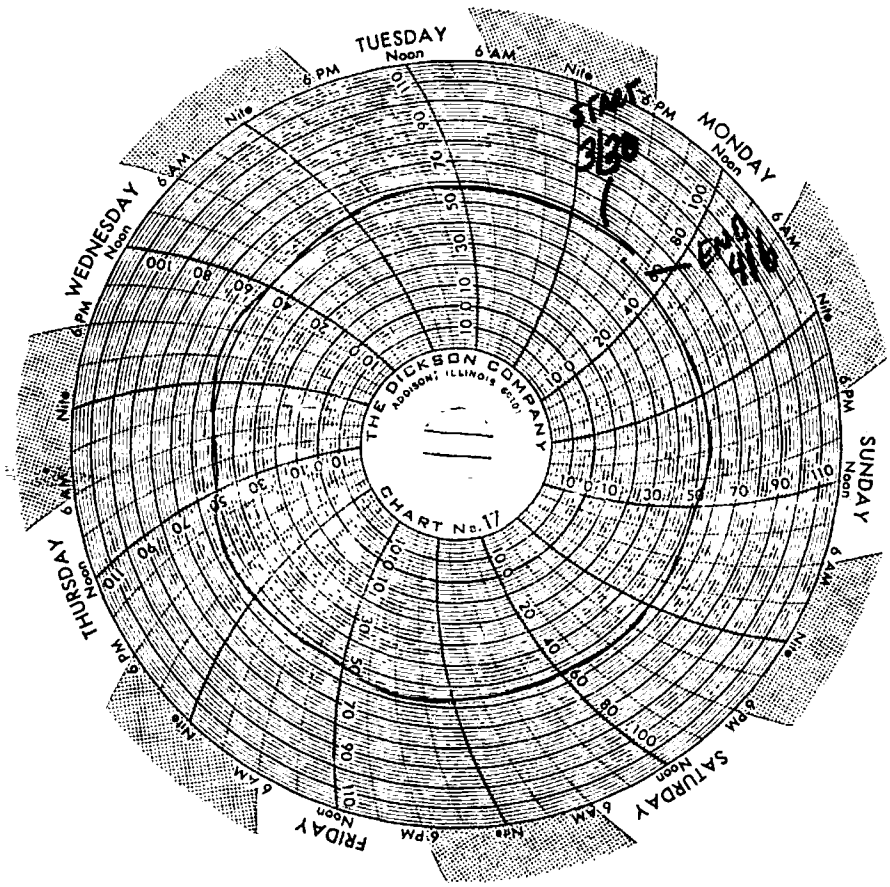
CHART No. 17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Noon
6 AM
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START 8:30
END 4:15
THE DICKSON COMPANY
ADDISON, ILLINOIS U.S.A.
CHART No. 17

APPENDIX 3

Summary of Analayses

POLY-CARB SITE

Wells, Nevada

Project No. 3-70-06190999

May 1, 1987

Submitted to: Robert Evangelista

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J. E. T. Syslo

Reviewed by:

J. J. Cullinane

TABLE OF CONTENTS

Phenol and Cresols in Soil Analysis

INTRODUCTION

On the following dates a total of 40 soil samples were received from the Poly-Carb site in Wells Nevada:

3/23/87	8 samples
3/31/87	8 samples
4/07/87	8 samples
4/14/87	16 samples

Samples were analyzed for Phenol, Ortho Cresol, Meta Cresol, and Para Cresol using a capillary column and flame ionization detector. The results of this analysis are presented in Table 1.

ANALYTICAL PROCEDURES

Extraction Procedure

Approximately 10.0 grams of soil was placed in a 100 ml crimp top vial to which 1.0 ml of 10 mg/ml 2,3,5-Trichlorophenol surrogate spike was added. Samples were extracted with two 50 ml portions of methylene chloride on a gyrotory shaker table at 350 rpm for 1 hour. The methylene chloride portions were combined, and concentrated if necessary.

Instrument parameters

Sample extracts were analyzed using a Shimadzu GC-9A gas chromatograph utilizing the Flame Ionization Detector. A Supelco borosilicate glass, non-bonded, SPB-5, 60 meter X 0.75mm ID wide bore capillary column was used for the analysis. The Shimadzu AOC-9 automatic sampler was used to make injections onto the column. Chromatograms were processed using the Shimadzu Chromatopac C-R3A data processor. The temperature program, autosampler, and integrator parameters are listed in the beginning of Section III, preceding the sample chromatograms.

Calibration parameters

A five point calibration range from 10 ug/ml to 200 ug/ml was analyzed using a standard mixture prepared from Aldrich standards of Phenol, Ortho Cresol, Meta Cresol, and Para Cresol. A calibration error (Ec) of less than 10% was considered acceptable. A 50 ug/ml standard containing a mixture of each compound was used as the daily standard. The response of this standard was within 10% of the calibration standard and used as the daily standard, and for sample calculations.

Determination of Detection Limit

The theoretical detection limit (TDL) for each compound was determined by analyzing a 5.0 ug/ml standard five times. The standard deviation and average response were calculated, and used to predict the TDL using the data from 4/09/87. Based on this data the compounds had theoretical detection limits of less than 1 ug/ml. A 1.0 ug/ml standard was analyzed to confirm this limit. The following equation was used to predict the theoretical detection limits.

$$\frac{5\text{ug/ml}}{\text{Average Response}} \times 3 \text{ Standard Deviations} = \text{Theoretical Detection Limit (ug/ml)}$$

Compound	Average Response	Standard Deviation	3 Standard Deviations	TDL ug/ml	Actual Detection Limit ug/ml
Phenol	2490	21.45	64.36	0.13	1.0
Ortho Cresol	3432	16.18	48.54	0.07	1.0
Meta+Para Cresol	5155	28.12	84.38	0.08	2.0

Results

Results for the analysis are presented in Table 1. Samples were quantified, and calculations based on a 50 ug/ml daily standard. Calculations were performed using the following formula:

$$CONC = SR/DSR \times 50^{(1)} \times DF \times CF^{*}$$

CONC = Concentration in ug/ml
SR = Sample response
DSR = Daily standard response
50 = Concentration of the daily standard in ug/ml
(1) Meta+Para Cresol concentration based on 100 ug/ml
DF = Dilution factor
CF* = Concentration factor (when required)

Response was determined using the peak height mode on the CR3-A integrator

Confirmation of Phenol, Ortho Cresol, and Meta+Para Cresol

Sample E02 was selected and analyzed on a Finnigan MAT Ion Trap Mass Spectrometer to confirm the presence of the compounds of interest. The ion chromatogram of a 50 ug/ml daily standard was analyzed to identify the surrogate standard (2,3,5-Trichlorophenol), internal standard (2,4,6-Tribromophenol), and the compounds of interest. The spectra and library confirmation for each of these parameters are presented in section IV. The ion chromatogram of sample E02 was analyzed. The spectra, and library confirmation of the internal standard, surrogate standard, phenol, ortho cresol, and meta+para cresol were positive, thus proving a positive identification in the samples. Meta and para cresol are coeluting compounds, and have identical spectra.

TABLE 1. SAMPLE RESULTS FOR PHENOL AND CRESOLS

Concentrations reported in ug/g.

SAMPLE NUMBER	PHENOL	ORTHO CRESOL	PARA+META CRESOL
E01	951	84.6	365
E02(1)	993	89.4	385
E03	1020	100	409
E04	1000	94.9	394
N01	594	[41.4]	175
N02	543	[39.4]	162
N03	544	[38.2]	161
N04	559	[38.4]	165
Soil Blank	ND	ND	ND
E71	555	[58.3]	259
E72(1)	607	[64.0]	274
E73	645	[69.3]	287
E74	639	[68.5]	291
N71	256	11.0	94.8
N72	279	12.2	105
N73	239	11.0	91.1
N74	264	11.2	100
E141	460	[44.7]	238
E142(1)	441	[49.4]	236
E143	458	[43.0]	234
E144	436	[44.8]	221
N141	189	10.1	124
N142	164	[8.88]	117
N143	187	[9.75]	124
N144	214	10.4	133

ND denotes not detected

(1) answer based on the average of the original and duplicate runs

[] denotes that values are approximate due to the response being below that of the lower limit of quantification (LOQ) of 10 ug/g.

TABLE 1. SAMPLE RESULTS FOR PHENOL AND CRESOLS

Concentrations reported in ug/g.

SAMPLE NUMBER	PHENOL	ORTHO CRESOL	PARA+META CRESOL
E211	375	[37.5]	197
E212(1)	449	[44.8]	240
E213	412	[39.9]	222
E214	424	[44.3]	228
N211	188	[7.94]	103
N212	201	[8.32]	112
N213	182	[7.97]	106
N214	195	[8.25]	108
EC1	867	[71.8]	315
EC2(1)	902	[79.4]	338
EC3	785	[71.8]	297
EC4	938	[82.4]	347
NC1	506	[36.7]	141
NC2	514	[36.9]	144
NC3	488	[32.0]	131
NC4	512	[37.8]	142

ND denotes not detected

(1) answer based on the average of the original and duplicate runs

[] denotes that values are approximate due to the response being below that of the lower limit of quantification (LOQ) of 10 ug/g.

QA/QC PROCEDURES

Table 2 lists the surrogate and internal standard recoveries of samples, EMSL sample, and calibration range standards. The surrogate standard of 2,3,5-Trichlorophenol was spiked into each soil sample before extraction to attain a concentration of 100 ug/ml after dilution, to monitor the extraction efficiency and to determine any matrix interferences. Surrogate standard recoveries between 80% to 120% were considered acceptable. Due to a low concentration of compounds in the samples, some sample extracts had to be concentrated to keep the response within the limits of the calibration range. Surrogate recoveries were not reported for concentrated because the surrogate response was 10 times higher due to the concentration factor.

An internal standard of 100 ug/ml 2,4,6-Tribromophenol was spiked into each sample extract before analysis to monitor the auto sampler efficiency . The concentration of samples affected internal standard recoveries due to the magnification a of coeluting interferent peak with the internal standard. Internal standard recoveries of between 80% to 120% were considered acceptable. The majority of surrogate and internal standard recoveries fell within the 80% to 120% recovery level.

Table 3 lists the results for the duplicate analysis. Samples E02, E72, E142, E212, and EC2 were split, extracted, and analyzed in duplicate. The relative percent difference between the concentration of the duplicate samples was less than 20%.

Table 4 lists the results for the method spike recoveries. The method spike was extracted and run to check the efficiency of the extraction procedure. Baked, beach sand was used as a blank sample for spiking purposes. The sample was spiked to attain a concentration of 10.0 ug/ml of each compound. The percent recovery of the method spike was above 85%.

Table 5 lists the results for the matrix spike recoveries. Samples E02, E72, E142, E212, and EC2 were split, extracted and spiked with 100 ug/ml of each compound. . The percent recovery for the matrix spikes were between 47% to 121%.

Table 6 lists the results of the EMSL performance evaluation sample, WP985, which was analyzed to validate the accuracy of the calibration range, and the extraction procedure. The EMSL contained a mixture of 10 phenols, but only the compound of interest, phenol was used. The recovered concentration for phenol was 76.2 ug/ml, and the percent recovery was 76.2%. This was well within the 95% confidence interval, which gave a range of recovering 666 ug/ml to 1000 ug/ml. No EMSL sample was available for any of the cresol standards.

TABLE 2. SURROGATE AND INTERNAL STANDARD RECOVERIES

Sample Number	% Recovery Surrogate Standard	% Recovery Internal Standard	Sample Number	% Recovery Surrogate Standard	% Recovery Internal Standard
Calibration range: 3/30/87			4/8/87		
$MeCl_2$ blank	-	96.2	$MeCl_2$ blank	93.9	110
50 mg/L	-	100	N71	*	121
25 mg/L	-	101	N72	*	122
10 mg/L	-	107	N73	*	123
5 mg/L	-	103	N74	*	123
100 mg/L	-	99.1			
200 mg/L	-	94.6	4/9 Theoretical detection limits		
4/3/87			$MeCl_2$ blank	87.0	108
			5 mg/L	-	94.6
Soil blank	91.3	89.2	5 mg/L	-	93.7
E01	107	107	5 mg/L	-	93.2
E02	104	108	5 mg/L	-	93.9
E02d	106	110	5 mg/L	-	95.3
E02s	101	112	1 mg/L	-	93.7
E03	107	108			
E04	106	109	4/10/87		
Method spk	97.0	92.6			
N01	99.5	94.9	$MeCl_2$ blank	98.8	110
N02	100	97.7	EMSL	*	117
N03	102	99.6	E72d	100	114
N04	106	106	E72s	99.1	109
4/6/87			4/13/87		
$MeCl_2$ blank	90.8	98.3	$MeCl_2$ blank	104	104
N71	108	113	E141	128	109
N72	114	119	E142	125	119
N73	108	108	E142d	124	87.3
N74	119	116	E142s	122	117
E71	109	123	E143	126	123
E72	113	126	E144	125	120
E73	117	121	N141	121	102
E74	117	116	N142	120	105
			N143	118	86.7
			N144	124	97.9

- denotes that no surrogate standard was added
* denotes sample extract concentrated 10X; surrogate standard was concentrated 10X with extract and results were not attained.
d denotes a duplicate sample
s denotes a spikes sample

Calculations based on response of surrogate and internal standard in the 50 mg/L daily standard.

TABLE 2. SURROGATE AND INTERNAL STANDARD RECOVERIES

Sample Number	% Recovery Surrogate Standard	% Recovery Internal Standard	Sample Number	% Recovery Surrogate Standard	% Recovery Internal Standard
4/15/87					
$MeCl_2$ blank	104	111			
E212	122	106			
EC1	124	110			
E213	128	108			
E214	131	98.2			
E212	128	95.0			
E212d	132	97.6			
E212s	129	99.6			
N211	*	135			
N212	*	141			
N213	*	139			
N214	*	133			
N141	*	136			
N142	*	135			
N143	*	137			
N144	*	137			
4/16/87					
$MeCl_2$ blank	103	104			
EC2	114	98.9			
EC2d	118	101			
EC2s	113	91.4			
EC3	114	102			
EC4	118	106			
NC1	113	95.7			
NC2	114	100			
NC3	115	102			
NC4	114	107			

- denotes that no surrogate standard was added
* denotes sample extract concentrated 10X; surrogate standard was concentrated 10X with extract and results were not attained. A coeluting internal standard interferent peak that was present in the sample were concentrated, which affected the internal standard recovery.
d denotes a duplicate sample
s denotes a spiked sample

Calculations based on response of surrogate and internal standard in the 50 mg/L daily standard.

TABLE 3. RESULTS OF DUPLICATE ANALYSIS FOR PHENOL AND CRESOLS ANALYSIS

Concentrations reported in ug/g

PARAMETER	RUN 1	RUN 2	DIFFERENCE	RPD
SAMPLE NO. E02				
PHENOL	986	1000	14.0	1.41
ORTHO CRESOL	84.2	94.7	10.4	11.7
META+PARA CRESOL	375	394	20.0	5.19
SAMPLE NO. E72				
PHENOL	593	621	28.0	4.61
ORTHO CRESOL	64.7	63.2	1.50	2.34
META+PARA CRESOL	271	277	6.00	2.19
SAMPLE NO. E142				
PHENOL	438	443	5.00	1.14
ORTHO CRESOL	53.8	45.0	8.80	17.8
META+PARA CRESOL	243	229	14.0	5.93
SAMPLE NO. E212				
PHENOL	429	469	40.0	8.91
ORTHO CRESOL	41.1	48.4	7.3	16.3
META+PARA CRESOL	228	232	24.0	10.0
SAMPLE NO. EC2				
PHENOL	876	928	52.0	5.76
ORTHO CRESOL	75.2	83.5	8.30	10.5
META+PARA CRESOL	325	350	25.0	7.41

RPD denotes relative percent difference

TABLE 4 . RESULTS OF METHOD SPIKE RECOVERY FOR PHENOL AND CRESOLS ANALYSIS

Concentrations reported in ug/g

PARAMETER	SAMPLE CONC.	SPIKE CONC.	RECOVERED CONC.	PERCENT RECOVERY
PHENOL	ND	10.0	8.58	85.8
ORTHO CRESOL	ND	10.0	9.14	91.4
META+PARA CRESOL	ND	20.0	17.0	85.0

ND denotes not detected

TABLE 5. RESULTS OF MATRIX SPIKE RECOVERY FOR PHENOL AND CRESOLS ANALYSIS

Concentrations reported in ug/g

PARAMETER	INITIAL SAMPLE CONC.	SPIKE CONC.	RECOVERED SAMPLE CONC.	SPIKE CONC.	PERCENT RECOVERY
SAMPLE NO. E02					
PHENOL	993	100	1040	47.0	47.0
ORTHO CRESOL	89.4	100	180	90.6	90.6
META+PARA CRESOL	385	200	551	166	83.0
SAMPLE NO. E72					
PHENOL	607	100	728	121	121
ORTHO PHENOL	64.0	100	155	91.0	91.0
META+PARA CRESOL	274	200	469	195	97.5
SAMPLE NO. E142					
PHENOL	441	100	542	101	101
ORTHO CRESOL	49.4	100	128	78.6	78.6
META+PARA CRESOL	236	200	403	167	83.5
SAMPLE NO. E212					
PHENOL	449	100	523	74.0	74.0
ORTHO CRESOL	44.8	100	135	90.2	90.2
META+PARA CRESOL	240	200	422	182	91.0
SAMPLE NO. EC2					
PHENOL	902	100	957	55.0	55.0
ORTHO CRESOL	79.4	100	168	88.6	88.6
META+PARA CRESOL	338	200	516	178	89.0

TABLE 6. RESULTS OF EMSL PERFORMANCE EVALUATION SAMPLE FOR PHENOL

Concentrations reported in ug/g

EMSL WP 985

Parameter	True Value*	Recovered Concentration	Percent Recovery	95% Confidence Interval*
PHENOL	1000	762	76.2	66 - 1000

* As reported by EMSL