Statistics
Special Study 71-12
Job No. 85050-16

BIODEGRADATION STUDIES
COMPARISON OF MCS 1016 WITH AROCLOR 1142 RESIDUE

INTRODUCTION

Data were collected over a 9 week period on the semi continuous activated sludge apparatus to study the differences in disappearance rates between MCS 1016 and Aroclor 1142 residue. The test compounds were fed at the beginning of each week, and sampled after 1, 2, 3, 4 and 7 days. Residual compound was determined by Ultra Violet and electron capture techniques, and disappearances (absolute and relative) were calculated on both individual and cummulative bases. The data were submitted for statistical analysis.

The statistical analyses were carried out in various phases as follows:

A. The total number of milligrams disappearing over a seven day period.

B. The number of milligrams of test compound disappearing daily.

C. Correlations between the UV data and the electron capture data for each material.

CONCLUSIONS

A. Seven Day Results

1. There was a significant difference in total mg. disappearing in 7 days between MCS 1016 and Aroclor 1142 residue. Significance level 95%.

2. The estimated percent disappearance (based on 5 mg. fed) for each compound was as follows (ave. of UV and electron capture).

	MCS 1016		Aroclor 1142 Residue	
	mg disappeared	% of 5 mg	mg disappeared	% of 5 mg
Ave	2.34	46.8%	1.15	23.0%
95% limits of ave	1.93 to 2.75	38.6-55.0%	0.74 to 1.56	14.8-31.2%

3. The data failed to show a consistent difference between the UV and the electron capture technique at the 95% level. However, the difference was significant at the 90% level. Average disappearance is shown for both compounds.

	MCS 1016	Aroclor 1142 Residue
Ultra Violet	2.70 (54%)	1.37 (27.4%)
Electron Capture	1.98 (39.6%)	0.92 (18.4%)

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4. There is a significant week-to-week variation in total mg. disappeared (Significance 99.9%)

Week	Ave mg disappeared	% of 5 mg feed
1	1.19	23.8%
2	0.81 gain	16.2% gain
3	1.43	38.6%
4	2.22	44.4%
5	0.50	10.0%
6	2.03	40.6%
7	3.93	78.6%
8	4.53	90.6%
9	0.68	13.6%

5. The difference between 1016 and 1142 varies significantly from week-to-week. (Significance 95%)

	Ave. Mg disappeared		
Week	MCS 1016	Aroclor 1142 Residue	Diff.
1	1.58	0.80	0.78
2	0.55	-2.17	2.72
3	2.85	0.02	2.83
4	1.47	2.87	-1.40
5	1.90	-0.89	2.79
6	3.05	1.01	2.04
7	3.56	4.30	-0.74
8	4.31	4.75	-0.44
9	1.80	-0.44	2.24

6. The difference between electron capture and UV results varies significantly from week-to-week.

	Ave. Mg. disappeared		
Week	UV Method	Electron Capture	Difference
1	1.51	0.88	0.65
2	-0.27	-1.31	1.04
3	1.75	1.11	0.64
4	1.89	2.55	-0.66
5	1.27	-0.27	1.54
6	2.00	2.06	-0.06
7	4.03	3.82	0.21
8	2.93	6.12	-3.19
9	3.22	-1.86	5.08

B. Daily Results

1. There was a significant difference in average total mg. disappearing per day, with the greatest amount disappearing on the first day, smaller amounts on the second day, and no further change (or gain) for the balance of the week. Average results follow: (Significance 99.9%)

	MCS 1016		Aroclor 1142 Residue		
Day	UV Method	Electron Capture	UV Method	Electron Capture	Ave.
1	1.73	1.65	1.34	1.74	1.615
2	0.87	0.08	0.39	0.40	0.435
3	0.31	0.35	0.23	0.34	0.308
4	-0.48	0.04	-0.44	-0.47	-0.338
7	0.22	0.00	-0.30	-1.14	-0.305

2. The daily disappearance data failed to show a significant difference between MCS 1016 and Aroclor 1142 residue. Sig. <80%.)

3. The daily pattern of disappearance varied significantly from week-to-week. The averages follow.

	Day				
Week	1	2	3	4	7
1	0.61	0.31	0.19	-0.10	0.18
2	0.38	-0.77	0.94	-0.70	-0.67
3	2.25	-1.00	0.97	-0.04	-0.91
4	2.13	-0.12	-0.99	0.22	0.92
5	-0.68	1.79	0.86	-0.71	-0.78
6	1.18	1.12	-0.30	1.23	-1.20
7	3.66	1.26	0.23	-0.25	-0.73
8	4.34	-0.22	1.16	-1.81	1.06
9	1.18	1.31	-0.26	-0.92	-0.64

4. The daily data failed to show a significant systematic weight disappearance from week-to-week.

C. Correlation of Test Methods

1. There was a significant correlation between the daily mg disappearance (UV method) and daily mg disappearance (EC method) on both MCS 1016 and Aroclor 1142 Residue. Significance 99.9%.

2. The correlation coefficients were r = 0.58 for the 1016 data and 0.75 for the 1142 data.

3. Predicted values for electron capture data as functions of the UV results are:

	Least Squares Line
For 1016	EC = 0.19 + 0.44 (UV) $\pm$ 1.41 (95% Limits)
For 1142	EC = -0.07 + 0.97 (UV) $\pm$ 2.41 (95% Limits)

The least squares line for the 1142 data is closer to theoretical (EC = UV) because the data extend over a wider range and the slope is less affected by stray values. (See Figures 1 and 2.)

4. A plot of the first daily sample tested by each method shows the correlations between actual determinations by Ultra Violet and Electron Capture. The least squares lines were not calcualted for these, but examination of the graphs indicate the correlation to be quite poor at levels of less than 4 milligrams. (See Figures 3 and 4.)

DISCUSSION

The daily disappearance figures in milligrams lost were selected (for statistical analysis) rather than the percent lost per day. The reason was that the percentage figures fluctuated wildly when the amount present was very low. For example, a change from 1.5 mg to 3.0 mg would represent a gain of 100%, and figures as large or larger than this were found in the data.

The conclusions in part A of the analysis were based on analysis of variance of the cumulative amount of compound disappearing over a 7 day period for each week. The data and calculations are shown in Table I.

The conclusions in part B are from analysis of variance tests run on the amount of compound disappearing daily. Separate analyses were run on each compound by each technique. (Tables II, III, IV and V.) Table VI shows the combined analysis of variance for both materials on the UV data.

The conclusions in part C are based on a correlation analysis of the amount of compound disappearing daily as calculated by the two methods of analysis (UV and electron capture). Details of these calculations are available on request.

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Monsanto Company
Organic Chemicals Division
Applied Sciences Section
St. Louis, Mo.

8/71 - J. D. Hinchen, R. E. Keller

MCS 1016

Mg Daily Disappearance

Electron Capture Vs UV

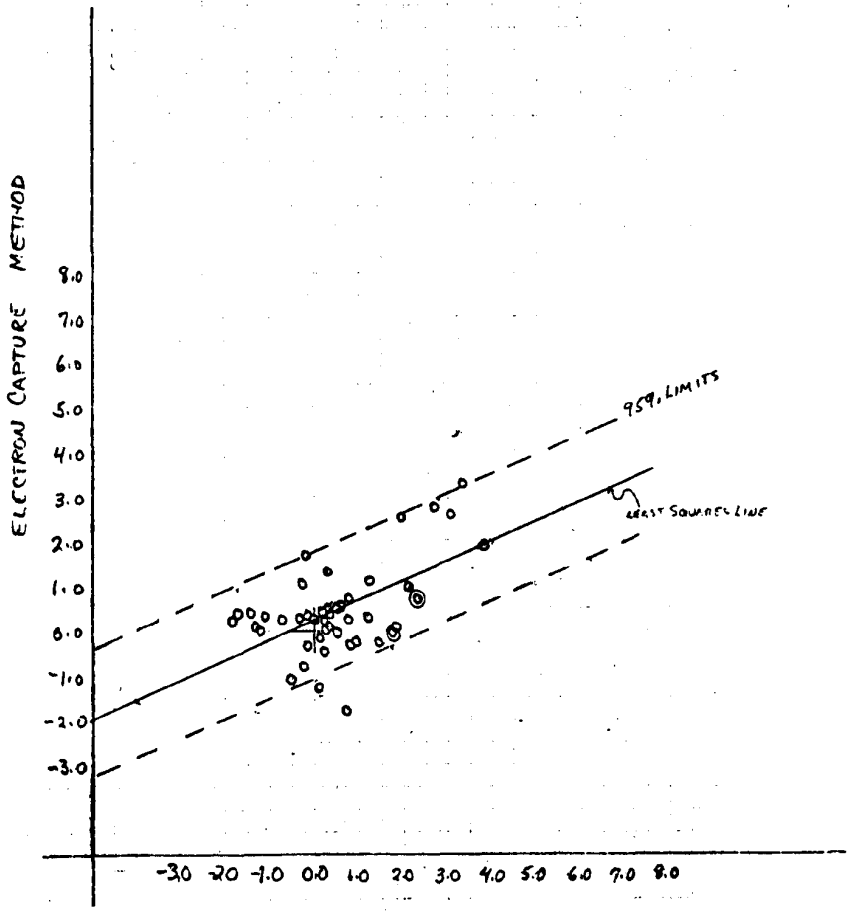

FIGURE 1

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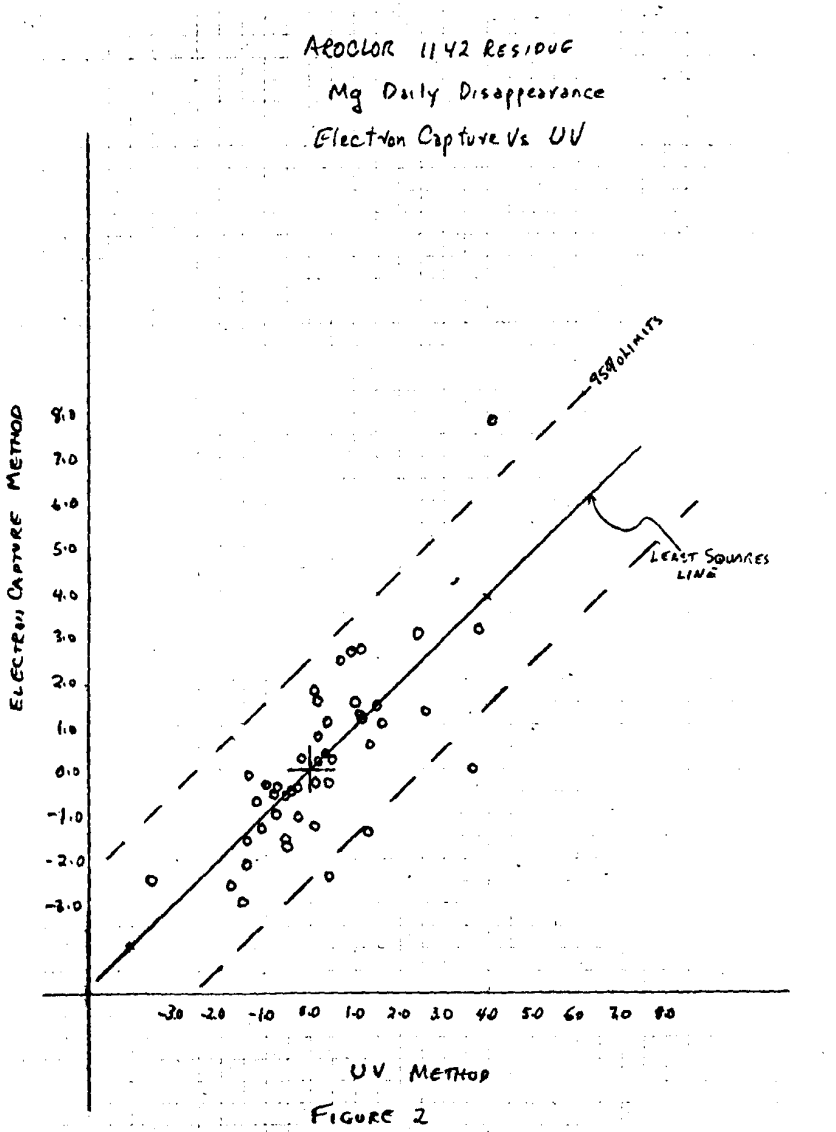

FIGURE 2

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1142 mg FOUND

ELECTRON CAPTURE VS UV
FIRST SAMPLE EACH DAY

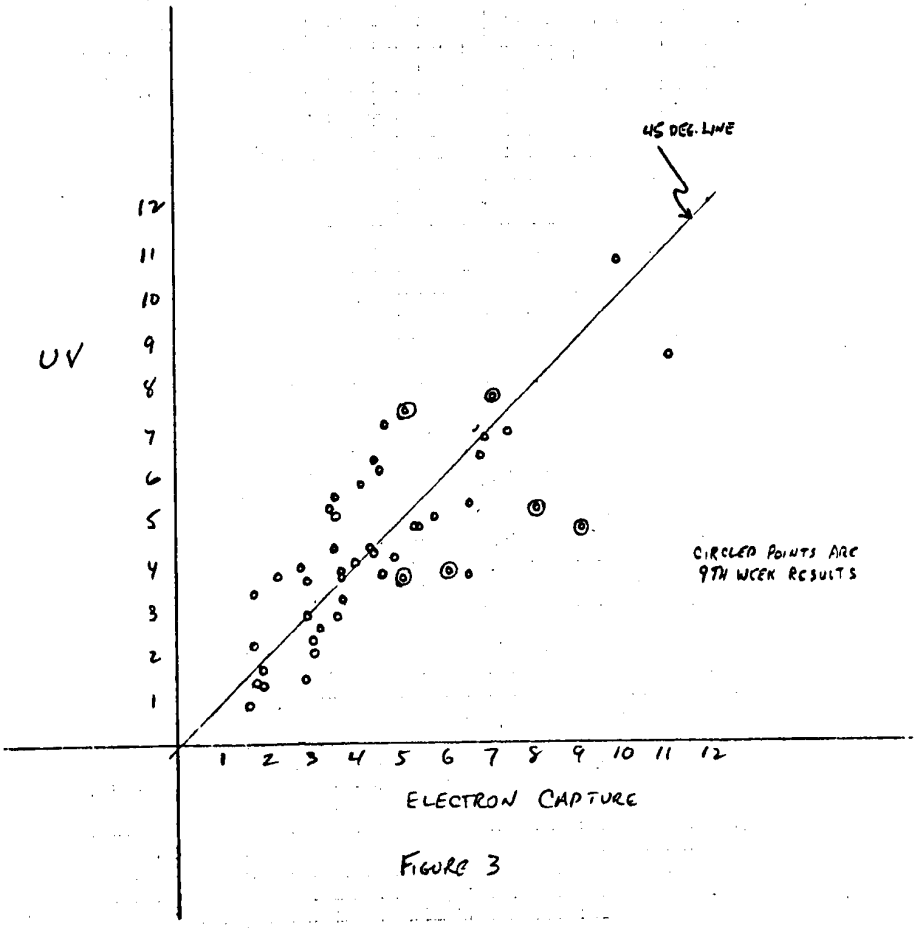

FIGURE 3

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1.016 mg Found

ELECTRON CAPTURE Vs UV

FIRST SAMPLE EACH DAY

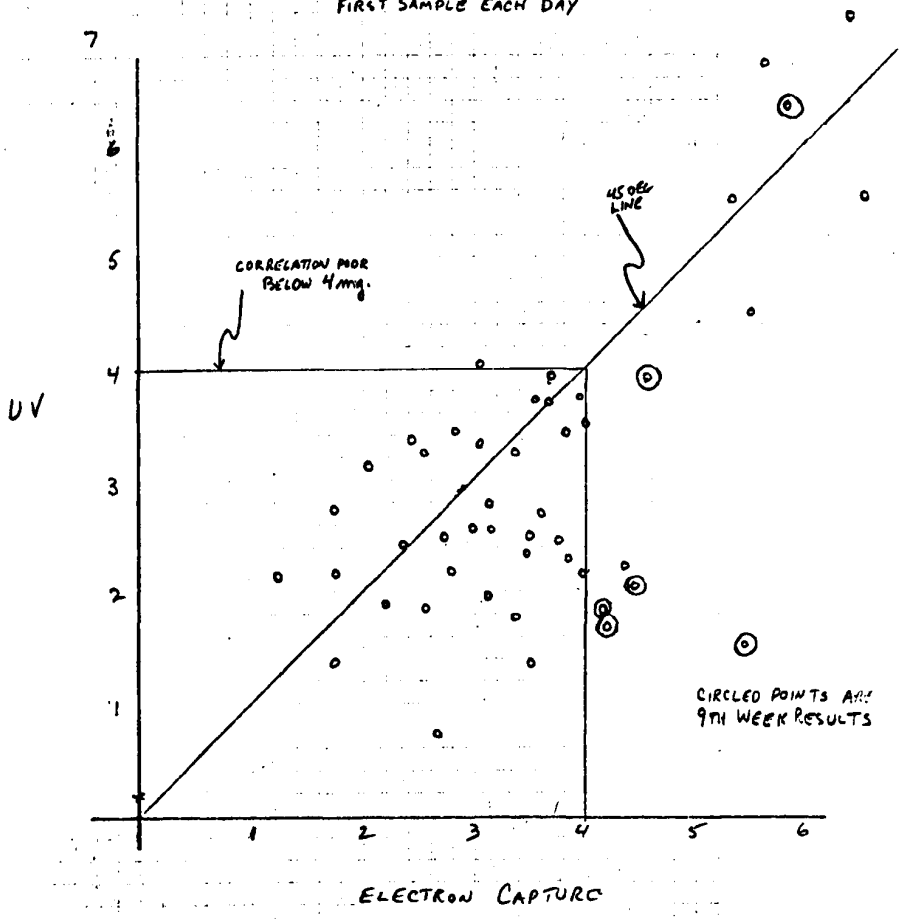

FIGURE 4

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TABLE I

Com Mg Disappeared After 7 Days

	1016		1142	
	UV	EC	UV	EC
1	2.26	0.91	0.76	0.84
2	0.71	0.38	-1.25	-3.10
3	3.32	2.37	0.19	-0.15
4	1.03	1.91	2.75	3.19
5	2.06	1.73	0.49	-2.27
6	2.88	3.22	1.81	0.91
7	4.15	2.98	3.92	4.67
8	3.55	5.07	2.32	7.18
9	4.38	-0.79	2.07	-2.94

MATERIAL X WEEK

	1016	1142	
1	3.17	1.60	4.77
2	1.09	-4.35	-3.26
3	5.69	0.04	5.73
4	2.94	5.94	8.88
5	3.79	-1.78	2.01
6	6.10	2.02	8.12
7	7.13	8.59	15.72
8	8.62	9.50	18.12
9	3.59	-0.87	2.72
	42.12	20.69	62.81

METHOD X WEEK

	UV	EC	
1	3.02	1.75	4.77
2	-0.54	-2.72	-3.26
3	3.51	2.22	5.73
4	3.78	5.10	8.88
5	2.55	-0.54	2.01
6	8.99	4.13	8.12
7	8.07	7.65	15.72
8	5.87	12.25	18.12
9	6.45	-3.73	2.72
	36.70	26.11	62.81

MATERIAL X METHOD

	1016	1142	
UV	24.34	12.36	36.70
EC	17.78	8.33	26.11
	42.12	20.69	62.81

ANOVA

SS IND = 282.7953 - 109.5860 = 173.2093

SS MAT = 122.3428 - 109.5860 = 12.7568

SS METH = 112.7012 - 109.5860 = 3.1152

SS WKS = 199.4738 - 109.5860 = 89.8874

SS MAT X METH = 125.6358 - 109.5860 - 12.7586 - 3.1152 = 0.1760

SS MAT X WKS = 235.3358 - 109.5860 - 12.7586 - 89.8874 = 23.1038

SS METH X WKS = 240.4366 - 109.5860 - 3.1152 - 89.8874 = 37.8480

SS RESIDUAL = 6.3221

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TABLE I (Continued)

ANOVA TABLE

SOURCE	SS	DF	MS	F	
MATERIALS	12.7568	1	12.7568	16.08	99%
METHODS	3.1152	1	3.1152	3.93	N.S
WEEKS	89.8874	8	11.2359	14.16	99.9%
MAT X METHOD	0.1760	1	0.1760	0.22	N S
MAT X WEEKS	23.1038	8	2.8879	3.64	95%
METHOD X WEEKS	37.1848	8	4.7310	5.97	98%
RESIDUAL	6.3221	8	0.7902		
TOTAL	173.2093	35			

1. Significant Difference Between 1016 and 1142 Residue in Total Mgs Disappeared in 7 Day Period.

2. No consistent difference between test methods

3. There is a consistent week to Week variation in Total mgs disappeared

4. The difference between 1016 and 1142 varies significantly from week to week. Note weeks 4, 7 and 8.

5. The difference between methods varies significantly from week to week. Note especially weeks 8 and 9

6. The estimated standard deviation of an individual result is 0.89

7. 95% confidence limits of mean of 9 observations = $\pm \frac{2(.89)}{3}$

$= \pm 0.59$

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MCS 1016 TABLE II

mg. daily discrepancy - diction capture

WEEKS	DAYS 1	2	3	4	7	
1	0.53	0.57	-0.04	-1.84	1.69	0.91
2	1.32	-1.10	0.10	0.44	-0.38	0.38
3	3.19	-1.18	0.39	0.46	0.49	3.35
4	0.98	0.28	0.17	-0.02	0.50	1.91
5	0.29	1.90	0.03	0.31	-0.80	1.73
6	2.55	0.21	0.27	0.70	-0.51	3.22
7	2.57	-0.29	1.04	0.35	-0.34	3.33
8	2.74	0.42	1.06	0.09	0.76	5.07
9	0.64	-0.05	0.17	-0.16	-1.39	-0.79
	14.81	0.76	3.19	0.33	0.02	19.11
avr	1.65	0.08	0.35	0.04	0.00	

avr = 0.42

		DF	MEAN SQUARE	
SS IND =	55.2413 - 8.1154 = 47.1259	44		
SS DAYS =	25.5777 - 8.1154 = 17.4623	4	4.3656	SIG 99.9%
SS WEEKS =	13.3245 - 8.1154 = 5.2091	8	0.6511	NS
SS RESIDUAL	24.4545	32	0.7642	

RESIDUAL STD DEV = $\sqrt{0.7642} = 0.87$

95% CONF LIMITS DAILY MEAN = $\pm \frac{2(0.87)}{\sqrt{9}} = \pm 0.58$

$LSD_9 = 2(.87)\left(\sqrt{\frac{1}{9}+\frac{1}{9}}\right) = 0.82$

95% CONFIDENCE LIMITS - OVERALL MEAN = $\frac{\pm 0.58}{\sqrt{5}} = \pm 0.26$

POOLED SD (ELECTRON CAPTURE) = $\sqrt{\frac{(.87)^2+(1.82)^2}{2}} = \sqrt{2.0782} = 1.44$

$LSD_{45} = (1.44)(2)\sqrt{\frac{1}{45}+\frac{1}{45}} = 2.88(0.21) = 0.60$

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MCS 1016 TABLE III

mg daily disappearance - UV

WK	DAY 1	2	3	4	7	
1	0.53	0.53	0.50	0.75	-0.05	2.26
2	0.35	-0.55	1.84	-1.70	0.77	0.71
3	3.33	0.00	1.18	-1.43	0.24	3.32
4	2.13	-0.01	-1.82	0.23	0.30	0.83
5	-0.77	3.83	0.28	-1.05	-0.23	2.06
6	1.98	0.78	-0.33	0.29	0.17	2.89
7	3.10	1.48	-0.26	-0.21	-0.17	3.94
8	2.64	0.07	1.25	-1.31	0.90	3.55
9	2.30	1.73	0.18	0.09	0.08	4.38
	15.59	7.86	2.82	-4.34	2.01	23.94 ✓
ave	1.73	0.87	0.31	-0.48	0.22	ave = 0.53

		DF		F
SS IND =	83.7841 - 12.7361 =	71.0480		
SS DAYS =	37.2951 - 12.7361 =	24.5590	4	6.0932	4.76 Sig
SS WEEKS =	18.2418 - 12.7361 =	5.5057	8	0.6882	
SS RESIDUAL =		40.9833	32	1.2807	

Est Std Dev = $\sqrt{1.2807} = 1.13$

95% conf limit of daily mean = $\pm \frac{2(1.13)}{\sqrt{9}} = \pm 0.75$

LSD = $2(1.13)(.47) = 1.06$

95% conf limit - overall mean = $\frac{\pm 0.75}{\sqrt{5}} = \pm 0.34$

Pooled SD(UV) = $\sqrt{\frac{(1.13)^2+(1.57)^2}{2}} = \sqrt{1.87} = 1.37$

$LSD_{45} = 2(1.37)\sqrt{\frac{1}{45}+\frac{1}{45}} = 2.94(0.21) = 0.58$

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AROCLOR 1142 TABLE IV

mg. daily disappearance - UV

WEEK	DAY 1	2	3	4	7	
1	0.13	0.42	0.19	0.50	-0.48	0.76
2	1.26	-0.87	1.30	-1.46	-1.48	-1.25
3	1.00	-0.80	1.06	0.12	-1.79	-0.41
4	2.80	-0.29	-1.15	0.34	1.45	2.75
5	-0.50	0.36	0.69	-0.52	0.46	0.49
6	-0.11	0.90	-0.74	2.59	-1.53	1.11
7	3.81	1.19	-0.12	-0.59	-1.06	3.23
8	4.10	-0.98	1.18	-3.56	1.58	2.32
9	0.01	3.62	-0.28	-1.40	0.12	2.07
	12.10	3.55	2.13	-3.98	-2.73	11.07 ← ave = 0.25
ave	1.34	0.39	0.23	-0.44	-0.30	

			MS	F
SS_{IND} = 103.0979 − 2.7232 =	100.3747			
SS_{DAYS} = 20.7603 − 2.7232 =	18.0371	4	4.5093	1.83 ns
SS_{WEEKS} = 6.2886 − 2.7232 =	3.5654	8	0.4457	
$SS_{RESIDUAL}$ =	78.7722	32	2.4616	

Est Std Dev = $\sqrt{2.4616}$ = 1.57

95% Limits of Daily Mean = $\pm \frac{2(1.57)}{\sqrt{9}}$ = ± 1.05

LSD = 2(1.57)(.47) = 1.48

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TABLE V

AROCLOR 1142

mg. Daily Disappearance - electron capture

WEEKS	DAYS 1	2	3	4	7	
1	1.25	-0.30	0.11	0.20	-0.42	0.84
2	-1.42	-0.55	0.53	-0.08	-1.58	-3.10
3	1.48	-1.00	1.24	0.72	-2.58	-0.14
4	3.03	-0.46	-1.17	0.34	1.45	3.19
5	-1.76	1.09	2.43	-1.57	-2.44	-2.27
6	0.30	2.60	-0.40	1.36	-2.95	0.91
7	3.13	2.66	0.25	-0.56	-1.37	4.11
8	7.87	-0.40	1.16	-2.47	1.02	7.18
9	1.77	-0.04	-1.11	-2.19	-1.37	-2.94
	15.65	3.58	3.04	-4.25	-10.24	7.78 — ave = 0.17
	1.74	0.40	0.34	-0.47	-1.14	

		DF	MEAN SQUARE	F
SS IND =	168.7428 − 1.3451 = 167.3977	44		
SS DAYS =	43.3223 − 1.3451 = 41.9772	4	10.4943	3.16 95%
SS WEEKS =	20.7161 − 1.3451 = 19.3710	8	2.4214	NS
SS RESIDUAL	106.0495	32	3.3140	

EST STD DEV = $\sqrt{3.314} = 1.82$

95% LIMITS OF DAILY MEAN = $\pm \frac{2(1.82)}{\sqrt{9}} = \pm 1.21$

$LSD = 2(1.82)\left(\sqrt{\frac{1}{9}+\frac{1}{9}}\right) = 1.71$

TABLE VI

MCS 1016 VS AROCLOR 1142 RESIDUE — UV Data

Mg DAILY DISAPPEARANCE

DAY X MATERIAL TOTALS

	MCS 1016	AROCLOR 1142	TOTAL
DAY 1	15.59	12.10	27.69
DAY 2	7.86	3.55	11.41
DAY 3	2.82	2.13	4.95
DAY 4	-4.34	-3.98	-8.32
DAY 7	2.01	-2.73	-0.72
	23.94	11.07	35.01

OVERALL ANALYSIS OF VARIANCE

		DF	MONSQ	F
SS IND =	186.8820 - 13.6189 = 173.2631	89		
SS DAYS =	55.0648 - 13.6189 = 41.4459	4	10.3615	11.352
SS WEEKS =	18.0616 - 13.6189 = 4.4427	8	0.5553	—
SS MATERIALS =	15.4593 - 13.6189 = 1.8404	1	1.8404	2.016
SS DAYS X WEEKS =	152.9308 - 13.6189 - 41.4459 - 4.4427 = 93.3233	32	2.9164	3.195
SS DAYS X MAT. =	58.0823 - 13.6189 - 41.4459 - 1.8404 = 1.1711	4	0.2927	—
SS WKS X MAT. =	21.7345 - 13.6189 - 4.4427 - 1.8404 = 1.8325	8	0.2290	—
SS RESIDUAL =	29.2072	32	0.9127	

ESTIMATED STD DEV = 0.96

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