

SUPPLEMENTARY REPORT
ON
THE FATE OF DETERGENTS IN SEPTIC-TANK
SYSTEMS AND OXIDATION PONDS

Standard Service Agreement
No. UCB-Eng-1821

By
Stephen A. Klein

Faculty Investigator
P. H. McGauhey

1 May 1964

Sanitary Engineering Research Laboratory
College of Engineering
and
School of Public Health
University of California
Berkeley

SERL Report No. 64-1 (Supplement)

TABLE OF CONTENTS

	<u>Page</u>
LIST OF TABLES	v
LIST OF FIGURES	v
 <u>Chapter</u>	
I. INTRODUCTION	
Need for Investigation	1
Purpose and Scope of Investigation	1
Organization of Investigation	1
Acknowledgments	2
II. PONDED PERCOLATION FIELD STUDY	
Introduction	3
Procedure	3
Results	3
Ponding of Percolation Fields	3
Radioassay	3
Removal of ABS ³⁵	8
Removal of LAS ³⁵ in Septic Tank	8
Removal of Alcohol Sulfate in Septic Tank	8
Removal of ABS ³⁵ in Combined Septic Tank and Percolation Field	8
Removal of LAS ³⁵ in Combined Septic Tank and Percolation Field	8
Removal of Alcohol Sulfate in Combined Septic Tank and Percolation Field	9
Colorimetry	9
Dissolved Oxygen	11
Foamability	11

LIST OF TABLES

<u>Table</u>	<u>Title</u>	<u>Page</u>
I.	Degradation and Removal of Polypropyl ABS ³⁵ in Ponded Septic Tank System	5
II.	Degradation and Removal of LAS ³⁵ in Ponded Septic Tank System	6
III.	Degradation and Removal of Alcohol Sulfate in Ponded Septic Tank System	7
IV.	Colorimetric Determinations of Detergent Removal in Septic Tank System	10
V.	Foamability of Detergents in Septic Tank Systems	13
VI.	COD Removals in Septic Tanks	14
VII.	COD Removals in Septic-Tank Percolation-Field Systems.	15
VIII.	Suspended Solids Removal in Septic Tanks	16
IX.	Suspended Solids Removal in Septic-Tank Percolation-Field Systems	17
X.	Summary of Degradation and Removal of Detergents in Septic Tanks	21
XI.	Summary of Degradation and Removal of Detergents in Septic Tanks and Percolation Fields	21

LIST OF FIGURES

<u>Figure</u>	<u>Title</u>	<u>Page</u>
1.	Minimum Daily Piezometer Levels in Percolation Fields.	4
2.	Dissolved Oxygen Content of Percolation Field Effluent	12
3.	Maximum and Minimum Septic Tank Liquid Temperatures.	19

I. INTRODUCTION

NEED FOR INVESTIGATION

In a previous report [1], to which this is a supplement, the fate of ABS, LAS, and alcohol sulfate was evaluated in oxidation ponds and in septic tank systems. When operated under near optimum conditions in which the soil was allowed to drain periodically to restore infiltrative capacity, percolation systems were observed to degrade nearly 100% of the LAS and alcohol sulfate, and almost 80% of the branched polypropyl ABS. Thus it was concluded that in a properly operated percolation system, detergents pose no serious threat to ground water quality.

It is well-known, however, that many septic tank drainage systems are overloaded and yet may continue to operate for several years in a ponded or semi-ponded state before becoming totally inoperable. According to Craun [2] all drain fields are ponded to some extent. This is confirmed in studies by Winneberger, et al., [3] which demonstrate that trench bottoms clog almost immediately (after a few days) and from thereon sidewalls are the principal active infiltrative surfaces.

In view of the marginal conditions under which many percolation systems operate throughout the country, there is no assurance on the basis of the previous study that substitution of the experimental detergents for ABS will completely solve the detergent problem. It is therefore important to determine the ground water pollution potential, if any, of test materials passed through a system which is progressively ponded until surcharging occurs each time the septic tank discharges effluent to the percolation system. Such a system is considered a "failed" system and becomes unacceptable to public health authorities when ponded sewage breaks through to the ground surface.

Purpose and Scope of Investigation

The purpose of the investigation was to evaluate the biodegradability of detergents in a septic tank system in which the percolation field was deliberately ponded to simulate operation under the most adverse field conditions allowable. Test detergents included a straight chain ABS (now commonly referred to as linear alkylate sulfonate or LAS), alcohol sulfate and polypropyl ABS, which served as a reference for "hard" detergent behavior.

Organization of Investigation

The study herein reported was conducted at the Sanitary Engineering Research Laboratory (SERL) of the University of California

during the contract period 9 April 1963 to 9 April 1964, under the terms of Contract No. UCB-Eng-1857 between the Regents of the University of California and the Soap and Detergent Association. The principal investigative work was done by Mr. Stephen Klein with the assistance of Messrs. Deh-Bin Chan and Ze'ev Vered. Professor P. H. McGauhey served in the capacity of Faculty Investigator.

ACKNOWLEDGMENTS

The project staff is indebted to Mr. Ralph House and Dr. H. Sharman of the California Research Corporation for preparation of test detergents.

II. PONDED PERCOLATION FIELD STUDY

INTRODUCTION

The apparatus, materials and methods were identical to those used in the preceding study.

PROCEDURE

The procedure was also identical, with the exception that the percolation fields were not rested and thus became badly ponded during the course of the investigation. As before, the septic tanks were dosed six times in 16 hours each day and the loading was not changed during the course of the experiments. Composite samples of influent, septic tank effluent, and percolation field effluent were radioassayed for detergent concentration twice weekly over a three-month period.

Other sample analyses performed routinely on a weekly basis included COD, suspended solids, methylene blue ABS, dissolved oxygen, and foamability. Temperature readings of septic tank liquid and minimum liquid levels in the percolation fields were recorded daily.

RESULTS

Ponding of Percolation Fields

The extent to which the fields ponded during the course of the experiment is shown in Figure 1. It is evident that during the final month the ABS and LAS trenches were almost completely inundated, and the liquid level in the LAS unit was not receding below the surface layer of sand covering the trenches in the interval between doses. During the final three weeks surcharging occurred whenever the ABS and LAS fields received a dose, although the alcohol sulfate field did not pond quite as badly, it did surcharge infrequently. Thus, the fields were operated for several weeks under conditions which in actual practice would be considered on the brink of failure. Neither public health authorities nor neighbors would tolerate a system in this condition for long, since it not only constitutes a health hazard, but is malodorous.

Radioassay

Results of the radioassay are presented in Tables I, II, and III for the three detergents.

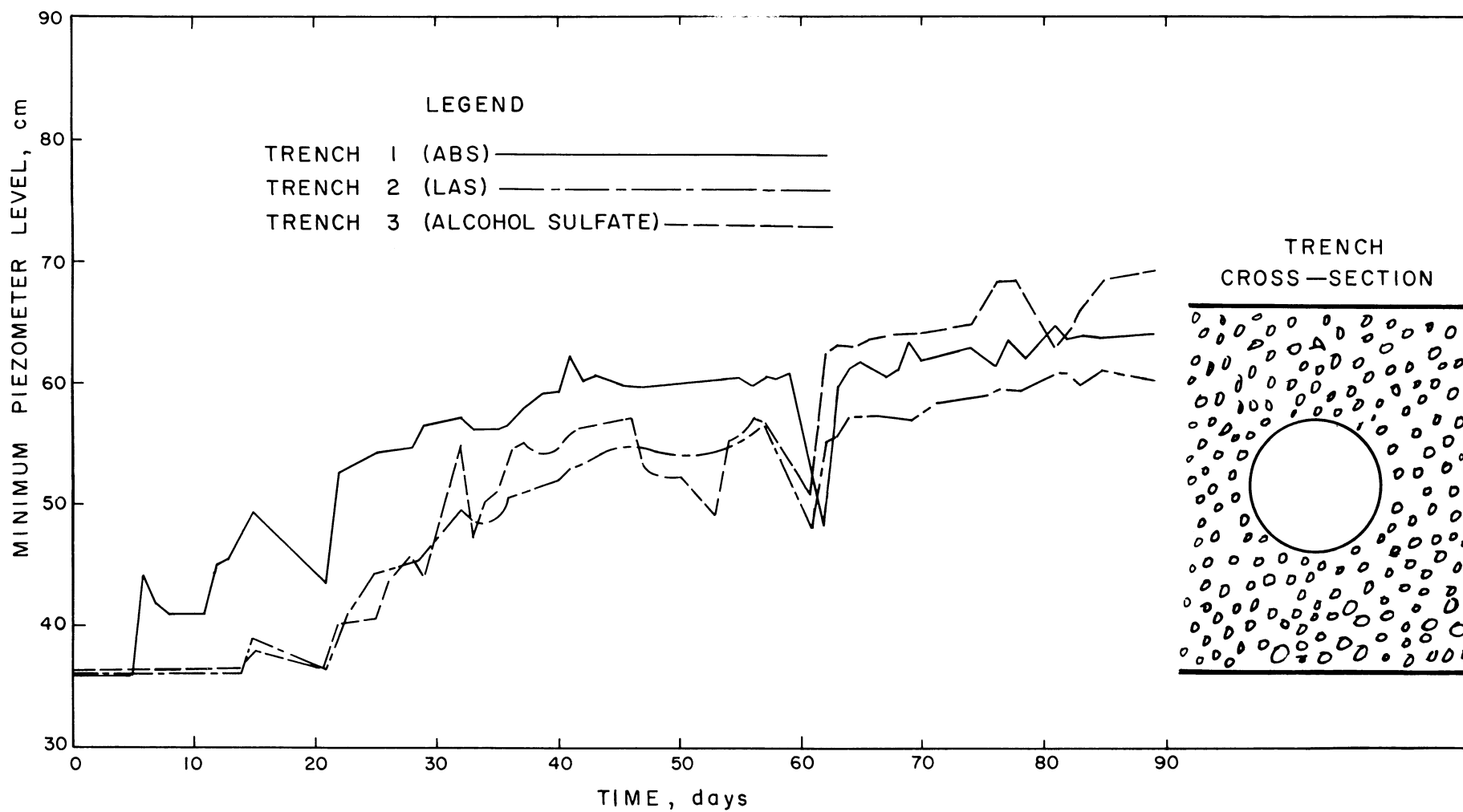


FIGURE 1. MINIMUM DAILY PIEZOMETER LEVELS IN PERCOLATION FIELDS

TABLE I
DEGRADATION AND REMOVAL OF POLYPROPYL ABS³⁵ IN PONDED SEPTIC-TANK SYSTEM

Day	Septic Tank Alone									Septic Tank and Percolation Field						
	S ³⁵ Activity			ABS ³⁵ Activity			BaS ³⁵ O ₄ Activity		Degradation S ³⁵ C/C ₀ , % Minus ABS ³⁵ C/C ₀ , %	S ³⁵ in Effluent		ABS ³⁵ in Effluent		Net BaS ³⁵ O ₄ in Effluent		Degradation S ³⁵ C/C ₀ , % Minus ABS ³⁵ C/C ₀ , %
	Influent	Effluent		Influent	Effluent		Net Effluent	Degradation								
	cpm/ ml	cpm/ ml	C/C ₀ %	cpm/ ml	cpm/ ml	C/C ₀ %	cpm/ ml	%		cpm/ ml	C/C ₀ %	cpm/ ml	C/C ₀ %	cpm/ ml	C/C ₀ %	
4	359	135	37.6	320	142	44.4	2	0.6	- 6.8	74	20.6	36	11.3	18	5.6	9.3
7	1023	256	25.0	910	243	26.7	1	0.1	- 1.7	100	9.8	78	8.6	4	0.4	1.2
11	1168	399	34.2	1040	383	36.8	2	0.2	- 2.6	177	15.2	136	13.1	23	2.2	2.1
14	756	482	63.8	673	480	71.3	0	0	- 7.5	225	29.8	209	31.1	15	2.2	- 1.3
21	745	603	80.9	663	599	90.3	0	0	- 9.4	406	54.5	295	44.5	47	7.1	10.0
25	986	831	84.3	878	641	73.0	-1	-0.1	11.3	405	41.1	247	28.1	52	5.9	13.0
28	935	685	73.3	832	623	74.9	3	0.4	- 1.6	505	54.0	253	30.4	63	7.6	23.6
32	890	649	72.9	792	636	80.3	-1	-0.1	- 7.5	549	61.7	356	44.9	43	5.4	16.8
35	734	700	95.4	653	624	95.6	-2	-0.3	- 0.2	575	78.3	329	50.4	71	10.9	27.9
39	776	741	98.0	691	650	94.1	-	--	3.9	555	71.5	337	48.8	69	10.0	22.7
42	742	675	91.0	660	637	96.5	1	0.2	- 5.5	509	68.6	420	63.6	80	12.1	5.0
46	760	720	94.7	676	636	94.1	0	0	0.6	635	83.6	397	58.7	73	10.8	24.9
49	691	635	91.9	615	565	91.9	2	0.3	0	663	95.9	357	58.0	102	16.6	37.9
53	816	667	81.7	726	589	81.1	-2	-0.3	0.6	640	78.4	347	47.8	84	11.6	30.6
56	716	763	106.6	637	675	106.0	-1	-0.2	0.6	637	89.0	300	47.1	96	15.1	41.9
60	813	722	88.8	724	771	106.5	0	0	-17.7	694	85.4	315	43.5	131	18.1	41.9
64	1030	920	89.3	917	936	102.1	-2	-0.2	-12.8	600	58.3	251	27.4	117	12.8	30.9
67	776	754	97.2	691	570	82.5	1	0.1	14.7	726	93.6	338	59.3	114	11.7	34.3
70	715	675	94.4	636	595	93.6	2	0.3	0.8	656	91.7	371	58.3	107	11.3	33.4
74	754	681	90.3	671	492	73.3	3	0.4	17.0	580	76.9	335	49.9	71	10.6	27.0
77	681	643	94.4	606	477	78.7	-1	0.2	15.7	538	79.0	277	45.7	83	13.7	33.3
81	820	804	98.0	730	725	99.3	-2	-0.3	- 1.3	617	75.2	181	24.8	101	13.8	50.4
85	705	691	98.0	627	677	108.0	-2	-0.3	-10.0	614	87.1	240	38.3	104	16.6	48.8
Avg	794	714	89.9	707	638	90.2	0.1	0	- 0.3	612	77.2	322	45.5	90	12.7	31.7

TABLE II

DEGRADATION AND REMOVAL OF IAS³⁵ IN PONDED SEPTIC-TANK SYSTEM

Day	Septic Tank Alone									Septic Tank and Percolation Field						
	S ³⁵ Activity			IAS ³⁵ Activity			BaS ³⁵ O ₄ Activity		Degradation S ³⁵ C/C ₀ , % Minus IAS ³⁵ C/C ₀ , %	S ³⁵ in Effluent		IAS ³⁵ in Effluent		Net BaS ³⁵ O ₄ in Effluent		Degradation S ³⁵ C/C ₀ , % Minus IAS ³⁵ C/C ₀ , %
	Influent	Effluent		Influent	Effluent		Net Effluent	Degradation								
	cpm/ ml	cpm/ ml	C/C ₀ %	cpm/ ml	cpm/ ml	C/C ₀ %	cpm/ ml	%		cpm/ ml	C/C ₀ %	cpm/ ml	C/C ₀ %	cpm/ ml	C/C ₀ %	
4	104	49	47.1	92	62	67.4	0	0	-20.3	55	52.9	3	3.3	39	42.4	49.6
7	806	210	26.1	717	207	28.9	12	1.7	- 2.8	50	6.2	7	1.0	19	2.6	5.2
11	2011	379	18.8	1788	370	20.7	2	0.1	- 1.9	306	15.2	29	1.6	75	4.2	13.6
14	1307	490	37.5	1162	435	37.4	7	0.6	0.1	375	28.7	42	3.6	105	9.0	25.1
21	918	477	52.0	816	435	53.3	0	0	- 1.3	359	39.1	32	3.9	166	20.3	35.2
25	794	564	71.0	706	404	57.2	2	0.3	13.8	394	49.6	24	3.4	171	24.2	46.2
28	1210	414	34.2	1076	371	34.5	0	0	- 0.3	450	37.2	15	1.4	212	19.7	35.8
32	1058	308	29.1	941	315	33.5	1	0.1	- 4.4	125	11.8	37	3.9	69	7.3	7.9
35	841	433	51.5	748	334	44.7	2	0.3	6.8	233	27.7	14	1.9	109	14.6	25.8
39	885	550	62.1	787	515	65.4	3	0.4	- 3.3	299	33.8	16	2.0	149	18.9	31.8
42	745	628	84.3	662	590	89.1	2	0.3	- 4.8	305	40.9	18	2.7	172	26.0	38.2
46	800	691	86.4	711	615	86.5	3	0.4	- 0.1	426	53.3	17	2.4	211	29.7	50.9
49	606	652	107.6	539	523	97.0	5	0.9	10.6	562	92.7	20	3.7	273	50.6	89.0
53	804	690	85.8	715	580	81.1	3	0.4	4.7	566	70.4	13	1.8	314	43.9	68.6
56	1012	811	80.1	900	750	83.3	2	0.2	- 3.2	494	48.8	9	1.0	266	29.6	47.8
60	852	870	102.1	757	760	100.4	32	4.2	1.7	694	81.5	28	3.7	210	27.7	77.8
63	1326	1068	80.5	1179	882	74.8	23	2.0	5.7	416	31.4	24	2.0	236	20.0	29.4
67	1035	1073	103.7	920	905	98.4	4	0.4	5.3	543	52.5	20	2.2	313	34.0	50.3
70	1007	945	93.8	895	861	96.2	4	0.5	- 2.4	702	69.7	20	2.2	428	47.8	67.5
74	904	860	95.1	804	749	93.2	8	1.1	1.9	595	65.8	21	2.6	358	44.5	63.2
77	783	774	98.9	696	660	94.8	2	0.3	4.1	763	97.4	23	3.3	402	57.8	94.1
81	882	815	92.4	784	688	87.8	-1	-0.1	4.6	709	80.4	24	3.1	457	58.3	77.3
85	784	748	95.4	697	733	105.2	2	0.3	- 9.8	646	82.4	19	2.7	372	53.4	79.7
89	844	732	86.7	750	730	97.3	-2	-0.3	-10.6	671	79.5	31	4.1	282	37.6	75.4
Avg	885	811	91.6	787	716	91.0	5	0.6	0.6	613	69.3	23	2.9	326	41.4	66.4

TABLE III
DEGRADATION AND REMOVAL OF ALCOHOL SULFATE IN PONDED SEPTIC-TANK SYSTEM

Day	Septic Tank Alone							Septic Tank and Percolation Field				
	S^{35} Activity			Alcohol $S^{35}O_4$			Degradation S^{35} C/C _O , % Minus Alc. C/C _O , %	S^{35} in Effluent		Alcohol $S^{35}O_4$ in Effluent		Degradation S^{35} C/C _O , % Minus Alc. C/C _O , %
	Influent	Effluent		Influent	Effluent			cpm/ml	C/C _O , %	cpm/ml	C/C _O , %	
	cpm/ml	cpm/ml	C/C _O , %	cpm/ml	cpm/ml	C/C _O , %						
4	986	731	74.1	744	36	4.8	69.3	151	15.3	0	0	15.3
7	986	674	68.4	744	357	48.0	20.4	475	48.2	5	0.7	47.5
11	986	524	53.1	744	352	47.3	5.8	748	75.9	19	2.6	73.3
14	986	467	47.4	744	312	41.9	5.5	708	71.8	7	0.9	70.9
21	986	242	24.5	744	114	15.3	9.2	630	63.9	2	0.3	63.6
25	986	522	52.9	744	236	31.7	21.2	466	47.3	0	0	47.3
28	986	736	74.6	744	350	47.0	27.6	300	30.4	3	0.4	30.0
32	986	548	55.6	744	296	40.0	15.6	186	18.9	6	0.8	18.1
35	986	587	59.5	744	359	48.3	11.2	203	20.5	5	0.7	19.8
39	986	555	56.3	744	313	42.1	14.2	171	17.3	6	0.8	16.5
42	986	496	50.3	744	334	44.9	5.4	158	16.0	5	0.7	15.3
46	986	457	46.3	744	83	11.2	35.1	234	23.7	3	0.4	23.3
49	986	629	63.8	744	530	71.2	- 7.4	246	24.9	5	0.7	24.2
53	986	760	77.1	744	434	58.3	18.8	192	19.5	3	0.4	19.1
56	986	417	42.3	744	231	31.0	11.3	189	19.2	0	0	19.2
60	986	574	58.2	744	342	46.0	12.2	272	27.6	0	0	27.6
63	986	649	65.8	744	387	52.0	13.8	381	38.6	3	0.4	38.2
67	986	632	64.1	744	196	26.3	37.8	406	41.2	5	0.7	40.5
70	986	560	56.8	744	234	31.5	25.3	296	30.0	0	0	30.0
74	986	514	52.1	744	145	19.5	32.6	183	18.6	0	0	18.6
77	986	629	63.8	744	132	17.7	46.1	209	21.2	0	0	21.2
81	986	585	59.3	744	181	24.3	35.0	214	21.7	0	0	21.7
85	986	633	64.2	744	176	23.7	40.5	227	23.0	0	0	23.0
89	986	486	49.3	744	169	22.7	26.6	234	23.7	0	0	23.7
Avg	986	560	56.8	744	272	36.6	20.2	251	25.5	2	0.3	25.2

Influent S^{35} concentrations were measured in composite samples, and the influent detergent concentrations were computed by applying the known total activity to detergent activity ratio of the tracer.

Removal of ABS^{35} in Septic Tank. In Table I the breakthrough of S^{35} in the septic tank itself averaged 89.9% and ABS^{35} breakthrough averaged 90.2% at steady state which was taken as existing from the 21st to the 85th day. The difference in S^{35} and ABS^{35} breakthrough, which measures degradation, was essentially zero (-0.3% within experimental error). Thus, the total removal of 9.8% (100 - ABS^{35} breakthrough) was entirely attributable to absorption on settleable solids. This result is similar to the removal found in the first study, which was reported at 16.3%, but, as was pointed out, might have varied from about 10% to 16% depending on which portion of the experimental period was chosen as reflecting steady state conditions. The present experiment indicates that the 10% figure is more reliable. $BaS^{35}O_4$ tests agreed with previously reported results in which there was no production of sulfate, and hence no complete degradation of ABS in the septic tank itself.

Removal of LAS^{35} in Septic Tank. Removal of LAS^{35} was observed to be 9% in the septic tank. This compares favorably with the 9.6% removal found in the first study. It is apparent from both studies that the order of removal of ABS and LAS in the septic tank is substantially the same and that neither material is degraded to an appreciable degree during residence in the tank.

Removal of Alcohol Sulfate in Septic Tank. Alcohol sulfate was efficiently removed as shown in Table III. The breakthrough of total S^{35} activity was 56.8% indicating a removal of 63.4%. Subtracting the detergent breakthrough of 36.6% from total activity breakthrough, the degradation is computed to be 20.2%. These figures confirm the results of the first study which show virtually identical values (20.9% degradation and 60.8% removal).

Removal of ABS^{35} in Combined Septic Tank and Percolation Field. Taking steady state as existing from the 32nd to the 85th day the combined system was capable of removing only 54.5% ABS^{35} as shown by the 45.5% ABS^{35} breakthrough in the percolation field effluent. This contrasts with 78.2% removal found in the non-ponded percolation field study. Thus, there is a considerable loss of efficiency (23.7%) in the ponded field. Degradation was 31.7% of which only 12.7% was complete to inorganic sulfate (or 31% of the total degradation). In the previous study, comparable figures are 60.5% total degradation of which 29.9% was complete to inorganic sulfate (or 49.5% of the total degradation). Thus, there is not only a significant decrease in the amount of degradation, but also the proportion of sulfate produced to total degradation is markedly less.

Removal of LAS^{35} in Combined Septic Tank and Percolation Field. The breakthrough of LAS^{35} in the percolation field effluent was only 2.9%--virtually the same as in the first study (3.1%). Of the total removal of 97.1%, 66.4% was attributable to degradation and 30.7% to adsorption. This represents a considerable change from the previous study

in which a much larger proportion of removal was due to degradation (87.3%). Furthermore, sulfate production was only 41.4% or approximately two-thirds of total degradation compared to the previous level of 70% which was about four-fifths of total degradation.

Removal of Alcohol Sulfate in Combined Septic Tank and Percolation Field. Alcohol sulfate breakthrough computed from day 25 to 89 averaged 0.3% and from the 70th to the 89th day was zero. It, too, paralleled previous results (99.6% removal) and removal due to degradation was proportionately about one-half the previous level.

Colorimetry

Colorimetric determinations of detergent removal were made once a week and the results are presented in Table IV. Average background ABS in the influent sewage was 6.3 mg/l with a range of 2.4 to 9.6 mg/l. Addition of 25 mg/l of test detergents to the influent resulted in a total detergent concentration of 31.3 mg/l.

In Unit 1 (ABS unit) the septic tank effluent had an average concentration of 24.0 mg/l representing a 23.3% removal. Survival of 13.3 mg/l in the percolation field effluent represented a 57.5% ABS removal, which is in close agreement with radioassay results (54.5% removal).

In the septic tank effluent of Unit 2 (IAS unit) there was a survival of 18.7 mg/l detergent, a portion of which was surviving ABS background. On the basis of the per cent ABS removal found in Unit 1, i.e., 23.3% applied to the background ABS (6.3 mg/l) the fraction of ABS survival was calculated as 4.8 mg/l. This background was subtracted yielding a IAS survival of 13.9 mg/l or a 44.4% removal in the septic tank. Similarly, the background ABS was subtracted from the detergent survival of Unit 3 (alcohol sulfate) giving a net of only 7.1 mg/l, which indicates a removal of 71.5%.

Percolation field effluent detergent concentrations of the two test units was corrected by subtracting the calculated ABS background of 3.7 mg/l. Net survival of IAS in the final effluent was thus only 0.1 mg/l (99.7% removal). These values are in good agreement with radioassay results, and indicate that sewage effluents passed through soil systems may be analyzed by colorimetry with a reasonable degree of accuracy.

Considerably more discrepancy may be seen in septic tank removals. It is notable that all of the detergents, and particularly ABS and IAS, are seemingly removed to a significantly higher degree (23.3 and 44.4%, respectively) by colorimetry compared to only about 9% removal found by radioassay. It is suggested that this discrepancy may be attributed to sedimentation of positive interference to the colorimetric method which would yield seemingly higher detergent removals in the septic tank.

TABLE IV

COLORIMETRIC DETERMINATION OF DETERGENT REMOVAL IN
SEPTIC-TANK SYSTEM

Day	Influent Sewage ABS (mg/l)	Added Detergent (mg/l)	Total Influent Detergent (mg/l)	Effluent Detergent (mg/l)					
				Septic Tank			Percolation Field		
				Unit 1	Unit 2	Unit 3	Unit 1	Unit 2	Unit 3
4	9.6	25	34.6	14.2	9.1	15.7	6.0	2.2	1.8
7	4.2	25	29.2	17.0	14.6	17.6	7.2	2.8	3.7
14	3.9	25	28.9	24.6	19.4	12.8	10.4	5.1	4.8
21	2.4	25	27.4	28.0	20.0	9.6	17.2	5.4	6.6
28	7.0	25	32.0	28.6	18.0	12.8	14.2	4.6	11.0
35	8.5	25	33.5	28.2	15.6	15.6	18.9	3.7	4.4
42	9.7	25	34.7	28.0	20.8	13.2	19.5	4.3	4.7
49	5.6	25	30.6	23.0	18.8	11.2	18.6	5.7	6.9
56	5.7	25	30.7	25.0	19.0	7.5	13.1	2.7	2.9
63	7.3	25	32.3	31.4	25.8	11.0	10.9	2.8	4.5
70	7.0	25	32.0	20.4	22.8	8.4	13.1	3.0	2.4
78	5.0	25	30.0	19.2	20.2	6.8	10.0	3.2	2.0
Average	6.3	25	31.3	24.0	18.7	11.9	13.3	3.8	4.6
Minus ABS Background ^a				--	4.8	4.8	--	3.7	3.7
Net Detergent Survival				24.0	13.9	7.1	13.3	0.1	0.9
% Detergent Removal				23.3	44.4	71.5	57.5	99.7	96.5

^aComputed on basis of ABS removal in Unit 1, i.e., 23.3% removal in septic tank and 57.5% removal through system applied to average background ABS concentration of 6.3 mg/l.

Dissolved Oxygen

Analyses showed the dissolved oxygen content diminished drastically in the percolation field effluent as the study progressed (see Figure 2). Values fluctuated erratically for the first 50 days, but were generally on the order of 5-7 ppm. During the final month there was a sharp decline and by the 85th day both Unit 1 and Unit 2 produced an effluent containing only 1.4 ppm. By contrast in the first study the effluent of the LAS unit (unit 2) was never less than 5 ppm dissolved oxygen. It is significant, however, that despite the prolonged ponding to which the systems were subjected the oxygen was never completely depleted.

Foamability

Foamability of the three materials was determined by placing a 10-ml sample in a 1.64-cm diameter test tube and shaking vigorously for 30 seconds. Foam height was then measured immediately and results are reported in Table V. There is a significant reduction of frothing tendency by septic tank treatment, but, except for LAS, foamability increased after aerobic treatment in the percolation field. This pattern is especially pronounced in the case of alcohol sulfate which did not foam at all in the influent or septic-tank effluent, but showed a marked frothing tendency in the final effluent.

A complicating factor, of course, is the ABS background which contributes an unknown amount of froth to the effluents from Units 2 and 3. Despite this lack of preciseness, it is evident that at least a three-fold improvement has been attained in the reduction of foamability by use of the test materials.

System Performance

Performance of the systems in terms of sewage treatment is indicated by COD and suspended solids reduction. Table VI presents data on COD removals in the septic tanks. The average influent COD concentration of 359.5 mg/l was reduced approximately 25% through the tanks. Table VII shows the COD removal for the entire system to be low for Unit 1 (82.5%) and satisfactory for Unit 2 at 89.0%. Compared to the first study, which effected 5% or higher removals, the deleterious sewage treatment aspects of the ponded field became noticeable. Suspended solids removal in the septic tank (see Table VIII) was inexplicably not as efficient (35-45%) as was previously the case (over 50%). The removal through the entire systems also decreased (see Table IX)--about 6% for Unit 1 (from 96.9 to 90.8%) and over 8% for Unit 2 (from 99.1 to 90.8%).

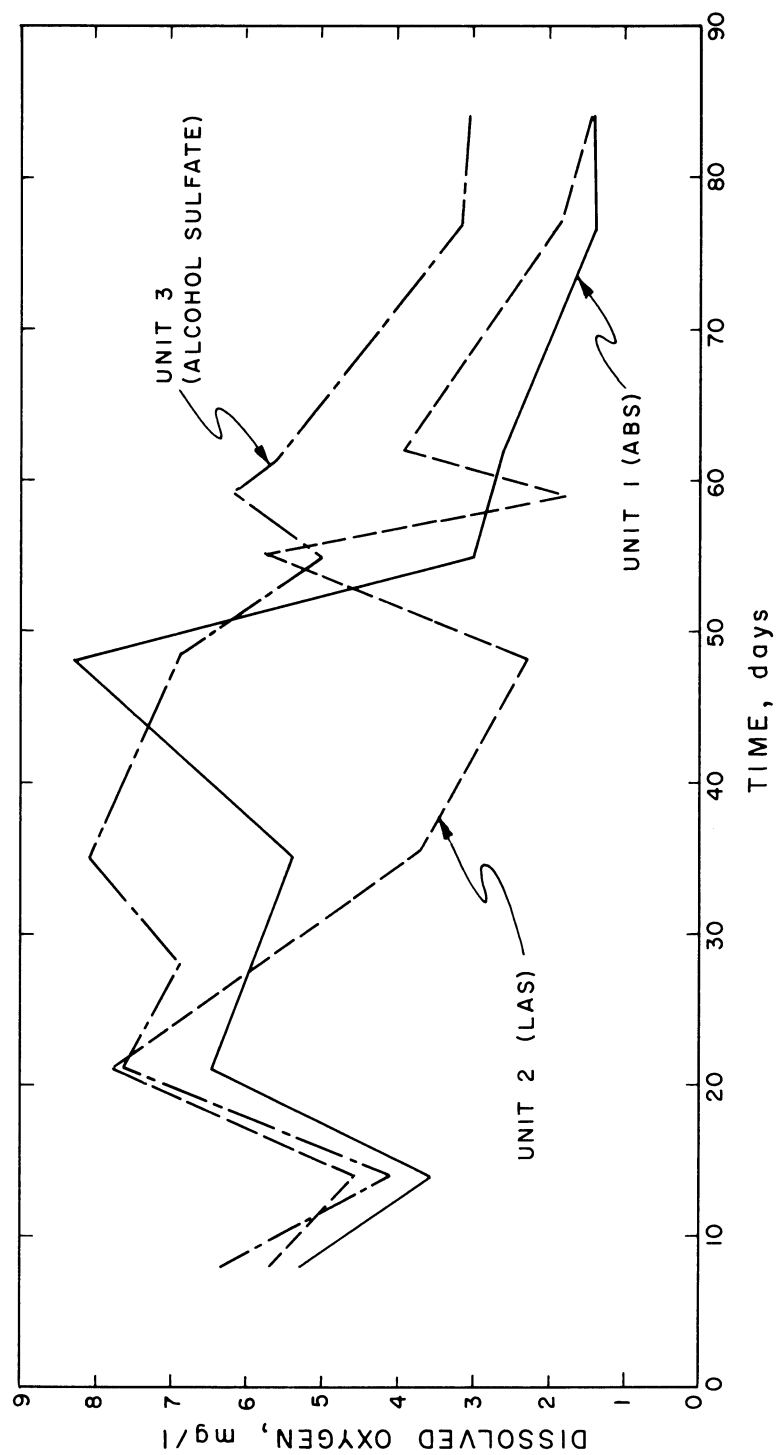


FIGURE 2. DISSOLVED OXYGEN CONTENT OF PERCOLATION FIELD EFFLUENT

TABLE V
FOAMABILITY OF DETERGENTS IN SEPTIC-TANK SYSTEMS
(Foam height in cm)^a

Day	Influent			Effluent					
				Septic Tank			Percolation Field		
	Unit 1	Unit 2	Unit 3	Unit 1	Unit 2	Unit 3	Unit 1	Unit 2	Unit 3
4	1.3	1.3	0.2	1.0	0.9	0.1	1.0	0.6	0.3
7	7.0	4.5	0	1.5	1.2	0	1.5	0.7	0.8
11	1.7	2.6	0	0.7	0.8	0	1.7	1.0	0.3
14	1.6	1.7	0	0.8	0.8	0	2.5	1.1	0.8
21	1.6	1.4	0	1.9	1.2	0	2.6	1.0	1.2
25	8.0	3.5	0	2.0	0.9	0	2.0	0.9	0.8
28	2.5	2.0	0.1	2.0	0.9	0	2.5	1.0	0.4
32	1.5	1.4	0.1	1.7	0.9	0	2.5	0.8	0.9
35	1.8	1.4	0	1.5	0.8	0	2.5	1.1	0.7
39	0.8	0.6	0	1.2	0.6	0	2.3	0.6	0.7
42	1.1	1.0	0	1.0	0.8	0	3.2	0.8	0.9
46	1.7	1.4	0	1.7	1.2	0.1	2.7	1.0	1.0
49	0.9	0.9	0	1.2	1.0	0	2.6	0.8	0.8
53	1.4	1.1	0	1.4	1.1	0	1.9	0.9	0.7
56	1.0	0.9	0.1	1.7	1.4	0	2.8	0.7	0.7
60	1.5	0.9	0	2.3	1.2	0.1	1.6	0.9	0.8
63	1.6	0.9	0	1.9	1.4	0	1.7	0.6	0.5
67	1.2	0.8	0	2.0	1.2	0	2.2	0.6	0.5
70	1.3	1.0	0	1.1	0.9	0	2.7	0.6	0.6
74	0.9	1.1	0	1.2	0.9	0	3.2	0.7	0.6
77	1.3	0.9	0	1.3	1.2	0.7	2.7	1.0	0.8
81	1.8	0.9	0	1.9	0.8	0	2.8	0.8	0.7
Average	2.0	1.5	0	1.5	1.0	0	2.3	0.8	0.7

^a Measured on 10-ml samples immediately after 30 seconds vigorous shaking in 1.64-cm diameter test tube.

TABLE VI
COD REMOVALS IN SEPTIC TANKS

Day	Influent (mg/l)	Unit 1 (Polypropyl ABS)		Unit 2 (Straight Chain ABS)		Unit 3 (Alcohol Sulfate)	
		mg/l	% Removed	mg/l	% Removed	mg/l	% Removed
8	367	299	18.5	307	16.3	302	17.7
28	424	333	21.5	253	40.3	338	20.3
35	406	301	25.9	234	42.4	320	21.2
42	388	302	22.2	292	24.7	301	22.4
49	262	201	23.3	201	23.3	181	30.9
56	286	232	18.9	208	27.3	255	10.8
63	355	302	14.9	275	22.5	334	5.9
70	338	261	22.8	263	22.2	243	28.1
77	405	308	24.0	278	31.4	242	40.2
85	364	288	20.9	274	24.7	211	42.0
Average	359.5	282.7	21.4	258.5	28.1	272.7	24.1

TABLE VII

COD REMOVALS IN SEPTIC-TANK PERCOLATION-FIELD SYSTEMS

Day	Influent (mg/l)	Unit 1 (Polypropyl ABS)		Unit 2 (Straight Chain ABS)		Unit 3 (Alcohol Sulfate)	
		mg/l	% Removed	mg/l	% Removed	mg/l	% Removed
8	367	35.1	90.4	23.6	93.6	20.1	94.5
28	424	84.5	80.1	70.7	83.3	20.9	95.1
35	406	66.0	83.7	62.0	84.7	8.4	97.9
42	388	79.2	79.6	47.0	87.9	14.4	96.3
49	262	53.8	79.5	26.6	89.8	19.8	92.4
56	286	72.2	74.8	32.8	88.5	20.8	92.7
63	355	62.5	82.4	19.8	94.4	24.0	93.2
70	338	55.7	83.5	29.0	91.4	7.9	97.7
77	405	61.9	84.7	31.7	92.2	10.9	97.3
85	364	58.6	83.9	53.5	85.3	16.8	95.4
Average	359.5	63.0	82.5	39.7	89.0	16.4	95.4

TABLE VIII
SUSPENDED SOLIDS REMOVAL IN SEPTIC TANKS

Day	Influent (mg/l)	Unit 1 (Polypropyl ABS)		Unit 2 (Straight Chain ABS)		Unit 3 (Alcohol Sulfate)	
		mg/l	% Removed	mg/l	% Removed	mg/l	% Removed
14	158	68	57.0	74	53.2	83	47.5
28	234	148	36.8	150	35.9	130	44.4
35	258	158	38.8	204	20.9	106	58.9
42	188	96	48.9	114	39.4	102	45.7
49	176	88	50.0	114	35.2	66	62.5
56	170	90	47.0	98	42.4	150	11.8
63	154	95	38.3	88	42.9	---	----
70	196	90	54.1	94	52.0	122	37.8
77	228	172	24.6	178	21.9	126	44.7
85	208	176	15.4	162	22.1	78	62.5
Average	197	118	40.1	128	35.0	107	45.7

TABLE IX
SUSPENDED SOLIDS REMOVAL IN SEPTIC-TANK PERCOLATION-FIELD SYSTEMS

Day	Influent (mg/l)	Unit 1 (Polypropyl ABS)		Unit 2 (Straight Chain ABS)		Unit 3 (Alcohol Sulfate)	
		mg/l	% Removed	mg/l	% Removed	mg/l	% Removed
14	158	0.6	99.6	0.2	99.9	0.2	99.9
28	234	14	94.0	46	80.3	9.0	96.2
35	258	25	90.3	85	67.1	43	83.3
42	188	17	91.0	15	92.0	0	100.0
49	176	1.6	99.1	1.0	99.4	2.4	98.6
56	170	6.6	96.1	8.0	95.3	3.8	97.8
63	154	23	85.1	4.0	97.4	18	88.3
70	196	39	80.1	20	89.8	1.8	99.1
77	228	48	78.9	1.2	99.5	2.0	99.1
85	208	6	97.1	2.0	99.0	1.0	99.5
Average	197	18.1	90.8	18.2	90.8	7.3	96.3

Temperature in Septic Tanks

During the experimental period temperature fluctuations of the septic tank liquid were from 1 to 10 degrees Fahrenheit (see Figure 3). The daily range averaged 6° for each tank and the mean was 55°F . The temperature range during the previous study was approximately 10° higher, but the daily variation was of the same order of magnitude.

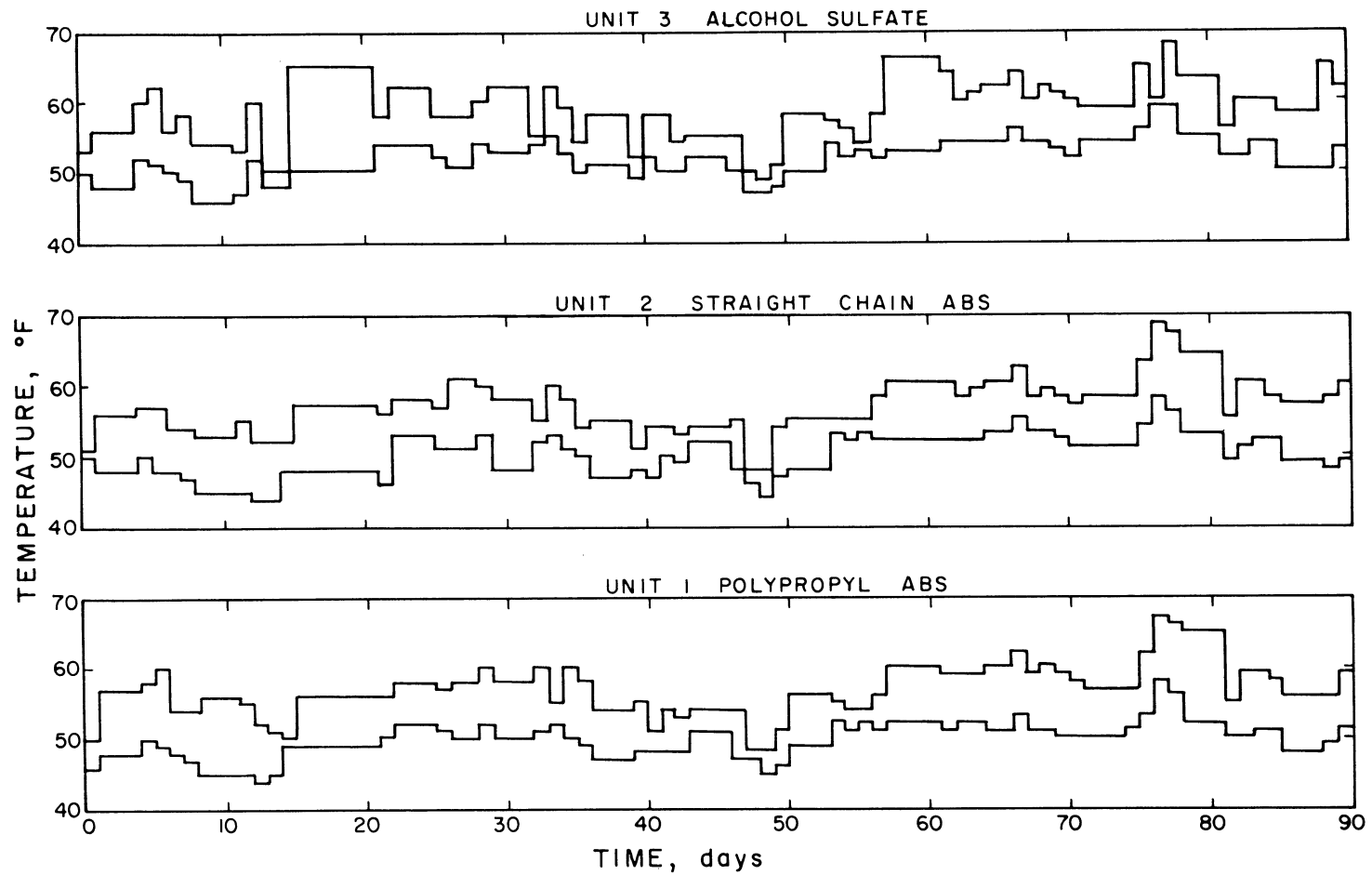


FIGURE 3. MAXIMUM AND MINIMUM SEPTIC TANK LIQUID TEMPERATURE

III. SUMMARY AND CONCLUSIONS

To encompass the range of field conditions under which septic tank systems operate, two studies were conducted--the first on a normally loaded drain field, and the second on a badly overloaded drain field. Results of the first study were previously reported [1] and the second study is herein reported.

From both studies it was evident that no more than a 10-15% removal of ABS and LAS occurs in the septic tank itself, and such removal is almost entirely attributable to adsorption. Table X summarizes the septic tank removals found in the ponded study. The data again show considerable removal of alcohol sulfate (63.4%) and serve to confirm results obtained in the first study.

Table XI summarizes removals through the entire system. The experimental detergents, LAS and alcohol sulfate, were removed to almost exactly the same extent as was previously the case. It seems apparent, therefore, that no lessening of the effectiveness of their removal may be expected under adverse field conditions. Although ultimate removal is unaffected by ponding the disposition between adsorption and degradation was quite different in the latter study. A much larger proportion of removal was attributable to adsorption--for example, LAS degradation was 66.4% compared to the previous 83.3%, and more strikingly, alcohol sulfate degradation dropped from 54.3 to 25.2%.

Only ABS removal was significantly lowered by the ponded percolation field. It dropped nearly 20%- from 73.9 to 54.5%.

Higher adsorption in the ponded study indicates that the progressive ponding provided more adsorptive surfaces as a result of extending the area of biological growth. It seems clear, however, that the experimental detergents, which escape adsorption, are readily degraded even when the dissolved oxygen is drastically reduced. At the close of the experiment there was only 1.4 mg/l dissolved oxygen present in the percolate of the LAS field, but this was sufficient to degrade that portion of the detergent which survived adsorption. An identical level of dissolved oxygen in the ABS unit resulted in a reduced efficiency.

The fact that oxygen was always present in the percolate even during the surcharging period is significant. Although the liquid remaining in the trench is anaerobic as demonstrated by the formation of ferrous sulfide, the overflow must always come into contact with air. Thus, the percolate reaching ground waters may be expected to have had sufficient aeration to degrade the biologically "soft" materials adequately.

TABLE X

SUMMARY OF DEGRADATION AND REMOVAL OF DETERGENTS IN SEPTIC TANKS

Detergent	Degraded (%)		Adsorbed (%)	Removed (%)
	Sulfate	Total		
ABS	0	-0.3	10.1	9.8
IAS	0.6	0.6	8.4	9.0
Alcohol Sulfate	---	20.2	43.2	63.4

TABLE XI

SUMMARY OF DEGRADATION AND REMOVAL OF DETERGENTS IN SEPTIC TANKS
AND PERCOLATION FIELDS

Detergent	Degraded (%)		Adsorbed (%)	Removed (%)
	Sulfate	Total		
ABS	12.7	31.7	22.8	54.5
IAS	41.4	66.4	30.7	97.1
Alcohol Sulfate	----	25.2	74.5	99.7

REFERENCES

1. Klein, S. A. The Fate of Detergents in Septic-Tank Systems and Oxidation Ponds. Berkeley: Sanit. Eng. Research Lab., Univ. of Calif., 1 January 1964.
2. Craun, B. T. Technical Advisory Section, Federal Housing Authority, Washington, D.C. Private Communication.
3. Winneberger, J. H., A. B. Menar, and P. H. McGauhey. A Study of Methods of Preventing Failure of Septic-Tank Percolation Fields. Second Annual Report. Berkeley: Sanit. Eng. Research Lab., Univ. of Calif., 22 December 1962.