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STUDIES OF SEWAGE PURIFICATION

XVII. THE UTILIZATION OF ORGANIC SUBSTRATES BY ACTIVATED SLUDGE[1]

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INTRODUCTION

These studies on sewage purification were started with a paper on the development of an apparatus for determining dissolved oxygen in activated sludge over 10 years ago. Sixteen papers in the series had been completed to the beginning of world hostilities in December 1941, and two related studies have also been published. From the titles of these papers,[2] it will be noted that the studies have been

[1] From the Division of Sanitary Engineering, Water and Sanitation Investigations, Cincinnati, Ohio.

[2] Preceding papers in the series are:

Theriault, E. J., and McNamee, P. D.: Studies of sewage purification. I. Apparatus for the determination of dissolved oxygen in sludge-sewage mixtures. Pub. Health Rep., **50:** 480 (1935). Reprint 1680.

Butterfield, C. T.: Studies of sewage purification. II. A zooglea-forming bacterium isolated from activated sludge. Pub. Health Rep., **50:** 671 (1935). Reprint 1686.

Theriault, E. J.: Studies of sewage purification. III. The clarification of sewage; a review. Sewage Works J., **7:** 377 (1935). Pub. Health Rep., **50:** 1581 (1935). Reprint 1715.

Smith, Russell S., and Purdy, W. C.: Studies of sewage purification. IV. The use of chlorine for the correction of sludge bulking in the activated sludge process. Sewage Works J., **8:** 223 (1936). Pub. Health Rep., **51:** 617 (1936). Reprint 1746.

McNamee, P. D.: Studies of sewage purification. V. Oxidation of sewage by activated sludge. Sewage Works J., **8:** 562 (1936). Pub. Health Rep., **51:** 1034 (1936). Reprint 1774.

Butterfield, C. T.; Ruchhoft, C. C.; and McNamee, P. D.: Studies of sewage purification. VI. Biochemical oxidation by sludges developed by pure cultures of bacteria isolated from activated sludge. Sewage Works J., **9:** 173 (1937). Pub. Health Rep., **52:** 387 (1937). Reprint 1812.

Ruchhoft, C. C.; McNamee, P. D.; and Butterfield, C. T.: Studies of sewage purification. VII. Biochemical oxidation by activated sludge. Sewage Works J., **10:** 661 (1938). Pub. Health Rep., **53:** 1690 (1938). Reprint 1987.

Butterfield, C. T., and Wattie, Elsie: Studies of sewage purification. VIII. Observations on the effect of variations in the initial numbers of bacteria and of the dispersion of sludge flocs on the course of oxidation of organic material by bacteria in pure culture. Pub. Health Rep., **53:** 1912 (1938). Reprint 1999.

Ruchhoft, C. C.; Butterfield, C. T.; McNamee, P. D.; and Wattie, Elsie: Studies of sewage purification. IX. Total purification, oxidation, adsorption, and synthesis of nutrient substrates by activated sludge. Sewage Works J., **11:** 195 (1939). Pub. Health Rep., **54:** 468 (1939). Reprint 2050.

Ruchhoft, C. C., and Smith, R. S.: Studies of sewage purification. X. Changes in characteristics of activated sludge induced by variations in applied load. Sewage Works J., **11:** 409 (1939). Pub. Health Rep., **54:** 924 (1939). Reprint 2074.

Ruchhoft, C. C.; Kachmar, J. F.; and Moore, W. A.: Studies of sewage purification. XI. The removal directed largely toward increasing our knowledge and understanding of the fundamental physical, chemical, and biological mechanisms of the secondary processes of sewage purification with the object of the application of this knowledge to the practical problems of plant design and operation.

Papers XI and XII were concerned with a study of the mechanism of the rapid removal and ultimate disposal of the nonelectrolyte solutes which occur in sewage. In the above two papers, glucose was used as an example of this type of compound and the mechanism of its removal and utilization by activated sludge was intensively studied. This study was then extended to include various other organic solutes and was well under way when interrupted by the war. Transfer of personnel and other activities prevented the continuation of the study for a number of years. Now the data which were accumulated over a period of years and embrace a wide range of compounds, including sugars, alcohols, aldehydes, organic acids, amino acids, and certain miscellaneous compounds, have finally been gathered together and summarized.

The data presented are particularly informative in the case of carbohydrates as they confirm conclusions previously drawn from glucose studies. They illustrate to some extent the great versatility of activated sludge through its ability to attack and utilize a wide variety of quite dissimilar materials. In view of the fact that activated sludge is commonly considered in relation to its utilization and stabilization of normal wastes, these data are remarkable not so much for the materials not oxidized and not usable as a source of energy, but for the very large number of chemically unlike materials utilized. Some interesting accessory phenomena such as adapability with carbohydrates and growth of *Sphaerotilus natans* are included.

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of glucose from substrates by activated sludge. Sewage Works J., 12: 27 (1940). Pub. Health Rep., 55: 393 (1940). Reprint 2142.

Ruchhoft, C. C.; Kachmar, J. F.; and Placak, O. R.: Studies of sewage purification. XII. Metabolism of glucose by activated sludge. Sewage Works J., 12: 485 (1940). Pub. Health Rep., 55: 582 (1940). Reprint 2149.

Lackey, James B., and Wattie, Elsie: Studies of sewage purification. XIII. The biology of *Sphaerotilus natans* Kutzing in relation to bulking of activated sludge. Sewage Works J., 12: 669 (1940). Pub. Health Rep., 55: 975 (1940). Reprint 2166.

Ruchhoft, C. C., and Kachmar, J. F.: Studies of sewage purification. XIV. The role of *Sphaerotilus natans* in activated sludge bulking. Sewage Works J., 13: 3 (1941). Pub. Health Rep., 56: 1727 (1941). Reprint 2309.

Butterfield, C. T., and Wattie, Elsie: Studies of sewage purification. XV. Effective bacteria in purification by trickling filters. Sewage Works J., 13: 639 (1941). Pub. Health Rep., 56: 2445 (1941). Reprint 2343.

Ruchhoft, C. C., and Placak, O. R.: Studies of sewage purification. XVI. Determination of dissolved oxygen in activated sludge-sewage mixtures. Sewage Works J., 14: 638 (1942). Pub. Health Rep., 57: 1047 (1942). Reprint 2390.

Moore, W. Allan; Ruchhoft, C. C.; and Wattie, Elsie: Oxidation-reduction studies. I. Oxidation-reduction potentials developed by pure cultures in sewage. Sewage Works J., 14: 980 (1942).

Moore, W. Allan, and Ruchhoft, C. C.: Oxidation-reduction studies. II. Potentials developed in sewage and sewage activated sludge mixtures. Sewage Works J., 15: 880 (1943).

These data are not to be construed as an attempt to discover the optimum conditions for the utilization of each material used. They should, instead, be interpreted as the response of activated sludge to each material under more or less average and standardized conditions.

PROCEDURE

The oxidation studies were carried out using an aeration device previously described (*1*). Essentially it is a closed-system aeration chamber actuated by a mercury pump and containing a known volume of air. The initial oxygen content may be determined as well as subsequent changes at appropriate intervals by withdrawing small samples of air for analysis. Aeration with each substance was continued for 22–24 hours, and samples taken at 1-, 3-, 5-, and 22–24-hour periods. A constant temperature of 20° C. was maintained throughout the oxidation period.

A basic mineral buffer solution (*1*) was used throughout the entire series of experiments. This was presumed to contain the same mineral materials in about the same concentrations as are normally found in sewage. The following ions were contained in this solution: ammonium, sodium, potassium, calcium, magnesium, phosphate, sulphate, and chloride. The urea and peptone mentioned in the reference were omitted for these studies. An equivalent quantity of this solution was used to replace the supernatant withdrawn from one liter of activated sludge. It was thought advisable to keep the concentration of activated sludge solids at about 2,000 parts per million but at times there were variations from this ideal. In these experiments, the test material to be used as the sole source of energy or carbon was added to the prepared activated sludge mixture and the increment of oxygen utilized by this addition was determined. In all cases, an identical control sludge minus the test material was similarly run. A record of pH was kept and in most cases the sludge index was determined. The biochemical oxygen demand of the test material was determined at 2-day intervals through 10 days. In certain instances pure culture zooglea sludges with much lower solids content were used.

CARBOHYDRATES

Seven carbohydrates were studied: l-xylose, glucose, maltose, lactose, sucrose, dextrin, and soluble starch. The carbohydrate data obtained are interesting, confirming previously published data on the mechanism of glucose removal from solution by activated sludge (*2*, *3*) and extending those conclusions to a greater variety of carbohydrates, some of which are more complex in molecular structure.

Tabulated in table 1 are data concerning the nature of the carbohydrates used and the theoretical oxygen demands to be anticipated. Table 2 gives solids and biochemical oxygen demand data, and table 3 lists the experimental oxidation figures and results obtained when individual carbohydrates are used alone as a substrate feed with sludge.

It would seem that size, chemical structure, and solubility of the carbohydrate molecules are all important factors in their rate of removal from the supernatant liquor by activated sludge. Different sludges, however, would probably exert some influence; that is, the initial capacity to utilize carbohydrates might be greater in some than in others.

TABLE 1.—*Basic data on carbohydrates studied*

Carbohydrate	Class	Formula	Molecular weight	Equivalent of oxygen for oxidation	Theoretical B. O. D. per mg. per liter,[1] p. p. m.	
					Ultimate	5 day
L-xylose	Pentose	$C_5H_{10}O_5$	150.13	160	1.07	0.73
D-glucose	Hexose	$C_6H_{12}O_6$	180.15	192	1.07	.73
Maltose	Disaccharide-reducing	$C_{12}H_{22}O_{11}+H_2O$	360.31	384	1.07	.73
Lactose	Disaccharide-reducing	$C_{12}H_{22}O_{11}+H_2O$	360.31	384	1.07	.73
Sucrose*	Disaccharide-nonreducing.	$C_{12}H_{22}O_{11}$	342.29	384	1.12	.77
Dextrin	Polysaccharide	$(C_6H_{10}O_5)x$	162.14	192	1.18	.81
Starch	Polysaccharide	$(C_6H_{10}O_5)x$	162.14	192	1.18	.81

*Common sugar.
[1] On the assumption that the substrate contains enough nitrogen for the metabolic needs of the microorganisms to permit complete oxidation.

TABLE 2.—*B. O. D. removal data on activated sludge fed with carbohydrates*

[Aeration time in all experiments is 22 to 24 hours]

Carbohydrate fed	Initial concentration of carbohydrate fed in sludge liquor, p. p. m.	Sludge index	pH		Suspended solids, p. p. m.			5-day B. O. D. of supernatants, p. p. m.			Percentage of theoretical initial 5-day B. O. D. removed in 22–24 hours	Percentage of B. O. D. observed after mixing removed in 22–24 hours
			Initial	Final	Initial	Final	Indicated change	Theoretical initial	Observed immediately after mixing	Observed after 22–24 hours		
L-xylose	500	37.5	6.7	5.7	1,984	1,960	−24	365	340	140.0	61.6	58.8
Do	500	37.5	6.7	5.7	1,972	1,984	+12	365	315	155.0	57.5	50.8
D-glucose*	699	------	------	------	2,011	------	------	510	486	1.5	99.7	99.6
Do.*	979	------	------	------	1,884	------	------	715	672	3.0	99.7	99.6
Maltose	667	41.7	6.8	5.9	2,088	2,356	+268	487	320	4.1	99.1	98.7
Do	667	41.7	6.9	5.8	2,104	2,348	+244	487	310	7.1	98.5	97.7
Lactose	500	------	6.6	6.1	3,176	3,592	+416	365	249	4.2	98.8	98.4
Sucrose	500	------	6.4	6.6	3,024	3,284	+260	385	332	4.5	98.8	98.6
Dextrin	667	54	7.0	6.7	2,292	2.400	+108	540	126	51.0	90.6	60.3
Do	667	54	7.0	6.5	2,372	2,412	+40	540	117	21.0	96.1	32.1
Do	500	------	6.5	6.4	2,936	3,504	+568	405	288	5.8	98.6	98.0
Starch	500	36.3	6.5	6.7	2,492	2,380	−112	405	98	9.5	97.6	90.3
Do	500	36.3	6.5	6.5	2,528	2,412	−116	405	75	8.2	98.0	89.1
Do	500	------	6.6	5.6	3,596	3,772	+176	405	224	5.0	98.8	97.1

*From paper XII, this series, table 1, p. 583.

TABLE 3.—*Oxidation of carbohydrates by activated sludge* [1]

Carbohydrates fed	Quantity of carbohydrates fed, p. p. m.	Quantity of sludge used in experiment, p. p. m.	Mg. O_2 used in 24 hours by control sludge	Mg. of O_2 used in indicated time as a result of carbohydrate feed				Percentage of theoretical ultimate carbohydrate demand satisfied in indicated time			
				1 hour	3 hours	3 hours	22–24 hours	1 hour	3 hours	5 hours	22–24 hours
L-xylose	500	1,984	132.3	0	0	0	52.3	0	0	0	9.78
Do	500	1,972	132.3	0	1.6	2.6	37.5	0	0.30	0.49	7.50
Glucose*	1,000	-------	139.9	34.3	60.2	75.0	107.8	3.21	5.63	7.01	10.1
Do	720	3,228	246.7	27.0	48.1	59.1	-------	3.50	6.24	7.67	-------
Maltose	684	2,784	141.4	8.6	5.0	6.6	0	1.17	.68	.90	0
Do	684	3,272	176.2	27.9	56.8	71.5	163.8	3.81	7.76	9.77	22.4
Do	667	2,088	113.2	9.0	42.5	58.4	61.5	1.26	5.94	8.18	8.61
Do	667	2,104	113.2	7.3	26.7	41.5	45.2	1.02	3.74	5.81	6.33
Lactose	684	3,228	246.7	25.0	51.9	90.6	157.9	3.41	7.09	12.4	21.6
Do	684	3,028	154.4	24.6	59.4	77.5	175.1	3.36	8.11	18.6	23.9
Sucrose	684	2,784	141.4	16.6	49.3	70.0	54.1	2.17	6.44	9.14	7.11
Dextrin	667	2,292	184.5	0	13.8	10.2	0	0	1.75	1.30	0
Do	667	2,372	184.5	16.8	37.7	33.2	38.8	2.13	4.79	4.22	4.92
Starch	500	2,492	86.2	0	0	0	0	0	0	0	0
Do	500	2,528	86.2	0	0	0	0	0	0	0	0

*From paper XII, this series, table 1, p. 583.
[1] Normal activated sludge (i. e., plant sludge).

There is an adsorption of carbohydrate immediately after mixing with sludge solids. The percentage, evident in all cases, varied with the carbohydrate. It amounts to 4–7 percent for l-xylose, glucose and lactose, 13–15 percent for sucrose and maltose, and 30–80 percent for dextrin and starch. After this initial adsorption there is a continuous removal of dissolved material from solution. Referring to table 2, it is at once apparent that during a 22–24-hour aeration period, better than 90 percent of the theoretical biochemical oxygen demand (B.O.D.) of all carbohydrates used, with the exception of l-xylose, was removed from solution. Fifty to sixty percent of the l-xylose was removed. That even this low percentage may be increased under certain conditions may be seen by referring to table 4.

It has been previously demonstrated with respect to glucose that repeated feedings of that material produce a sludge capable of removing glucose at much higher rates than the unacclimated sludge. Table 4 demonstrates that this property of activated sludge can be applied to l-xylose to increase its utilization and can also be extended to starch and dextrin to increase their rate of removal. With respect to the pentose sugar, l-xylose, not only is the rate of removal more rapid over a 22–24-hour aeration period but the over-all removal is increased to about 98 percent. This is especially significant in view of the rather poor B. O. D. removal in a similar period by an unacclimated sludge. Starch exhibits a similar increased rate of removal. The over-all removal for dextrin is also much more rapid using the acclimated sludge, the 5-hour rate approaching the 22–24-hour rate in the case of the unacclimated sludge.

TABLE 4.—*Comparison of sludges acclimated to various carbohydrates with unacclimated sludges*

Carbohydrate	Acclimated sludges							Control sludges					
	Interval in hours	pH	Suspended solids, p. p. m.	Percentage ash	5-day B. O. D., p. p. m.	Percentage reduction	Percentage reduction of B. O. D. per gram solids	pH	Suspended solids, p. p. m.	Percentage ash	B. O. D., p. p. m.	Percentage reduction	Percentage reduction of B. O. D. per gram solids
Xylose	0	7.5	2,940	15.0	610	------	------	7.3	1,468	24.2	726	------	------
Do	1	-----	3,016	15.1	464	23.9	25.8	-----	1,516	22.7	673	7.27	10.3
Do	3	-----	3,316	13.5	210	65.6	69.5	-----	1,524	25.4	572	21.21	24.1
Do	5	-----	3,312	13.3	42	93.1	93.9	-----	1,524	19.4	598	17.63	20.7
Do	23	7.4	3,212	14.2	8	98.7	98.8	5.4	1,616	16.1	439	39.53	45.1
Dextrin	0	7.7	2,236	10.55	1,118	------	------	7.5	1,580	22.1	1,350	------	------
Do	1	-----	2,700	8.00	582	47.94	56.8	-----	1,696	20.0	1,276	5.48	11.9
Do	2	-----	2,856	7.98	386	65.47	73.0	-----	1,812	19.2	1,002	25.80	35.3
Do	3	-----	3,260	8.48	264	76.39	83.8	-----	1,872	17.95	878	34.97	45.1
Do	5	-----	3,192	8.47	106	90.52	93.4	-----	1,968	16.65	644	52.30	61.7
Do	23	7.3	3,132	6.90	4	99.64	99.7	7.1	2,616	13.46	26.9	98.01	98.8
Starch	0	7.5	5,532	8.97	1,506	------	------	7.4	1,616	21.0	1,540	------	------
Do	1	-----	6,140	7.88	1,048	30.41	37.3	-----	1,836	18.2	1,430	7.14	18.3
Do	3	-----	6,720	7.19	542	64.01	70.4	-----	1,920	17.3	1,266	17.80	30.8
Do	5	-----	7,124	6.90	140	90.70	92.8	-----	2,108	15.75	1,156	24.99	42.5
Do	23	7.5	6,992	7.21	16.9	98.88	99.1	7.3	2,768	12.15	204.5	86.72	92.2
Do	0	7.5	1,852	6.5	1,462	------	------	7.3	1,740	20.0	1,466	------	------
Do	22	7.3	3,244	5.8	16	98.91	99.4	7.1	2,880	14.45	213	85.60	91.2

In acclimating the activated sludges used in table 4, the solids were considerably increased and some of the data presented in the table were obtained by using acclimated sludges higher in suspended solids than the controls. That this does not alter the general trend or significance of the conclusions reached is attested by the second starch experiment run initially and at 22 hours. The acclimated sludge used here is the same one used in the first starch experiment but with the solids reduced to approximately the same as those found in a new control sludge. It will be seen that solids increase and percent B. O. D. removal are very similar to the preceding experiment.

The oxidation experiments, tabulated in table 3, emphasize that but a small portion of the material that was absorbed and utilized was completely oxidized. This is true for all carbohydrates studied. In a previous paper (*3*) it has been shown that only about 11–31 percent of the glucose that is removed from solution is completely oxidized in 22–24 hours. From the data presented in table 3, there is no evidence that any of the starch removed from solution in the first 24-hour aeration period was oxidized. In the case of dextrin about 5 percent of the material removed can be accounted for by the additional oxygen used in one experiment, but the other experiment indicates an even poorer performance. The remaining carbohydrates, l-xylose, maltose, lactose, and sucrose, were oxidized during a 22–24-hour aeration period in varying degrees ranging from 7 to 24 percent.

These values are of similar magnitude to those previously obtained for glucose. It is very apparent that all of these soluble carbohydrates which are so rapidly removed from solution by activated sludge, are not oxidized to as great an extent as the peptones and that they are utilized and retained as protoplasm in the zoogleal and other cells.

These interesting facts led to a more complete study of the removal of the complex carbohydrate dextrin from solution. The data obtained are tabulated in tables 5a and 5b. Biochemical oxygen demand removal rates, solids increases, and partition characteristics were determined using a normal activated sludge and also one which had been acclimated to dextrin by previous feedings over a period of several days. The partition characteristic was determined by incubating the several portions with diastase and titrating the reducing sugars formed with ceric sulphate (*4*).

From the data obtained it is possible to determine an approximate correlation between the biochemical oxygen demand and the amount

TABLE 5a.—*Characteristics of dextrin-acclimated and -unacclimated sludges*

[B. O. D. and solids data]

Time interval	Suspended solids, p. p. m.		Suspended-solids increase, p. p. m.		Percentage of suspended-solids increase		5-day B. O. D. of supernatant, p. p. m.		Percentage of B. O. D. utilized	
	Acclimated	Unacclimated	Acclimated	Unacclimated	Acclimated	Unacclimated	Acclimated	Unacclimated	Acclimated	Unacclimated
Before feeding	2,072	1,552					5.2	4.8		
After feeding	2,236	1,580	164	28	7.9	1.8	1,118.0	1,350.0	23.2	7.3
1-hour	2,700	1,696	628	144	30.3	9.3	582.0	1,276.0	60.0	12.5
2-hour	2,856	1,812	784	260	37.9	16.7	386.0	1,002.0	73.7	31.2
3-hour	3,260	1,872	1,188	320	57.3	20.6	264.0	878.0	82.0	39.7
5-hour	3,192	1,968	1,120	416	54.1	26.8	106.0	644.0	93.0	55.7
23-hour	3,132	2,416	1,060	864	51.2	55.7				

5-day B. O. D. of dextrin feed added=1,457 p. p. m.

TABLE 5b.—*Characteristics of dextrin-acclimated and -unacclimated sludges*

[Reducing materials data]

Time interval	Reducing carbohydrates in supernatant				Reducing carbohydrates in sludge				Percentage of dextrin not detectable as reducing material	
	Quantity, p. p. m.		Quantity, percentage		Quantity, p. p. m.		Quantity, percentage			
	Acclimated	Unacclimated	Acclimated	Unacclimated	Acclimated	Unacclimated	Acclimated	Unacclimated	Acclimated	Unacclimated
Before feeding	20	62			178	138				
After feeding	2,535	2,825	84.0	93.5	470	415	16.0	14.4	0	−7.5
1-hour	1,137	2,303	37.6	76.0	702	387	23.2	12.5	39.2	11.5
2-hour	378	1,683	12.5	55.8	473	239	15.7	7.9	71.8	36.3
3-hour	53	1,388	1.8	46.0	418	222	13.9	7.4	84.3	46.6
5-hour	14	1,020	.5	33.8	376	236	12.0	7.8	87.5	58.4
23-hour	70	103	2.3	3.4	219	232	7.2	7.7	90.5	88.9

Reducing-material value of added dextrin feed=3,020 p. p. m.

of reducing material present and also to subdivide the reducing material into those portions present in the supernatant, in the sludge, and that increment not detectable as dextrin or its degradation products. This latter portion represents the portion removed and wholly utilized, probably retained as protoplasm in the zoogleal or other cells and contributing, together with the fraction found as reducing material in the sludge, to the increase in solids. After resolution into these three components, the portion not detectable as reducing material, with the exception of the acclimated sample during the first hour, agrees approximately with the B. O. D. removed from solution during comparable intervals.

It is erroneous to assume, as frequently is done in the case of carbohydrates, that lack of acid or gas production indicates biochemical inactivity. Rather the reverse is true, and these soluble materials are capable of being utilized in relatively large quantities and frequently at high rates.

It may be stated, then, that during a 23-hour aeration period, it is immaterial whether a sludge has been acclimated to dextrin or not as measured by over-all removal. In either case 2–3 percent of the dextrin is found in the supernatant, 7–8 percent is recoverable from the sludge, and approximately 90 percent has been completely utilized with the production of a 51–55 percent increase in sludge solids. In the intervening time intervals, however, no such agreement is indicated. In the acclimated sample these 23-hour figures are closely approached in 3 hours, 1.8 percent is found in the supernatant, 13.9 percent in the sludge and 84.3 percent utilized. At 3 hours in the unacclimated sample 46 percent is found in the supernatant, 7.4 percent in the sludge and only 46.6 percent completely utilized. It is quite evident that the rate of removal, though not the total removal, has been altered by the program of previous feedings. About twice as much reducing material is found in the acclimated sludge as in the unacclimated sludge until the twenty-third hour is reached. At the end of the first hour these amounts are 23.2 percent and 12.5 percent; from the second to the fifth hour the amount in the acclimated sludge decreases slowly from 15.7 percent to 12 percent, and in the unacclimated sludge very little change, from 7.4 percent to 7.9 percent, occurs. At 23 hours they are similar, 7.2 percent and 7.7 percent.

These differences in removal mechanism then stand out. An acclimated sludge removes approximately the same amount of dextrin from solution in 2–3 hours as an unacclimated sludge does in from 5 to 23 hours, producing at the same time proportionate increases in the amount of sludge solids. About twice as much removed material is contained in the acclimated sludge as in the unacclimated sludge until stabilization is reached at some time interval between the fifth and twenty-third hour. After 2–3 hours any removal in the acclimated sample is at the expense of reducing material contained in the sludge. In the unacclimated sample, it is being removed from the supernatant. Both systems are similar at 23 hours and have produced approximately 50 percent more solids, the ash content of which has been reduced by about 40 percent. These solids figures deserve more consideration and will be discussed after the introduction of one more table.

In view of the considerable interest in *Sphaerotilus natans*, the ability of this organism to utilize various carbohydrates other than glucose as sources of food material was investigated. The nutrient materials used were glucose, l-xylose, soluble starch, and dextrin. The glucose sample permits a check on previously published data (*5*). In these tests contamination by other organisms was precluded.

Data obtained are tabulated in table 6. The growth response of *Sphaerotilus natans* to dextrin and soluble starch as sole sources of energy is comparable to its response to glucose. It seems, however, unable to utilize l-xylose at least within a 22–24-hour aeration period. It is probable, however, that in most cases the introduction of a carbohydrate will promote growth of *Sphaerotilus natans* (*6*).

TABLE 6.—*Growth response of* Sphaerotilus natans *to various carbohydrate substrates*

Carbohydrate	Carbohydrate feed (p. p. m.)	Initial solids (p. p. m.)	24-hour pH	24-hour solids (p. p. m.)	Increase in solids (p. p. m.)
Control	None	5.2	7.7	74	68.8
L-xylose	1250	5.2	7.3	72	66.8
Glucose	1250	5.2	5.7	640	634.8
Dextrin	1250	5.2	6.9	612	606.8
Soluble starch	1250	5.2	6.7	560	554.8

Solids figures have not been stressed much, but reference to any of the tables shows large increases in sludge solids when a carbohydrate feed is used. This fact is so persistently obtrusive that it cannot be ignored, and it possesses real significance. Whenever an activated sludge which is perfectly normal in all respects is suddenly subjected to an increase of carbohydrate feed, a fine state of balance is upset. The sludge immediately attempts to adjust itself to this alien feed and soon is consuming it in ever increasing quantities. In itself, this is desirable but, as a necessary corollary, adsorption and assimilation at rapid rates produce enormous quantities of sludge with a low ash content. This sludge production may amount to 50 percent or more in a 24-hour period (table 5a). Such increases in solids would seriously affect the equilibrium of the average plant not designed to cope with such a factor. This is not bulking per se but simply an unruly sludge production. However, the conditions most favorable for zooglea are also well suited for the growth of *Sphaerotilus natans*. Also, as has been shown in table 6, all of the carbohydrates studied with the exception of the pentose sugar l-xylose were readily utilized by *Sphaerotilus*, resulting in a rapid increase of that organism. This is an additional hazard.

The effect then on a plant called upon to handle sudden increases in carbohydrates should be a tremendous and perhaps unmanageable increase in sludge solids, this sludge having a greatly decreased ash content. As a complicating factor, conditions conducive to the growth of *Sphaerotilus natans* would exist. Either is undesirable and serious, but if the two occur simultaneously the operation of an activated sludge plant will be seriously impaired.

ALCOHOLS AND ORGANIC ACIDS

Compounds studied belonging to the classes of alcohols and organic acids included methyl and ethyl alcohols, ethylene glycol, glycerine, formaldehyde, ammonium acetate, calcium gluconate, and formic, acetic, tartaric, citric, lactic, and oxalic acids.

The alcohols and organic acids are quite readily removed from solution with the exception of methyl alcohol and oxalic acid, as will be observed by referring to table 8. Two initial biochemical oxygen-demand figures are given, one theoretical and one observed immediate-

TABLE 7.—*Basic data on alcohols, aldehydes, and organic acids*

Compound	Synonym	Formula	Molecular weight	Equivalent weight of oxygen for oxidation	Theoretical B. O. D. per mg. per liter, p. p. m.	
					Ultimate	5 days
Methyl alcohol	wood alcohol (methanol).	CH_3OH	32.03	48.0	1.50	1.03
Ethyl alcohol	ethanol	CH_3CH_2OH	46.05	96.0	2.08	1.42
Ethylene glycol	glycol	$(CH_2OH)_2$	62.05	80.0	1.29	.88
Glycerine	glycerol	$C_3H_5(OH)_3$	92.06	112.0	1.22	.83
Formaldehyde	formalin (methanal)	$HCHO$	30.02	32.0	1.07	.73
Formic acid	methanoic acid	$HCOOH$	46.03	16.0	.348	.24
Acetic acid	ethanoic acid	CH_3COOH	60.05	64.0	1.07	.73
Tartaric acid, d or l.	weinsaure	$(CHOHCO_2H)_2$	150.09	80.0	.533	.36
Citric acid		$HO_2CCH_2C(OH)(CO_2H)CH_2CO_2H$.	192.12	144.0	.750	.51
Lactic acid		$CH_3CHOHCO_2H$	90.08	96.0	1.07	.73
Oxalic acid	ethandioic	$(CO_2H)_2.2H_2O$	126.07	16.0	.127	.086
Calcium gluconate		$C_{12}H_{22}O_{14}Ca$	430.35	352.0	.818	.56
Ammonium acetate		$C_2H_3O_2NH_4$	77.08	64.0	.83	.56

TABLE 8.—*B. O. D. removal data on activated sludge fed with alcohols and organic acids*

Compound Fed	Initial concentration of compound fed in sludge liquor, p. p. m.	Sludge index	pH		Suspended solids, p. p. m.			5-day B. O. D. of supernatants, p. p. m.			Percentage of theoretical initial 5-day B. O. D. removed in 22-24 hours	Percentage of B. O. D. observed after mixing removed in 22-24 hours
			Initial	Final	Initial	Final	Indicated change	Theoretical initial	Observed immediately after mixing	Observed after 22-24 hours		
Methyl alcohol	997	110.9	7.1	6.8	2,028	1,884	−144	1,027.0	1,004	968.0	5.74	3.6
Do	997	110.9	7.1	6.8	2,024	1,824	−200	1,027.0	914	1,002.0	2.43	0
Ethyl alcohol	1,000	61.0	6.9	5.9	1,736	2,024	+288	1,420.0	770	6.5	99.5	99.2
Do	1,000	61.0	6.9	6.1	1,732	2,080	+358	1,420.0	740	5.1	99.6	99.3
Glycol	484	76.4	7.0	5.9	1,256	1,260	+4	426.0	------	98.0	76.5	-------
Do	484	76.4	7.0	5.9	1,236	1,256	+20	426.0	------	112.0	73.8	-------
Glycerine	720	------	------	------	2,316	------	------	597.6	497	------	-------	-------
Do	720	------	------	------	600	------	------	597.6	497	------	-------	-------
Acetic acid	578	59.1	6.9	5.5	2,068	2,268	+200	422.0	455	2.6	99.4	99.5
Do	578	59.1	6.9	5.5	2,132	2,296	+141	422.0	456	2.8	99.3	99.4
Citric acid	550	62.2	7.3	7.4	2,228	2,264	+36	280.0	265	4.5	98.4	98.3
Do	550	62.2	7.3	7.4	2,240	2,324	+84	280.0	253	4.5	98.4	98.2
Calcium gluconate	250	64.6	7.4	6.5	1,428	1,436	+8	138.0	93	25.3	81.7	72.8
Do	250	64.6	7.4	6.5	1,448	1,424	−24	138.0	86	33.0	74.6	61.6
Oxalic acid	250	87.7	7.2	6.9	2,044	2,072	+28	21.5	44	27.5	0	37.5
Do	250	87.7	7.2	6.9	2,048	2,084	+36	21.5	40	22.0	0	45.0

ly after mixing. Oxalic acid shows no removal of the theoretical B. O. D. and 37–45-percent removal of the observed B. O. D. With methyl alcohol in the concentrations tried, little removal is evidenced—only 3.6 percent of the B. O. D. observed after mixing in one case and none in the other. This corresponds to 13.9 percent and 10.9 percent of the theoretical initial B. O. D. Calcium gluconate and ethylene glycol are intermediate, showing removal data ranging from 60 to 80 percent. All of the remaining test materials in this group indicate a removal of biochemical oxygen demand from solution corresponding to 98 percent or more in 22–24 hours. It is interesting to note also, that in the case of methyl alcohol with a very low amount of B. O. D. removal, there is an 8.5 percent decrease in solids while the next higher alcohol, ethanol, with a B. O. D. removal of more than 99 percent, shows an 18.5 percent increase in solids.

It should perhaps be stated here that while exact norms are not established by oxidation experiments, reasonably accurate behavior expectancies are indicated. Although every attempt has been made to maintain uniform experimental conditions, certain deviations from the normal cannot be avoided. It is not possible, for example, to use exactly the same amount of an identical sludge throughout so many experiments. Consequently, variations due to the demands of the test sludge and to its particular initial predilection for the test material may occur. However, a reasonable basis for predicting whether oxidation of material removed from solution occurs, to what extent and at what rate it occurs, is established, and if viewed in this light the data presented in table 9 are helpful and informative.

TABLE 9.—*Oxidation of alcohols and organic acids by activated sludge*

Compound fed	Quantity of compound fed, p.p.m.	Quantity of sludge used in experiment	Mg. of O_2 used in 24 hours by control sludge	Mg. of O_2 used in indicated time as a result of alcohol or acid feed				Percentage of theoretical ultimate demand of compound satisfied in indicated time			
				1 hour	3 hours	5 hours	22–24 hours	1 hour	3 hours	5 hours	22–24 hours
Methyl alcohol	500	3,272	176.2	−8.4	−5.6	7.0	110.0	0	0	0.93	14.6
Do	997	2,028	219.2	6.1	------	4.8	41.0	.41	------	.32	2.74
Do	997	2,024	219.2	6.2	------	5.5	35.8	.41	------	.36	2.39
Ethyl alcohol	1,000	1,736	106.3	6.3	37.7	83.5	512.9	.30	1.81	4.01	24.6
Do	1,000	1,732	106.3	1.5	29.5	71.5	501.9	.07	1.42	3.43	24.1
Glycol [1]	484	1,256	82.7	−2.7	4.1	3.3	48.2	0	.66	.53	7.72
Do	484	1,236	82.7	−6.0	5.6	4.4	47.2	0	.90	.71	7.56
Glycerine	720	2,316	76.0	23.4	87.5	138.7	247.6	2.7	9.96	15.79	28.19
Do	720	*600	41.9	16.3	66.6	166.4	317.9	1.86	7.58	18.94	36.19
Formaldehyde	720	2,600	107.5	−8.1	−8.7	+2.1	−29.3	0	0	.28	0
Formic acid [2]	720	2,052	75.0	29.0	43.7	49.5	100.0	11.6	17.4	19.8	39.9
Acetic acid	716	3,228	246.7	33.2	121.2	150.3	143.5	4.3	15.8	19.6	18.73
Do	716	*610	41.2	13.9	43.6	139.2	425.1	1.8	5.7	18.2	55.5
Do	716	*768	55.5	2.0	14.9	35.0	437.2	.26	1.9	4.6	57.1
Do	716	2,884	46.9	15.0	46.2	83.2	409.0	1.9	6.0	10.9	53.4
Do	578	2,068	126.5	23.4	86.9	133.4	190.3	3.8	14.1	21.6	30.8
Do	578	2,132	126.5	22.2	78.8	122.9	178.9	3.6	12.7	19.9	28.9
Ammonium acetate	1,000	3,420	70.6	40.2	173.3	308.9	659.0	4.8	20.8	37.0	78.9
Tartaric acid	720	2,141	133.4	28.4	46.6	96.6	249.8	7.4	12.1	25.0	65.0
Do	720	2,880	236.0	0	62.5	94.8	308.0	0	16.3	24.7	80.3
Do	720	*748	26.2	6.7	2.6	13.6	112.3	1.7	.67	3.5	29.3
Do	720	*768	37.9	5.1	12.9	19.0	221.2	1.3	3.4	5.0	57.6
Citric acid	720	2,141	133.4	12.2	10.2	29.9	164.8	2.3	1.9	5.5	30.4
Do	720	2,880	236.2	−14.3	−24.7	−28.1	−158.0	0	0	0	0
Do	550	2,228	158.7	−6.4	−3.0	+7.2	26.9	0	0	2.5	9.2
Do	550	2,240	158.7	−.9	15.4	25.3	44.0	0	5.3	8.6	15.0
Do	720	*748	26.2	3.3	1.4	0	80.2	.61	.26	0	14.9
Lactic acid	720	*768	37.9	13.4	54.4	80.1	320.9	1.7	7.1	10.4	41.7
Do	720	*748	26.2	14.2	28.2	42.5	535.3	1.8	3.7	5.5	69.5
Calcium gluconate	250	1,428	98.0	−3.3	18.0	18.9	27.9	0	8.8	9.2	13.6
Do	250	1,448	98.0	−5.3	18.5	19.3	28.1	0	9.0	9.4	13.7
Oxalic acid	250	2,044	101.6	−.1	−1.2	−12.8	−18.3	0	0	0	0
Do	250	2,048	101.6	−3.4	+2.2	−13.3	−24.4	0	0	0	0
Do	720	2,780	132.8	5.5	18.1	29.0	11.1	6.0	19.7	31.9	12.2
Do	720	*226	28.4	0.5	------	5.0	18.1	.55	------	5.5	19.9

*Pure-culture zoogleal sludge was used.
[1] Glycol was not oxidized by pure-culture zooglea.
[2] Formic acid was not attacked by pure-culture zoogleal sludge in the single experiment performed.

Formaldehyde was the only material in this group that showed no evidence of oxidation by activated sludge. It had, in fact, a detrimental effect, less oxygen being used by the formaldehyde-fed sludge than by the control sludge. The other materials studied in this group indicated some measure of oxidation of the material removed from solution. Some are quite regular in performance while others show variability in degree and sometimes in the time interval required for appreciable oxidation. Acids, in general, are readily oxidized with the possible exception of oxalic acid in which contradictory results are apparent. Two samples with activated sludge indicated no oxygen utilization, while one showed progressive oxidation until the fifth hour, 31.9 percent, and a decline to 12.2 percent at 22–24 hours. With a pure culture sludge a progressive oxidation to 19.9 percent at 22–24 hours took place, the rate, however, being extremely slow until the fifth hour. Formic acid was readily attacked by activated sludge but not by pure culture sludge in the single experiment performed. Lactic acid was readily oxidized by pure-culture sludge.

Citric acid exhibited one irregularity indicating no oxidation, although a similar sludge on the same day had successfully oxidized 80 percent of the tartaric acid in 22–24 hours. Citric acid also had a tendency to start slowly and to indicate little oxygen utilization until the fifth to twenty-fourth hours. Acetic and tartaric acids are readily and very appreciably oxidized both by activated sludge and by pure-culture sludges, although a tendency is evident for pure-culture sludges to produce less oxygen utilization during the first 3 to 5 hours. Ammonium acetate is apparently more readily oxidized than acetic acid itself. Whether this is due to the additional nitrogen introduced with the salt has not been determined.

Of the acids studied then, all were capable in varying degrees of being oxidized by activated sludge. There is an apparent tendency for this oxidation to proceed slowly using oxalic and citric acids for the first 3 to 5 hours. When pure-culture sludges are used, this tendency is apparent with all acids used. The amount of oxidation is at least as great as is found with carbohydrates, and in the case of lactic, tartaric, and acetic acids, greatly exceeds the rates with carbohydrates.

Glycerine is apparently the most easily oxidized alcohol. It is the only one studied that is oxidized to any appreciable extent in the first hour. Neither methyl alcohol nor ethylene glycol are oxidized to any significant extent up to the fifth hour. Ethylene glycol is not attacked at all by pure culture zoogleal sludge. At 22–24 hours ethyl

TABLE 10.—*Basic data—amino acids, proteins and miscellaneous compounds*

Compound		Formula	Molecular weight	Equivalent weight of oxygen for oxidation	Theoretical carbonaceous B. O. D. per mg. per liter, p. p. m.	
Common name	Scientific name when known, or synonym				Ultimate	5-day
Glycine	a-amino acetic acid	NH_2CH_2COOH	75.07	48	0.64	0.44
Alanine	a-amino propionic acid	$NH_2CH(CH_3)\cdot COOH$	89.09	96	1.08	.74
Glutamic acid	a-amino glutaric acid	$HOOC\cdot CHNH_2(CH_2)_2COOH$	147.13	144	.98	.67
Tyrosine	B-(p-hydroxyphenyl) a-amino propionic acid.	$HO\cdot C_6H_4\cdot C_2H_3(NH_2)COOH$	181.18	304	1.68	1.15
Cystine	BB′-di-thio-di-(a-amino propionic acid).	$(HOOC\cdot CH(NH_2)CH_2S)_2$	240.29	176	.73	.50
Peptone	Polypeptide				1.03	.70
Meat extract	Mineral salts and peptones.				.47	.32
Gelatin					.98	.67
Olive oil					.153	.10
Soap	Sodium oleate	$CH_3(CH_2)_7CH{:}CH(CH_2)_7COONa$	304.45	800	2.14	1.46
Mineral oil					.012	.008
Potassium cyanide.		KCN	65.10			
Urea	Carbamide	$NH_2\cdot CO\cdot NH_2$	60.06	0	0	0
Acetonitrile	Methyl cyanide	CH_3CN	41.05	64	1.56	1.07
Thioacetamide	Acetothioamide	$CH_3\cdot CS\cdot NH_2$	75.13	75	1.00	.68
Thioglycolic acid		$HS\cdot CH_2\cdot COOH$	92.11	64	.69	.47

alcohol and glycerine are being actively oxidized, 24 percent in the former case, and 29.0–37.2 percent in the latter. This compares with about 7.5 percent for ethylene glycol. Methyl alcohol indicates a 2.7–14.6-percent oxidation of the material removed from solution but reference to table 8 shows that a very limited amount was actually removed from solution.

Generalizing from the materials studied, it would seem that the alcohols are not as readily oxidized as the organic acids.

AMINO ACIDS, PROTEINS, AND MISCELLANEOUS COMPOUNDS

In table 11, data on the removal of B. O. D. from substrates containing various amino acids and miscellaneous compounds are presented. The amino acids are quite readily removed from solution. The removal in 22–24 hours is approximately 90 percent or more with all amino acids studied except tyrosine and cystine. The indicated removal of 5-day B. O. D. with tyrosine amounts to about 30 percent. Cystine shows no removal of the 5-day B. O. D. observed

TABLE 11.—*B. O. D. removal data on activated sludge fed with amino acids and miscellaneous compounds*

Compound fed	Initial concentration of compound fed in sludge liquor, p. p. m.	Sludge index	pH		Suspended solids, p. p. m.			5-day B. O. D. of supernatants, p. p. m.			Percentage of theoretical initial 5-day B. O. D. removed in 22-24 hours	Percentage of B. O. D. observed after mixing, removed in 22-24 hours
			Initial	Final	Initial	Final	Indicated change	Theoretical initial	Observed immediately after mixing	Observed after 22–24 hours		
Glycine	720	------	7.2	6.5	2,196	2,924	728	317.0	326.0	42.6	86.6	86.9
Alanine	500	83.0	6.6	6.9	1,296	1,416	120	370.0	327.0	14.0	96.2	95.7
Do	500	83.0	6.6	6.9	1,316	1,452	132	370.0	310.0	12.5	96.6	96.0
Glutamic acid	500	79.8	6.8	6.9	1,504	1,692	188	335.0	275.0	6.2	98.1	97.7
Do	500	79.8	6.8	6.9	1,504	1,736	232	335.0	300.0	6.7	98.0	97.8
Tyrosine	500	53.2	6.6	5.7	1,848	1,920	72	575.0	540.0	400.0	30.4	25.9
Do	500	53.2	6.6	5.8	2,072	2,152	80	575.0	540.0	398.0	30.7	26.3
Cystine	1,000	50.8	6.6	5.7	2,876	2,720	−150	500.0	48.0	67.0	86.6	0
Do	1,000	50.8	6.6	5.6	2,832	2,580	−252	500.0	34.0	46.0	90.8	0
Peptone	720	------	7.4	6.5	2,172	2,508	336	504.0	583.0	10.0	98.0	98.3
Do*	720	------	7.4	7.0	1,260	------	------	504.0	------	------	------	------
Gelatin	1,025	38.8	5.8	7.2	1,396	1,660	264	687.0	570.0	128.0	81.4	77.5
Do	1,025	38.8	5.8	7.2	1,422	1,652	230	687.0	560.0	123.0	82.1	78.0
Olive oil	916	49.0	6.9	6.1	3,372	3,828	456	95.0	------	------	------	------
Do	916	49.0	6.9	6.1	3,260	3,700	440	95.0	------	------	------	------
Soap**	1,000	48.4	6.9	6.7	2,832	3,108	276	1,710.0	408.0	49.0	97.1	88.0
Do	1,000	48.4	6.9	6.5	2,832	3,168	336	1,710.0	420.0	19.5	98.9	95.4
Mineral oil	1,000	39.3	7.1	5.5	3,036	3,184	268	8.2	------	------	------	------
Do	1,000	39.3	7.1	5.5	2,916	3,136	220	8.2	------	------	------	------
Acetonitrile	490	61.0	7.0	6.7	2,516	2,516	0	524.0	20.5	17.0	96.7	17.1
Do	490	61.0	7.0	6.7	2,548	2,564	16	524.0	15.5	21.0	96.0	0
Thioacetamide	1,000	76.0	6.9	6.7	1,768	1,848	80	680.0	0	0	100.0	0
Do	1,000	76.0	6.9	6.7	1,768	1,856	88	680.0	0	0	100.0	0
Thioglycolic acid	662	78.8	6.8	6.4	1,764	1,736	−28	311.0	0	0	100.0	0
Do	662	78.8	6.8	6.4	1,808	1,748	−60	311.0	0	0	100.0	0

*Pure culture sludge used.
**Castile soap assumed to be sodium oleate in calculating theoretical B. O. D.

immediately after mixing. Castile soap is also readily removed from solution, to the extent of about 90 percent in 22–24 hours. Gelatin is not quite as effectively removed, the percentage being approixmately 80 percent in the same time interval. Soap is remarkable also, in that approximately 75 percent of the theoretical initial 5-day B. O. D. is adsorbed and not detectable in the substrate immediately after mixing. B. O. D. data for acetonitrile, thioacetamide, and thioglycolic acid are illustrative of the toxic nature of these substances which inhibits their removal from solution biochemically.

With the exception of cystine, the amino acids are quite readily oxidized, comparing in magnitude of oxidation more closely to the carbohydrates than to the organic acids and alcohols. Cystine is quite different, however. Of the two trials made, one shows no increase in oxygen consumption due to the cystine added and the other, while showing a slight increase, 1.5 percent at 1 and 3 hours, showed

TABLE 12.—*Oxidation of amino acids, proteins and miscellaneous compounds by activated sludge*

Material fed	Quantity of material fed, p. p. m.	Quantity of sludge used in experiment, p. p. m.	Mg. of O_2 used in 24 hours by control sludge	Mg. of O_2 used in indicated time as a result of material fed				Percentage of theoretical ultimate satisfied in indicated time			
				1 hour	3 hours	5 hours	22–24 hours	1 hour	3 hours	5 hours	22–24 hours
Glycine	720	2,884	46.9	14.8	47.4	66.1	269.0	3.2	10.3	14.3	58.4
Do	720	2,316	76.0	11.2	34.7	48.3	194.3	2.4	7.5	10.5	42.2
Do*	720	768	55.5	0	13.5	29.3	237.1	0	2.9	6.4	51.5
Do*	720	600	32.9	12.3	49.5	90.0	270.7	2.7	10.7	19.5	58.7
Alanine	500	1,296	63.6	0	13.2	25.8	183.4	0	2.45	4.78	33.95
Do	500	1,316	63.6	4.1	32.1	42.1	209.0	.76	5.95	7.80	38.70
Glutamic acid	500	1,504	98.9	5.1	21.7	46.6	103.1	1.04	4.43	9.52	21.50
Do	500	1,504	98.9	16.6	24.0	33.8	152.7	3.39	4.90	6.90	31.15
Tyrosine	500	1,848	59.7	0	3.2	13.6	114.4	0	.38	1.62	13.61
Do	500	2,072	59.7	0	0	0	103.0	0	0	0	12.27
Cystine	1,000	2,876	155.4	0	0	0	0	0	0	0	0
Do	1,000	2,832	155.4	11.1	11.5	5.5	0	1.52	1.58	.75	0
Peptone	720	3,308	[1] 56.1	45.9	132.7	213.2	------	6.2	17.9	28.7	------
Do*	720	1,260	15.8	48.3	150.2	227.5	376.5	6.5	20.3	30.7	**50.8
Meat extract*	720	1,260	15.8	47.2	93.9	149.8	171.2	14.36	28.58	45.59	**52.10
Do	720	3,308	150.8	59.7	131.4	259.2	495.7	18.17	39.99	78.88	**150.85
Gelatin	1,025	1,396	110.8	0	------	0	227.7	0	------	0	**22.60
Do	1,025	1,424	110.8	0	------	3.2	342.1	0	------	.31	**33.95
Olive oil	916	3,372	199.0	0	0	16.8	94.0	0	0	11.87	**71.38
Do	916	3,260	199.0	1.0	10.0	26.9	60.2	.7	7.06	19.01	**42.55
Soap	1,000	2,832	205.4	0	23.0	47.2	50.8	0	1.08	2.22	**2.38
Do	1,000	2,832	205.4	27.1	73.1	124.8	191.6	1.27	3.42	5.82	**8.96
Mineral oil	1,000	3,036	243.2	0	0	.8	16.5	0	0	6.66	**137.5
Do	1,000	2,916	243.2	0	3.8	2.2	13.1	0	31.4	18.33	**109.2
Acetonitrile	490	2,516	117.7	0	0	0	0	0	0	0	0
Do	490	2,548	117.7	0	0	0	0	0	0	0	0
Thioacetamide	1,000	1,768	72.0	------	6.5	0	0	------	.65	0	0
Do	1,000	1,948	72.0	------	0	0	0	------	0	0	0
Thioglycolic acid	662	1,764	142.5	20.5	20.4	9.8	0	4.48	4.46	2.14	0
Do	662	1,808	142.5	17.4	20.1	9.2	0	3.82	4.39	2.01	0
Potassium cyanide	480	2,600	107.5	0	0	0	0	------	------	------	------
Urea	1,200	2,316	76.0	.2	1.9	3.5	11.3	Theoretically, hydrolysis and not oxidation occurs.			
Do*	720	768	72.6	11.7	3.4	2.2	17.1				
Do*	720	600	32.9	1.7	2.8	2.3	2.2				

*Pure culture sludge.
**Ultimate demand computed from actual B. O. D. determinations obtained.
[1] 5 hours.

a decrease to 0.75 percent at 5 hours and no oxygen consumption at 22–24 hours. Obviously, little, if any, oxidation occurs.

With tyrosine oxidation proceeds very slowly to the fifth hour, but at 22–24 hours about 12–13 percent of the tyrosine that has been removed from solution is oxidized. Gelatin exhibits a similar slow oxidation until the fifth hour and then an appreciable increase of 22–34 percent in 22–24 hours. The more heterogeneous materials, peptone and meat extract, are apparently more easily and completely oxidized.

Two oils were used as test materials: olive oil and mineral oil, S. A. E. 30. Strict interpretations are difficult because of lack of satisfactory ultimate-demand figures. Certain conclusions may be drawn, however. Oxidation does occur in a 22–24-hour period. This oxidation is of rather small magnitude up to the third hour and it appears that a lag phase is involved.

Soap, which would normally be present as a constituent of sewage, is not too readily oxidized in the low concentrations employed for test purposes. Despite the fact that reference to table 11 indicates a removal from solution of 97–99 percent of the B. O. D. due to the added soap in 22–24 hours, only 2.38 percent is oxidized in one experiment and 8.96 percent in another.

Urea is apparently simply hydrolyzed, resulting in the production of free ammonia which accumulates to raise the pH. It does not measurably increase the carbonaceous demands or the oxygen utilization on nonnitrifying sludges.

Acetonitrile, thioacetamide, and potassium cyanide show no increase in oxygen utilization. Thioglycolic acid initially shows a small increase in the oxygen used, 3–4 percent, but this soon declines to about 2 percent at 5 hours and to none at all at 22–24 hours. These latter compounds are all apparently detrimental to the activated sludge.

DISCUSSION

Wastes vary greatly in composition and intensity. Any or even a majority of the materials considered in this paper might be found as constituents of any given waste. From even the most casual inspection of the data given, it will be evident that complex relationships must be at work in the catabolism of organic matter by activated sludge. Certainly the nature of the organic material used is a limiting factor in that it controls the extent and manner of utilization. Some materials, of course, especially those containing SH, CHO, or CN groups, are definitely detrimental. This is true also of various metallic ions not considered here.

The various organic materials may be classified according to their chemical nature and generalities made on the basis of the resulting divisions. However, great variability will be evident even within these divisions. Activated sludge responds quite differently to methyl than to ethyl alcohol, for example. Probably the greatest similarity is evidenced by the carbohydrates. L-xylose is quite dissimilar to the other carbohydrates studied, with respect to its behavior in an activated-sludge system and also with respect to its ability to stimulate the growth of *Sphaerotilus natans*. Another determining factor is, of course, the sludge itself. We are dealing with living things when we use activated sludge, and though we can formulate certain rules and be assured that they will hold true in most cases, we cannot always be certain of that strict and complete adherence that we find in a distinctly chemical reaction. Variations will appear, and although this is at times undesirable, it also has its beneficial aspects. It certainly adds to the versatility of the sludge so that it will attack and utilize a complex variety of materials. If the sludge initially is unable to do so to any great extent, in many cases, and particularly with carbohydrates, it will adjust itself to do so. This adjustment itself may be undesirable in part, as witness the large increase in solids with carbohydrates, but essentially it is desirable, increasing the rates of removal and the consequent capacity of an activated sludge for removing carbohydrates from solution in shorter time intervals. The ability to predict the occurrence of this adjustment should make it controllable. It is impossible to say from the data accumulated for this paper just what does happen, whether a selective change in organisms, an enzymatic reaction, or both occur. The rapidity of the acclimatization suggests the formation of adaptive enzymes. For practical purposes, however, mere knowledge of the phenomena should suffice.

In the case of dextrin, the carbohydrate receiving the most detailed study, this adaptive mechanism increases the percentage of B. O. D. removal in a 3-hour period from approximately 40 percent to about 80 percent, producing at the same time, however, nearly 3 times as great a solids increase. This increase will occur anyway, of course, with equivalent decreases in substrate B. O. D.; in other words, equivalent amounts of dextrin utilized, regardless of time, should produce the same amount of sludge solids. It has been repeatedly demonstrated that the presence of carbohydrates in the substrate feed leads to a transient deposition of material within the cell (7). However, this maximum increase in solids with an acclimated sludge occurs at intervals somewhat comparable to the detention periods used in practice, falling off slightly thereafter. It should be noted that acclimatization of activated sludge in the presence of sufficient carbohydrate material is unavoidable. With an unacclimated sludge, this maximum increase will not occur until the twenty-fourth hour is approached.

Ease of removal of B. O. D. from solution is more likely a function of the individual compound than of the class to which it belongs, and of course, is dependent incidentally on the characteristics of the sludge used. This removal is accomplished by several procedures—adsorption, oxidation, assimilation, and synthesis—all occurring concurrently but varying in proportion to the time interval and the substrate material.

Each grouping of the compounds studied shows some compounds with a B. O. D. removal amounting to 90 percent or more in 22–24 hours. But there are deviations from this in each group. Among carbohydrates it is l-xylose. It is true that it has been shown that adaptive procedures make l-xylose metabolism comparable to that of the other carbohydrates, but initially it is different. Among organic acids, oxalic acid and calcium gluconate show less B. O. D. removal; among alcohols, methyl alcohol and ethylene glycol; among amino acids, tyrosine. Nor does the rate of B. O. D. removal indicate infallibly to what extent oxidation may occur. The rate of oxidation is subject to great variations and each material is attacked in a different way. This has been observed on numerous occasions using specific organisms and amino acids, organic acids, alcohols and carbohydrates as substrates (*8*).

Although activated sludge consists of a tremendously varied flora and fauna and is capable of directional development in various ways under the stimulus of specific substrates, the necessary factors may not be initially present in quantity. Whether it means selective development of specific strains of organisms or production of certain enzymes, a lag phase may ensue with definite substrates. This is particularly true of certain organic and amino acids and of the oils. Since this lag phase frequently amounts to five or more hours and is longer than ordinary detention periods, it is of significance. This fact undoubtedly accounts for some of the results with pure-culture zoogleal sludges which do not attack ethylene glycol at all, and which show a trend toward slow rates of oxidation during the first 3–5 hours with organic acids.

SUMMARY

Data pertaining to the removal from solution, oxidation, and conversion to protoplasm by activated sludge, of 36 pure organic substances are presented. The materials used represent a wide range of compounds; namely, sugars, alcohols, aldehydes, organic acids, amino acids, and miscellaneous compounds. The data presented are designed to show the response of activated sludge to these materials

under average conditions and not necessarily to determine the criteria of optimum utilization.

Ease of removal of B. O. D. from solution is shown to be more likely a function of the individual compound than of the class to which it belongs, and of course to be dependent incidentally on the characteristics of the sludge used. This removal is accomplished by several procedures—adsorption, oxidation, assimilation, and synthesis—all occurring concurrently but varying in proportion to the time interval and the substrate material.

Certain pertinent facts concerning the behavior of carbohydrates when introduced into an activated-sludge system are demonstrated. There is an immediate adsorption of carbohydrate, varying from 4.7 percent with l-xylose, glucose, and lactose to 30–80 percent with dextrin and starch. It is shown, also, that the 5-day B. O. D. removed from solution in 24 hours is in excess of 90 percent in the case of all the carbohydrates tested with the exception of l-xylose. The data presented indicate, additionally, that activated sludge can be acclimated to all the carbohydrates studied and that this procedure will increase the over-all removal of l-xylose from solution, in 24 hours, from 50–60 percent to about 98 percent. It is further demonstrated that only a very small portion of these materials, which are so rapidly removed from solution, are oxidized.

Using the complex carbohydrate, dextrin, a comprehensive study of the effects of acclimatization was made by determining the partition characteristics of the dextrin in the supernatant, the sludge, and the unrecoverable carbohydrate which had been completely utilized.

The ability of all carbohydrates studied, with the exception of l-xylose, to promote the growth of the filamentous organism, *Sphaerotilus natans*, is demonstrated.

The alcohols, amino acids, and organic acids studied are shown to be quite readily removed from solution with the exception of methyl alcohol, tyrosine, and oxalic acid. All of these compounds are capable of being oxidized by activated sludge although in varying degree. Oxidation takes place readily with all amino acids studied with the exception of cystine, with which no oxidation occurs. Materials such as peptones and meat extract are shown to be more completely and easily oxidized, whereas soaps and oils are oxidized to only a minor extent. Certain compounds, especially those containing the groupings SH and CN, are not oxidized and are detrimental to sludge, while compounds such as urea are simply hydrolyzed.

Eliminating from consideration those compounds in each class that are not readily attacked by activated sludge, the data indicate the following general principle. After 24 hours of aeration with activated sludge, from 90 to 99 percent of the compound will be removed from solution and disposed of as follows for the following classes:

Class	Percentage oxidized		Percentage converted to protoplasm (organized sludge)
	Range	Mean	
Carbohydrates	5 to 25	13	65 to 85
Alcohols	24 to 38	30	52 to 66
Amino acids	22 to 58	42	32 to 68
Organic acids	30 to 80	50	10 to 60

In other words, in general, organic acids produce the smallest yield of activated sludge and carbohydrates the largest, with the alcohols and amino acids intermediate in sludge production. This explains why there is such a stimulation in sludge production when large quantities of carbohydrate wastes are added to sewage being treated by the activated sludge process.

It is demonstrated also that normal activated sludge, when subjected to an increase of carbohydrate feed, will become quickly acclimated, and because of adsorption and assimilation at rapid rates will produce enormous quantities of sludge with a low ash content. This factor should constitute an important consideration in the design of plants where this condition is likely to occur due to seasonal discharges of cannery wastes, corn or sugar products, or similar materials.

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SMALLPOX IMMUNIZATION REQUIREMENT IN CHINA

The Department of State has forwarded to the United States Public Health Service a copy of an alteration to the regulations for quarantine inspection of outbound vessels, issued by the Shanghai Quarantine Service. Pertinent portions of this alteration are presented below for the guidance of persons preparing to visit the areas concerned, and of physicians consulted by such persons.

WEISHENGSHU
SHANGHAI QUARANTINE SERVICE

Quarantine Notification No. 7 of 1947

Notice is hereby given that all outbound passenger vessels, navigating the Yangtze River ports and Ningpo, Wenchow are requested to anchor at Woosung awaiting inspection and are governed in this respect by the following regulations:

* * * * *

2. All passengers should produce valid vaccination certificates against smallpox, failing that they are required to be vaccinated before being permitted to depart and the agents will be subjected to a penalty for not abiding the regulation to book tickets with vaccination certificate.

* * * * *

4. Vessels outbound for other than the above-mentioned ports or for foreign ports are to be inspected at Shanghai as usual.
5. All outbound cargo boats or oil tankers carrying no passengers are exempted for inspection, provided that all of the crew are in possession of valid vaccination certificates.

The above regulations will become effective on and after February 17, 1947.

INCIDENCE OF COMMUNICABLE DISEASES IN THE UNITED STATES

March 23–April 19, 1947

The accompanying table summarizes the incidence of nine important communicable diseases, based on weekly telegraphic reports from State health departments. The reports from each State for each week are published in PUBLIC HEALTH REPORTS under the section "Incidence of Disease." The table gives the number of cases of these diseases for the 4 weeks ended April 19, 1947, the number reported for the corresponding period in 1946, and the median number for the years 1942–46.

DISEASES ABOVE MEDIAN INCIDENCE

Diphtheria.—For the 4 weeks ended April 19 there were 922 cases of diphtheria reported, as compared with 1,274 for the corresponding period in 1946 and a 1942–46 median of 903 cases. The small excess over the 5-year median was due in considerable part to an increase of cases in the Atlantic coast regions. In other sections the incidence

Number of reported cases of 9 communicable diseases in the United States during the 4-week period March 23–April 19, 1947, the number for the corresponding period in 1946, and the median number of cases reported for the corresponding period, 1942–46

Division	Current period	1946	5-year median	Current period	1946	5-year median	Current period	1946	5-year median
	Diphtheria			Influenza [1]			Measles [2]		
United States	922	1,274	903	120,721	7,219	8,650	28,280	152,615	104,809
New England	47	37	29	225	19	27	7,076	7,487	8,710
Middle Atlantic	165	262	132	119	17	71	4,328	49,711	20,955
East North Central	118	205	166	3,868	276	427	5,055	35,074	26,395
West North Central	85	103	70	14,564	30	108	1,444	7,441	8,226
South Atlantic	170	191	131	36,811	1,975	2,486	4,369	11,886	11,745
East South Central	88	90	83	9,740	375	606	1,465	3,182	3,182
West South Central	127	177	169	48,582	3,831	3,831	2,070	11,676	11,676
Mountain	49	84	50	4,946	495	609	1,401	8,097	5,167
Pacific	73	125	125	1,866	201	344	1,072	18,061	14,014
	Meningococcus meningitis			Poliomyelitis			Scarlet fever		
United States	383	550	794	112	111	81	9,898	15,894	17,096
New England	12	28	45	2	3	2	899	1,287	2,211
Middle Atlantic	57	140	155	20	19	12	2,769	6,009	5,679
East North Central	85	112	152	13	10	7	2,971	3,948	4,247
West North Central	37	42	72	9	4	4	824	1,194	1,576
South Atlantic	68	68	122	9	17	10	645	1,340	1,340
East South Central	38	51	68	9	5	6	419	344	509
West South Central	45	48	73	18	21	20	195	314	492
Mountain	6	9	10	1	11	5	395	397	855
Pacific	35	52	103	31	21	21	781	1,061	1,061
	Smallpox			Typhoid and paratyphoid fever			Whooping cough [2]		
United States	43	60	60	161	241	244	10,545	7,216	10,035
New England	0	0	0	24	9	9	824	901	1,124
Middle Atlantic	13	0	0	15	23	37	1,738	1,627	1,997
East North Central	8	7	9	18	30	30	2,110	1,476	1,476
West North Central	2	3	8	13	14	10	318	214	362
South Atlantic	0	0	2	26	31	59	1,363	1,016	1,533
East South Central	5	2	4	16	26	25	588	285	463
West South Central	15	4	8	25	73	52	2,313	848	946
Mountain	0	2	2	4	15	15	324	378	547
Pacific	0	42	6	20	20	17	967	471	1,662

[1] Mississippi, New York, and North Carolina excluded; New York City included.
[2] Mississippi excluded.

was about the same or less than the preceding 5-year median for this period.

Influenza.—The number of reported cases of influenza dropped from approximately 125,000 during the 4 weeks ended March 22 to 120,721 during the 4 weeks ended April 19. The current incidence was 70 percent above the 1946 incidence for the corresponding 4 weeks and 40 percent above the 1942–46 median. While apparently every section of the country felt the recent epidemic, the largest excesses over the median expectancy occurred in the West North Central, South Atlantic, and West South Central sections; minor increases were reported from other sections, the smallest increase appearing in the Middle Atlantic section. The peak of the current rise was reached during the week ended March 22 with a total of 52,000 cases reported for the week; the cases dropped rapidly during the succeeding weeks to a total of 12,616 for the last week of the current period (week ended April 19). The death rate from all causes in large cities reached a small peak during the week ended March 29, with a total of 10,814 deaths which was an increase of more than 14 percent over the preceding 3-year median for the same week.

Poliomyelitis.—The number of cases of poliomyelitis dropped from 156 during the preceding 4 weeks to 112 for the 4 weeks ended April 19. The number of cases was about the same as that for the corresponding period in 1946, and 1.4 times the 1942–46 median. The Middle Atlantic, East North Central, West North Central, East South Central, and Pacific sections reported increases over the median, while in other sections the incidence was the same as the median or fell below it.

Whooping cough.—There were 10,545 cases of whooping cough reported during the current 4-week period. The number was about 1.5 times that reported for the corresponding period in 1946, but it was only slightly above the 1942–46 median. The increase was largely due to the number of cases in the East North Central and West South Central sections. A slight increase occurred in the East South Central section, and in other sections the incidence was relatively low.

DISEASES BELOW MEDIAN INCIDENCE

Measles.—For the 4 weeks ended April 19 there was 28,280 cases of measles reported, as compared with 152,615 for the corresponding 4 weeks in 1946 and a 5-year (1942–46) median of 104,809 cases. The current incidence was considerably below the normal seasonal median in all sections of the country.

Meningococcus meningitis.—The 383 cases of meningococcus meningitis reported for the current 4 weeks was only 70 percent of the incidence during the corresponding 4-week period in 1946 and less than

50 percent of the 1942–46 median. For the country as a whole the current incidence was the lowest since 1941 when 225 cases were reported for this period. The incidence was below the seasonal expectancy in all sections of the country.

Scarlet fever.—The number of reported cases of scarlet fever (9,898) was less than 60 percent of the normal seasonal expectancy (17,096 cases). For the country as a whole the current incidence was the lowest for this period in the 19 years for which data are available in this form. Each section of the country reported a relatively low incidence.

Smallpox.—For the 4 weeks ended April 19 there were 43 cases of smallpox reported as compared with 60 for the corresponding period in 1946. The 1942–46 median was represented by the 1946 incidence. Of the total cases 12 were reported from New York City and its environs (4 from Millbrook about 60 miles north of New York City). This is the first occurrence of smallpox in New York State since 1939. The present infection was introduced by a person traveling from Mexico. That patient was hospitalized and later died. One other death was reported in New York City. A fatal case was also reported from Newark, N. J., on April 17. During the current 4-week period, cases of smallpox were reported from other States as follows: Texas 13, Indiana 6, Ohio, Tennessee, and Mississippi 2 each, and Iowa, Nebraska, and Kentucky 1 each. The 13 cases in Texas were all reported from Dimmit County, and the incidence there seems to be largely responsible for an increase of almost 100 percent over the normal median incidence in the West South Central section. In 1946 an outbreak of smallpox occurred in the Seattle-King County area in the State of Washington following exposure to a case in a soldier returned from the Orient, and 64 cases were reported during the months of March, April, and May.

Typhoid and paratyphoid fever.—The incidence of these diseases was also relatively low, the number of cases (161) reported for the 4 weeks ended April 19 being about 65 percent of the 1942–46 median for the corresponding weeks. The New England, West North Central, and Pacific sections reported a few more cases than might normally be expected, but in all other sections the incidence was considerably below the median expectancy.

MORTALITY, ALL CAUSES

For the 4 weeks ended April 19 there were 40,862 deaths from all causes reported to the National Office of Vital Statistics by 93 large cities. The median number reported for the corresponding weeks in 1944–46 was 36,845. The small peak in the death rate that occurred during the week ended March 29 was no doubt due in part to the influenza epidemic that appeared in most sections of the country; the number of cases during that week was 14 percent above the preceding 3-year median, but by the last week of the current 4-week period the number of deaths dropped to less than 7 percent above the median.

DEATHS DURING WEEK ENDED APR. 19, 1947

[From the Weekly Mortality Index, issued by the National Office of Vital Statistics]

	Week ended Apr. 19, 1947	Corresponding week, 1946
Data for 93 large cities of the United States:		
Total deaths	9,701	9,082
Median for 3 prior years	9,109	
Total deaths, first 16 weeks of year	161,513	159,800
Deaths under 1 year of age	740	631
Median for 3 prior years	631	
Deaths under 1 year of age, first 16 weeks of year	12,815	9,710
Data from industrial insurance companies:		
Policies in force	67,298,768	67,197,093
Number of death claims	12,681	11,184
Death claims per 1,000 policies in force, annual rate	9.8	8.7
Death claims per 1,000 policies, first 16 weeks of year, annual rate	9.9	11.0

INCIDENCE OF HOSPITALIZATION, JANUARY 1947

Through the cooperation of the Hospital Service Plan Commission of the American Hospital Association, data on hospital admissions among members of Blue Cross Hospital Service Plans are presented monthly. These plans provide prepaid hospital service. The data cover hospital service plans scattered throughout the country mostly in large cities.

Item	January	
	1947	1946
1. Number of plans supplying data	79	81
2. Number of persons eligible for hospital care	23,673,855	17,259,949
3. Number of persons admitted for hospital care	232,405	158,991
4. Incidence per 1,000 persons, annual rate during current month (daily rate × 365)	116	108
5. Average annual incidence per 1,000 for the 12 months ending Jan. 31, 1947	112	107
6. Number of plans reporting on hospital days	64	30
7. Days of hospital care per case discharged during month [1]	8.18	8.00

[1] Days include entire stay of patient in hospital whether at full pay or at a discount.

INCIDENCE OF DISEASE

No health department, State or local, can effectively prevent or control disease without knowledge of when, where, and under what conditons cases are occurring

UNITED STATES

REPORTS FROM STATES FOR WEEK ENDED APR. 26, 1947

Summary

While the incidence of influenza declined during the week, the current week's total of 8,037 cases, as compared with last week's 12,616 and a 5-year (1942–46) median of 1,734, is more than has been recorded for any corresponding week of the past 12 years, the largest number during these years (4,398) being reported for the corresponding week in 1936. Of the 8 States reporting currently more than 178 cases, with an aggregate of 7,133, or nearly 89 percent of the total, only one (Iowa, 159 to 696) showed any material increase, and this increase may represent delayed reports, as the incidence has been declining in that State since the week of March 29 (6,036 cases). Of the total this year to date, 286,790 cases, exceeding by more than 100,000 the total for any corresponding period of the past 5 years except 1944 (328,181), 246,199, or about 86 percent, occurred in the 8 weeks since March 1, following a period of comparatively low incidence throughout the fall and winter months.

Of 14 cases of smallpox reported for the week (last week 10), 4 occurred in New Mexico, 3 in Missouri, 2 in North Dakota, and 1 each in Kansas, South Carolina, Kentucky, Oklahoma, and Idaho. The last reported case in New York occurred on April 9. The total for the entire country for the year to date is 102, as compared with 167 for the same period last year, and a 5-year median of 198.

Of the total of 28 cases of poliomyelitis reported for the week, California reported 11 (last week 5), and Florida 5 (last week 2). The total since the approximate average date of seasonal low incidence (March 15) is 169, as compared with 184 for the same period last year and a 5-year median of 127.

The current and cumulative figures for diphtheria, measles, meningococcus meningitis, scarlet fever, and typhoid and paratyphoid fever are well below, while those for whooping cough are slightly above, the respective corresponding 5-year medians.

Deaths recorded for the week in 93 large cities of the United States totaled 9,434, as compared with 9,701 last week, 9,448 and 9,105, respectively, for the corresponding weeks of 1946 and 1945, and a 3-year (1944–46) median of 9,322. The total for the year to date is 170,947, as compared with 169,248 for the corresponding period last year.

Telegraphic morbidity reports from State health officers for the week ended Apr. 26, 1947, and comparison with corresponding week of 1946 and 5-year median

In these tables a zero indicates a definite report, while leaders imply that, although none was reported, cases may have occurred.

Division and State	Diphtheria			Influenza			Measles			Meningitis, meningococcus		
	Week ended—		Median 1942–46	Week ended—		Median 1942–46	Week ended—		Median 1942–46	Week ended—		Median 1942–46
	Apr. 26, 1947	Apr. 27, 1946		Apr. 26, 1947	Apr. 27, 1946		Apr. 26, 1947	Apr. 27, 1946		Apr. 26, 1947	Apr. 27, 1946	
NEW ENGLAND												
Maine	0	0	0	1	------	1	229	170	148	2	0	3
New Hampshire	0	0	0	21	------	------	7	31	35	1	2	1
Vermont	0	0	0	4	------	------	280	9	109	0	0	0
Massachusetts	13	4	4	------	------	------	332	2, 449	1, 559	5	3	6
Rhode Island	1	1	1	1	------	------	294	10	10	0	2	1
Connecticut	0	0	0	12	1	------	932	428	447	0	2	2
MIDDLE ATLANTIC												
New York	15	25	20	[1] 5	([1])	[1] 3	629	5, 285	1, 836	11	17	19
New Jersey	0	7	5	10	8	5	404	4, 531	1, 505	3	3	6
Pennsylvania	23	16	9	([2])	[2] 2	[2] 2	250	3, 829	1, 297	1	11	13
EAST NORTH CENTRAL												
Ohio	6	13	4	14	6	7	657	730	568	7	4	9
Indiana	9	16	5	6	3	3	119	632	198	2	5	5
Illinois	4	8	8	39	1	4	148	1, 213	918	8	5	11
Michigan [3]	9	8	7	4	------	1	128	1, 696	1, 078	9	6	7
Wisconsin	0	0	1	99	43	52	343	3, 458	1, 703	2	1	3
WEST NORTH CENTRAL												
Minnesota	6	16	3	------	------	------	258	53	322	2	3	1
Iowa	1	6	2	696	------	------	225	268	268	2	0	1
Missouri	2	3	1	6	1	3	22	212	276	2	4	7
North Dakota	1	3	1	4	------	1	16	5	42	0	0	0
South Dakota	0	3	1	------	------	------	57	29	29	0	0	0
Nebraska	1	1	1	5	3	3	6	671	270	0	0	1
Kansas	8	4	3	2	2	2	9	402	532	2	3	4
SOUTH ATLANTIC												
Delaware	0	0	0	2	------	------	2	48	15	0	0	1
Maryland [3]	12	22	14	16	2	3	35	664	489	1	3	6
District of Columbia	0	1	0	------	------	------	32	427	132	3	2	4
Virginia	1	14	5	2, 885	142	142	464	711	381	1	7	7
West Virginia	1	8	2	33	3	9	40	132	132	3	2	2
North Carolina	8	9	5	------	------	1	116	485	485	2	2	4
South Carolina	5	2	4	914	239	267	216	455	150	0	0	2
Georgia	4	2	3	94	5	8	111	262	211	0	0	1
Florida	1	5	5	13	------	1	124	311	289	0	2	2
EAST SOUTH CENTRAL												
Kentucky	7	5	4	13	------	1	53	135	142	1	5	5
Tennessee	3	4	3	178	15	29	120	227	227	4	1	6
Alabama	2	3	7	445	11	45	305	143	143	4	8	8
Mississippi [3]	3	6	5	49	------	------	15	------	------	0	0	3
WEST SOUTH CENTRAL												
Arkansas	1	3	3	194	44	44	53	149	149	1	2	2
Louisiana	6	6	5	8	47	4	79	287	102	2	0	1
Oklahoma	2	3	3	347	17	32	4	227	227	0	0	1
Texas	16	31	29	1, 459	508	654	393	2, 240	1, 720	4	7	15
MOUNTAIN												
Montana	2	0	1	78	------	12	96	48	115	1	0	0
Idaho	3	4	0	22	5	1	5	178	52	0	1	1
Wyoming	0	0	0	------	------	------	21	43	67	0	0	0
Colorado	5	6	8	28	10	22	69	1, 289	308	0	0	2
New Mexico	1	3	2	3	7	6	62	51	51	0	0	0
Arizona	3	8	0	193	38	85	122	234	178	0	0	0
Utah [3]	0	2	0	54	2	5	11	389	270	0	0	0
Nevada	0	0	0	------	------	------	------	------	2	0	0	0
PACIFIC												
Washington	2	8	2	15	------	------	46	771	318	1	3	3
Oregon	1	2	2	40	6	17	25	398	190	0	0	1
California	13	25	22	25	28	28	219	3, 657	3, 657	5	10	16
Total	201	316	211	8, 037	1, 199	1, 734	8, 183	40, 072	26, 526	92	126	202
17 weeks	4, 633	6, 180	4, 878	286, 790	181, 831	71, 036	98, 993	379, 228	314, 834	1, 517	3, 075	4, 009
Seasonal low week [4]	(27th) July 5–11			(30th) July 26–Aug. 1			(35th) Aug. 30–Sept. 5			(37th) Sept. 13–19		
Total since low	12, 199	17, 824	13, 623	319, 765	544, 079	106, 898	121, 880	405, 352	352, 847	2, 489	4, 579	6, 461

[1] New York City only. [2] Philadelphia only. [3] Period ended earlier than Saturday.
[4] Dates between which the approximate low week ends. The specific date will vary from year to year.

Telegraphic morbidity reports from State health officers for the week ended Apr. 26, 1947, and comparison with corresponding week of 1946 and 5-year median—Con.

Division and State	Poliomyelitis			Scarlet fever			Smallpox			Typhoid and paratyphoid fever		
	Week ended—		Median 1942–46	Week ended—		Median 1942–46	Week ended—		Median 1942–46	Week ended—		Median 1942–46
	Apr. 26, 1947	Apr. 27, 1946		Apr. 26, 1947	Apr. 27, 1946		Apr. 26, 1947	Apr. 27, 1946		Apr. 26, 1947 [5]	Apr. 27, 1946	
NEW ENGLAND												
Maine	0	0	0	10	36	36	0	0	0	0	1	0
New Hampshire	0	0	0	8	16	16	0	0	0	0	0	0
Vermont	0	0	0	3	6	6	0	0	0	0	0	0
Massachusetts	0	2	0	106	183	326	0	0	0	4	1	2
Rhode Island	0	0	0	8	12	19	0	0	0	0	0	0
Connecticut	0	0	0	56	73	83	0	0	0	0	0	0
MIDDLE ATLANTIC												
New York	2	6	3	317	705	580	0	0	0	2	1	4
New Jersey	0	0	0	111	170	170	0	0	0	0	3	0
Pennsylvania	0	1	0	188	364	502	0	0	0	4	5	3
EAST NORTH CENTRAL												
Ohio	1	0	0	235	425	397	0	0	0	3	3	3
Indiana	0	0	0	104	100	100	0	1	1	5	3	2
Illinois	0	2	1	98	212	239	0	0	0	2	0	0
Michigan [3]	1	0	0	111	157	157	0	0	0	1	0	1
Wisconsin	0	0	0	77	121	178	0	0	0	1	0	0
WEST NORTH CENTRAL												
Minnesota	0	0	0	33	55	72	0	0	0	0	1	1
Iowa	0	1	0	34	45	45	0	2	1	1	0	0
Missouri	1	0	0	23	44	82	3	0	0	1	0	1
North Dakota	0	0	0	5	11	11	2	0	0	0	2	0
South Dakota	0	0	0	6	5	16	0	0	0	0	0	0
Nebraska	0	0	0	9	23	32	0	1	0	0	0	0
Kansas	0	0	0	38	38	75	1	0	0	0	1	1
SOUTH ATLANTIC												
Delaware	0	0	0	7	7	7	0	0	0	0	0	0
Maryland [3]	0	0	0	36	51	146	0	0	0	0	2	2
District of Columbia	0	0	0	9	26	23	0	0	0	0	1	0
Virginia	0	0	0	7	135	64	0	0	0	1	0	2
West Virginia	0	0	0	15	28	28	0	0	0	0	0	1
North Carolina	0	1	0	26	45	37	0	0	0	1	1	2
South Carolina	3	0	0	5	8	8	1	0	0	1	2	1
Georgia	0	0	0	8	4	15	0	0	0	3	3	5
Florida	5	14	0	9	5	9	0	0	0	2	3	3
EAST SOUTH CENTRAL												
Kentucky	0	0	0	29	31	54	1	0	0	2	0	1
Tennessee	0	0	1	32	22	44	0	0	0	0	2	3
Alabama	1	0	0	7	48	19	0	0	0	1	0	0
Mississippi [3]	0	0	0	8	5	5	0	0	0	0	1	1
WEST SOUTH CENTRAL												
Arkansas	0	0	0	4	15	11	0	0	0	2	2	1
Louisiana	2	1	0	6	10	10	0	1	1	3	3	3
Oklahoma	0	1	0	9	5	12	1	0	0	2	1	1
Texas	1	4	4	35	41	62	0	0	0	5	13	8
MOUNTAIN												
Montana	0	1	0	5	10	18	0	0	0	0	2	0
Idaho	0	0	0	1	5	37	1	0	0	0	0	0
Wyoming	0	0	0	1	21	13	0	0	0	0	1	0
Colorado	0	3	0	35	39	44	0	0	0	1	1	1
New Mexico	0	0	0	7	10	10	4	1	0	0	0	0
Arizona	0	1	0	10	11	11	0	0	0	1	0	0
Utah [3]	0	0	0	20	31	23	0	0	0	0	0	0
Nevada	0	0	0	0	0	0	0	0	0	0	0	0
PACIFIC												
Washington	0	1	1	32	12	44	0	2	0	1	1	0
Oregon	0	0	0	23	28	28	0	0	0	2	0	0
California	11	8	4	114	170	170	0	0	0	5	5	3
Total	28	47	27	2,080	3,624	4,104	14	8	9	57	65	87
17 weeks	795	650	429	44,960	59,920	67,902	102	167	198	738	845	995
Seasonal low week [4]	(11th) Mar. 15–21			(32nd) Aug. 9–15			(35th) Aug. 30–Sept. 5			(11th) Mar. 15–21		
Total since low	169	184	127	71,646	98,491	106,223	156	243	315	253	370	394

[3] Period ended earlier than Saturday.
[4] Dates between which the approximate low week ends. The specific date will vary from year to year.
[5] Including paratyphoid fever reported separately, as follows: Massachusetts 3 (salmonella infection); Virginia 1; Georgia 3; Alabama 1; Arkansas 1; Texas 1; Washington 1; Oregon 1; California 2.

Telegraphic morbidity reports from State health officers for the week ended Apr. 26, 1947, and comparison with corresponding week of 1946 and 5-year median—Con.

Division and State	Whooping cough			Week ended Apr. 26, 1947							
	Week ended—		Median, 1942–46	Dysentery			Encephalitis, infectious	Rocky Mt. spotted fever	Tularemia	Typhus fever, endemic	Undulant fever
	Apr. 26, 1947	Apr. 27, 1946		Amebic	Bacillary	Unspecified					
NEW ENGLAND											
Maine	23	25	25				1				1
New Hampshire											
Vermont	4	25	25								6
Massachusetts	111	122	129		2						
Rhode Island	14	7	18								
Connecticut	26	46	50		1						7
MIDDLE ATLANTIC											
New York	156	149	190	6	11		1			1	3
New Jersey	174	165	165	1		1					
Pennsylvania	201	126	205								1
EAST NORTH CENTRAL											
Ohio	176	69	171		1						2
Indiana	71	40	40			1					
Illinois	69	111	111	2					3		6
Michigan [3]	162	90	90	1							5
Wisconsin	193	104	104								4
WEST NORTH CENTRAL											
Minnesota	14	18	23								4
Iowa	17	29	20								9
Missouri	21	16	16			2	1				1
North Dakota			2								
South Dakota			2								
Nebraska	20		12	1							
Kansas	31	18	40		1				2		10
SOUTH ATLANTIC											
Delaware	4	1	1								
Maryland [3]	72	14	45			1					
District of Columbia	11	7	7								
Virginia	124	32	52			109					
West Virginia	32	29	17								1
North Carolina	77	55	159							1	
South Carolina	96	38	73	2	7						1
Georgia	11	9	14						1	5	3
Florida	63	5	16				1			6	1
EAST SOUTH CENTRAL											
Kentucky	11	8	28				1				
Tennessee	23	27	27			1			2		1
Alabama	120	13	16	1			1		1	3	4
Mississippi [3]	14			2	3					1	1
WEST SOUTH CENTRAL											
Arkansas	59	7	15	1	2				1		1
Louisiana	13	7	7	1					3	1	
Oklahoma	6	4	8			4		1			
Texas	644	229	316	3	218	57				9	10
MOUNTAIN											
Montana	7	3	5								
Idaho	9	12	2					1			7
Wyoming		1	1								
Colorado	14	53	25								1
New Mexico	19	5	17								
Arizona	56	14	19			29	2				1
Utah [3]	13	31	33		1				1		
Nevada											
PACIFIC											
Washington	29	47	45	3	1	7					
Oregon	13	12	19								
California	299	90	320	5	2		1				6
Total	3,322	1,913	2,832	29	250	212	9	2	14	27	97
Same week, 1946	1,913			35	420	132	11	7	11	45	102
Median, 1942–46	2,832			35	323	101	11	8	10	45	[6] 99
17 weeks: 1947	44,391			782	5,073	3,502	114	18	555	664	1,751
1946	30,962			643	4,939	1,739	142	21	315	782	1,351
Median, 1942–46	42,080			482	3,668	1,130	142	21	285	782	[6] 1,409

[3] Period ended earlier than Saturday.
[6] 2-year average, 1945–46.

Anthrax: Pennsylvania, 1 case.
Leprosy: Ohio, 1 case.
Relapsing fever: Oregon, 1 case.

WEEKLY REPORTS FROM CITIES[1]

City reports for week ended April 19, 1947

This table lists the reports from 90 cities of more than 10,000 population distributed throughout the United States, and represents a cross section of the current urban incidence of the diseases included in the table.

Division, State, and City	Diphtheria cases	Encephalitis, infectious, cases	Influenza		Measles cases	Meningitis, meningococcus, cases	Pneumonia deaths	Poliomyelitis cases	Scarlet fever cases	Smallpox cases	Typhoid and paratyphoid fever cases	Whooping cough cases
			Cases	Deaths								
NEW ENGLAND												
Maine:												
Portland	0	1	------	0	41	0	1	0	0	0	1	8
New Hampshire:												
Concord	0	0	------	0	------	0	0	0	0	0	0	------
Vermont:												
Barre	0	0	------	1	8	0	0	0	0	0	0	1
Massachusetts:												
Boston	9	0	------	0	56	0	13	0	18	0	2	12
Fall River	0	0	------	0	2	0	1	0	2	0	0	1
Springfield	0	0	------	0	11	0	0	0	7	0	0	10
Worcester	0	0	------	0	9	0	5	0	4	0	0	13
Rhode Island:												
Providence	0	0	3	0	187	0	3	0	0	0	0	3
Connecticut:												
Bridgeport	0	0	1	0	17	0	2	0	1	0	0	1
Hartford	0	0	------	0	52	0	2	0	2	0	0	------
New Haven	0	0	------	0	59	0	0	0	10	0	0	2
MIDDLE ATLANTIC												
New York:												
Buffalo	0	0	------	1	1	3	7	0	3	0	0	2
New York	17	0	4	2	278	2	63	2	95	0	1	57
Rochester	0	0	------	0	3	1	11	0	7	0	0	------
Syracuse	0	0	------	1	------	0	7	0	2	0	0	6
New Jersey:												
Camden	2	0	------	0	------	1	1	0	1	1	0	------
Newark	0	0	3	0	24	1	4	0	15	0	0	21
Trenton	0	0	3	0	22	0	5	0	5	0	0	1
Pennsylvania:												
Philadelphia	1	0	4	3	13	0	31	0	40	0	0	44
Pittsburgh	1	0	2	4	26	0	13	0	12	0	0	13
Reading	0	0	------	0	4	0	6	0	3	0	0	------
EAST NORTH CENTRAL												
Ohio:												
Cincinnati	0	0	1	0	4	1	8	0	6	0	0	2
Cleveland	0	0	5	1	166	1	13	0	29	0	0	49
Columbus	0	0	------	0	46	0	6	0	6	0	0	23
Indiana:												
Fort Wayne	0	0	------	0	6	0	2	0	1	0	0	2
Indianapolis	0	0	------	0	6	0	6	0	21	0	0	34
South Bend	0	0	------	0	21	0	0	0	0	0	0	1
Terre Haute	0	0	------	0	------	0	2	0	1	0	0	2
Illinois:												
Chicago	0	0	5	4	12	2	30	0	35	0	0	29
Springfield	0	0	------	0	17	0	0	0	3	0	0	1
Michigan:												
Detroit	2	1	1	0	5	2	19	0	32	0	0	82
Flint	0	0	------	0	------	0	5	0	5	0	0	------
Grand Rapids	0	0	------	0	1	0	2	0	4	0	0	5
Wisconsin:												
Kenosha	0	0	------	0	------	1	0	0	1	0	0	6
Milwaukee	0	0	------	0	46	0	7	0	14	0	0	40
Racine	0	0	------	0	3	0	1	0	12	0	0	16
Superior	0	0	------	0	------	0	1	0	0	0	0	------
WEST NORTH CENTRAL												
Minnesota:												
Duluth	0	0	------	0	------	0	1	0	3	0	0	3
Minneapolis	3	0	------	3	7	2	6	0	15	0	0	3
St. Paul	0	0	------	0	164	0	9	0	7	0	0	8
Missouri:												
Kansas City	0	0	1	0	1	0	3	0	3	0	0	6
St. Joseph	0	0	------	0	------	0	0	0	1	0	0	------
St. Louis	2	0	1	1	15	2	9	0	11	0	1	7

[1] In some instances the figures include nonresident cases.

City reports for week ended April 19, 1947—Continued

Division, State, and City	Diphtheria cases	Encephalitis, infectious, cases	Influenza		Measles cases	Meningitis, meningococcus, cases	Pneumonia deaths	Poliomyelitis cases	Scarlet fever cases	Smallpox cases	Typhoid and paratyphoid fever cases	Whooping cough cases
			Cases	Deaths								
WEST NORTH CENTRAL—continued												
Nebraska												
Omaha	0	0	------	1	------	0	4	0	5	0	0	------
Kansas:												
Topeka	0	0	------	0	1	0	1	0	3	0	0	4
Wichita	0	0	------	0	1	0	4	0	0	0	0	3
SOUTH ATLANTIC												
Delaware:												
Wilmington	1	0	1	0	------	1	2	0	2	0	0	------
Maryland:												
Baltimore	1	0	4	1	7	2	8	0	17	0	1	60
Cumberland	0	0	------	0	------	0	0	0	1	0	0	------
Frederick	0	0	------	0	------	0	0	0	0	0	0	------
District of Columbia:												
Washington	0	0	------	1	24	2	9	0	7	0	0	7
Virginia:												
Lynchburg	0	0	------	0	3	0	2	0	0	0	0	2
Richmond	0	0	1	1	101	0	1	0	1	0	0	1
Roanoke	0	0	------	0	19	0	0	0	5	0	0	------
West Virginia:												
Charleston	0	0	------	0	1	0	0	0	2	0	0	2
Wheeling	0	0	------	0	------	0	3	0	0	0	0	------
North Carolina:												
Raleigh	0	0	------	0	------	0	2	0	0	0	0	1
Wilmington	0	0	------	0	13	0	1	0	0	0	0	------
Winston-Salem	0	0	------	0	28	0	1	0	2	0	0	------
South Carolina:												
Charleston	0	0	47	1	37	0	1	0	0	0	0	------
Georgia:												
Atlanta	0	0	1	1	10	0	4	0	3	0	0	------
Brunswick	0	0	------	0	------	0	0	0	0	0	0	------
Savannah	0	0	5	1	5	0	0	0	0	0	0	------
Florida:												
Tampa	1	0	4	1	5	0	2	0	1	0	0	5
EAST SOUTH CENTRAL												
Tennessee:												
Memphis	0	0	1	3	------	1	12	0	1	0	0	5
Nashville	0	0	------	1	1	0	0	0	5	0	1	3
Alabama:												
Birmingham	0	0	20	0	35	0	6	0	2	0	0	1
Mobile	0	0	33	1	43	1	1	0	1	0	0	31
WEST SOUTH CENTRAL												
Arkansas:												
Little Rock	0	0	2	0	------	0	1	0	0	0	0	------
Louisiana:												
New Orleans	0	0	6	0	48	2	4	2	4	0	0	1
Shreveport	0	0	------	0	------	0	5	0	0	0	0	------
Oklahoma:												
Oklahoma City	0	0	14	0	------	0	2	0	0	0	0	4
Texas:												
Dallas	1	0	------	0	114	0	4	0	6	0	0	12
Galveston	0	0	------	0	------	0	0	0	0	0	0	------
Houston	1	0	2	1	4	1	1	2	1	0	0	------
San Antonio	1	0	------	0	4	0	6	0	2	0	0	4
MOUNTAIN												
Montana:												
Billings	0	0	------	0	3	0	0	0	1	0	0	------
Great Falls	0	0	------	0	69	0	1	0	1	0	0	------
Helena	0	0	------	0	1	0	0	0	1	0	0	4
Missoula	0	0	------	0	19	0	0	0	2	0	0	4
Idaho:												
Boise	0	0	------	0	------	0	1	0	0	0	0	2
Colorado:												
Denver	6	0	------	0	38	0	4	0	14	0	0	22
Pueblo	0	0	------	0	------	0	2	0	0	0	0	------
Utah:												
Salt Lake City	0	0	------	0	1	0	1	0	5	0	0	------

City reports for week ended April 19, 1947—Continued

Division, State, and City	Diphtheria cases	Encephalitis, infectious, cases	Influenza Cases	Influenza Deaths	Measles cases	Meningitis, meningococcus, cases	Pneumonia deaths	Poliomyelitis cases	Scarlet fever cases	Smallpox cases	Typhoid and paratyphoid fever cases	Whooping cough cases
PACIFIC												
Washington:												
Seattle	0	0		0	3	1	3	0	2	0	0	5
Spokane	0	0		0		0	1	0	0	0	0	
Tacoma	0	0		0	1	0	0	0	2	0	0	5
California:												
Los Angeles	5	0	5	0	13	1	3	2	25	0	1	36
Sacramento	0	0		0		0	0	0	0	0	0	4
San Francisco	2	0		0	16	0	2	0	8	0	0	
Total	56	2	180	35	2,001	31	410	8	569	1	8	742
Corresponding week, 1946*	89		28	15	13,111		302		1,323	4	22	426
Average, 1942–46*	66		71	[2] 21	[3] 6,762		[2] 362		1,613	1	13	758

[2] 3-year average, 1944–46.
[3] 5-year median, 1942–46.
*Exclusive of Oklahoma City.

Dysentery, amebic.—Cases: Buffalo 1; New York 9; New Orleans 2.
Dysentery, bacillary.—Cases: Worcester 1; Los Angeles 3.
Dysentery, unspecified.—Cases: Cincinnati 4; Memphis 1.
Tularemia.—Cases: St. Louis 1.
Typhus fever, endemic.—Cases: New York 3; Tampa 1; New Orleans 1.

Rates (annual basis) per 100,000 population, by geographic groups, for the 90 cities in the preceding table (latest available estimated population, 34,602,700)

	Diphtheria case rates	Encephalitis, infectious, case rates	Influenza Case rates	Influenza Death rates	Measles case rates	Meningitis, meningococcus, case rates	Pneumonia death rates	Poliomyelitis case rates	Scarlet fever case rates	Smallpox case rates	Typhoid and paratyphoid fever case rates	Whooping cough case rates
New England	23.5	2.6	10.5	2.6	1,155	0.0	70.6	0.0	115	0.0	7.8	133
Middle Atlantic	9.7	0.0	7.4	5.1	172	3.7	68.5	0.9	85	0.5	0.5	67
East North Central	1.2	0.6	7.3	3.0	202	4.3	62.0	0.0	103	0.0	0.0	178
West North Central	10.1	0.0	4.0	10.1	380	8.0	74.4	0.0	97	0.0	2.0	68
South Atlantic	4.9	0.0	103.0	11.4	414	8.2	58.8	0.0	67	0.0	1.6	127
East South Central	0.0	0.0	318.7	29.5	466	11.8	112.1	0.0	53	0.0	5.9	236
West South Central	7.6	0.0	61.0	2.5	432	7.6	58.4	10.2	33	0.0	0.0	53
Mountain	47.7	0.0	0.0	0.0	1,040	0.0	71.5	0.0	191	0.0	0.0	254
Pacific	11.1	0.0	7.9	0.0	52	3.2	14.2	3.2	59	0.0	1.6	79
Total	8.5	0.3	27.2	5.3	302	4.7	62.0	1.2	86	0.2	1.2	113

PLAGUE INFECTION IN ARIZONA AND WASHINGTON

Under dates of April 21 and 22, 1947, plague infection was reported proved in ectoparasites from rodents in Arizona and Washington, as follows:

ARIZONA

Navajo County.—In a pool of 96 fleas and 1 tick from 2 ground squirrels, *Citellus variegatus*, collected April 2 at a location 10 miles northeast of Show Low on U. S. Highway 60, and proved positive on April 21.

WASHINGTON

Yakima County.—In a pool of 6 fleas from 1 ground squirrel, *Citellus townsendii*, and a pool of 30 fleas from field mice, *Microtus* sp., all specimens collected on April 11 at a location 6 miles east of Firing Range Headquarters, and proved positive on April 22.

FOREIGN REPORTS

CANADA

Provinces—Communicable diseases—Week ended April 5, 1947.—During the week ended April 5, 1947, cases of certain communicable diseases were reported by the Dominion Bureau of Statistics of Canada as follows:

Disease	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Total
Chickenpox	2	17	3	163	264	24	20	38	65	596
Diphtheria		1	3	16	4	1	1			26
Dysentery:										
Bacillary				2						2
Unspecified					1					1
German measles				9	39	2	4	2	7	63
Influenza	28	13			17	3			2,504	2,565
Measles	2	69	1	69	102	335	76	130	158	942
Meningitis, meningococcus	1		1		2					4
Mumps		7		18	434	49	108	35	48	699
Poliomyelitis				1						1
Scarlet fever		2	78	70	60	2	9	1	4	226
Tuberculosis (all forms)		8	27	26	16	26	3	25	25	155
Typhoid and paratyphoid fever				1	4					5
Undulant fever				1	2				1	4
Venereal diseases:										
Gonorrhea	5	21	11	61	52	[1]	26	31	43	250
Syphilis	4	7		86	48	[1]	3	9	29	186
Other forms						[1]			5	5
Whooping cough				9	63	23	4	6	1	106

[1] Report from Manitoba for the above period not received.

JAMAICA

Notifiable diseases—4 weeks ended April 5, 1947.—During the 4 weeks ended April 5, 1947, cases of certain notifiable diseases were reported in Kingston, Jamaica, and in the island outside of Kingston, as follows:

Disease	Kingston	Other localities	Disease	Kingston	Other localities
Cerebrospinal meningitis	2	4	Puerperal sepsis		1
Chickenpox	5	5	Scarlet fever	1	
Diphtheria	3		Tuberculosis, pulmonary	32	60
Dysentery, unspecified	1	4	Typhoid fever	11	73
Erysipelas	1	2	Typhus fever (murine)	1	
Leprosy		3			

JAPAN

Notifiable diseases—5 weeks ended March 29, 1947, and total reported for the year to date.—For the 5 weeks ended March 29, 1947, and for the year to date, certain notifiable diseases were reported in Japan as follows:

Disease	5 weeks ended Mar. 29, 1947		Total reported for the year to date	
Diphtheria	3,651	341	9,123	910
Dysentery, unspecified	354	70	815	181
Encephalitis, Japanese "B"	1	0	1	2
Gonorrhea	18,980		45,042	
Malaria	1,027	4	2,243	9
Meningitis, epidemic	642	175	1,077	287
Paratyphoid fever	234	16	643	42
Scarlet fever	227	7	584	15
Smallpox	67	9	183	20
Syphilis	13,410		29,935	
Typhoid fever	817	106	2,745	357
Typhus fever	105	5	500	35

MOROCCO (FRENCH)

Notifiable diseases—February 1947.—During the month of February 1947, cases of certain notifiable diseases were reported in French Morocco as follows:

Disease	Cases	Disease	Cases
Cerebrospinal meningitis	4	Paratyphoid fever	5
Conjunctivitis and ophthalmia of the newborn	5,900	Poliomyelitis	1
Diphtheria	15	Puerperal infection	11
Dysentery:		Recurrent fever	1
Amebic	1,872	Scarlet fever	1
Bacillary	169	Smallpox	14
Leprosy	10	Tuberculosis, pulmonary	863
Measles and German measles	362	Typhoid fever	65
Ophthalmia neonatorum	9,924	Typhus fever	22

TUNISIA

Notifiable diseases—Year 1946.—During the year 1946, cases of certain notifiable diseases were reported in Tunisia as follows:

Disease	Cases	Disease	Cases
Cerebrospinal meningitis	29	Poliomyelitis	70
Diphtheria	81	Rabies	21
Dysentery, amebic and bacillary	32	Recurrent fever	966
Leprosy	1	Scarlet fever	28
Malaria	7,855	Smallpox	797
Measles	368	Tuberculosis	578
Mediterranean fever	1	Typhoid and paratyphoid fever	833
Mumps	112	Typhus fever	512

REPORTS OF CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER RECEIVED DURING THE CURRENT WEEK

NOTE.—Except in cases of unusual incidence, only those places are included which had not previously reported any of the above-mentioned diseases, except yellow fever, during recent months. All reports of yellow fever are published currently.

A table showing the accumulated figures for these diseases for the year to date is published in the PUBLIC HEALTH REPORTS for the last Friday in each month.

Cholera

India—Calcutta.—Cholera has been reported in Calcutta, India, as follows: Weeks ended—April 5, 1947, 147 cases; April 19, 1947, 441 cases, 146 deaths.

Plague

China—Amoy.—For the week ended April 5, 1947, 1 case of plague was reported in Amoy, China.

Madagascar.—During the month of February 1947, 59 cases of plague with 49 deaths were reported in Madagascar. During the month of March 1947, 24 cases of plague with 23 deaths were reported.

Turkey (in Asia)—Urfa Province—Akcakale.—For the week ended April 12, 1947, 10 cases of plague were reported in Akcakale, Urfa Province, Turkey.

Smallpox

Belgium—Liege.—On April 19, 1947, 16 cases of smallpox (alastrim) were reported in Liege, Belgium.

China—Shanghai.—For the week ended April 5, 1947, 122 cases of smallpox with 23 deaths were reported in Shanghai, China.

Colombia.—For the month of March 1947, 225 cases of smallpox with 2 deaths were reported in Colombia.

Great Britain—England—Stepney.—For the week ended March 22, 1947, 1 case of smallpox was reported in Stepney, England.

Malay States (Federated).—For the week ended April 5, 1947, 114 cases of smallpox with 33 deaths were reported in the Federated Malay States.

Morocco (International Zone)—Tangier.—For the week ended February 22, 1947, 14 cases of smallpox were reported in Tangier, Morocco (International Zone).

Sierra Leone.—For the week ended February 22, 1947, 53 cases of smallpox with 5 deaths were reported in Sierra Leone.

Tunisia.—Smallpox has been reported in Tunisia as follows: February 11–20, 1947, 38 cases; February 21–28, 1947, 67 cases; March 1–10, 1947, 62 cases.

Typhus Fever

Colombia.—For the month of March 1947, 159 cases of typhus fever with 3 deaths were reported in Colombia.

Tunisia.—Typhus fever has been reported in Tunisia as follows: February 11–20, 1947, 27 cases; February 21–28, 1947, 21 cases; March 1–10, 1947, 22 cases.

Union of South Africa.—For the month of January 1947, 41 cases of typhus fever were reported in the Union of South Africa.

Yellow Fever

Colombia—Santander Department.—Yellow fever has been reported in Santander Department, Colombia, as follows: Bolivar, Landazuri, February 14, 1947, 1 death; Jesus Maria, La Belleza, March 2, 1947, 1 death; San Vincente de Chucuri, Aguadulce, February 17, 1947, 1 death; Velez, Jordan, February 24, 1947, 1 death.

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