Public Health Reports

Vol. 54 • MARCH 24, 1939 • *No. 12*

DISABLING SICKNESS AND NONINDUSTRIAL INJURIES AMONG DRIVERS AND OTHER EMPLOYEES OF CERTAIN BUS AND CAB COMPANIES, 1930–34, INCLUSIVE*

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INTRODUCTION

Information in regard to disabling sickness and nonindustrial injuries among workers in the bus and cab industry was made available by the Occupational Morbidity and Mortality Study of the National Health Survey. The disability data of this study, covering the period from 1930 to 1934, inclusive, were transcribed from the records of sick benefit organizations. The present analysis is based upon schedules from 5,702 employees of 2 bus companies and 1 cab company, representing a total of 154,809 person-months of exposure,[1] yielding 1,144 cases and 35,985 days of disability. One of the companies operated in Illinois, 1 in California, and 1 in several of the Pacific Coast States.

Type of sick benefit organization.—In two of the bus and cab companies studied, sickness benefits were provided through an employees' sick benefit association, while in the third company aid was extended through a group insurance plan.[2]

Limitations of the study.—It should be remembered that the group studied was limited to those employees who had qualified for member-

* From the Division of Industrial Hygiene, National Institute of Health, Washington, D. C. The supporting data of this report are drawn from material collected by the Occupational Morbidity and Mortality Study of the National Health Survey. The study was made possible by a grant from the Works Progress Administration in 1935.

Acknowledgment is made to Dr. W. M. Gafafer for his assistance in the preparation of this paper.

[1] On the basis of continuous membership during the entire study period of 60 months this would mean that there were at least 2,580 employees, but actually there were 5,702 employees, which results in an average membership of 27 months instead of 60 for the 5 years.

[2] One company required a waiting period of 3 days after onset of disability before sick benefits could begin and the other two companies required a 7-day waiting period. The maximum length of time that benefits could be paid for any one illness during a year was 91 days for both sick benefit associations and 182 days for the sickness insurance plan. Under the insurance plan, benefits would end on the 189th day after onset, including the 7-day waiting period, during which there were no payments. In two companies benefits could be paid during an entire year for different illnesses provided no one of them exceeded the maximum period. The other company, which had a maximum benefit period of 13 weeks, allowed a total of only 13 weeks' payment for all the different illnesses which might occur during a calendar year.

There was no general provision barring persons from membership because of chronic ailments; however, in all organizations benefits were refused for one or more of the following reasons: Voluntary self-injury, immoral practices, venereal diseases, fighting, and improper use of stimulants or narcotics.

Membership did not begin simultaneously with employment nor cease when the employee was temporarily laid off. Two bus and cab companies required 6 months' and one company required 30 days' service before eligibility for membership could be established. Membership might be retained after lay-offs for 30 days in two companies and 6 months in one company. Membership in the sick benefit organization was voluntary except for one company where it was compulsory for all white employees, although Negroes were excluded.

ship and that this group formed a varying proportion of all persons employed at any time during the 5 years, 1930–34. The need for comparability of results required the establishment of standard conditions. Thus only those disabilities that began during the study period and lasted 8 days or longer were counted as cases, with the result that in the company having a 3-day waiting period all cases lasting 4, 5, 6, or 7 days were disregarded. Cases reopened within 7 days after the termination of a disability were not considered new cases; however, the number of days lost from such a relapse was added to the number lost from the original case. The number of cases reported during the entire study period was greater than the total number of individuals, which indicates that sometimes two or more cases were reported for the same person.

"Days of disability" included only those days falling within the study period. Thus, for cases that did not end in, and cases that began prior to and extended into, the study period, only the number of calendar days disabled during the study period was included. Under standard conditions the maximum benefit period for all cases was 91 days. As a result, the company with a maximum benefit period of 182 days had all cases over 91 days arbitrarily reduced to that figure. No change was required in the data from the other companies. Rates which include days of disability whether based on standard or actual conditions are influenced by maximum benefit cases. These cases tend toward an understatement of duration because they end with the termination of benefits rather than with the termination of the disability.

ANALYSIS OF THE DATA

Of the total of 1,144 cases reported, all but 3.7 percent represented white males. The miscellaneous group was composed of 42 cases distributed as follows: White females, 25; Negro females, 2; males of unknown color, 3; Negro males, 11; and Mexican males, 1. For present purposes the analysis will be limited to those data dealing with white males only.

The desirability of classification by specific occupation was recognized, but the available data were such that only a twofold division, drivers and all other employees, was practicable. Drivers represented 73.3 percent of all cases, while the other employees were distributed by occupation as follows: Officials, 1.5 percent; clerical workers, 4.8 percent; ticket agents, 1.4 percent; foremen and safety supervisors, 1.1 percent; conductors, 2.0 percent; mechanics, 8.9 percent; laborers, 3.2 percent; and other workers, 3.8 percent. The above group is diversified as to age, social and economic status, conditions of work, and environmental exposure. On the other hand, drivers form a relatively homogeneous group.

Table 1 shows the number of months of exposure for drivers and other workers. There is a definite concentration of the former in the age group 25–34 years, while the latter show a wider distribution, resulting in an excess under 25 years as well as in the age group 45 years and over. Certain occupations, such as office workers and laborers, have a large proportion of young persons; other occupations, as officials, foremen, and mechanics, have relatively more persons of the middle and older ages. The grouping at both extremes in the age distribution for persons other than drivers reflects the influence of different occupations.

TABLE 1.—*Months of exposure by age groups of drivers and other employees of selected bus and cab companies, 1930–34, inclusive*

WHITE MALES

Occupation	All ages	Age in years as of July 1, 1932					
		Under 25	25–34	35–44	45–54	55–64	65 and over
	Percentage distribution of months of exposure						
All occupations	100.0	4.0	55.4	29.7	8.7	1.8	0.4
Drivers	100.0	1.7	62.7	28.9	5.9	.7	.1
Others	100.0	8.5	40.6	31.4	14.3	4.2	1.0
	Number of months of exposure						
All occupations	[1] 148,327	5,845	81,696	43,834	12,800	2,686	535
Drivers	[1] 99,155	1,672	61,853	28,499	5,817	659	72
Others	[1] 49,172	4,173	19,843	15,335	6,983	2,027	463

[1] Includes some months of exposure for persons of unknown age.

Table 2 shows the frequency and duration of disabling sickness and nonindustrial injuries among drivers and other employees of the three bus and cab companies. The number of cases per 1,000 for drivers under 25 years of age is 86.3. It rises in each succeeding age group until, for the age period 45 years and over, it is 137.4, representing an increase of 59 percent. The rate for other employees fails to show an increase until the age group 45 years and over is attained, and then the rate is but 22 percent in excess of that under 25 years. Because of these differing trends the ratio of drivers to others becomes greater for the age periods 25–34 and 35–44 years, and slightly less at 45 years and over.

The average annual number of days of disability per person for all ages was 2.9 for drivers as compared with 2.6 for others. Again, drivers have an increasingly unfavorable rate in the older age groups, although for each specific period under 45 years the excess is not so great as it was with respect to the frequency rates. Evidently it is

TABLE 2.—*Frequency of sickness and nonindustrial injuries causing disability lasting 8 calendar days or longer, annual number of days of disability per person, and average number of days per case, by age groups among drivers and other employees of selected bus and cab companies, 1930–34, inclusive*

WHITE MALES

Occupation	All ages[1]	Age in years as of July 1, 1932: Under 25	25–34	35–44	45 and over
	Annual number of cases per 1,000 persons[2]				
All occupations	89.2	78.0	85.3	89.2	110.1
Drivers	97.8	86.3	90.6	104.8	137.4
Others	71.7	74.7	68.9	60.3	91.3
Ratio, drivers to others	136	116	131	174	150
	Annual number of days of disability per person				
All occupations	2.773	2.618	2.430	3.025	3.699
Drivers	2.862	1.748	2.465	3.395	4.443
Others	2.595	2.966	2.322	2.340	3.184
Ratio, drivers to others	110	59	106	145	140
	Average number of days per case[3]				
All occupations	31.1	33.6	28.5	33.9	33.6
Drivers	29.3	20.2	27.2	32.4	32.3
Others	36.2	39.7	33.7	38.8	34.9
Ratio, drivers to others	81	51	81	84	93
	Number of cases beginning during 1930–34, inclusive				
All occupations	1,102	38	581	326	147
Drivers	808	12	467	249	75
Others	294	26	114	77	72
	Number of calendar days of disability[3]				
All occupations	34,278	1,275	16,543	11,052	4,938
Drivers	23,645	243	12,703	8,062	2,426
Others	10,633	1,032	3,840	2,990	2,512
	Number of person-years of membership				
All occupations	12,361	487	6,808	3,653	1,335
Drivers	8,263	139	5,154	2,375	546
Others	4,098	348	1,654	1,278	789

[1] Includes some persons of unknown age.

[2] Cases include only those which began during the study period, but days of disability include days for cases which began prior to, as well as during, the study period. This seeming excess of days of disability is compensated in part by the fact that days subsequent to 1934 are not included, even though some cases had not ended or reached 91 days at the close of the study period.

[3] Includes all days of disability during the study period, regardless of when the disability began. Disabilities which reached 91 days or over were arbitrarily terminated at 91 days; those with a maximum benefit period of less than 91 days were raised to 91 days.

the influence of duration which tends to reduce the difference between the two occupational groups. Comparing the number of days per person at the upper and lower age extremes it is apparent that the rate for drivers increases more than two and one-half times, while for others the increase is only 7 percent.

Contrary to the two rates previously discussed, drivers have a more favorable experience than others with respect to the average number of days of disability per case. Under 25 years of age, disability periods among drivers were, on the average, 19 days shorter, while at 45 years and over the difference was less than 3 days.

Mortality and fatality rates.—While it is recognized that detailed analysis of mortality and fatality are not possible because of the small numbers involved, yet it is of interest to examine the material shown in table 3. It is evident that the lower mortality rate for drivers is influenced by the difference in age distribution. After 35 years of age, drivers have a distinctly higher rate than nondrivers. The mortality rate for 45 years of age and over compared with the rate under 35 years is more than eight times as great for drivers and more than three times as great for other employees. A smaller proportion of cases terminated fatally among drivers than among other employees. Even in the older age groups the fatality rate was lower for drivers, although the most marked difference was for younger persons.

Sickness rates by broad diagnostic groups.—For one of the three bus and cab companies, designated company A, it was possible to calculate rates of sickness for broad diagnostic groups. Respiratory diseases, which were the most common type of disabling sickness, had the shortest duration, 71 percent lasting less than 29 days. Digestive diseases were only one-half as frequent but lasted much longer than the respiratory diseases. Nonrespiratory-nondigestive diseases were distributed as follows: Diseases of the circulatory system, 12 percent; genitourinary diseases, 11 percent; rheumatic diseases, 27 percent; infectious and parasitic diseases, 22 percent; other diseases, 28 percent. Slightly more than one-fifth lasted 50 days and over.

The annual number of cases per 1,000 persons is shown in table 4 to be 31.6 for all respiratory diseases, 22.7 for nonrespiratory-nondigestive diseases, and 15.9 for digestive diseases. Respiratory diseases have the highest rate for durations of 8–14 days, 15–28 days, and 29–49 days. For durations of 50–91 days the other two diagnostic groups have higher rates than respiratory diseases.

The occurrence of sickness by broad diagnostic groups and age among drivers and other employees of company A is shown in table 5. Because of the small number of cases, the effect of age may perhaps best be shown by a series cumulated at 10-year intervals from 25 through 54 years. Certain general trends are evident. As was found for all bus and cab companies, increasing age tends to make

TABLE 3.—*Mortality and fatality rates from sickness and nonindustrial injuries by age groups among drivers and other employees of selected bus and cab companies, 1930–34, inclusive*

WHITE MALES

Occupation	All ages [1]	Age in years as of July 1, 1932		
		Under 35	35–44	45 and over
	Annual number of deaths per 1,000 persons			
All occupations	3.5	1.6	4.7	9.7
Drivers	3.0	1.3	5.1	11.0
Others	4.4	2.5	3.9	8.9
Ratio, drivers to others	68	52	131	124
	Percent of cases ending fatally			
All occupations	3.9	1.9	5.1	8.4
Drivers	3.1	1.5	4.8	7.5
Others	6.0	3.6	6.2	9.3
Ratio, drivers to others	52	42	77	81
	Number of deaths during 1930–34, inclusive [2]			
All occupations	43	12	17	13
Drivers	25	7	12	6
Others	18	5	5	7
	Number of cases that terminated during 1930–34, inclusive [3]			
All occupations	1,116	618	332	155
Drivers	816	479	252	80
Others	300	139	80	75
	Number of person-years of membership			
All occupations	12,361	7,295	3,653	1,335
Drivers	8,263	5,293	2,375	546
Others	4,098	2,002	1,278	789

[1] Includes some persons of unknown age.
[2] Includes sudden deaths and deaths which occurred before the end of the waiting period.
[3] Includes sudden deaths, all cases which ended in recovery or death before the 91st day, and cases which were arbitrarily closed on the 91st day after onset.

the relative difference between drivers and other employees greater with respect to the frequency of cases and the number of days of disability per person, and less with respect to the number of days per case. This would appear to indicate that the adverse influence of age is more strongly felt among drivers.

Among drivers the case frequency and the number of days per person increased most rapidly with age for respiratory diseases, less rapidly for nonrespiratory-nondigestive diseases, and very slightly for digestive diseases. Persons other than drivers showed an opposite tendency. With them respiratory and digestive diseases were less common when the older age groups were included in the calculations. Nonrespiratory-nondigestive diseases did not change greatly.

TABLE 4.—*Frequency of sickness causing disability lasting 8 calendar days or longer, by broad diagnostic groups and by duration in calendar days, among employees of bus company A, 1930–34, inclusive*

WHITE MALES

Duration of case in calendar days	Total	Respiratory diseases	Digestive diseases	Nonrespiratory-nondigestive diseases	Unknown
	Annual number of cases per 1,000 persons				
All durations [1]	73.7	31.6	15.9	22.7	3.5
8–14	19.2	9.2	3.0	5.7	1.3
15–28	25.9	13.3	4.1	6.9	1.6
29–49	14.5	5.1	4.3	4.5	.6
50–91	7.5	2.0	2.5	3.0	
92 and over	4.9	1.6	1.2	2.1	
	Number of cases beginning during 1930–34, inclusive				
All durations [2]	376	161	81	116	18
8–14	98	47	15	29	7
15–28	132	68	21	35	8
29–49	74	26	22	23	3
50–91	38	10	13	15	
92 and over [3]	25	8	6	11	

[1] Number of person-years of membership, 5,100.
[2] Includes some cases of unknown duration.
[3] Maximum benefit cases.

The average number of days of disability per case varied little with age, either for drivers or other employees. Except for respiratory diseases among drivers, which lasted a very short time, and digestive diseases among other employees, which were of long duration, there was little variation in the length of case according to occupation and diagnostic group.

Throughout all three age groups and for both drivers and nondrivers there was a remarkable similarity in the relative magnitude of case frequency rates and days per person, respectively. For both drivers and nondrivers the highest rates were, in general, for respiratory diseases, the next to the highest were for nonrespiratory-nondigestive diseases, and the lowest for digestive diseases. The relative magnitudes were reversed for days per case. Those diagnostic groups which had the highest frequency of cases had the shortest duration of disability.

From table 5 may be determined the percentages the rates for drivers are above or below the corresponding rates for nondrivers.

TABLE 5.—*Frequency of sickness causing disability lasting 8 calendar days or longer, annual number of days of disability per person, and average number of days per case, by broad diagnostic groups, and by age group (cumulated) among drivers and other employees of bus company A, 1930–34, inclusive*

WHITE MALES

Diagnostic group	25–34			25–44			25–54			All ages [2]		
	Drivers	Others	Ratio, drivers to others	Drivers	Others	Ratio, drivers to others	Drivers	Others	Ratio, drivers to others	Drivers	Others	Ratio, drivers to others
	Annual number of cases per 1,000 persons [3]											
All sickness [1]	75.5	53.5	141	80.5	44.5	181	84.8	46.5	182	86.3	47.4	182
Respiratory diseases	32.2	23.8	135	35.5	18.3	194	36.8	19.4	190	37.6	18.8	200
Digestive diseases	17.4	11.9	146	17.3	11.3	153	18.7	10.4	180	18.5	10.3	180
Nonrespiratory-nondigestive diseases	22.5	14.9	151	24.1	13.1	184	25.2	15.3	165	25.8	16.4	157
	Annual number of days of disability per person											
All sickness [1]	2.195	1.970	111	2.388	1.623	147	2.552	1.624	157	2.620	1.707	153
Respiratory diseases	.810	.826	98	.938	.621	151	.986	.583	169	1.030	.553	186
Digestive diseases	.609	.578	105	.587	.514	114	.646	.468	138	.647	.490	132
Nonrespiratory-nondigestive diseases	.723	.529	137	.793	.467	170	.841	.556	151	.861	.629	137
	Average number of days per case [3]											
All sickness [1]	29.1	36.8	79	29.7	36.5	81	30.1	35.0	86	30.4	36.0	84
Respiratory diseases	25.1	34.8	72	26.4	33.9	78	26.8	30.0	89	27.4	29.4	93
Digestive diseases	35.0	48.6	72	34.0	45.3	75	34.6	45.0	77	34.9	47.4	74
Nonrespiratory-nondigestive diseases	32.2	35.6	90	32.9	35.7	92	33.4	36.5	92	33.4	38.4	87
	Number of cases beginning during 1930–34, inclusive											
All sickness [1]	178	36	------	261	51	------	286	67	------	298	78	------
Respiratory diseases	76	16	------	115	21	------	124	28	------	130	31	------
Digestive diseases	41	8	------	56	13	------	63	15	------	64	17	------
Nonrespiratory-nondigestive diseases	53	10	------	78	15	------	85	22	------	89	27	------
	Number of calendar days of disability [4]											
All sickness [1]	5,177	1,326	------	7,743	1,862	------	8,611	2,342	------	9,050	2,810	------
Respiratory diseases	1,910	556	------	3,040	712	------	3,328	840	------	3,558	911	------
Digestive diseases	1,437	389	------	1,902	589	------	2,180	675	------	2,236	806	------
Nonrespiratory-nondigestive diseases	1,705	356	------	2,570	536	------	2,838	802	------	2,973	1,036	------
Number of person-years of membership	2,359	673	------	3,242	1,147	------	3,374	1,442	------	3,454	1,646	------

[1] Includes unknown diagnoses.

[2] Includes persons of unknown age, persons under 25 years of age, and persons 55 years of age and over.

[3] Cases include only those which began during the study period, but days of disability include days for cases which began prior to, as well as during, the study period. This seeming excess of days of disability is compensated in part by the fact that days subsequent to 1934 are not included, even though some cases had not ended or reached 91 days at the close of the study period.

[4] Includes all days of disability during the study period, regardless of when the disability began. Disabilities which reached 91 days or over were arbitrarily terminated at 91 days; those with a maximum benefit period of less than 91 days were raised to 91 days.

The excess in the frequency rate of drivers was greatest for respiratory diseases, reaching 94 percent at ages 25 through 44 years. During the same period the excess in the rate of nonrespiratory-nondigestive diseases rose to a maximum of 84 percent. With the inclusion of persons 45–54 years of age the frequency rates for both of the above diagnostic groups were slightly less unfavorable for drivers. This was not due to a decline in the frequency of cases among drivers, but to a reversal of the trend among nondrivers. On the other hand, the excesses in the rates for digestive diseases were successively greater as the age groups were cumulated, reaching 80 percent in the age group 25 through 54 years. The position of drivers was decidedly less unfavorable during youth. During the period 25–34 years the excess in the frequency rate for drivers compared with nondrivers was 35 percent for respiratory diseases, 46 percent for digestive diseases, and 51 percent for nonrespiratory-nondigestive diseases.

The percentage excess in the days lost per person among drivers was less than the excess in the frequency rate per 1,000 cases for each corresponding diagnosis and age group. Indeed, from 25 through 34 years drivers had a slightly more favorable experience than nondrivers with respect to days lost per person from respiratory diseases. When older ages were included, this was no longer in evidence.

The experience of drivers was favorable with respect to the average number of days lost per case. The average duration of cases of respiratory disease among drivers of all ages was 7 percent shorter than among nondrivers; nonrespiratory-nondigestive diseases were 13 percent shorter, and digestive diseases were 26 percent shorter. With the exception of nonrespiratory-nondigestive diseases, which showed little change with age, there was a tendency for the duration of cases among drivers to become relatively less favorable as the older age groups were included.

When nonrespiratory-nondigestive diseases are further subdivided, it appears that the frequency rates for drivers are definitely in excess for rheumatic diseases, infectious and parasitic diseases, diseases of the organs of vision, and nervous diseases. Some portion of this excess among drivers may be due to the nature of their occupation, which may prevent them from working when persons in other occupations with similar symptoms would be able to attend to their regular duties.

SUMMARY

In a study of three bus and cab companies, drivers were found to have a higher frequency of disabling sickness and nonindustrial injuries and a greater average number of days of disability per person than nondrivers in the corresponding companies. On the other

hand, the average number of days per case was less among drivers than among nondrivers. There was a tendency for the relative difference between drivers and others to increase with age until 45 years and over.

Examination of the records of one company where separation by diagnostic groups was practicable revealed that at all ages the most common diseases were also those which showed the greatest excess among drivers. In order of decreasing magnitude these were as follows: Respiratory diseases, nonrespiratory-nondigestive diseases, and digestive diseases; when arranged according to duration, those types of sickness which were most frequent were found to have the shortest average number of days per case.

A consideration of the age factor as related to diagnosis showed that the relative excess in the frequency rates of drivers compared with nondrivers was little different for each of the three diagnostic groups at ages 25–34 years, but at ages 25–44 years there was a sharp rise in the excess of respiratory diseases, and at 25–54 the excess of digestive diseases rose.

STUDIES OF SEWAGE PURIFICATION

IX. TOTAL PURIFICATION, OXIDATION, ADSORPTION, AND SYNTHESIS OF NUTRIENT SUBSTRATES BY ACTIVATED SLUDGE*

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The first phenomenon taking place when a nutrient substrate such as sewage is aerated with activated sludge has been described (Parsons (*1*), Theriault (*2*), Heukelekian (*3*), and others) as the clarification stage. The term clarification has been defined as the removal of carbonaceous and nitrogenous organic matter in all states of dispersion (suspension, colloidal, and true solution) from the substrate by the sludge as a result of coagulation, adsorption, and other mechanisms. A number of theories to explain the mechanism of clarification have been proposed and have been recently reviewed by Theriault (*2*). Theriault (*4*), (*5*), (*6*), has also proposed a new biozeolitic theory. These theories will not be discussed here. The clarification process is generally considered to be very rapid, equilibrium being reached in 30 to 40 minutes. This stage is followed by what has been described as reactivation, or restoration of the powers of clarification. The present paper is a further presentation of the results of a study of clarification and reactivation phenomena of the activated sludge process.

* Published also in the March issue of the Sewage Works Journal.—Ed.

In three earlier papers (*7*, *8*, *9*) of this series, data upon the oxidation rates of nutrient substrates aerated with activated sludge during the clarification stage have been obtained by the "difference" method. In these papers data were presented on the rate of reduction of the biochemical oxygen demand of the organic matter in the substrates that resulted during portions of the first 24-hour aeration period with activated sludge. The studies showed definitely that rates of biochemical oxidation of substrates by activated sludge are much higher than the rates obtained normally in polluted streams or in dilution bottles. The tremendous bacterial populations containing oxidation enzymes, present and active, when fresh nutrient substrates are mixed with activated sludge was proposed as the explanation of the high rates of biochemical oxidation that are observed.

It is the purpose of this paper to present data on the total removal of biochemical oxygen demand (B. O D.) of nutrient substrates by activated sludge and to show what portion of the total removal may be accounted for by oxidation. The demonstration of the portion of the total B. O. D. removal that is the result of oxidation has not been made before. The removal of organic matter as measured by the reduction of the total carbonaceous oxygen demand (*L* value) of the substrate will be defined here as the total B. O. D. removal or total purification. The quantity of oxygen utilized by the sludge—nutrient substrate mixture as a result of the addition of the substrate (as has been described (*8*, *9*)—is defined as the B. O. D. of the substrate removed by oxidation. The difference between the total B. O. D. removal and the oxidation of the substrate will be referred to here as the net adsorption and synthesis. It should be understood, however, that the term "net adsorption and synthesis" is used simply for convenience and that this term includes also any B. O. D. removal accomplished by coagulation, hydrolysis, and any possible mechanisms other than oxidation.

EXPERIMENTAL METHODS

Sludge.—Data will be presented showing the total purification and oxidation of substrates when aerated in the presence of pure culture and plant activated sludges. The pure culture sludges used were identical with those already described (*8*). The plant sludges were obtained from the north side plant at Lancaster, Pa., and from the experimental plant at this station.

Nutrient substrates.—Synthetic sewage of the composition given in an earlier paper (*8*) of this series was used in experiments with both pure culture and plant activated sludge. This material simulated sewage in its biochemical oxygen demand value but had no suspended detritus and contained all of the nutrient material in true colloidal or soluble form. It contained peptone and meat extract as nutrients besides small quantities of urea, disodium-hydrogen phosphate, and other inorganic salts usually found in sewage. Domestic sewage filtered through cotton was used in experiments with normal activated sludge and after sterilization also with the pure culture sludge. The domestic sewage was heat sterilized (15 pounds steam pressure for 20 minutes) when used in experiments with pure culture sludge. Previous experimental work (*8*) indicated that heat sterilization altered the condition of the sewage less than other sterilization methods and also that this sterilized sewage was as suitable a substrate for activated sludge development as the sewage before sterilization.

Dilution water.—The quarter strength phosphate buffered (*10*) (formula C) water was used for all dilution purposes in these experiments.

General procedure.—The procedure followed in these experiments has been described in detail (*8*). Briefly it consisted of aerating simultaneously and at approximately the same rate, 6 liters of sludge-nutrient substrate mixtures in one large bottle and a liter of sludge-dilution water mixture and a liter of sludge-nutrient substrate mixture in two separate closed aeration bottles. The total B. O. D. removal was determined by periodic examination of the substrate in the large bottle and the extent of oxidation was followed in the closed bottles.

In order to save the time required to separate the sludge from the supernatant by settling and to reduce the quantity of sample required, each aeration mixture sample taken to determine total B. O. D. removal was first filtered through No. 1 Whatman paper, and diluted portions of the filtrate were then immediately prepared for incubation. This procedure, used in experiments with synthetic sewage, did not remove any oxidizable material which would not have been removed by settling, for the synthetic sewage nutrients were entirely in colloidal and soluble form. In the experiments with cotton filtered sewage it is possible that the procedure may have indicated in some cases a slightly higher organic matter removal than would have been obtained by settling after short periods of aeration.

However, comparative B. O. D. tests on filtered supernatant and supernatant after one hour's settling, following 24-hour aeration periods of sterile sewage and synthetic sewage with pure culture activated sludge, indicated that there was very little difference between the two procedures. These computed L values as derived from B. O. D. results at various periods of incubation are given in the accompanying tabulation:

Experiment number	Substrate feed	Initial L value of substrate		L value of substrate after 24 hours		Percentage reduction	
		Settled	Filtered	Settled	Filtered	Settled	Filtered
1	Sterile sewage	279	277	33.7	21.8	87.9	92.1
2	Do	517	515	49.0	56.8	90.5	88.9
3	Synthetic sewage	----------	400	36.7	34.2	90.8	91.5

The filtration procedure was, therefore, adopted for all experiments as being the best method of removing the sludge particles quickly in order to obtain an estimate of the total quantity of nutrient material remaining in the substrate.

PURE CULTURE ACTIVATED SLUDGE EXPERIMENTS

The pure culture sludges represent the simplest activated sludge system because they contain the flocs of only one bacterial species and no plankton or protozoa. Accordingly, the data on the experiments performed with pure culture sludge will be presented first. In table 1 are presented the basic data of biochemical oxygen demands of the nutrient substrates used in all our experiments with pure culture sludge. The initial B. O. D. of the mixture of nutrient substrate and remaining sludge liquor was calculated from the B. O. D. of the old supernatant removed and the B. O. D. of the nutrient substrate added. The B. O. D. of the supernatant after various periods of aeration was determined by the dilution method. Using the theoretical formula for rate of carbonaceous oxidation of sewage at 20° C [$y=L\ (1-10^{-kt})$] with $k=0.1$ and each B. O. D. value of the supernatant shown in table 1, an L value or total carbonaceous oxygen demand was calculated. However, B. O. D. observations for long incubation periods, where examination showed nitrification, were not included in calculations of the L value. The means of the L values calculated from all incubation time B. O. D. observations for the supernatant after each aeration time are shown in table 2.

From the data in table 2, the percentage reduction in the total carbonaceous oxygen demands (L values) of the substrates obtained after various periods of aeration with pure culture sludge were calculated and are shown in table 3. Curves showing the mean percentage reduction of these L values for the experiments with sterile sewage and with synthetic sewage substrates aerated with pure culture sludge are shown in figure 1. Curves showing the maximum and minimum substrate L value reductions obtained on both sterile sewage and on synthetic sewage are shown in figure 2. These curves indicate that the L value of the substrate was removed very rapidly by pure culture activated sludge which had been developed on either sterile sewage or on synthetic sewage. The fact that there is a con-

TABLE 1.—*B. O. D. of supernatants when nutrient substrates are aerated in the presence of pure culture activated sludge*

Experiment No.	Suspended solids, p. p. m.	Nutrient substrate	B. O. D. incubation period, days	B. O. D. of supernatant liquor after the indicated aeration time in hours						
				0	½	1½	3	5	10	24
1	1,420	Sterile sewage	2	109.0	59.5	19.8	12.8	12.0	-------	[1] 7.9
			3	138.0	62.0	23.8	15.2	15.0	-------	[1] 10.1
			4	164.0	81.0	27.4	17.0	18.0	-------	[1] 12.2
			5	186.0	97.5	31.8	22.2	19.7	-------	[1] 14.9
2	1,632	Synthetic sewage	2	174.0	85.0	61.0	22.5	12.5	-------	[1] 7.0
			3	193.0	114.0	89.0	35.0	23.5	-------	[1] 11.2
			4	208.0	141.0	103.0	47.5	39.5	-------	[1] 15.3
			5	228.0	157.0	114.0	51.0	38.5	-------	[1] 15.8
3	843	Sterile sewage	2	159.0	67.5	[2] 32.2	-------	[3] 18.0	-------	8.2
			5	202.0	95.5	[2] 46.0	-------	[3] 26.4	-------	14.4
			7	242.0	112.0	[2] 51.2	-------	[3] 27.2	-------	26.0
			11	230.0	100.0	[2] 53.7	-------	[3] 32.6	-------	28.0
			13	249.0	104.0	[2] 63.5	-------	[3] 35.8	-------	31.5
4	2,644	do	2	90.0	30.5	19.0	13.0	9.4	9.2	7.2
			5	129.0	40.0	-------	15.0	13.0	9.6	12.6
			7	130.0	39.0	15.5	20.7	18.4	10.8	13.9
			10	135.0	61.0	27.7	21.0	16.8	16.0	17.6
			15	133.0	60.5	36.5	36.0	24.4	22.0	[4] 21.6
			20	186.0	79.0	39.7	[4] 57.0	31.8	26.0	[4] 34.2
5	1,560	Synthetic sewage	2	113.0	-------	28.2	10.0	18.8	19.6	10.3
			5	154.0	66.0	44.5	27.2	22.6	28.0	15.5
			7	172.0	110.0	47.5	28.5	24.8	36.0	17.3
			10	205.0	122.0	51.7	30.7	35.4	37.8	23.3
			15	215.0	120.0	55.0	44.0	39.2	45.0	29.2
			20	305.0	149.0	68.5	42.7	[4] 67.6	43.2	[4] 53.8
6	2,428	do	2	113.0	78.5	51.5	20.0	13.8	8.0	13.5
			5	154.0	114.0	78.0	31.2	19.6	16.4	20.8
			7	171.0	121.0	74.0	34.5	25.2	21.8	26.0
			10	205.0	133.0	90.5	40.0	18.8	26.0	35.0
			15	214.0	149.0	107.0	51.5	40.4	23.4	[4] 78.9
			20	305.0	165.0	131.0	[4] 100.0	45.0	29.2	[4] 161.0
7	1,632	Sterile sewage	2	89.9	27.5	27.0	21.2	17.8	11.2	22.6
			5	129.0	42.5	41.0	27.2	18.0	15.4	26.4
			7	130.0	45.0	39.0	34.0	23.8	19.4	28.7
			10	135.0	55.0	53.0	36.7	33.4	19.6	30.0
			15	132.0	-------	57.0	52.7	51.0	19.9	46.4
			20	190.0	-------	109.0	85.5	69.6	36.0	81.2
8	1,056	do	2	196.0	88.5	40.5	23.2	17.8	14.6	12.1
			5	289.0	115.0	56.0	35.7	28.0	18.2	19.5
			7	286.0	113.0	64.5	42.2	33.6	22.0	22.8
			10	337.0	124.0	72.0	45.7	37.2	40.0	29.7
			15	358.0	135.0	78.2	49.8	46.2	43.8	30.8
			20	435.0	150.0	85.0	85.0	41.6	46.0	38.2
9	2,112	do	2	196.0	56.5	29.5	18.5	17.2	11.6	9.5
			5	289.0	95.0	51.0	28.0	24.2	17.0	17.0
			7	277.0	96.5	64.5	35.7	24.0	24.0	19.5
			10	336.0	110.0	67.5	39.0	28.6	34.0	18.0
			15	359.0	106.0	73.0	39.5	27.2	34.8	23.9
			20	434.0	140.0	77.5	44.7	33.0	35.4	28.5
10	1,112	Synthetic sewage	2	81.3	65.5	44.5	22.5	[5] 18.0	8.6	13.6
			5	108.0	85.0	65.0	31.2	[5] 23.6	20.6	16.0
			7	123.0	98.0	78.0	36.0	[5] 27.8	24.0	19.0
			10	166.0	105.0	90.0	41.7	[5] 29.6	30.0	22.4
			15	172.0	-------	122.5	48.5	[5] 41.0	35.0	24.6
			20	210.0	128.0	102.0	49.7	[5] 41.4	36.4	26.3
11	2,232	do	2	79.6	43.0	19.5	17.5	8.4	15.0	9.6
			5	106.0	66.0	33.5	21.2	25.0	19.0	11.5
			7	122.0	72.0	40.0	23.7	30.4	20.0	12.8
			10	165.0	85.0	35.0	28.7	35.8	22.0	18.1
			15	170.0	88.5	48.0	38.2	32.0	24.0	18.7
			20	207.0	115.0	53.5	47.5	40.0	35.0	24.7

[1] 22 hours. [2] 2 hours. [3] 4 hours. [4] Nitrification indicated. [5] 4½ hours.

sistent difference between the curves representing the L value removed in the synthetic sewage and in the sterile sewage experiments may be explained in whole or in part by chemical as well as physical differences between the two substrates, but the possibility cannot be ruled out that part of the observed difference may be a reflection of an unequal response of the sterile sewage and synthetic sewage substrates to the filtration technique. However, it is believed that future research will probably show that most of the difference may be ascribed to the chemical and physical differences between the two substrates. It will be noted from table 3 and figures 1 and 2 that the total purification was less rapid with synthetic sewage, that is, in a substrate in which all of the nutrient material was in colloidal or true solution.

TABLE 2.—*Total carbonaceous oxygen demand (L value) of supernatant when nutrient substrates are aerated in the presence of pure culture activated sludge*

Experiment No.[1]	L value of supernatant liquor initially and after the indicated aeration time in hours						
	Initial	½	1½	3	5	10	24
1	279	141	48.4	31.5	30.3		[2] 20.9
2	384	231	170.0	71.2	50.7		[2] 22.5
3	277	124	[3] 64.1		[4] 36.4		29.3
4	178	66.7	35.9	28.7	23.9	19.9	18.7
5	251	129	64.0	37.5	38.9	45.2	25.7
6	250	167	115.0	48.1	34.3	25.9	34.6
7	179	63.5	59.9	47.0	38.8	25.9	43.4
8	416	163	86.5	59.3	43.7	38.3	32.2
9	414	131	77.3	44.1	34.2	32.6	24.8
10	184	134	107.0	49.7	[5] 39.2	31.6	26.8
11	182	101	49.1	37.9	35.1	29.7	20.5

[1] Sterile sewage feed used in experiments 1, 3, 4, 7, 8, 9. Synthetic sewage feed used in experiments 2, 5, 6, 10, 11. [2] 22 hours. [3] 2 hours. [4] 4 hours. [5] 4½ hours.

TABLE 3.—*Percentage reduction of total carbonaceous oxygen demand (L value) of supernatants when nutrient substrates are aerated in the presence of pure culture activated sludge*

Experiment No.	L value of initial supernatant, p. p. m.	Percentage reduction of L value after indicated aeration time in hours					
		½	1½	3	5	10	24
1	279	49.5	82.7	88.7	89.1		[1] 92.5
2	384	39.8	55.7	81.5	86.8		[1] 94.1
3	277	55.2	[2] 76.9		[3] 86.9		89.4
4	178	62.5	79.8	83.9	86.6	88.8	89.5
5	251	48.6	74.5	85.1	84.5	82.0	89.8
6	250	33.2	54.0	80.8	86.3	89.6	86.2
7	179	64.5	66.5	73.7	78.3	85.5	75.8
8	416	60.8	79.2	85.7	89.5	90.7	92.3
9	414	68.4	81.3	89.3	[4] 91.7	92.1	94.0
10	184	27.2	41.8	73.0	78.7	82.8	85.4
11	182	44.5	73.0	79.2	80.7	83.7	88.7
Sterile sewage, average [5]	290	60.2	77.7	84.3	87.0	89.3	88.9
Synthetic sewage, average [6]	250	38.7	59.8	79.9	83.4	84.5	88.8

[1] 22 hours.
[2] 2 hours.
[3] 4 hours.
[4] 4½ hours.
[5] Sterile sewage feed used in experiments 1, 3, 4, 7, 8, 9.
[6] Synthetic sewage feed used in experiments 2, 5, 6, 10, 11.

As the larger suspended particles would be removed from sewage by filtration through paper, the sewage purification, as illustrated by these curves, might be criticized as being too rapid, due to the filtration employed to separate the supernatant from the sludge before the B. O. D. tests were made. It has been shown (*3, 11*) that suspended matter is easily removed by aeration of sewage followed by

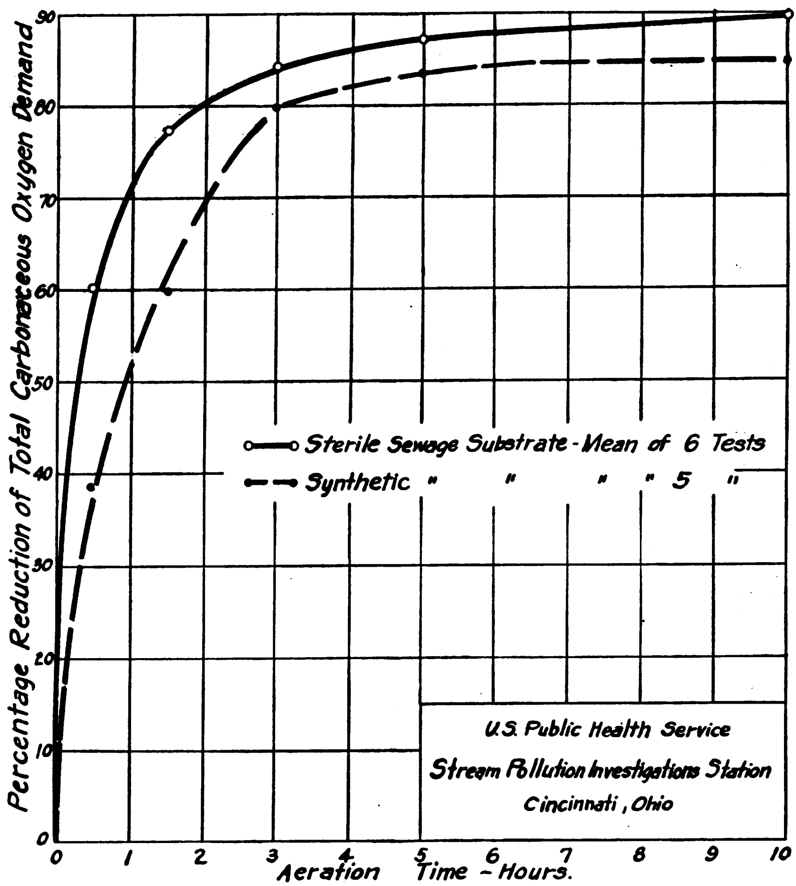

FIGURE 1.—Total purification of nutrient substrate aerated in the presence of pure culture activated sludge.

sedimentation and more easily by aeration in the presence of activated sludge. Also, as stated previously, comparative tests on supernatants after filtration and after settling showed no material differences. It is believed, therefore, that the filtration, introduced to separate the sludge quickly, did not alter materially the B. O. D. removal results in the experiments employing normal sewage.

The quantities of oxygen used to oxidize the nutrient substrates in the experiments with pure culture sludge are shown in table 4. The method of obtaining these data has been described (*8*) in detail and need not be repeated here. Table 5 shows the data of table 4 computed to percentages of the initial L values of the supernatant. These results represent the proportion of the substrate L values oxidized in successive periods. In figure 3 are representative curves illustrative of the rate of reduction of the L value of the substrate produced by oxidation. It should be noted that between 27 and 40 percent of

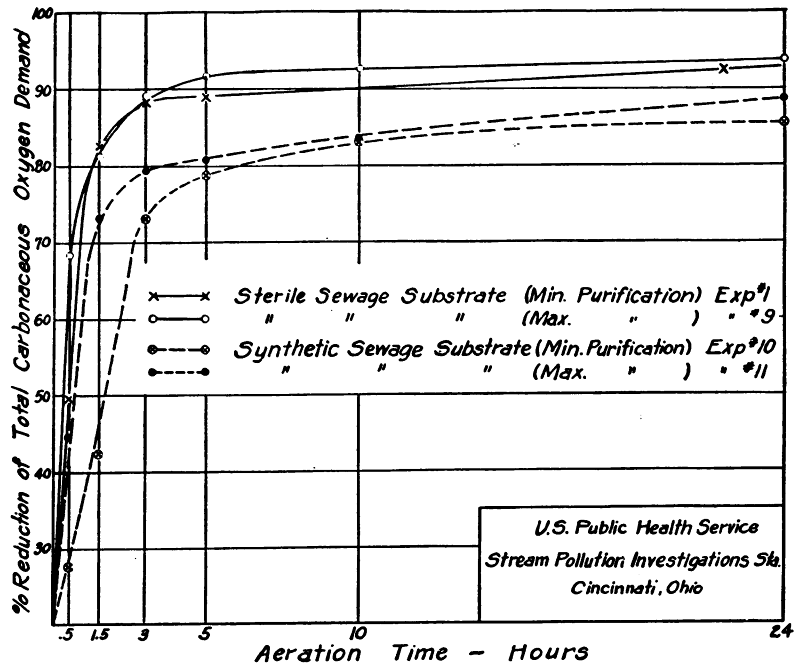

FIGURE 2.—Representative curves showing total purification of nutrient substrates aerated in the presence of pure culture activated sludge.

TABLE 4.—*Quantities of oxygen used to oxidize the nutrient substrate when aerated in the presence of pure culture activated sludge*

Experiment No.	Initial L value of supernatant, p. p. m.	Milligrams of oxygen used per liter in indicated time in hours					
		½	1½	3	5	10	24
1	279	24.8	47.5	63.8	75.3		[1] 111.9
2	384	31.0	79.3	106.9	121.0		[1] 158.3
3	277	20.7	[2] 54.4		[3] 75.5		159.8
4	178	21.3	40.7	56.7	52.0	75.8	107.9
5	251	22.7	56.8	77.8	94.5	105.8	115.8
6	250	12.3	38.3	63.0	83.8	99.5	155.8
7	179	20.4	40.9	46.3	64.4	74.8	103.9
8	416	29.7	63.2	86.7	118.0	166.4	233.0
9	414	48.6	72.4	102.9	130.1	158.4	193.2
10	184	27.0	40.8	53.3	[4] 67.2	86.3	95.6
11	182	24.7	47.8	63.6	74.5	83.5	84.2

[1] 22 hours.
[2] 2 hours.
[3] 4 hours.
[4] 4½ hours.

TABLE 5.—*Percentage of the total carbonaceous oxygen demand (L value) of the nutrient substrate oxidized when aerated in the presence of pure culture activated sludge*

Experiment No.	Percentage oxidized in the indicated time in hours					
	½	1½	3	5	10	24
1	8.9	17.0	22.9	27.0		[1] 40.1
2	8.1	20.7	27.8	31.5		[1] 41.2
3	7.5	[2] 19.6		[3] 27.3		57.5
4	12.0	22.9	31.9	29.2	42.6	60.6
5	9.0	22.6	31.0	37.6	42.2	45.9
6	4.9	15.3	25.2	33.5	39.8	62.3
7	11.4	22.8	25.9	36.0	41.8	58.0
8	7.1	15.2	20.8	28.4	40.0	56.0
9	11.7	17.5	24.9	31.4	38.3	46.7
10	14.7	22.2	29.0	[4] 36.5	46.9	52.0
11	13.6	26.3	34.9	40.9	45.9	46.3

[1] 22 hours. [2] 2 hours. [3] 4 hours. [4] 4½ hours.

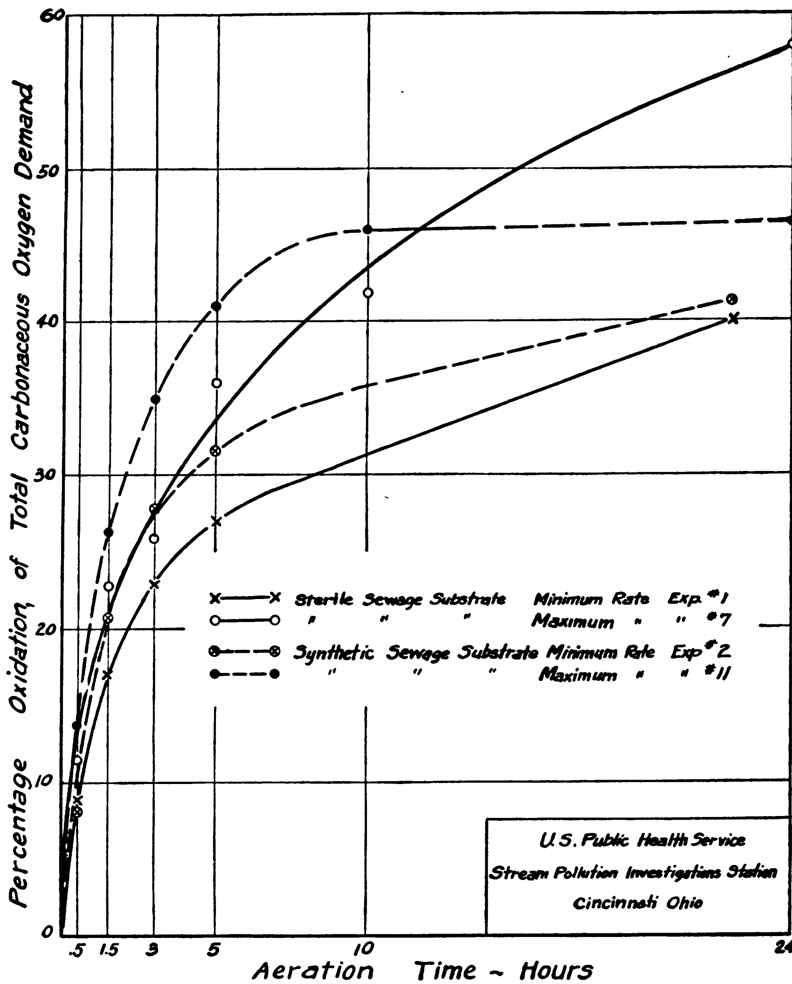

FIGURE 3.—Representative curves showing oxidation of nutrient substrates aerated in the presence of pure culture activated sludge.

the L value of the substrate has been oxidized in 5 hours' aeration and that these figures increase to about 40 to 60 percent at the end of 24 hours. This shows that with these activated sludge systems, a greater proportion of the L value of the substrate was satisfied in the first 5 hours than is satisfied in the first day under normal biochemical oxidation (20.5 percent with a k of 0.1 at 20° C.).

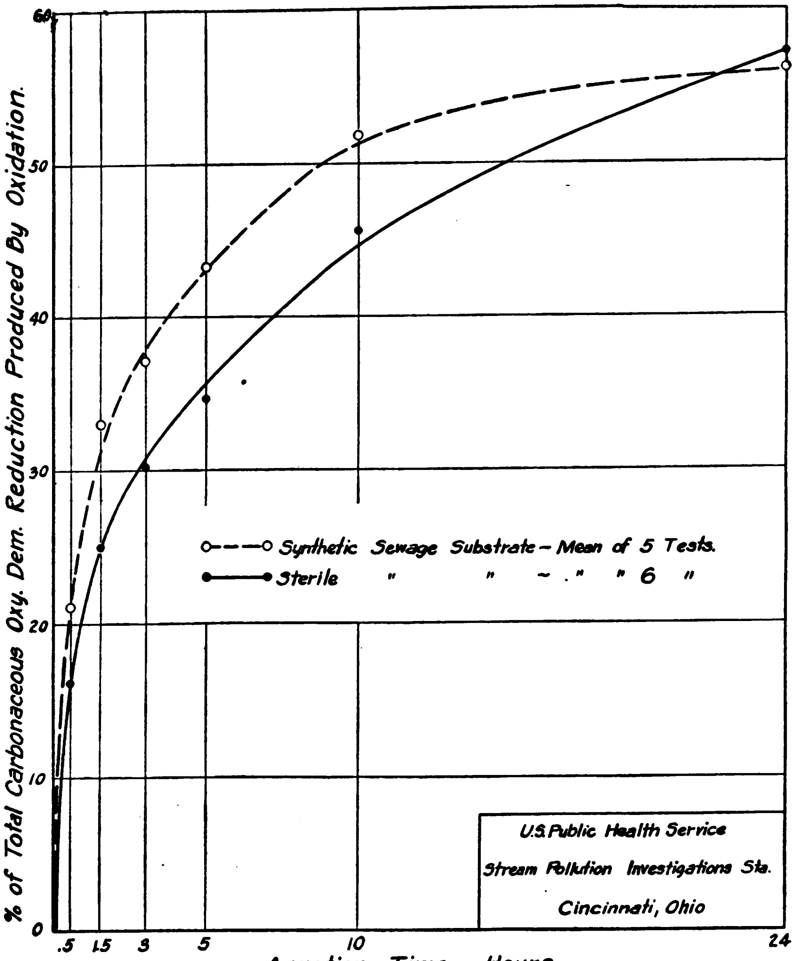

FIGURE 4.—Percentage of total carbonaceous oxygen demand reduction produced by oxidation of nutrient substrates aerated with pure culture activated sludge.

PURIFICATION BY OXIDATION

When the percentages of the L value of the substrates that are oxidized, as given in table 5, are divided by the corresponding percentages of total purification, as given in table 3, the fractions of the total purification that have been accomplished by oxidation are obtained. The results of these computations are shown in table 7. The mean percentages of the total carbonaceous purification that is accomplished by oxidation for the synthetic and sterile sewage experiments are plotted in figure 4. These data indicate that, with pure culture activated sludge (developed by one species of bacteria rather than a grossly mixed culture), an average of 16 and 21 percent of the *L* value removed during the first half hour was the result of oxidation. These percentages increased rapidly and, at the end of 5 hours, an average of about 35 and 43 percent, respectively, of the total purification of sterile sewage and of synthetic sewage was the result of oxidation. The data definitely indicate that biochemical oxidation is a factor of major importance to the clarification stage of these activated sludge systems.

TABLE 6.—*Net percentage of the total carbonaceous oxygen demand (L value) of the nutrient substrate that is removed by adsorption and synthesis when aerated in the presence of pure culture activated sludge*

Experiment No.	Nutrient substrate used	Net percentage removed by adsorption and synthesis in indicated time in hours					
		½	1½	3	5	10	24
1	Sterile sewage	40.6	65.7	65.8	62.1	-------	52.4
3	do	47.7	[1] 57.3	-------	59.6	-------	31.9
4	do	50.5	56.9	52.0	57.4	46.2	28.9
7	do	53.1	43.7	47.8	42.3	43.7	17.8
8	do	53.7	64.0	64.9	61.1	50.7	36.3
9	do	56.7	63.8	64.4	60.3	53.8	47.3
Mean	do	50.4	58.6	59.0	57.1	48.6	35.8
2	Synthetic sewage	31.7	35.0	53.7	55.3	-------	[3] 52.9
5	do	39.6	51.9	54.1	46.9	39.8	43.9
6	do	28.3	38.7	55.6	52.8	49.8	23.9
10	do	12.5	19.6	44.0	[4] 42.2	35.9	33.4
11	do	30.9	46.7	44.3	39.8	37.8	42.4
Mean	do	28.6	38.4	50 3	47.4	40.8	39.3

[1] 2 hours. [2] 4 hours. [3] 22 hours. [4] 4½ hours.

NET ADSORPTION AND SYNTHESIS

As the percentage of the *L* value of the substrate that has been removed and the percentage that has been oxidized are given in tables 3 and 5, respectively, it is necessary only to subtract the percentages in the latter table from the corresponding percentages in the former to obtain an estimate of the percentages of purification that were the result of net adsorption and synthesis. The net percentages of the *L* value of the substrate that is removed by adsorption and synthesis, computed in this way, are shown in table 6. In figures 5 and 6 are shown the total purification, oxidation, and net adsorption and synthesis curves for experiments 9 and 11 with sterile sewage and with synthetic sewage, respectively. These two figures illustrate the proportions of the total purification assignable to oxidation and to net adsorption and synthesis which may be expected to occur duing the first 10 hours of aeration with pure culture sludges.

Figure 7 shows the mean net adsorption and synthesis curves for sterile and for synthetic sewage aerated with pure cultures.

Table 7.—*Percentage of the total carbonaceous oxygen demand reduction of the substrate actually oxidized when aerated with pure culture activated sludge*

Experiment No.	Substrate feed used	Percentage oxidized in the indicated aeration time in hours					
		½	1½	3	5	10	24
1	Sterile sewage	18.0	20.6	25.8	30.3	-------	[1] 43.4
3	do	13.6	[2] 25.5	-------	[3] 31.4	-------	64.3
4	do	19.2	28.7	38.0	33.7	48.0	67.7
7	do	17.7	34.3	35.1	46.0	48.9	76.5
8	do	11.7	19.2	24.3	31.7	44.1	60.7
9	do	17.1	21.5	27.9	34.2	41.6	49.7
Mean	do	16.2	25.0	30.2	34.6	45.6	[4] 57.2
2	Synthetic sewage	20.4	37.2	34.1	36.3	-------	[1] 43.8
5	do	18.5	30.3	36.4	44.5	51.5	51.1
6	do	14.8	28.3	31.2	38.8	44.4	72.3
10	do	54.0	53.1	39.7	[5] 46.4	56.6	60.9
11	do	30.6	36.0	41.1	50.7	54.8	52.2
Mean	do	[6] 21.1	[6] 33.0	37.1	43.3	51.8	56.1

[1] 22 hours. [2] 2 hours. [3] 4 hours. [4] Excluding No. 7. [5] 4½ hours. [6] Excluding No. 10.

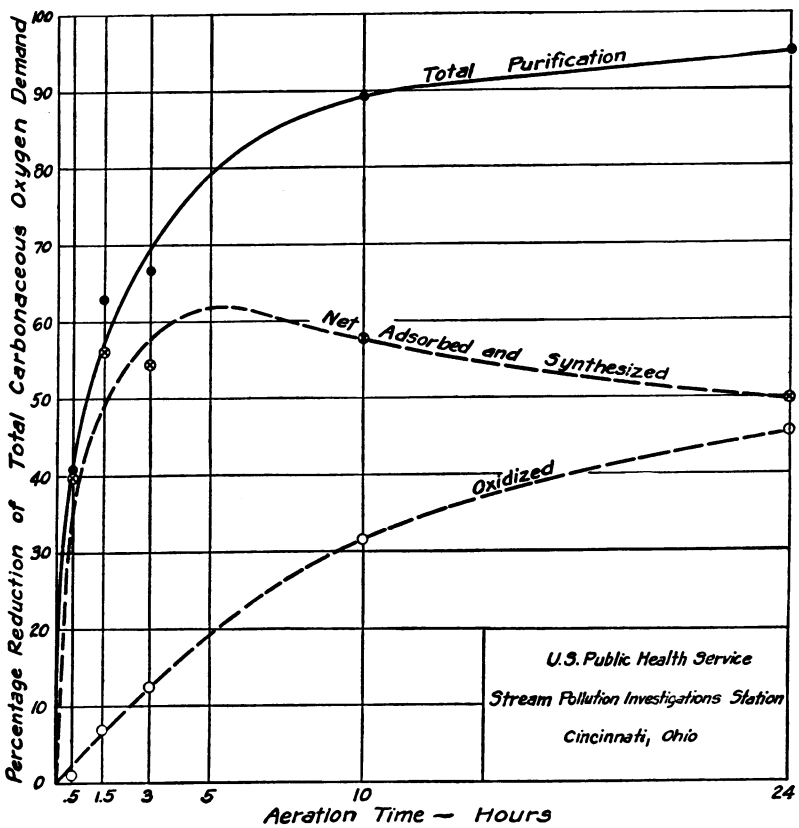

Figure 5.—Representative curves showing reduction of total carbonaceous oxygen demand of sterile sewage substrate aerated with pure culture activated sludge. (Exp. No. 9.)

NORMAL ACTIVATED SLUDGE EXPERIMENTS

The experiments with normal (i. e., grossly mixed cultures) activated sludge were conducted in exactly the same way as those with pure culture sludge. Activated sludge from the north plant at Lancaster, Pa., was used in the first eight experiments. Experiment 9 consisted of a series of tests made on sludge from our experimental

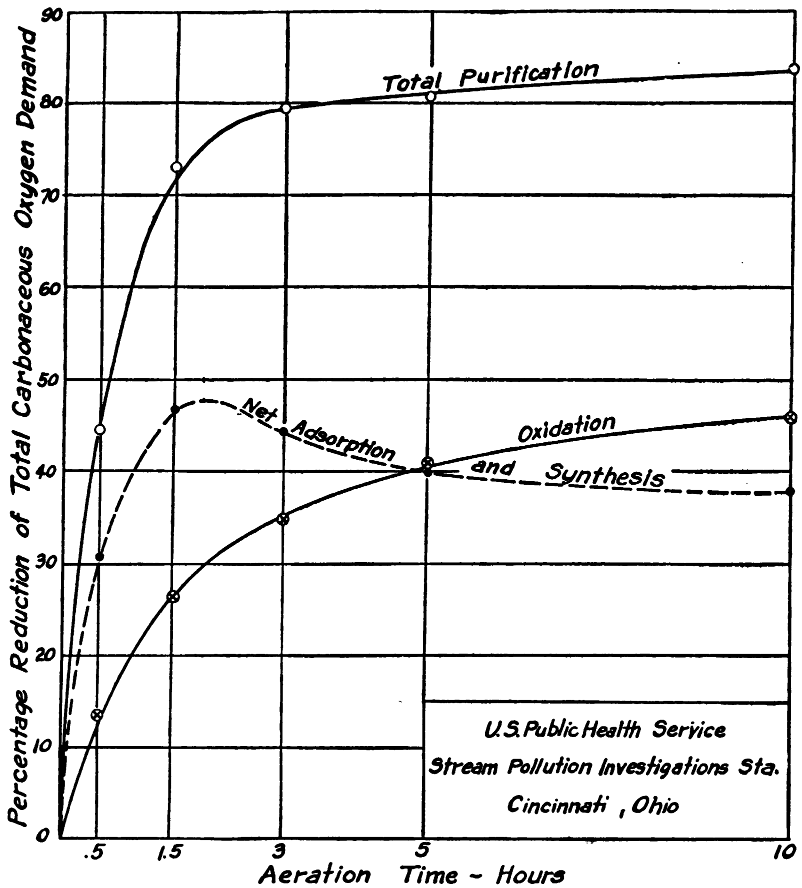

FIGURE 6.—Representative curves showing reduction of total carbonaceous oxygen demand of synthetic sewage substrate aerated with pure culture activated sludge. (Exp. No. 11.)

plant during the development of activated sludge. The details of experiment 9 have been described (9) and need not be repeated.

The basic data showing the biochemical oxygen demands of the supernatants in this series of experiments are given in table 8. The mean total carbonaceous oxygen demands (L values) were calculated from the data in table 8 in the manner previously described. These calculated data are presented in table 9. The percentages of reduction of the total carbonaceous oxygen demands were calculated as for the pure culture experiments. These percentages are shown in table 10.

The quantities of oxygen used to oxidize the nutrient substrates in these experiments are given in table 11. With these quantities and the initial total carbonaceous B. O. D. (L value) of the substrate the

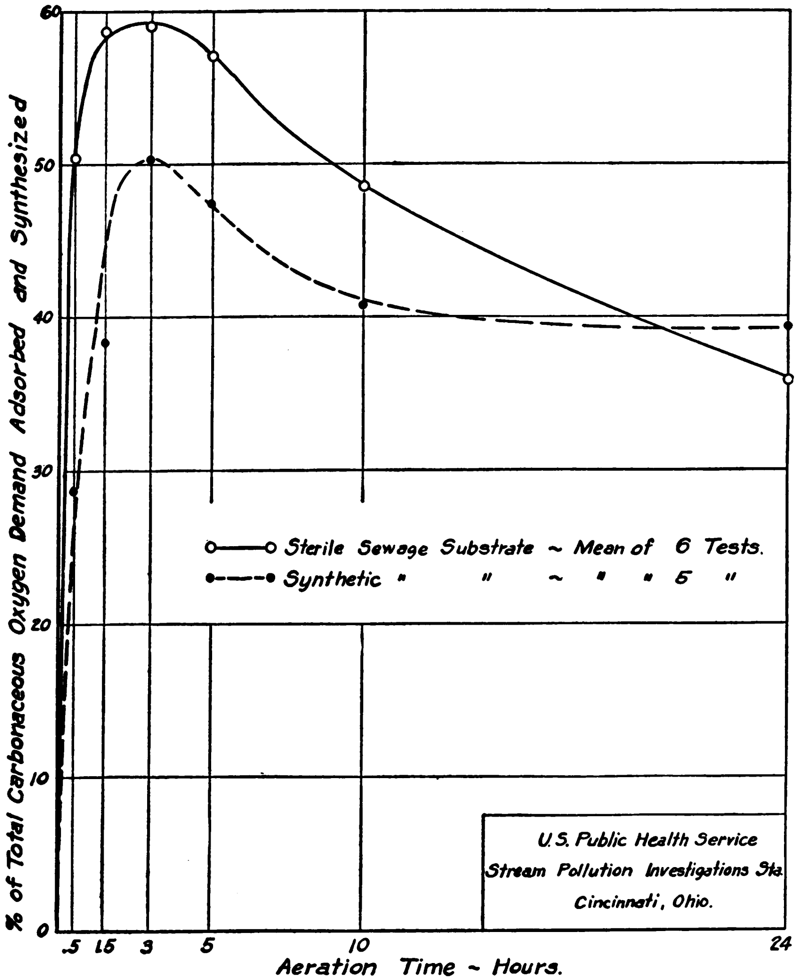

FIGURE 7.—Net percentage of total carbonaceous oxygen demand (L value) of nutrient substrates removed by adsorption and synthesis when aerated in the presence of pure culture activated sludge.

percentages of the L value oxidized were calculated as shown in table 12.

The asterisks in tables 11 and 12 indicate that, in experiments 4, 8, and 9–S9, nitrification of the substrate was under way at the completion of the experiments when examinations for nitrite and nitrate were made. As examinations for nitrite and nitrate had not been made

TABLE 8.—*B. O. D. of supernatants when nutrient substrates are aerated in the presence of normal activated sludge*

Experiment No.	Suspended solids, p. p. m.	Nutrient substrate	B. O. D. incubation period, days	B. O. D. of supernatant liquor after the indicated aeration time in hours: Initial 0	¼	1¼	3	5	10	24
1	4,610	Settled sewage	3	132	32.4	15.1	8.8	9.2	5.8	4.5
			5	162	42.8	24.0	13.0	10.7	8.0	11.7
			7	168	49.6	32.6	17.1	13.0	9.0	13.6
			10	200	62.0	40.0	21.4	15.8	14.0	13.8
2	1,000	do	3	189	124.0	73.6	56.5	-------	19.3	10.5
			5	251	152.0	82.0	84.0	-------	29.0	12.0
			7	296	173.0	111.0	188.0	-------	32.8	12.6
			10	394	209.0	150.0	139.0	-------	41.1	21.1
3	2,448	do	2	96.6	24.8	15.6	6.2	6.1	5.0	6.9
			5	142.0	42.0	28.3	17.4	6.8	8.8	6.0
			7	155.0	48.0	29.1	17.0	-------	13.8	10.8
			10	171.0	123.0	77.3	62.5	50.0	21.4	------
			15	244.0	169.0	132.0	94.0	64.8	40.6	25.2
			20	352.0	189.0	137.0	-------	69.6	34.6	25.0
4	2,504	Clarified sewage	2	47.6	11.4	10.8	2.3	2.0	3.5	8.3
			5	67.0	19.6	24.9	6.4	7.8	6.0	8.7
			7	77.4	61.6	40.0	25.5	15.0	15.2	13.0
			10	80.6	59.0	60.6	38.0	33.5	15.9	------
			15	132.5	135.0	88.6	75.9	51.8	23.5	28.9
			20	186.6	155.0	109.2	-------	54.0	24.5	19.8
5	2,812	Synth. sewage	2	160	111.0	95.2	80.0	70.0	26.9	14.4
			5	257	172.0	161.0	140.0	124.0	62.5	22.0
			7	297	206.0	188.0	182.0	145.0	86.2	32.5
			10	322	253.0	234.0	190.0	195.0	119.4	58.9
			15	336	390.0	323.0	-------	221.0	152.0	75.2
			20	384	449.0	-------	-------	-------	157.0	80.7
6	2,676	do	2	182	162.0	112.0	95.0	74.0	27.6	6.7
			5	268	220.0	171.0	149.0	123.0	47.6	13.0
			7	280	239.0	195.0	176.0	168.0	55.4	12.0
			10	311	260.0	220.0	289.0	246.0	74.8	18.5
			15	335	399.0	393.0	298.0	264.0	142.0	49.7
			20	547	465.0	402.0	377.0	309.0	163.0	62.0
7	2,268	Settled sewage	2	159	60.0	[1] 23.8	-------	[2] 13.6	9.1	4.6
			5	235	96.0	[1] 36.8	-------	[2] 21.7	10.3	10.5
			7	250	110.0	[1] 46.0	-------	[2] 31.7	17.0	11.3
			10	264	128.0	[1] 92.0	-------	[2] 58.0	32.1	9.3
			15	282	227.0	[1] 162.0	-------	[2] 91.8	35.0	27.2
			20	381	276.0	[1] 180.0	-------	[2] 97.1	44.9	28.5
8	3,564	do	2	53.7	18.2	[1] 8.6	-------	[2] 14.8	[3] 6.0	8.0
			5	96.8	27.5	[1] 10.8	-------	[2] 20.0	[3] 10.9	10.0
			7	106.0	35.7	[1] 22.4	-------	[2] 18.6	[3] 14.0	11.9
			10	122.0	42.5	[1] 37.4	-------	[2] 35.0	[3] 18.0	13.0
			15	125.0	52.0	[1] 33.2	-------	[2] 31.4	[3] 18.5	14.9
			20	124.0	118.5	[1] 46.2	-------	[2] 30.4	[3] 18.7	15.0
9-S1	182	do	2	60.6	51.5	[1] 37.5	-------	[2] 26.0	-------	10.1
			5	114.3	80.0	[1] 59.5	-------	[2] 31.7	-------	13.6
			7	164.3	101.0	[1] 60.5	-------	[2] 35.0	-------	19.3
			10	165.5	105.0	[1] 72.0	-------	[2] 71.2	-------	20.5
			15	216.3	100.0	[1] 89.5	-------	[2] 60.7	-------	34.6
			20	264.5	158.0	[1] 115.0	-------	[2] 97.5	-------	70.3
9-S3	760	do	2	129	10.0	[1] 13.5	-------	-------	-------	6.2
			5	234	32.0	[1] 46.0	-------	[2] 26.0	-------	17.0
			7	200	78.0	[1] 66.0	-------	[2] 38.5	-------	18.0
			10	219	80.0	[1] 40.5	-------	[2] 21.0	-------	21.8
			15	285	107.0	[1] 25.0	-------	[2] 64.5	-------	------
			20	415	253.0	[1] 138.0	-------	[2] 169.0	-------	------
9-S4	1,188	do	5	57.5	24.0	[1] 13.6	-------	[2] 11.8	-------	13.4
			7	63.7	51.0	[1] 14.0	-------	[2] 22.6	-------	15.5
			10	64.5	40.0	[1] 24.0	-------	[2] 21.0	-------	21.7
			15	96.8	42.5	[1] 16.8	-------	-------	-------	------
			20	126.0	76.5	-------	-------	-------	-------	------

See footnotes at end of table.

TABLE 8.—*B. O. D. of supernatants when nutrient substrates are aerated in the presence of normal activated sludge*—Continued

Experiment No.	Suspended solids, p. p. m.	Nutrient substrate	B. O. D. incubation period, days	B. O. D. of supernatant liquor after the indicated aeration time in hours						
				Initial 0	½	1½	3	5	10	24
9-S5	1,462	Settled sewage	2	54.5	30.5	[1] 10.6	-------	[2] 9.8	-------	5.2
			5	125.0	44.5	[1] 15.6	-------	[2] 11.4	-------	9.4
			7	140.0	52.5	[1] 21.0	-------	[2] 15.6	-------	16.2
			10	148.0	65.5	[1] 24.2	-------	[2] 26.6	-------	24.0
			15	148.0	93.0	[1] 43.0	-------	[2] 35.8	-------	-------
			20	177.0	94.0	[1] 62.0	-------	-------	-------	-------
9-S6	1,448	do	2	51.9	16.0	[1] 12.7	-------	[2] 18.8	-------	3.0
			5	83.6	31.5	[1] 23.2	-------	[2] 22.0	-------	7.5
			7	99.6	26.5	[1] 24.0	-------	[2] 21.0	-------	9.8
			10	113.0	40.5	[1] 42.5	-------	[2] 24.2	-------	-------
			15	121.0	46.5	-------	-------	[2] 44.8	-------	11.2
			20	129.0	66.0	-------	-------	[2] 52.8	-------	15.1
10-S8	2,920	do	2	135.0	10.0	[1] 13.0	-------	[2] 9.0	-------	8.0
			5	182.0	17.5	[1] 16.5	-------	[2] 16.8	-------	13.4
			7	225.0	29.0	[1] 26.2	-------	[2] 23.4	-------	15.0
			10	266.0	29.0	[1] 24.2	-------	[2] 27.2	-------	17.8
			15	306.0	55.5	[1] 29.2	-------	[2] 30.2	-------	16.8
			20	336.0	76.0	[1] 35.2	-------	[2] 31.2	-------	22.8
10-S9	2,864	do	2	147	[4] 18.5	-------	17.8	8.8	-------	8.5
			5	144	[4] 25.5	-------	29.0	14.6	-------	12.7
			7	231	[4] 34.5	-------	30.5	22.2	-------	14.4
			10	228	[4] 36.0	-------	32.0	23.6	-------	15.5
			15	231	[4] 39.0	-------	37.0	27.4	-------	19.4
			20	251	[4] 51.5	-------	41.5	26.8	-------	18.9

[1] 2 hours.
[2] 4 hours.
[3] 12 hours.
[4] 1 hour.

TABLE 9.—*Total carbonaceous oxygen demand (L value) of supernatant when nutrient substrates are aerated in the presence of normal activated sludge*

Experiment No.[1]	Activated sludge suspended solids, p. p. m.	*L* value of supernatant liquid initially and after the indicated time in hours						
		0	½	1½	3	5	10	24
1	4,610	234	64.6	37.6	20.4	17.0	12.5	14.6
2	1,000	388	230.0	144.0	130.0	-------	42.0	19.4
3	2,448	214	62.9	40.0	21.1	13.2	14.6	13.7
4	2,504	103	50.6	45.8	22.4	18.2	15.2	14.5
5	2,812	385	273.0	247.0	215.0	184.0	90.8	37.3
6	2,676	395	337.0	260.0	232.0	197.0	74.2	18.2
7	2,268	334	150.0	[2] 69.4	-------	[3] 43.2	24.2	13.1
8	3,564	135	47.0	[2] 34.8	-------	[3] 32.4	[4] 18.0	16.0
9-S1	182	189	121.0	[2] 87.4	-------	[3] 60.5	-------	23.6
9-S3	760	296	74.0	[2] 51.4	-------	[3] 36.5	-------	22.1
9-S4	1,188	83.8	46.8	[2] 20.4	-------	[3] 22.9	-------	21.0
9-S5	1,462	165	76.4	[2] 29.8	-------	[3] 25.9	-------	18.7
9-S6	1,448	128	43.1	[2] 36.4	-------	[3] 36.5	-------	10.7
9-S8	2,920	305	35.7	[2] 29.8	-------	[3] 27.9	-------	19.4
9-S9	2,864	287	43.8	-------	40.7	[3] 25.8	-------	19.3

[1] Settled sewage feed used in experiments 1, 2, 3, 7, 8, and 9. Clarified sewage feed used in experiment 4. Synthetic sewage feed used in experiments 5 and 6.
[2] 2 hours.
[3] 4 hours.
[4] 12 hours.

TABLE 10.—*Percentage reduction of total carbonaceous oxygen demand (L value) of supernatants when nutrient substrates are aerated in the presence of normal activated sludge*

Experiment No.[1]	L value of initial supernatant	Percentage reduction of L value after indicated time in hours					
		½	1½	3	5	10	24
1	234	72.4	83.9	91.4	92.7	94.7	93.8
2	388	40.7	62.9	66.5	----------	89.2	95.0
3	214	70.6	81.3	90.1	93.8	93.2	93.6
4	103	50.9	55.5	78.3	82.3	85.2	85.9
5	385	29.1	35.8	44.2	52.2	76.4	90.3
6	395	14.7	34.2	41.3	50.1	81.2	95.4
7	334	55.1	[2] 79.2	----------	[3] 87.1	92.8	96.1
8	135	65.2	[2] 74.2	----------	[3] 76.0	[4] 86.7	88.1
9-S1	189	36.0	[2] 53.8	----------	[3] 68.0	----------	87.6
9-S3	296	75.0	[2] 82.6	----------	[3] 87.7	----------	92.5
9-S4	83.8	44.2	[2] 75.7	----------	[3] 72.7	----------	74.9
9-S5	165	53.7	[2] 81.9	----------	[3] 84.3	----------	88.7
9-S6	128	66.3	[2] 71.6	----------	[3] 71.5	----------	91.6
9-S8	305	88.3	[2] 90.2	----------	[3] 90.9	----------	93.6
9-S9	287	84.7	----------	85.8	[3] 91.0	----------	93.3

[1] Settled sewage used in experiments 1, 2, 3, 7, 8, and 9. Clarified sewage used in experiment 4. Synthetic sewage used in experiments 5 and 6.
[2] 2 hours. [3] 4 hours. [4] 12 hours.

TABLE 11.—*Quantities of oxygen used to oxidize the nutrient substrate when aerated in the presence of normal activated sludge*

Experiment No.[1]	Initial L value of supernatant	Milligrams of oxygen used per liter in indicated time in hours					
		½	1½	3	5	10	24
1	234	13.9	46.9	81.0	134.2	161.5	173.8
2	388	3.9	26.7	47.7	----------	122.2	176.3
3	214	8.3	24.0	50.4	75.1	101.7	----------
4	103	22.0	44.1	80.7	107.3	*124.4	----------
5	385	8.2	36.6	54.1	71.4	121.4	130.0
6	395	18.8	45.5	71.0	89.8	139.0	184.6
7	334	7.1	[2] 41.2	----------	[3] 88.7	145.6	189.8
8	135	25.2	[2] 49.7	----------	[3] 106.7	[4] 155.9	*213.7
9-S1	189	0	[2] 7.3	----------	[3] 16.0	----------	46.6
9-S3	296	16.4	[2] 39.0	----------	[3] 49.0	----------	86.4
9-S4	83.8	.4	[2] 10.0	----------	[3] 13.8	----------	16.4
9-S5	165	21.2	[2] 34.8	----------	[3] 42.6	----------	121.7
9-S6	128	20.5	[2] 36.5	----------	[3] 45.6	----------	94.6
9-S8	305	[5] 47.0	----------	84.8	92.8	----------	89.2
9-S9	287	[5] 29.1	----------	137.3	158.6	----------	*226.4

[1] Settled sewage used in experiments 1, 2, 3, 7, 8, and 9. Clarified sewage used in experiment 4. Synthetic sewage used in experiments 5 and 6.
[2] 2 hours.
[3] 4 hours.
[4] 12 hours.
[5] 1 hour.
*Substrate was being nitrified.

earlier it is not possible to tell when the nitrification began. It seems reasonable to assume that, in these three experiments with actively nitrifying activated sludge, the nitrification of the substrate began between the first and third hour of aeration. Consequently the oxidation values given in table 11 for these experiments should be reduced by the quantity of oxygen required to produce the nitrites and nitrates present, as the observations on total purification were confined to the carbonaceous stage. Corrections for nitrification could not be made in these experiments because of the lack of the intermediate nitrite and nitrate data. The results of these experiments are retained to

Table 12.—*Percentage of the total carbonaceous oxygen demand (L value) of the nutrient substrate oxidized when aerated in the presence of normal activated sludge*

Experiment No.[1]	Percentage oxidized in the indicated time in hours					
	½	1½	3	5	10	24
1	5.9	20.0	34.6	57.4	69.0	74.3
2	1.0	6.9	12.3	----	31.5	45.4
3	3.9	11.2	23.6	35.1	47.5	----
4	21.4	42.8	78.3	104.1	[6]120.8	----
5	2.1	9.5	14.1	18.5	31.5	83.8
6	4.8	11.5	18.0	22.7	35.2	46.7
7	2.1	[2]12.3	----	[3]26.6	43.6	56.8
8	18.7	[2]36.8	----	[3]79.0	[4]115.5	[6]158.3
9–S1	0.0	[2]3.9	----	[3]8.5	----	24.7
9–S3	5.5	[2]13.2	----	[3]16.6	----	29.2
9–S4	0.5	[2]11.9	----	[3]16.5	----	19.5
9–S5	12.8	[2]21.1	----	[3]25.8	----	73.8
9–S6	16.0	[2]28.5	----	[3]35.6	----	73.9
9–S8	[5]15.4	----	27.8	30.4	----	29.2
9–S9	[5]10.1	----	47.8	55.2	----	[6]78.9

[1] Settled sewage used in experiments, 1, 2, 3, 7, 8, and 9. Clarified sewage used in experiment 4. Synthetic sewage used in experiments 5 and 6.
[2] 2 hours.
[3] 4 hours.
[4] 12 hours.
[5] 1 hour.
[6] Substrate was being nitrified.

Table 13.—*Net percentage of the total carbonaceous oxygen demand (L value) of the nutrient substrate that is removed by adsorption and synthesis when aerated in the presence of normal activated sludge*

Experiment No.	Nutrient substrate used	Net percentage removed by adsorption and synthesis in indicated time in hours					
		½	1½	3	5	10	24
1	Settled sewage	66.5	63.9	56.8	35.3	25.7	19.5
2	do	39.7	56.0	54.2	----	57.7	49.6
3	do	66.7	70.1	66.5	58.7	45.7	----
7	do	53.0	[1]66.9	----	[2]60.5	49.2	39.3
8	do	46.5	[1]37.4	----	[2]0	[3]0	0
4	Clarified sewage	29.5	12.7	0	0	0	0
5	Synthetic sewage	27.0	26.3	30.1	33.7	44.9	56.5
6	do	9.9	22.7	23.3	37.4	46.0	48.7
9–S1	Settled sewage	36.0	[1]49.9	----	[2]59.5	----	62.9
9–S3	do	69.5	[1]69.4	----	[2]71.1	----	63.3
9–S4	do	43.7	[1]63.8	----	[2]56.2	----	55.4
9–S5	do	40.5	[1]60.8	----	[2]58.5	----	14.9
9–S6	do	50.3	[1]43.1	----	[2]35.9	----	17.7
9–S8	do	[4]72.9	----	62.7	[2]60.5	----	64.4
9–S9	do	[4]74.6	----	38.0	[2]35.8	----	14.4

[1] 2 hours. [2] 4 hours. [3] 12 hours. [4] 1 hour.

demonstrate the wide differences in the purification obtained under these conditions even though the total purification and oxidation in such cases may not be strictly comparable. This complication did not enter into the pure culture sludge experiments because the cultures employed were incapable of oxidizing ammonia nitrogen. In all of the normal activated sludge experiments, except the three mentioned above, nitrites and nitrates were not found in the substrate at the completion of the aeration period, and consequently all of the oxygen was utilized in oxidizing carbonaceous material. In these experiments, therefore, the total purification and oxidation data are as comparable as in the pure culture sludge experiments.

The net percentages of the *L* value of the substrate removed by adsorption and synthesis (obtained as above for pure culture sludges) are given in table 13. The percentages of *L* value removal accomplished by total purification, by oxidation, and by net adsorption and synthesis for a number of experiments with normal activated sludge have been plotted in figures 8 to 13. For this presentation the experi-

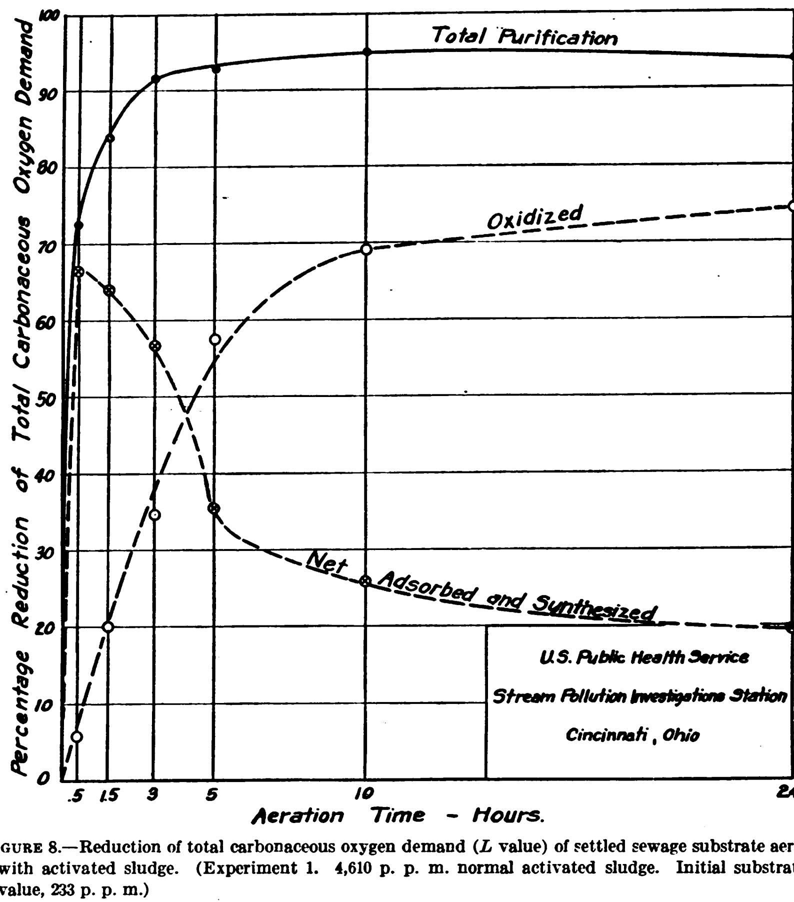

FIGURE 8.—Reduction of total carbonaceous oxygen demand (*L* value) of settled sewage substrate aerated with activated sludge. (Experiment 1. 4,610 p. p. m. normal activated sludge. Initial substrate *L* value, 233 p. p. m.)

ments were selected to illustrate the effects of some of the factors which influence the purification mechanism.

In experiment 1 a sewage with an *L* value of 233 p. p. m. was aerated with a sludge of 4,610 p. p. m. of suspended solids. The results plotted in figure 8 show that total purification was very rapid, 72.4 percent of the *L* value being removed in 0.5 hour and over 90 percent in 3 hours. The *L* value reduction produced by oxidation was 5.9 percent in 0.5 hour. This rapidly increased to 57.4 percent in 5 hours. The net adsorbed and synthesized results reached a maximum of about 66.5 percent in 0.5 hour and then dropped rapidly, falling below the percentage oxidized after about 4 hours. After 24 hours 74.3 percent of the L value had been oxidized and only 19.5 percent remained as adsorbed and synthesized material. As it seems reasonable that most of the biochemical synthesis accompanying bacterial multiplication had been completed before the 24-hour period, and that such synthesis might be estimated at from 5 to 10 percent of the L value, this would

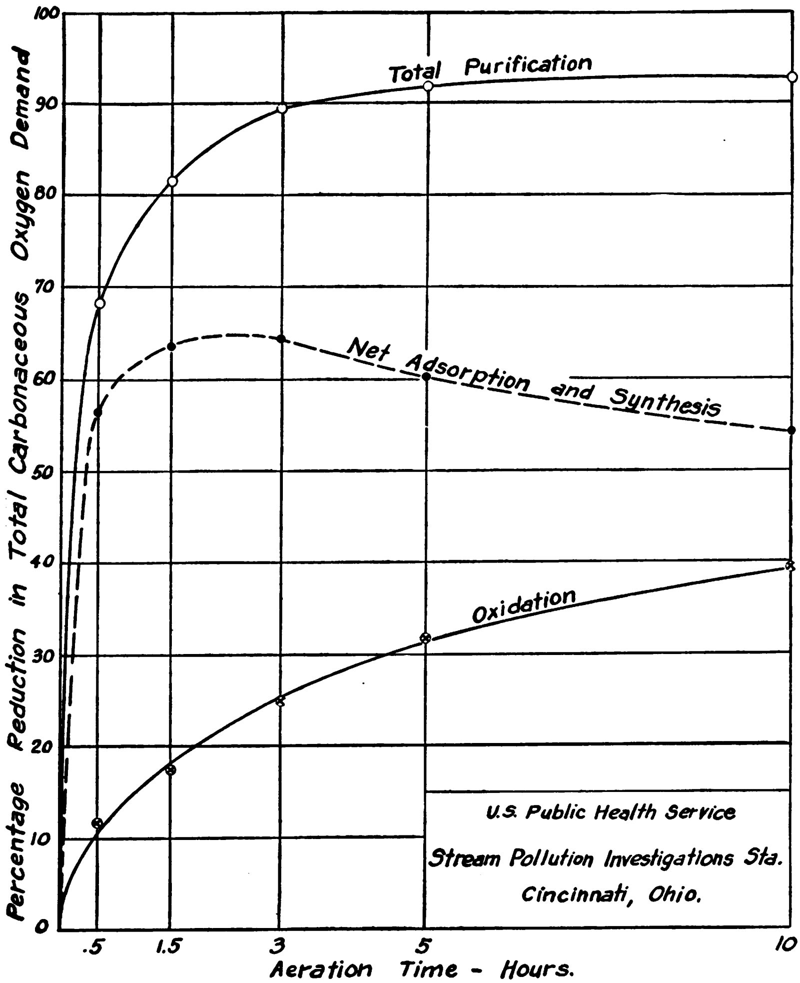

FIGURE 9.—Reduction of total carbonaceous oxygen demand (L value) of settled sewage substrate aerated with activated sludge. (Experiment 2. 1,000 p. p. m. normal activated sludge. Initial substrate L value, 389 p. p. m.)

leave 9.5 to 14.5 percent of the material removed from the substrate still adsorbed or coagulated in the sludge after 24 hours. The results of experiment 1, just discussed, illustrate the activated sludge purification mechanism when a large quantity of nonnitrifying activated sludge is given a normal quantity of nutrient substrate.

The results of experiment 2 illustrate the mechanism of purification when a small quantity of activated sludge (1,000 p. p. m. suspended solids) is dosed with a substrate having a rather high (389 p. p. m.) *L* value. The purification results as plotted in figure 9 for this experiment are quite different from those shown in figure 8. In this case the total purification is only about 40.7, 62.9, 66.5, and 89.2 percent of the *L* value after 0.5, 1.5, 3, and 10 hours, respectively, although in 24 hours a high value of 95 percent was reached. The percentages of

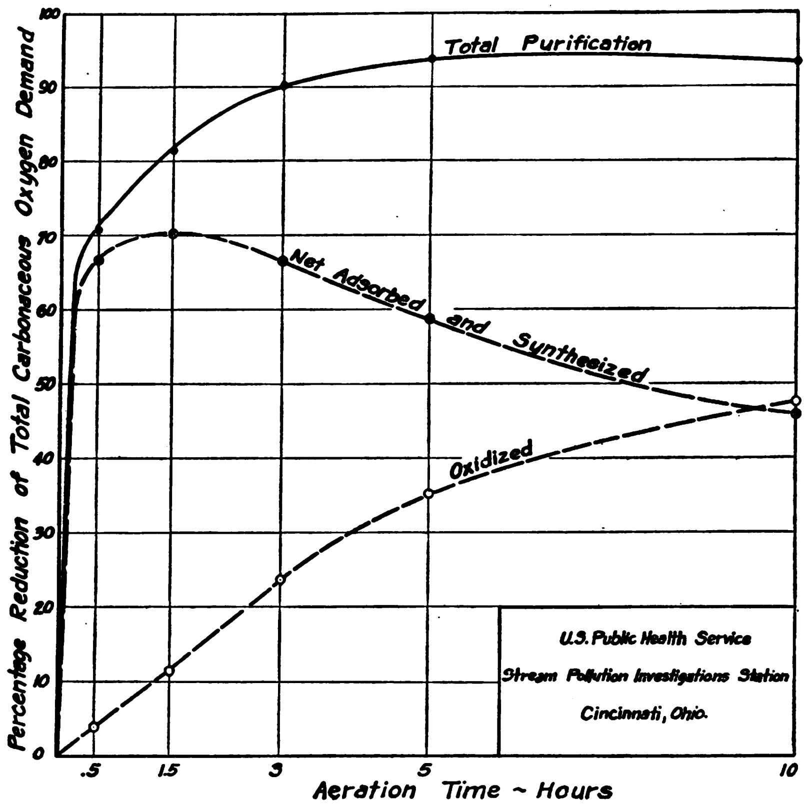

FIGURE 10.—Reduction of total carbonaceous oxygen demand (*L* value) of settled sewage substrate aerated with activated sludge. (Experiment 3. 2,448 p. p. m. normal activated sludge. Initial substrate *L* value, 214 p. p. m.)

oxidation of the *L* value are also much lower than in experiment 1, being 1.0, 6.9, 12.3, and 31.5 after 0.5, 1.5, 3, and 10 hours. Consequently the net adsorbed and synthesized results attain a value of 56 percent after 1.5 hours, after which this value slowly increases, reaching a maximum of about 60 percent at about the fifth hour and then falls very slowly to about 58 percent in 10 hours. After 24 hours of aeration about 50 percent of the *L* value is still retained as adsorbed and synthesized materials. In this case the percentage oxidized has not reached 50 at the end of the 24-hour period. This may be interpreted as the result of an overdose of nutrient material for the quantity of sludge used in this experiment.

The results of experiment 3 are shown in figure 10 and illustrate an intermediate condition between those of experiments 1 and 2. In this experiment the total purification is more rapid than in experiment 2 and very similar to that observed in experiment 1. The percentage

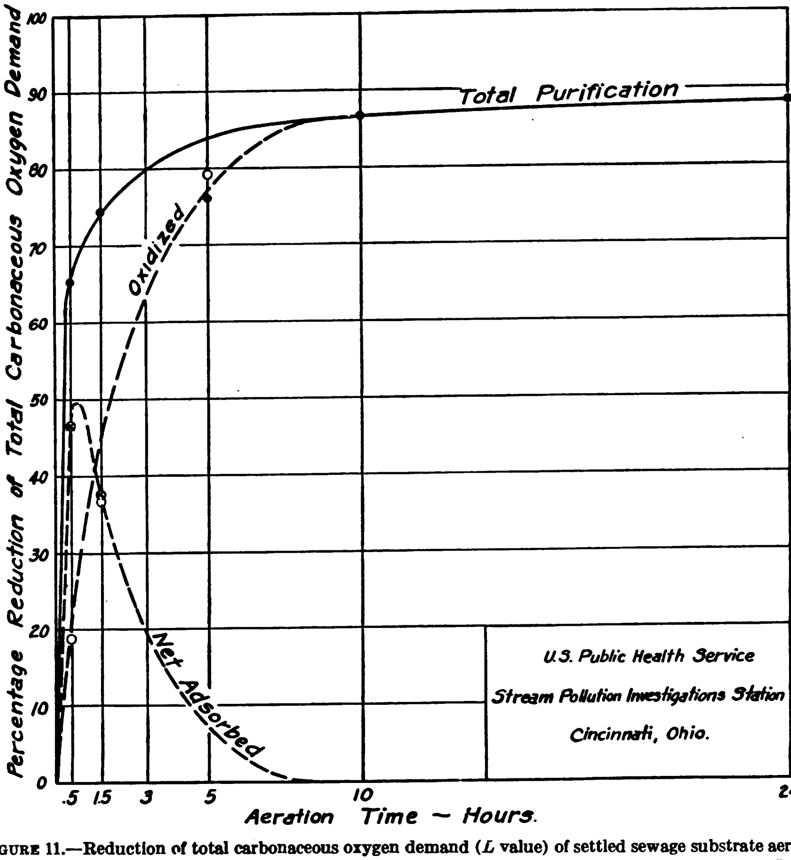

FIGURE 11.—Reduction of total carbonaceous oxygen demand (L value) of settled sewage substrate aerated with activated sludge. (Experiment 8. 3,564 p. p. m. of an actively nitrifying activated sludge. Initial substrate L value, 135 p. p. m.)

oxidation results are considerably lower than those of experiment 1 and considerably higher than were observed in experiment 2. As a consequence, the net adsorbed and synthesized results reached a maximum of about 70 percent at the end of the 1.5-hour period and the then receded rapidly, falling below the percentage oxidized by the tenth hour. It seems apparent from the results presented in these three figures (8, 9, and 10) that the aeration time required for the percentage oxidation to exceed the percentage net adsorbed and synthesized is an index of the adsorption-oxidation balance. A proper adsorption-oxidation balance is essential for the satisfactory operation of an activated sludge system.

At present the optimum proportion of oxidation to net adsorption and synthesis for any practical aeration time is unknown. It would seem from these experiments that figure 10 might illustrate a system with an approximately optimum adsorption-oxidation equilibrium.

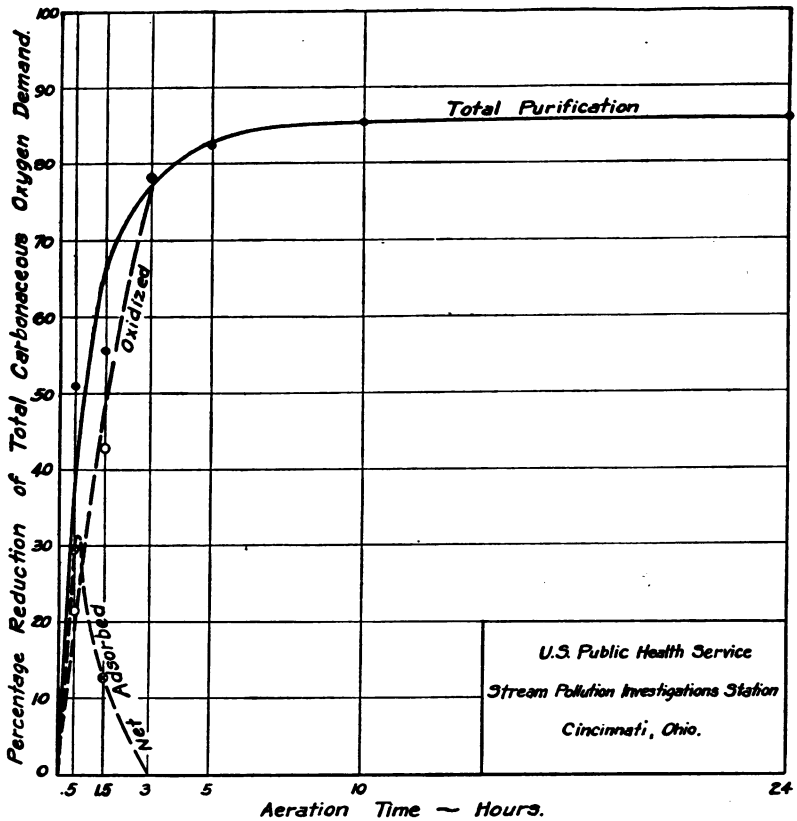

FIGURE 12.—Reduction of total carbonaceous oxygen demand (*L* value) of clarified sewage aerated with activated sludge. (Experiment 4. 2,504 p. p. m. normal activated sludge. Initial substrate *L* value, 106 p. p. m.)

The data obtained in two experiments in which the sludge actively nitrified the substrate during the 24-hour aeration period are plotted in figures 11 and 12. For reasons previously explained, no corrections for nitrification were made. It is possible that nitrification did not start until the third or fifth hour of aeration, in which case the carbonaceous oxidation and adsorption relationships are about as indicated in the figures for the first 3 hours. It will be noted that the time at which the percentage of the substrate organic matter oxidized exceeds the percentage net adsorbed and synthesized in these experiments is much shorter than in experiments 1, 2, and 3, where nitrification had not been initiated. It seems reasonable to conclude that in experiments 4 and 8 most of the total purification of the substrate could be accounted for by oxidation by the end of the fifth hour of aeration and that the proportion of purification resulting from oxidation was higher than in the first three experiments. It is also noted in experiments 4 and 8, with active nitrification, that the proportion of total purification resulting from adsorption and synthesis rapidly

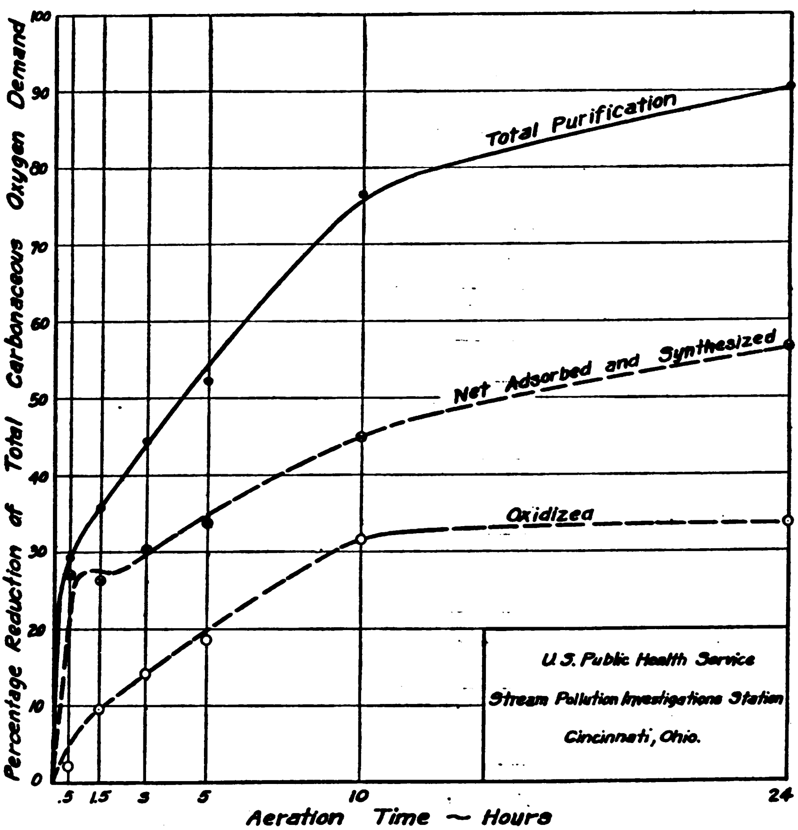

FIGURE 13.—Reduction of total carbonaceous oxygen demand (*L* value) of synthetic sewage substrate aerated with activated sludge. (Experiment 5. 2,812 p. p. m. normal activated sludge. Initial substrate *L* value, 385 p. p. m.)

becomes negligible. Further studies on the course of total purification, carbonaceous oxidation, nitrification, and adsorption and synthesis of substrates aerated with nitrifying sludges are needed to interpret more intelligently the clarification phenomenon in such systems.

The data obtained in experiment 5 with a synthetic sewage substrate and normal activated sludge are plotted in figure 13. In this figure the curves are somewhat similar to those in figure 9, illustrating a case of overloading. But in this case the rate of total purification was much lower than in any of the experiments with domestic sewage. In fact, this rate is also very much lower than that obtained with similar substrates aerated with pure culture sludges.

The substrate oxidation rates with synthetic sewage in experiments 5 and 6 are similar to those with domestic sewage for the first few hours. Consequently, the failure of these sludges to remove the car-

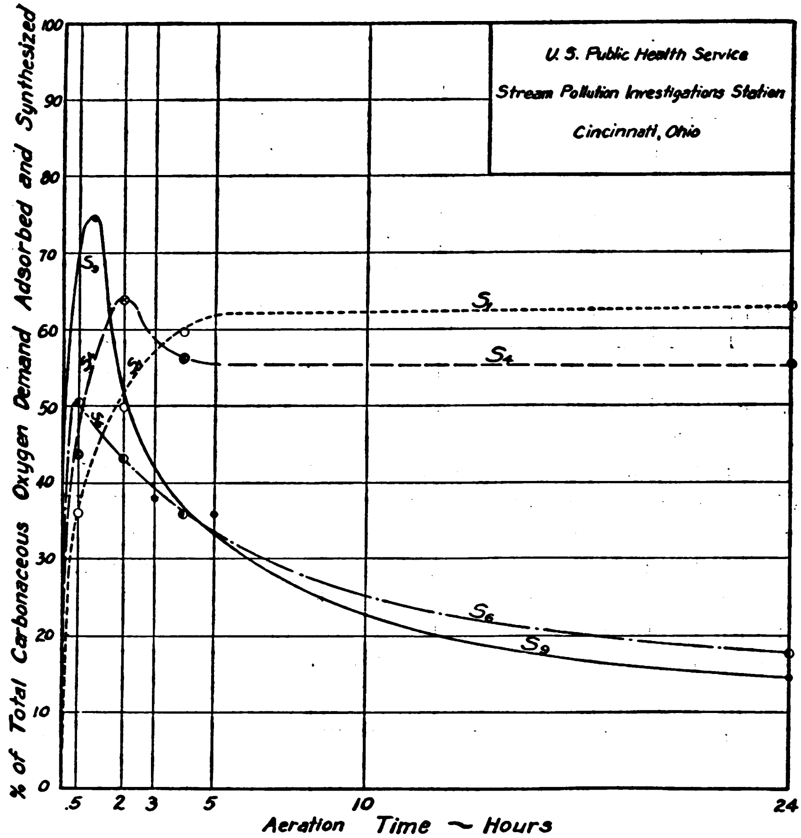

FIGURE 14.—Types of curves for net adsorption of L value of substrates obtained during the development of an activated sludge. (Experiment 9.)

bonaceous demand of colloidal and soluble material at a higher rate cannot be ascribed to a failure of bacterial oxidation. The proportion of the L value of the substrate to the quantity of sludge was even lower than this proportion in the pure culture sludge experiments. The results of experiments 5 and 6 in the normal activated sludge series indicate that such sludge does not have as great a capacity for removing organic matter from colloidal or true solution as does pure culture sludge. This may be interpreted as evidence indicating that the larger quantity of inert inorganic or mineral matter, which normal activated sludge always contains, reduces the capacity of the active bacterial surfaces for removing colloidal and soluble organic matter.

The percentages of the net adsorption and synthesis of the substrate L value obtained in a number of the tests made in experiment 9 are presented in figure 14. The four curves in this figure, defining the rate of change in the percentage of the L value removed by adsorption and synthesis, illustrate the change in the form of the curves that takes place during the development of a good activated sludge. The first test (S1) was made after the aeration tank had been operated on the fill and draw principle for 3 days and 182 p. p. m. of sludge as suspended solids were present. The curve representing the net proportion of L value of the substrate adsorbed and synthesized for S1 has the same form as the total purification curve. The fourth test (S4) was made 28 days after aeration had been started and 1,188 p. p. m. of sludge as suspended solids were present. The net adsorption and synthesis curve for this test had changed form considerably from the first test and it will be noted that it reached a maximum of about 63.8 percent in 1.5 hours, after which the percentage slowly dropped to 55.4 in 24 hours. In every test thereafter (S6, S9) a maximum point in the net percentage adsorbed and synthesized was reached at about the 0.5- to 1.5-hour aeration time, and from this point on the values decreased. The maximum rate of reduction in the percentage net adsorbed and synthesized values was observed in the ninth test (S9), in which a small quantity of nitrate was found at the end of the experiment. The change in the form of these curves is ascribed to the increasing quantity of adsorbing surface and to the increasing capacity of the sludge to oxidize substrate during the early hours of aeration. Data on the development of the oxidizing capacity of the sludge have been presented in greater detail in an earlier paper (*9*).

TABLE 14.—*Percentage of the total carbonaceous oxygen demand reduction of the substrate actually oxidized when aerated with non-nitrifying activated sludge*

Experiment No.[1]	Percentage oxidized in indicated time in hours					
	½	1½	3	5	10	24
1	8.15	23.8	37.9	61.9	72.9	79.2
2	2.46	11.0	18.5	----------	35.3	47.8
3	5.52	13.8	26.2	37.4	51.0	----------
5	7.22	26.5	31.9	35.4	41.2	37.4
6	32.7	33.6	43.6	45.3	43.3	49.0
7	3.81	15.5	----------	30.5	47.0	59.1
9-S4	1.13	15.7	----------	22.7	----------	26.0
9-S5	23.8	25.8	----------	30.6	----------	83.2
9-S6	18.1	31.6	----------	39.2	----------	79.0
Mean	11.4	21.9	31.6	37.9	48.4	57.6

[1] Settled sewage used in experiments 1, 2, 3, 7, and 9. Synthetic sewage used in experiments 5 and 6.

The proportions of substrate L value reductions produced by oxidation when the substrate is aerated with nonnitrifying sludge have been calculated and are shown in table 14. These data indicate again, as was the case with pure culture sludge, that oxidation is an important factor in B. O. D. removal with activated sludge. There is, however, a considerable variation in the percentage of total purification accomplished by oxidation. After aeration of settled sewage substrates with normal activated sludge for half an hour, from 2.45 to 23.7 percent of the total observed purification was accomplished by oxidation. After 1.5 hours these values increased to 11.0 to 31.6 percent and in 5 hours to 22.7 to 61.5 percent. The data indicate that, at the temperature of the experiment (20° C.), the percentage of total purification produced by oxidation varied with the condition of the sludge, with the dispersion and chemical composition of the substrate, and with the proportions of sludge and substrate in the mixture.

DISCUSSION

These experiments have indicated the proportions of total removal of the carbonaceous biochemical oxygen demand of a substrate which may be credited to oxidation and to net adsorption and synthesis, respectively, when various conditions obtain. Great differences in the ratio of the extent of oxidation to the net adsorption and synthesis occurred under conditions of underdosing and overdosing. Additional experiments, which are not described here, have shown the effect of prolonging these conditions on the activated sludge mechanism. It is certain that the quality and dosing rate of the substrate must be such as to promote an optimum oxidation, net adsorption, and synthesis equilibrium for the continued success of the activated sludge process. If this is not done, the efficiency of the process falls and eventually unexpected and formerly unexplainable failure results.

These experiments suggest that, although sludge reaeration is often resorted to as an activated sludge corrective measure, this is not always the proper procedure. A number of cases might be mentioned where sludge reaeration was harmful because the bacteria were not maintained in a state of activity as the result of lack of food, and the oxidation adsorption equilibrium was upset. In general, it would appear that long aeration periods should be avoided when weak sewages are being treated. The data indicate that the ratio of sludge to sewage and the aeration period must be carefully adjusted to maintain the sludge in a state of optimum activity for maximum B. O. D. removal and economical operation. As long as sufficient air is used to keep all of the sludge suspended and dispersed throughout the liquor and to satisfy the oxygen requirements of the aeration mixture, the exact quantity is unimportant from the standpoint of sludge adsorption and oxidation efficiency. From the economic standpoint, therefore, the air should be adjusted to the minimum necessary to maintain the above conditions.

SUMMARY AND CONCLUSIONS

Two series of experiments have been performed, one with activated sludges developed by a pure culture of bacteria and one with normal activated sludge composed of grossly mixed bacterial species, including plankton. Some experiments with domestic sewage (as a substrate) and some with synthetic sewage were carried out in each series. Each experiment was arranged so that estimations of the removal of the total carbonaceous oxygen demand (*L* value) of the substrate and also of the oxidation of the *L* value of the substrate were obtained simultaneously. The proportion of the *L* value of the substrate removed by oxidation and by net adsorption and synthesis and the total removal have been calculated for each experiment from the data obtained. The results for the proportions of purification of the substrate *L* value accomplished by these various mechanisms during the clarification stage of the activated sludge process have been plotted for a number of representative experiments. The following conclusions appear to be warranted by the results obtained:

1. There is a remarkable similarity between the purification accomplished by these mechanisms with both pure culture and normal activated sludges. This seems to justify the conclusion that the clarification mechanism of normal activated sludge is essentially the same as with the biologically simple, pure culture sludge.

2. The rate of removal of the *L* value (total carbonaceous B. O. D.) of the substrate is very high for the first half hour and this high rate may continue for an hour and a half or even 3 hours. From 80 to 95 percent of the *L* value of a sewage substrate can be removed in 5 hours' aeration with such sludges. The quantity and quality of the sludge influences the rate and extent of total purification accomplished in a given time.

3. The synthetic sewage used in these experiments contains no suspended matter and has undoubtedly a somewhat different chemical composition than sterile sewage. The fact that activated sludge reduced the *L* value of sterile sewage more rapidly than the *L* value of synthetic sewage indicates, therefore, that either the state of dispersion or the chemical composition or both may be factors which influence the *L* value reduction of substrates. Nutrients in soluble form seemed to be more rapidly removed by pure culture sludge than by normal activated sludge.

4. The proportion of the *L* value reduction of the substrate that is actually oxidized varies from about 2.5 to 30 percent in 30 minutes, and these values are increased to 30 to 60 percent after 5 hours' aeration. These variations depend upon the quality and quantity of both sludge and substrate in the aeration mixture. From these results it must be concluded that biochemical oxidation is a factor of major importance to the success of the purification phenomenon.

5. The percentage of the *L* value removed from the substrate as a result of net adsorption and synthesis (all mechanisms other than oxidation) increases rapidly from the start for from 0.5 to 3 hours. During this period a maximum of about 50 to 70 percent of the *L* value is removed by adsorption and synthesis. After the maximum point has been reached, the net percentage of the *L* value removed by adsorption and synthesis decreases. The rapidity of this decrease varies considerably in different systems and apparently depends to a great extent upon the oxidation mechanism.

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INFLUENZA PREVALENCE

For the week ended March 18, 1939, the number of cases of influenza reported to the United States Public Health Service by the State health officers dropped to 15,921 as compared with 18,135 for the preceding week. The incidence declined in most of the States which have been reporting the largest numbers of cases. Practically every State in the East and West North Central groups showed a decrease in incidence during the current week, but increases were recorded in certain other States, the most important of which are as follows: Virginia (from 1,991 to 2,443), Alabama (1,126 to 1,862), Oklahoma (387 to 682), Texas (968 to 1,718), Arizona (191 to 476), and California (73 to 209).

Cases of influenza reported by weeks, Jan. 1–Mar. 18, 1939

Division and State	Jan. 7	Jan. 14	Jan. 21	Jan. 28	Feb. 4	Feb. 11	Feb. 18	Feb. 25	Mar. 4	Mar. 11	Mar. 18
NEW ENGLAND											
Maine	1	3	2	10	4	1	8	25	46	103	30
New Hampshire	------	------	------	1	------	------	------	------	------	------	40
Vermont	------	------	------	------	------	------	------	------	------	------	------
Massachusetts	------	------	------	------	------	------	------	------	------	------	------
Rhode Island	------	------	------	------	------	------	------	------	------	1	------
Connecticut	10	6	13	4	7	26	22	29	30	141	20
MIDDLE ATLANTIC											
New York	44	57	37	155	159	183	137	101	91	57	38
New Jersey	14	24	12	19	56	61	99	44	24	19	13
Pennsylvania	------	------	------	------	------	------	------	------	------	------	------
EAST NORTH CENTRAL											
Ohio	------	------	------	------	------	------	------	------	------	------	------
Indiana	12	11	22	4	21	21	363	1,085	607	35	210
Illinois	18	12	60	30	36	227	955	1,478	1,241	838	541
Michigan	------	------	1	2	------	1	39	255	429	674	220
Wisconsin	62	65	52	47	68	65	56	346	584	1,516	1,484
WEST NORTH CENTRAL											
Minnesota	------	2	3	2	------	1	3	24	12	40	22
Iowa	------	4	10	2	1	8	27	291	1,083	695	643
Missouri	70	59	24	33	24	42	137	------	644	678	452
North Dakota	34	11	12	6	27	15	14	64	364	741	254
South Dakota	6	------	------	2	1	10	3	6	77	50	22
Nebraska	------	------	------	1	------	------	------	------	2	1	22
Kansas	16	9	9	6	6	3	9	77	116	226	205
SOUTH ATLANTIC											
Delaware	------	------	------	------	------	------	------	------	------	------	------
Maryland	4	5	12	10	61	103	182	209	124	53	79
District of Columbia	2	2	6	------	5	5	18	25	25	11	3
Virginia	454	420	282	617	1,100	553	1,338	1,604	1,509	1,991	2,443
West Virginia	21	13	34	41	21	26	33	36	271	71	218
North Carolina	3	7	28	9	9	18	71	230	97	386	172
South Carolina	909	495	865	649	772	701	972	592	1,181	1,142	872
Georgia	133	136	143	110	131	118	139	110	140	420	286
Florida	1	1	2	5	------	1	1	------	9	3	5
EAST SOUTH CENTRAL											
Kentucky	56	65	37	27	198	54	478	405	1,348	1,792	560
Tennessee	36	64	87	109	58	75	63	83	146	469	420
Alabama	158	191	188	169	259	186	160	180	599	1,126	1,862
Mississippi	------	------	------	------	------	------	------	------	------	------	------
WEST SOUTH CENTRAL											
Arkansas	181	203	145	139	159	87	113	182	1,473	1,532	577
Louisiana	7	36	12	8	10	20	11	9	30	82	27
Oklahoma	222	149	119	193	162	207	129	193	334	387	682
Texas	492	716	531	703	699	621	983	737	965	968	1,718
MOUNTAIN											
Montana	5	26	33	50	25	42	35	200	126	125	145
Idaho	4	2	1	1	1	------	------	12	1	14	4
Wyoming	------	------	------	------	------	------	------	------	1	8	------
Colorado	21	21	31	45	35	93	125	121	150	136	73
New Mexico	2	1	21	10	6	9	1	3	57	677	670
Arizona	138	117	132	81	68	114	82	94	144	191	476
Utah	7	1	2	9	20	24	16	44	53	119	86
PACIFIC											
Washington	------	4	1	------	------	1	3	------	8	3	------
Oregon	71	39	46	53	25	40	42	34	97	261	118
California	41	41	82	33	76	43	28	59	50	73	209
Total	3,255	3,018	3,097	3,395	4,310	3,802	6,895	8,987	14,288	18,135	15,921

The current mild epidemic of influenza is of no great significance from the standpoint of numbers of cases reported; but, as has been pointed out previously, it is of special interest because the peak falls much later than usual. The rise started this year at the time when the decline began in 1937, and the plotted graph of cases shows a seasonal peak several weeks later than that to be expected by comparison with the plotted course of the 9-year median. The peak of the 1918–19 epidemic came in October 1918; that of 1920 came during the first week of February; in the 1928–29 epidemic, in January; in 1932–33, in December; and in 1937 during the week ended January 30.

The accompanying table presents the numbers of cases of influenza reported by States, arranged by geographical divisions and by weeks, from the first of the year to and including the week ended March 18.

DEATHS DURING WEEK ENDED MARCH 4, 1939

[From the Weekly Health Index, issued by the Bureau of the Census, Department of Commerce]

	Week ended Mar. 4, 1939	Corresponding week, 1938
Data from 88 large cities of the United States:		
Total deaths	10,018	[1] 8,752
Average for 3 prior years	[1] 9,501	
Total deaths, first 9 weeks of year	85,558	80,899
Deaths under 1 year of age	574	[1] 546
Average for 3 prior years	[1] 593	
Deaths under 1 year of age, first 9 weeks of year	5,007	4,883
Data from industrial insurance companies:		
Policies in force	67,876,040	69,774,031
Number of death claims	16,095	14,021
Death claims per 1,000 policies in force, annual rate	12.4	10.5
Death claims per 1,000 policies, first 9 weeks of year, annual rate	10.3	10.1

[1] Data for 86 cities.

PREVALENCE OF DISEASE

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

UNITED STATES

CURRENT WEEKLY STATE REPORTS

These reports are preliminary, and the figures are subject to change when later returns are received by the State health officers.

In these and the following tables, a zero (0) indicates a positive report and has the same significance as any other figure, while leaders (----) represent no report, with the implication that cases or deaths may have occurred but were not reported to the State health officer.

Cases of certain diseases reported by telegraph by State health officers for the week ended Mar. 11, 1939, rates per 100,000 population (annual basis), and comparison with corresponding week of 1938 and 5-year median

Division and State	Diphtheria				Influenza				Measles			
	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases	1934-38, median	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases	1934-38, median	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases	1934-38, median
NEW ENG.												
Maine	36	6	7	1	622	103	8	8	97	16	147	147
New Hampshire	0	0	0	0	----	----	----	----	20	2	26	26
Vermont	0	0	0	0	----	----	----	----	255	19	259	54
Massachusetts	5	4	6	5	----	----	----	----	958	815	260	810
Rhode Island	0	0	1	1	8	1	----	----	69	9	2	39
Connecticut	3	1	7	2	418	141	9	9	1,766	595	20	89
MID. ATL.												
New York	15	37	33	37	[1] 39	[1] 57	[1] 10	[1] 22	593	1,482	1,881	1,881
New Jersey	8	7	21	15	23	19	28	28	49	41	1,186	1,058
Pennsylvania	22	44	46	48	----	----	----	----	88	174	7,982	3,063
E. NO. CEN.												
Ohio	13	17	21	21	----	----	----	28	12	16	2,984	810
Indiana	24	16	33	19	468	315	17	70	7	5	906	468
Illinois	22	33	37	36	549	838	19	63	15	23	6,451	1,473
Michigan [3]	8	8	12	14	712	674	1	3	394	373	4,449	95
Wisconsin	0	0	4	3	2,664	1,516	53	89	1,373	781	4,970	1,278
W. NO. CEN.												
Minnesota	16	8	0	4	78	40	6	2	2,028	1,046	68	272
Iowa	10	5	4	4	1,408	695	17	8	587	290	163	158
Missouri	8	6	26	26	872	678	109	195	18	14	986	873
North Dakota	7	1	4	4	5,411	741	2	6	825	113	9	9
South Dakota	8	1	0	2	376	50	1	----	1,097	146	----	14
Nebraska	4	1	4	8	4	1	21	----	145	38	12	50
Kansas	6	2	4	11	632	226	3	21	137	49	417	256

See footnotes at end of table.

Cases of certain diseases reported by telegraph by State health officers for the week ended Mar. 11, 1939, rates per 100,000 population (annual basis), and comparison with corresponding week of 1938 and 5-year median—Continued

Division and State	Diphtheria				Influenza				Measles			
	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases	1934-38, median	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases	1934-38, median	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases	1934-38, median
SO. ATL.												
Delaware	39	2	0	0	------	------	------	------	------	------	28	69
Maryland [3]	22	[illegible]	5	7	163	53	21	64	3,145	1,020	85	195
Dist. of Col	8	1	9	10	89	11	------	3	243	80	12	82
Virginia	39	21	10	12	3,732	1,991	------	------	795	424	401	401
West Virginia	19	7	8	14	191	71	35	135	40	15	357	48
North Carolina [3]	19	13	22	18	564	386	7	67	1,590	1,088	2,994	607
South Carolina	11	4	4	5	3,119	1,142	338	871	98	36	454	62
Georgia [3]	8	5	9	13	697	420	------	387	319	192	420	------
Florida [3]	24	8	14	7	9	3	2	20	139	46	1,313	36
E. SO. CEN.												
Kentucky	16	9	8	15	3,115	1,792	24	103	177	102	576	576
Tennessee	4	2	11	11	827	469	59	228	206	117	513	89
Alabama [3]	16	9	11	11	1,982	1,126	214	761	697	396	1,108	433
Mississippi [2, 3]	13	5	5	5	------	------	------	------	------	------	------	------
W. SO. CEN.												
Arkansas	27	11	11	8	3,800	1,532	174	174	97	39	501	41
Louisiana [3]	60	25	9	18	198	82	8	27	486	201	11	70
Oklahoma	14	7	15	15	779	387	133	298	517	257	83	83
Texas [3]	31	38	44	62	802	968	726	1,279	115	139	309	420
MOUNTAIN												
Montana [4]	19	2	2	2	1,170	125	------	23	4,625	494	80	57
Idaho	0	0	1	1	143	14	17	4	602	59	1	20
Wyoming	22	1	0	0	175	8	------	------	153	7	82	82
Colorado	58	12	15	8	655	136	------	------	963	200	570	235
New Mexico	12	1	2	3	8,365	677	4	9	334	27	89	58
Arizona	135	11	0	1	2,343	191	99	99	466	38	42	42
Utah [2]	10	1	0	0	1,182	119	------	------	1,440	145	273	23
PACIFIC												
Washington	9	3	0	2	9	3	2	2	1,727	560	8	173
Oregon	5	1	0	0	1,297	261	57	81	204	41	16	95
California [3]	23	28	39	39	68	73	54	377	2,874	3,504	348	598
Total	17	431	524	548	856	18,135	2,278	7,030	615	15,224	43,802	31,420
10 weeks	21	5,370	6,327	6,466	326	69,182	29,694	63,757	490	121,348	286,689	208,708

Division and State	Meningitis, meningococcus				Poliomyelitis				Scarlet fever			
	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases	1934-38, median	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases	1934-38, median	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases	1934-38, median
NEW ENG.												
Maine	6	1	0	0	0	0	0	0	121	20	17	17
New Hampshire	0	0	0	0	0	0	0	0	91	9	18	18
Vermont	0	0	0	0	0	0	2	0	201	15	19	17
Massachusetts	0	0	1	2	0	0	0	0	258	219	407	275
Rhode Island	0	0	1	0	0	0	0	0	38	5	24	23
Connecticut	0	0	0	1	0	0	0	0	329	111	107	107
MID. ATL.												
New York	2.8	7	11	11	0	0	2	1	299	747	937	952
New Jersey	1.2	1	3	3	0	0	1	0	192	161	148	216
Pennsylvania	4	8	5	6	0.5	1	0	0	329	649	759	749
E. NO. CEN.												
Ohio	0	0	4	9	0.8	1	0	0	393	511	471	471
Indiana	0	0	0	3	1.5	1	0	0	333	224	155	238
Illinois	3	5	4	5	0.7	1	2	2	256	543	714	888
Michigan [2]	1.1	1	1	2	0	0	0	0	644	609	794	794
Wisconsin	0	0	0	2	1.8	1	0	0	418	238	182	379

See footnotes at end of table.

Cases of certain diseases reported by telegraph by State health officers for the week ended Mar. 11, 1939, rates per 100,000 population (annual basis), and comparison with corresponding week of 1938 and 5-year median—Continued

Division and State	Meningitis, meningococcus				Poliomyelitis				Scarlet fever			
	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases	1934–38, median	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases	1934–38, median	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases	1934–38, median
W. NO. CEN.												
Minnesota	0	0	0	1	0	0	0	0	235	121	153	153
Iowa	2	1	2	1	0	0	0	0	401	198	286	155
Missouri	1.3	1	3	3	0	0	0	0	120	93	230	195
North Dakota	7	1	0	0	0	0	0	0	95	13	14	53
South Dakota	0	0	0	0	0	0	0	0	195	26	45	40
Nebraska	8	2	4	1	0	0	0	0	157	41	69	57
Kansas	0	0	0	0	0	0	0	0	355	127	207	207
SO. ATL.												
Delaware	0	0	0	0	0	0	0	0	0	0	13	11
Maryland [3]	3	1	1	2	0	0	0	0	126	41	74	95
Dist. of Col.	8	1	0	3	0	0	0	0	121	15	24	24
Virginia	4	2	2	4	1.9	1	0	0	67	36	36	36
West Virginia	5	2	5	5	0	0	0	0	129	48	64	64
North Carolina [3]	1.5	1	1	2	0	0	4	0	83	57	27	37
South Carolina	5	2	2	2	2.7	1	0	0	22	8	3	5
Georgia	1.7	1	1	2	0	0	3	0	28	17	8	11
Florida [3]	0	0	0	0	0	0	0	0	48	16	9	8
E. SO. CEN.												
Kentucky	1.7	1	6	6	1.7	1	2	0	167	96	114	60
Tennessee	0	0	3	8	0	0	0	0	86	49	28	28
Alabama [3]	0	0	8	4	0	0	1	1	40	23	17	17
Mississippi [2] [3]	2.5	1	1	1	8	3	1	0	13	5	1	8
W. SO. CEN.												
Arkansas	0	0	1	1	0	0	0	0	37	15	5	5
Louisiana [3]	5	2	4	1	0	0	1	0	34	14	19	17
Oklahoma	0	0	1	9	2	1	0	0	66	33	35	22
Texas [3]	0.8	1	5	5	0.8	1	2	1	65	79	139	120
MOUNTAIN												
Montana [4]	0	0	0	0	0	0	0	0	234	25	46	36
Idaho	31	3	0	0	0	0	1	0	306	30	16	16
Wyoming	0	0	1	0	0	0	0	0	240	11	14	19
Colorado	0	0	0	0	0	0	0	0	212	44	45	45
New Mexico	0	0	0	0	12	1	0	0	420	34	16	24
Arizona	25	2	0	0	0	0	0	0	147	12	9	13
Utah [3]	0	0	0	0	0	0	0	0	308	31	57	57
PACIFIC												
Washington	0	0	1	2	3	1	0	0	207	67	55	72
Oregon	0	0	0	1	0	0	1	0	293	59	35	38
California [3]	3	4	3	7	0.8	1	1	1	224	273	235	247
Total	2.1	52	85	174	0.6	16	24	17	231	5,818	6,900	7,739
10 weeks	2.1	533	943	1,161	0.6	161	216	211	215	53,966	61,200	65,433

Division and State	Smallpox				Typhoid and paratyphoid fever				Whooping cough		
	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases	1934–38 median	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases	1934–38, median	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases
NEW ENG.											
Maine	0	0	0	0	24	4	0	0	320	53	54
New Hampshire	0	0	0	0	0	0	0	0	51	5	7
Vermont	0	0	0	0	0	0	0	0	483	36	19
Massachusetts	0	0	0	0	1	1	0	1	220	187	120
Rhode Island	0	0	0	0	0	0	0	0	229	30	29
Connecticut	0	0	0	0	3	1	0	0	264	89	76

See footnotes at end of table.

Cases of certain diseases reported by telegraph by State health officers for the week ended Mar. 11, 1939, rates per 100,000 population (annual basis), and comparison with corresponding week of 1938 and 5-year median—Continued.

Division and State	Smallpox				Typhoid and paratyphoid fever				Whooping cough		
	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases	1934-38 median	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases	1934-38, median	Mar. 11, 1939, rate	Mar. 11, 1939, cases	Mar. 12, 1938, cases
MID. ATL.											
New York	0	0	0	0	2	6	4	6	230	575	451
New Jersey	0	0	0	0	5	4	3	2	490	412	219
Pennsylvania	0	0	0	0	4	7	7	6	245	482	309
E. NO. CEN.											
Ohio	21	27	10	1	1	1	6	3	85	110	188
Indiana	49	33	28	1	1	1	0	0	43	29	23
Illinois	6	9	45	22	2	3	5	6	220	336	122
Michigan [2]	15	14	6	1	1	1	12	3	218	206	254
Wisconsin	18	10	3	10	0	0	0	2	441	251	108
W. NO. CEN.											
Minnesota	14	7	10	7	0	0	0	0	107	55	18
Iowa	63	31	42	18	0	0	1	1	36	18	25
Missouri	14	11	50	6	13	10	3	3	22	17	60
North Dakota	0	0	9	3	15	2	0	0	44	6	20
South Dakota	60	8	12	10	8	1	0	0	15	2	34
Nebraska	73	19	10	10	0	0	0	0	19	5	9
Kansas	0	0	20	26	3	1	0	1	64	23	116
SO. ATL.											
Delaware	0	0	0	0	0	0	0	0	59	3	1
Maryland [2]	0	0	0	0	0	0	0	2	43	14	45
Dist. of Col.	0	0	0	0	16	2	0	0	291	36	5
Virginia	0	0	0	0	6	3	2	2	71	38	122
West Virginia	3	1	0	0	24	9	3	2	134	50	54
North Carolina [3]	0	0	1	0	9	6	3	3	491	336	412
South Carolina	0	0	0	0	16	6	0	1	232	85	56
Georgia	0	0	2	0	3	2	0	1	98	59	56
Florida [3]	0	0	0	0	3	1	3	1	172	57	10
E. SO. CEN.											
Kentucky	2	1	7	1	5	3	0	4	16	9	50
Tennessee	4	2	14	2	0	0	2	3	97	55	28
Alabama [3]	0	0	0	0	4	2	3	1	35	20	32
Mississippi [2, 3]	0	0	1	0	3	1	1	1	------	------	------
W. SO. CEN.											
Arkansas	5	2	9	2	15	6	6	2	62	25	34
Louisiana [3]	2	1	2	2	135	56	21	13	70	29	18
Oklahoma	95	47	16	2	6	3	1	3	0	0	43
Texas [3]	25	30	28	28	7	8	10	10	99	119	355
MOUNTAIN											
Montana [4]	0	0	7	7	0	0	0	0	47	5	16
Idaho	61	6	10	4	10	1	2	0	20	2	13
Wyoming	0	0	0	2	22	1	0	0	0	0	45
Colorado	77	16	3	2	0	0	0	0	347	72	9
New Mexico	12	1	1	0	0	0	0	0	161	13	81
Arizona	123	10	2	0	12	1	0	0	577	47	42
Utah [2]	0	0	1	1	0	0	0	0	407	41	30
PACIFIC											
Washington	0	0	81	14	3	1	2	3	37	12	179
Oregon	94	19	46	2	0	0	2	2	70	14	16
California [3]	17	21	24	4	2	3	4	4	134	164	529
Total	13	326	500	202	6	158	106	106	171	4,232	4,542
10 weeks	16	3,923	5,684	2,053	5	1,195	1,173	1,173	171	42,416	40,631

[1] New York City only.
[2] Period ended earlier than Saturday.
[3] Typhus fever, week ended Mar. 11, 1939, 22 cases as follows: North Carolina, 2; Georgia, 5; Florida, 1; Alabama, 3; Mississippi, 2; Louisiana, 1; Texas, 6; California, 2.
[4] Rocky Mountain spotted fever, week ended Mar. 11, 1939, Montana, 1 case.

SUMMARY OF MONTHLY REPORTS FROM STATES

The following summary of cases reported monthly by States is published weekly and covers only those States from which reports are received during the current week:

State	Meningitis, meningococcus	Diphtheria	Influenza	Malaria	Measles	Pellagra	Poliomyelitis	Scarlet fever	Smallpox	Typhoid and paratyphoid fever
December 1938										
Puerto Rico	0	49	730	2,849	9		0		0	17
January 1939										
Alaska	0	6					0	6	0	1
February 1939										
Idaho	1	9	13		244		0	50	19	1
Michigan	0	49	549		1,588		1	2,159	99	16
North Carolina	4	102	366	43	4,330	6	1	264	0	14
Tennessee	8	39	279	7	259	8	1	167	8	9
Vermont	0	1			85		0	29	0	0

December 1938

	Cases
Puerto Rico:	
Chickenpox	3
Dysentery	4
Mumps	1
Ophthalmia neonatorum	1
Puerperal septicemia	2
Tetanus	6
Tetanus, infantile	1
Whooping cough	91

January 1939

	Cases
Alaska:	
Chickenpox	13
German measles	6
Impetigo contagiosa	3
Whooping cough	11

February 1939

	Cases
Botulism:	
Tennessee	1
Chickenpox:	
Idaho	144
Michigan	2,026
North Carolina	689
Tennessee	344
Vermont	134
Dysentery:	
Michigan (amoebic)	1
Michigan (bacillary)	8
Tennessee (amoebic)	8
Tennessee (bacillary)	2
Encephalitis, epidemic or lethargic:	
Tennessee	1
German measles:	
Idaho	1
Michigan	61
North Carolina	35
Tennessee	6
Vermont	5
Hookworm disease:	
Tennessee	3
Impetigo contagiosa:	
Tennessee	3
Jaundice, infectious:	
Michigan	4
Mumps:	
Idaho	41
Michigan	535
Tennessee	107
Vermont	128
Ophthalmia neonatorum:	
Tennessee	4
Puerperal septicemia:	
Tennessee	2
Rabies in man:	
Michigan	1
Septic sore throat:	
Idaho	2
Michigan	21
North Carolina	12
Tennessee	29
Tetanus:	
Michigan	1
Tennessee	1
Tularaemia:	
Michigan	2
North Carolina	3
Tennessee	6
Typhus fever:	
North Carolina	2
Undulant fever:	
Michigan	42
North Carolina	1
Tennessee	1
Vermont	3
Vincent's infection:	
Idaho	1
Michigan	13
Tennessee	10
Vermont	1
Whooping cough:	
Idaho	7
Michigan	886
North Carolina	1,124
Tennessee	157
Vermont	129

CASES OF VENEREAL DISEASES REPORTED FOR JANUARY 1939

These reports are published monthly for the information of health officers in order to furnish current data as to the prevalance of the venereal diseases. The figures are taken from reports received from State and city health officers. They are preliminary and are therefore subject to correction. It is hoped that the publication of these reports will stimulate more complete reporting of these diseases.

Reports from States

	Syphilis		Gonorrhea	
	Cases reported during month	Monthly case rates per 10,000 population	Cases reported during month	Monthly case rates per 10,000 population
Alabama	1,082	3.74	250	.86
Arizona	190	4.61	101	2.45
Arkansas	713	3.48	268	1.31
California	1,732	2.81	1,213	1.97
Colorado	81	.76	40	.37
Connecticut	224	1.29	136	.78
Delaware	245	9.39	37	1.42
District of Columbia	491	7.83	266	4.24
Florida	1,238	7.41	105	.63
Georgia	1,768	5.73	176	.57
Idaho [1]				
Illinois	2,541	3.23	1,222	1.55
Indiana	346	1.00	74	.21
Iowa	230	.90	120	.47
Kansas	290	1.60	159	.85
Kentucky	982	3.36	279	.96
Louisiana	738	3.46	68	.32
Maine	43	.50	25	.29
Maryland	1,050	6.25	262	1.56
Massachusetts [1]				
Michigan	1,129	2.34	490	1.01
Minnesota	258	.97	176	.66
Mississippi	2,189	10.82	2,549	12.60
Missouri	1,260	3.16	129	.32
Montana	56	1.04	20	.37
Nebraska	71	.52	68	.50
Nevada	27	2.67	12	1.19
New Hampshire	38	.75	21	.41
New Jersey	910	2.10	259	.60
New Mexico	115	2.73	40	.95
New York	4,835	3.73	1,891	1.46
North Carolina	5,283	15.13	741	2.12
North Dakota	31	.44	15	.21
Ohio [1]				
Oklahoma	96	.38	16	.06
Oregon	68	.66	119	1.16
Pennsylvania	1,252	1.23	180	.18
Rhode Island	100	1.47	36	.53
South Carolina [1]				
South Dakota	28	.40	22	.32
Tennessee	802	2.77	308	1.06
Texas	1,757	2.85	392	.64
Utah	21	.40	24	.46
Vermont	14	.37	19	.50
Virginia	1,676	6.19	308	1.14
Washington	209	1.26	250	1.51
West Virginia	380	2.04	136	.73
Wisconsin	41	.14	102	.35
Wyoming [1]				
Total	36,639	3.17	13,124	1.14

See footnotes at end of table.

Reports from cities of 200,000 population or over

	Syphilis		Gonorrhea	
	Cases reported during month	Monthly case rates per 10,000 population	Cases reported during month	Monthly case rates per 10,000 population
Akron, Ohio [2]				
Atlanta, Ga	304	10.13	75	2.50
Baltimore, Md	603	7.22	162	1.94
Birmingham, Ala	254	8.63	41	1.39
Boston, Mass	163	2.05	148	1.86
Buffalo, N. Y	324	5.39	54	.90
Chicago, Ill	1,751	4.78	878	2.40
Cincinnati, Ohio	205	4.34	53	1.12
Cleveland, Ohio	227	2.40	74	.78
Columbus, Ohio	23	.73	4	.13
Dallas, Texas	214	7.04	118	3.88
Dayton, Ohio	41	1.85	0	0
Denver, Colo	76	2.52	57	1.89
Detroit, Mich	423	2.33	190	1.05
Houston, Tex	303	8.46	63	1.76
Indianapolis, Ind	25	.65	18	.47
Jersey City, N. J	30	.92	11	.34
Kansas City, Mo.[1]				
Los Angeles, Calif.[1]				
Louisville, Ky	360	10.62	66	1.95
Memphis, Tenn	287	9.83	115	3.94
Milwaukee, Wis.[2]				
Minneapolis, Minn	64	1.28	58	1.16
Newark N. J	326	7.18	130	2.86
New Orleans, La.[1]				
New York, N. Y	3,530	4.71	1,433	1.91
Oakland, Calif	90	2.87	72	2.30
Omaha, Nebr	26	1.16	21	.94
Philadelphia, Pa.[1]				
Pittsburgh, Pa	324	4.60	16	.23
Portland, Oreg	33	1.03	43	1.34
Providence, R. I.[1]				
Rochester, N. Y	49	1.43	30	.88
St. Louis, Mo	255	3.02	43	.51
St. Paul, Minn	39	1.36	16	.56
San Antonio, Tex	161	6.15	74	2.83
San Francisco, Calif	114	1.65	221	3.21
Seattle, Wash	118	3.05	124	3.20
Syracuse, N. Y	82	3.64	20	.89
Toledo, Ohio [1]				
Washington, D. C	491	7.83	266	4.24

[1] No report for current month.
[2] Not reporting.

WEEKLY REPORTS FROM CITIES

City reports for week ended March 4, 1939

This table summarizes the reports received weekly from a selected list of 140 cities for the purpose of showing a cross section of the current urban incidence of the communicable diseases listed in the table.

State and city	Diphtheria cases	Influenza		Measles cases	Pneumonia deaths	Scarlet fever cases	Smallpox cases	Tuberculosis deaths	Typhoid fever cases	Whooping cough cases	Deaths, all causes
		Cases	Deaths								
Data of 90 cities:											
5-year average	184	736	128	7,773	989	2,423	25	409	18	1,297	--------
Current week [1]	118	1,285	200	4,268	917	1,454	48	356	37	1,178	--------
Maine:											
Portland	0	4	0	1	2	0	0	0	0	6	25
New Hampshire:											
Concord	0	------	0	0	0	0	0	0	0	0	9
Manchester	0	------	2	0	1	0	0	0	0	0	16
Nashua	0	------	0	0	0	1	0	0	0	0	5
Vermont:											
Barre	0	------	0	0	0	0	0	0	0	0	1
Burlington	0	------	0	1	0	0	0	0	0	4	10
Rutland	0	------	0	0	3	0	0	0	0	0	8
Massachusetts:											
Boston	1	------	2	214	25	53	0	11	0	21	258
Fall River	0	------	1	1	0	0	0	0	0	0	35
Springfield	0	------	0	26	4	3	0	0	0	1	36
Worcester	0	------	0	5	6	24	0	0	0	42	64
Rhode Island:											
Pawtucket	0	------	0	0	0	0	0	0	0	4	10
Providence	0	3	1	8	5	6	0	2	0	90	72
Connecticut:											
Bridgeport	0	3	1	1	2	1	0	3	0	1	31
Hartford	1	1	0	116	9	5	0	0	0	16	54
New Haven	0	2	1	49	3	2	0	0	0	3	47
New York:											
Buffalo	0	------	1	112	11	64	0	7	0	31	140
New York	23	91	3	77	115	215	0	69	4	138	1,530
Rochester	0	1	0	87	3	24	0	1	1	17	61
Syracuse	0	------	0	81	0	29	0	0	0	41	60
New Jersey:											
Camden	1	3	1	0	5	6	0	3	0	5	32
Newark	0	1	1	3	9	42	0	7	0	60	113
Trenton	0	------	1	2	8	4	0	0	0	9	44
Pennsylvania:											
Philadelphia	8	27	15	37	48	0	0	20	1	81	625
Pittsburgh	11	17	15	4	40	37	0	9	0	32	246
Reading	1	------	0	3	2	2	0	0	0	1	22
Scranton	1	------	--------	5	-------	33	0	-------	0	14	--------
Ohio:											
Cincinnati	2	14	8	2	23	31	0	3	0	1	176
Cleveland	2	333	4	3	34	69	0	14	0	24	253
Columbus	4	4	4	1	8	7	0	2	0	5	98
Toledo	0	13	3	1	7	17	0	2	0	16	91
Indiana:											
Anderson	0	------	0	0	2	4	1	1	0	0	13
Fort Wayne	1	------	2	1	4	0	0	0	0	0	34
Indianapolis	2	------	10	4	30	53	24	1	0	13	137
Muncie	0	------	1	0	4	2	0	1	0	1	11
South Bend	0	------	2	0	7	0	0	0	0	2	21
Terre Haute	0	------	3	0	11	1	0	1	0	0	116
Illinois:											
Alton	0	------	0	0	1	1	0	0	0	0	6
Chicago	10	130	28	6	99	180	0	39	0	125	931
Elgin	0	------	1	1	6	1	0	0	0	1	20
Moline	0	57	0	0	1	0	0	0	0	1	13
Springfield	0	------	0	0	5	5	0	0	0	3	30
Michigan:											
Detroit	1	44	11	9	46	102	0	22	0	71	383
Flint	0	------	0	113	9	24	0	0	0	0	38
Grand Rapids	0	214	4	3	3	18	0	0	0	4	37
Wisconsin:											
Kenosha	0	------	1	1	0	6	0	0	0	19	12
Madison	0	------	0	1	6	9	0	0	0	17	22
Milwaukee	0	35	7	5	9	59	0	3	0	68	120
Racine	0	------	1	7	0	8	0	1	0	0	16
Superior	0	------	0	4	1	2	0	0	0	0	7

[1] Figures for Los Angeles estimated; reports not received.

City reports for week ended March 4, 1939—Continued

State and city	Diphtheria cases	Influenza		Measles cases	Pneumonia deaths	Scarlet fever cases	Smallpox cases	Tuberculosis deaths	Typhoid fever cases	Whooping cough cases	Deaths, all causes
		Cases	Deaths								
Minnesota:											
Duluth	0	10	0	9	2	2	0	1	0	3	20
Minneapolis	0		5	274	9	19	4	0	0	26	102
St. Paul	0	1	1	321	5	21	0	0	0	5	67
Iowa:											
Cedar Rapids	0			0		3	0		0	2	
Davenport	0			0		5	1		0	3	
Des Moines	0		0	2	0	17	1	0	0	0	41
Sioux City	0			28		1	0		0	4	
Waterloo	0			0		17	0		0	0	
Missouri:											
Kansas City	0		7	5	25	23	0	0	0	0	139
St. Joseph	1		0	0	7	1	0	2	0	1	34
St. Louis	3	22	0	1	20	36	2	7	0	16	256
North Dakota:											
Fargo	0		0	0	0	0	0	0	0	0	6
Grand Forks	0			1		0	0		0	0	
Minot	0		0	7	0	0	0	0	0	0	6
South Dakota:											
Aberdeen	1			0		0	6		0	0	
Sioux Falls	0		0	19	0	0	0	0	0	0	11
Nebraska:											
Lincoln	0			15		3	0		0	1	
Omaha	0		2	5	6	9	2	2	0	0	53
Kansas:											
Lawrence	0	43	0	0	0	0	0	0	0	0	3
Topeka	0		0	0	5	1	0	0	0	0	36
Wichita	0	1	1	4	0	2	0	0	0	3	26
Delaware:											
Wilmington	2		0	1	8	4	0	0	0	0	37
Maryland:											
Baltimore	1	61	2	942	26	24	0	14	0	10	250
Cumberland	0	1	0	0	1	0	0	0	0	0	12
Frederick	0		0	0	1	0	0	0	0	5	4
Dist. of Col.:											
Washington	6	18	7	31	11	17	0	6	0	24	168
Virginia:											
Lynchburg	0		0	99	2	4	0	1	0	11	16
Norfolk	0	33	1	2	6	7	0	0	0	1	39
Richmond	0		4	37	6	2	0	0	0	0	60
Roanoke	0		0	0	2	1	0	0	0	1	9
West Virginia:											
Charleston	0	2	0	0	4	1	0	0	0	0	28
Huntington	0			0		0	1		0	0	
Wheeling	0		0	2	3	0	0	0	0	9	23
North Carolina:											
Gastonia	0			0		0	0		0	0	
Raleigh	0		0	0	6	8	0	0	1	2	18
Wilmington	1		0	0	0	0	0	0	0	8	15
Winston-Salem	0	1	2	201	4	2	0	0	0	0	13
South Carolina:											
Charleston	0	54	1	1	2	1	0	0	1	4	16
Florence	1		0	0	0	0	0	1	0	0	5
Greenville	0		0	0	0	0	0	0	0	3	8
Georgia:											
Atlanta	0	26	1	0	3	6	0	3	0	0	66
Brunswick	0		0	30	1	0	0	0	0	0	4
Savannah	0	29	1	0	1	1	0	1	0	12	28
Florida:											
Miami	0	5	0	0	1	0	0	1	0	3	40
Tampa	0	2	2	61	0	3	0	3	0	2	25
Kentucky:											
Ashland	1	6	0	0	1	0	0	1	0	0	6
Covington	0	6	0	1	3	11	0	6	0	0	21
Lexington	1		0	0	5	5	0	0	0	0	20
Louisville	0	611	1	1	8	11	0	4	0	6	97
Tennessee:											
Knoxville	0	11	1	1	2	0	0	1	0	0	44
Memphis	2	6	3	1	2	17	0	4	0	27	72
Nashville	0		1	3	3	5	0	0	0	7	62
Alabama:											
Birmingham	1	61	8	2	8	5	0	3	0	1	82
Mobile	1		2	1	4	0	0	0	0	0	28
Montgomery	0	8		2		0	0		0	0	

City reports for week ended March 4, 1939—Continued

State and city	Diphtheria cases	Influenza		Measles cases	Pneumonia deaths	Scarlet fever cases	Smallpox cases	Tuberculosis deaths	Typhoid fever cases	Whooping cough cases	Deaths, all causes
		Cases	Deaths								
Arkansas:											
Fort Smith	0	9		17		0	0		0	1	
Little Rock	0		0	0	8	6	0	1	0	0	4
Louisiana:											
Lake Charles	0		0	33	1	0	0	0	0	0	5
New Orleans	6	17	9	54	16	3	0	15	28	1	188
Shreveport	1		0	5	4	1	0	3	0	0	41
Oklahoma:											
Oklahoma City	1	14	0	2	7	15	3	2	0	0	51
Tulsa	0			1		13	0		0	1	
Texas:											
Dallas	0	10	2	2	8	6	4	5	0	0	67
Fort Worth	2	25	0	2	3	1	1	2	1	1	44
Galveston	0		0	0	1	1	0	2	0	2	13
Houston	5	1	1	12	20	2	0	6	0	0	98
San Antonio	0		3	1	10	0	0	13	0	1	77
Montana:											
Billings	0		0	4	2	0	0	0	0	0	8
Great Falls	0		0	4	1	2	0	1	0	0	10
Helena	0		0	107	1	0	0	0	0	0	4
Missoula	0		0	48	2	1	3	0	0	0	8
Idaho:											
Boise	1		0	0	1	0	0	0	0	0	8
Colorado:											
Colorado Springs	0		0	68	5	5	0	2	0	8	13
Denver	2		3	28	17	4	0	9	0	26	112
Pueblo	0		0	8	1	2	0	1	0	2	9
New Mexico:											
Albuquerque	0		0	1	2	0	0	3	0	0	17
Utah:											
Salt Lake City	0		0	8	5	11	0	4	0	1	44
Washington:											
Seattle	0		2	81	4	11	0	3	1	5	102
Spokane	0	1	1	55	4	0	0	0	0	0	39
Tacoma	0		0	1	0	1	0	0	0	1	27
Oregon:											
Portland	1		0	2	7	9	2	0	0	0	102
Salem	0			0		0	0		0	0	
California:											
Los Angeles											
Sacramento	0		0	222	8	2	8	3	0	0	33
San Francisco	3	3	0	361	12	23	0	2	0	9	203

State and city	Meningitis, meningococcus		Poliomyelitis cases	State and city	Meningitis, meningococcus		Poliomyelitis cases
	Cases	Deaths			Cases	Deaths	
Massachusetts:				**District of Columbia:**			
Boston	1	0	0	Washington	1	0	0
Rhode Island:				**Alabama:**			
Pawtucket	1	0	0	Birmingham	0	1	0
New York:				**Louisiana:**			
New York	3	0	1	Shreveport	0	2	0
Pennsylvania:				**Texas:**			
Pittsburgh	1	0	0	Dallas	0	1	0
Ohio:							
Cincinnati	2	0	0				
Toledo	1	0	0				

Encephalitis, epidemic or lethargic.—Cases: Philadelphia, 1; Pittsburgh, 1; Chicago, 1; Baltimore, 1.
Pellagra.—Cases: Atlanta, 3; Miami, 1; New Orleans, 1.
Typhus fever.—Cases: New York, 1; Savannah, 2; Lake Charles, 1; Fort Worth, 1.

FOREIGN AND INSULAR

CANADA

Provinces—Communicable diseases—Weeks ended February 4 and 11, 1939.—During the weeks ended February 4 and 11, 1939, cases of certain communicable diseases were reported by the Department of Pensions and National Health of Canada as follows:

Week ended Feb. 4, 1939

Disease	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Total
Cerebrospinal meningitis		1		1						2
Chickenpox		6	6	148	335	32	43	24	114	708
Diphtheria		3	1	56	7	11	11		1	90
Dysentery					1					1
Influenza		27			57				30	114
Measles		5		160	1,335	33	2	1	5	1,541
Mumps		2	30	55	110	66	1	6	4	274
Pneumonia		5			27	2	3		17	54
Poliomyelitis				1			1			2
Scarlet fever		4	23	72	236	36	51	26	14	462
Smallpox							10			10
Trachoma							1		2	3
Tuberculosis	1	2	8	108	60	1	1	3	24	208
Typhoid and paratyphoid fever			1	11	2					14
Whooping cough		1	5	146	283	14	16		61	526

Week ended Feb. 11, 1939

Disease	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Total
Cerebrospinal meningitis		1			2					3
Chickenpox		4	12	211	363	27	38	32	75	762
Diphtheria			7	42	1	5	7	1		63
Dysentery					1					1
Influenza		14	7		27				31	79
Measles		413		237	1,033	14	6		5	1,708
Mumps				70	91	64		15	3	243
Pneumonia		7			30		1		17	55
Poliomyelitis					1			3		4
Scarlet fever		10	22	107	191	42	22	28	21	443
Smallpox									4	4
Tuberculosis	1	4	8	52	45	5	24		10	149
Typhoid and paratyphoid fever			1	9	1				1	12
Whooping cough		55	1	109	297	18	2	1	79	562

CUBA

Habana—Communicable diseases—4 weeks ended February 11, 1939.—During the 4 weeks ended February 11, 1939, certain communicable diseases were reported in Habana, Cuba, as follows:

Disease	Cases	Deaths	Disease	Cases	Deaths
Diphtheria	22		Tuberculosis	17	5
Malaria	8		Typhoid fever	91	10
Scarlet fever	1				

DENMARK

Notifiable diseases—October–December 1938.—During the months of October, November, and December 1938 cases of certain notifiable diseases were reported in Denmark as follows:

Disease	October	November	December	Disease	October	November	December
Cerebrospinal meningitis	1	5	4	Mumps	175	253	220
Chickenpox	385	626	572	Paradysentery	20	68	21
Diphtheria	82	82	74	Paratyphoid fever	9	2	3
Epidemic encephalitis		3	1	Poliomyelitis	135	50	12
Erysipelas	282	330	239	Puerperal fever	18	17	22
Gastroenteritis, infectious	2,384	1,672	1,324	Scarlet fever	1,041	1,247	857
German measles	165	225	159	Syphilis	43	42	44
Gonorrhea	862	734	666	Tetanus, neonatorum	5	1	3
Influenza	4,408	5,799	5,595	Typhoid fever	7	4	4
Lymphogranuloma		2		Undulant fever	58	45	38
Malaria	6	7		Weil's disease	1	4	
Measles	1,337	1,753	1,684	Whooping cough	1,702	3,021	2,652

ITALY

Communicable diseases—4 weeks ended January 1, 1939.—During the 4 weeks ended January 1, 1939, cases of certain communicable diseases were reported in Italy as follows:

Disease	Dec. 5–11	Dec. 12–18	Dec. 19–25	Dec. 26–Jan. 1, 1939
Anthrax	27	20	6	8
Cerebrospinal meningitis	17	11	18	12
Chickenpox	395	445	324	302
Diphtheria	777	705	612	568
Dysentery	18	25	11	2
Hookworm disease	22	22	10	4
Lethargic encephalitis		3	2	2
Measles	1,337	1,231	914	1,185
Mumps	218	188	204	103
Paratyphoid fever	89	93	70	68
Pellagra				1
Poliomyelitis	37	33	22	21
Puerperal fever	34	28	32	33
Scarlet fever	306	324	277	200
Typhoid fever	560	542	422	349
Undulant fever	40	54	41	35
Whooping cough	255	224	171	173

SCOTLAND

Vital statistics—Quarter ended December 31, 1938.—Following are vital statistics for Scotland for the fourth quarter ended December 31, 1938:

Disease	Number	Rate per 1,000 population	Disease	Number	Rate per 1,000 population
Population	4,985,300		Deaths from—Continued.		
Marriages	9,526	7.6	Heart disease	3,731	
Births	20,951	16.7	Influenza	95	
Deaths	16,094	12.8	Measles	5	
Deaths under 1 year of age	1,576	[1] 75	Nephritis, acute and chronic	415	
Deaths from:					
Appendicitis	116		Pneumonia (all forms)	906	.72
Cancer	2,131	1.70	Puerperal sepsis	34	
Cerebral hemorrhage	1,663		Scarlet fever	17	
Cerebrospinal fever	23		Senility	606	
Cirrhosis of the liver	50		Suicide	96	
Diabetes mellitus	220		Tuberculosis (all forms)	769	.61
Diarrhea	246		Typhoid fever	5	
Diphtheria	110		Whooping cough	72	

[1] Per 1,000 live births.

Vital statistics—Year 1938.—Following are vital statistics for Scotland for the year 1938:

Disease	Number	Rate per 1,000	Disease	Number	Rate per 1,000
Marriages	38,744	7.8	Deaths from—Continued.		
Births	88,604	17.7	Influenza	396	
Deaths	62,952	12.6	Measles	549	
Deaths under 1 year of age	6,161	[1] 70	Nephritis, acute and chronic	1,769	
Deaths from:					
Appendicitis	430		Pneumonia (all forms)	3,831	
Cancer	8,073	16.2	Puerperal sepsis	151	1.7
Cerebral hemorrhage	6,254		Scarlet fever	98	
Cerebrospinal fever	106		Senility	2,304	
Cirrhosis of the liver	203		Suicide	459	
Diabetes mellitus	859		Tuberculosis (all forms)	3,431	
Diarrhea	981		Typhoid fever	27	
Diphtheria	430		Whooping cough	219	
Heart disease	14,115				

[1] Per 1,000 live births.

SWEDEN

Notifiable diseases—January 1939.—During the month of January 1939 cases of certain notifiable diseases were reported in Sweden as follows:

Disease	Cases	Disease	Cases
Diphtheria	6	Scarlet fever	2,430
Dysentery	55	Syphilis	35
Gonorrhea	958	Typhoid fever	5
Paratyphoid fever	9	Undulant fever	16
Poliomyelitis	32	Weil's disease	7

CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER

NOTE.—A table giving current information of the world prevalence of quarantinable diseases appeared in the PUBLIC HEALTH REPORTS for February 24, 1939, pages 322-333. A similar cumulative table will appear in future issues of the PUBLIC HEALTH REPORTS for the last Friday of each month.

Cholera

India—Allahabad.—During the week ended March 4, 1939, 1 suspected case of cholera was reported in Allahabad, India.

Plague

India—Bassein.—During the week ended March 4, 1939, 1 fatal case of plague was reported in Bassein, India.

Yellow Fever

Brazil.—Yellow fever has been reported in Brazil as follows: Espirito Santo State—February 4–13, 1939, 9 deaths; Minas Geraes State—February 5–11, 1939, 4 deaths.

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