CHAPTER IV

RESULTS AND DISSCUSION OF THE EXPERIMENTS

General Characteristics of Waste

The concentration of the waste from the plant effluent varied everyday. After the observation, the BOD_5 concentrations varied from 4671 mg./l. to 1412 mg./l. and the COD concentrations varied from 7077 mg./l. to 2140 mg./l. The pH values were found during the experiments varying from 6.1 to 8.1. Sample no. 1 and sample no. 2 had few variations in pH, which didnot require pH adjustment. But sample no. 3 and sample no. 4 must be adjusted pH to neutral daily. Another factors affected the growth of organisms are nitrogen and phosphorus. In order to maintain optimum process efficiency, suitable quantities of nitrogen and phosphorus are required. HELMERS et. al. (1951) determined minimal quantities equivalent to a BOD : N : P ratio of 100 : 5 : 1.

Relationship between BOD_5/COD Ratio

BOD_5 and COD tests were determined during the aeration time intervals and their relationships were shown in Fig. 9 A and Fig. 9 B. The ratio of BOD_5 to COD is ranging from 0.65 to 0.68. The mean value was 0.667. With this mean value , BOD_5 could be approximately calculated after COD tests were determined.

The Variations of pH

The variation in pH of sample no. 1 and sample no. 2 were in small scale, but sample no. 3 and sample no. 4 pH varied during the time of aeration from 6.1 to 8.1 as shown in Fig. 14 B. and Fig. 15 B.

Sludge Growth and Oxidation

The patterns of sludge growth and oxidation are shown in Fig. 3 , Fig. 4 , Fig. 5 , and Fig. 6 . which follow the sigmoidal curve.

Nitrogen Utilization

Fig. 20 and Fig. 21 showed that nitrogen is utilized for synthesis during the auto - oxidation process and nitrogen is released back to the solution in the form of NO_3- N. Some of this nitrogen will be recovered and reused for synthesis. According to Table 20 and Table 21 showed the quantities of Ammonia - nitrogen of sample no. 1 and sample no. 2 were 544 mg./1. and 523 mg./1. which had been reduced to 391 mg./1. and 436 mg./1. respectively after 24 hours of aeration. After the oxidation, nitrate - nitrogen had been oxidised from 7.8 mg./1. and 9.0 mg./1. to 60.7 mg./1. and 57.1 mg./1. in sample no. 1 and sample no. 2 respectively.

Determination of Nitrogen Requirements

The nitrogen content of sludges is dependent on the type and nature of the active organisms produced in aerobic waste treatment systems, the concentration of biological volatile solids and the concentration of available nitrogen in the waste. The ratio of microbial mass to total volatile solids will determine the critical nitrogen content. This ratio will be variable depending on the waste ECKENFELDER and O' CONNER (1966). From Table 16 and Table 17 showed the nitrogen requirements based on COD removal which expressed as the ammonia - nitrogen requirements = 3.65 lb.N./100 lb. COD removed for sample no. 1 and 3.80 lb. N/100 lb. COD removed for sample no. 2. The other Table 18 and Table 19 showed the nitrogen requirements based on BOD_5 removal which expressed as the ammonia - nitrogen requirements = 6.10 lb.N./100 lb. BOD_5 removed and 6.35 lb. N/100 lb. BOD_5 removed for sample no. 1 and no. 2 respectively. These are shown that the high contents of the ammonia - nitrogen in dairy waste are adequate for nutrition.

Dissolved Oxygen Available

Fig.22,Fig. 23, Fig. 24 and Fig. 25 showed the concentrations of the dissolved oxygen in the mixed liquor. It is found that dissolved oxygen concentrations varied from 6.9 mg./1. to 6.7 mg./1. The oxygen concentration is high enough to ensure adequate oxygen utilization.

Batch Process

The dairy waste taken from the plant effluent each time will be fed with the acclimatized sludge in the aeration tank except sample no. 3 and no. 4. By means of the acclimatized sludge, the detention period of treatment was shorter than that of without acclimatized one. Sample no. 1 and sample no. 2 required the detention time 8 - 10 hrs. to obtain optimum efficiency but the others required 7 - 8 days.

Calculation of Organic Removal Rate (m) by Assimilation

The specific relationship between the fraction removal of organics and the loading intensity for any particular waste can be established with data derived from a batch process. Often it is found that the relationship approximately.

$$C/Co = 1 - 10^{-mi}$$

A semi - log plot between removal (1 - C/Co) and organic loading (i) can be used to establish the value of m. as shown in Fig. 7 and Fig. 8 to be = 0.430 and 0.438 respectively. These values will be the criteria to design the aeration tank capacity and the aeration period.

Determination of Logarithmic Growth Rate Constant

The logarithmic growth rate constant (k_1, K_1) for the log growth phase of sample no. 1 and no. 2 are shown in Fig. 26 A and Fig. 28 A. The constant k_1 and K_1 of sample no. 1 were 0.066 $hr.^{-1}$ and 0.152 $hr.^{-1}$; k_1 and K_1 of sample no. 2 were 0.054 $hr.^{-1}$ and 0.124 $hr.^{-1}$

The logarithmic growth rate K_1 might be employed to determine the initial BOD removal of the high BOD wastes.

The equation: $2.3 \log. (1 + aLr/So.) = K_1.t.$ is applicable when the initial BOD / sludge solids ratio exceeds 2 and the equation: $Lr/t = K_1 Sa/a$ is applicable when initial BOD sludge ratio is less than 2 ECKENFELDER and O' CONNER (1966).

From the equation $dO_2/dt = (\frac{a'}{a} . K_1 + b') S$

The growth rate K_1 could be used to calculate the maximum oxygen uptake rate which encountered in a waste oxidation system and would be related to the sludge growth rate and to the endogenous respiration rate. The logarithmic growth phase of sample no. 1 and no. 2 were 8 hrs. and 10 hrs. respectively.

Determination of the Declining Growth Rate Constant

The declining growth rate constant ($-k_2$, $-K_2$) for the declining growth phase of sample no. 1 and sample no. 2 are shown in Fig. 27 and Fig. 29. The constants $-k_2$ and $-K_2$ of sample no. 1 were 0.116 $hr.^{-1}$ and 0.267 $hr.^{-1}$; $-k_2$ and $-K_2$ of sample no.2. were 0.111 $hr.^{-1}$ and 0.255 $hr.^{-1}$ respectively.

If the removal rate follows first - order kinetics, it can be shown by a material balance that the BOD removal efficiency in the case of complete mixing will be.

$$\% \text{ Efficiency} = 100. \frac{K_2'. Sa.t}{1 + K_2'. Sa.t}$$

Where $$K_2 = K_2'. Sa.$$

ECKENFELDER and Mc. CABE (1960)

This phase occured two or three hours after starting the aeration.

Determination of the Endogenous Rate Constant

The endogenous rate constant ($-k_3$, $-K_3$) for the endogenous phase of sample no. 1 and no. 2 are shown in Fig. 26. B and Fig. 28 B. The constants $-k_3$ and $-K_3$ of sample no. 1 were 0.0224 $hr.^{-1}$ and 0.0515 $hr.^{-1}$; $-k_3$ and $-K_3$ of sample no. 2 were 0.0294 $hr.^{-1}$ and 0.0667 $hr.^{-1}$

ECKENFELDER and Mc. CABE (1960) developed an equation using the endogenous rate constant to estimate the net sludge production.

$$\Delta S = aY - K_3 . Sa.$$

And also used to design an extended aeration process. The quantity of sludge which must be maintained under aeration so that no degradable sludge will be accumulate could be computed by the relationship:

$$Sa = a. Y/K_3$$

Where:

- a = The Fraction of the BOD Removed.
- S = Net Sludge accumulative
- Sa = lb. Volatile Suspended Solids in Mixed Liquor.
- Y = BOD Removed.

This phase occurred after 8 to 10 hours after starting the aeration.

Biological Treatment:

BOD_5- COD at Various Time of Aeration

Sample no. 1 as shown in Table 10 , COD after 24 hrs. of aeration had been reduced from 3475 mg./l. to 268 mg./l. (92.3 % COD removal). The BOD_5 had been reduced from 2328 mg./l. to 182 mg./l. (92.2 % BOD_5 removal).

Sample no. 2 as shown in table 11, COD after 24 hrs. of aeration had been reduced from 2140 mg./l. to 195 mg./l. (90.9% COD removal). The BOD_5 had been reduced from 1412 mg./l. to 127 mg./l. (91.1 % BOD_5 removal).

Sample no. 3 as shown in Table 12, COD after 7 days of aeration had been reduced from 7077 mg./l. to 283 mg./l.(96.0% COD removal). The BOD_5 had been reduced from 4671 mg./l. to 192 mg./l. (95.9 % BOD_5 removal).

Sample no. 4 as shown in Table 13 , COD after 7 days of aeration had been reduced from 2334 mg./l. to 158 mg./l.(93.2% COD removal). The BOD_5 had been reduced from 1555 mg./l. to 105 mg./l. (93.2 % BOD_5 removal).

The patterns of COD - BOD_5 removal are shown in Fig. 10 A, Fig. 10 B, Fig. 11 A, Fig. 11 B respectively.

Fat Removal and Measurement

Fat determination has been made but the result was not shown in the data because it was rather unreliable. There were so many errors in collecting the samples such as fat often accumulated into "fat balls" and attached to the wall of aeration tank so the samples did not represent the true quantity of fat.

Fat causes many problems in the dairy waste treatment, i.e. 1- Fat balls usually coat the biological forms and may obstruct the oxygen transfer from the liquid to the living cells of the flocs. This was sometimes described as "somthering action" SAWYER (1966).

2- Fat would prevent the settling of the flocs. As we can see from this research that when fat was not skimmed off, the rate of settling will be slow so $Fe\ Cl_3$ 0.5 mg./l. was added to settle the flocs as in Table 12. and Table 13.

Examination of Micro - organisms

The protozoa in the form of stalked ciliates are commonly found in dairy waste treatment. In this study, stalked ciliates were found to be *Colpidium sp.*, *Vorticella sp.* and *Epistylis sp.*. Besides these stalked ciliates, free swimming types were also found i.e. *Paramoecium sp.* and *Trichoda sp.*

Table (a)

Raw Characteristics of Dairy Waste

Subjects	Sample No.1	Sample No.2	Sample No.3	Sample No.4
BOD_5	2328	1412	4671	1555
COD	3475	2140	7077	2334
D.O.	0.4	0.2	0	0
NH_3-N	544	523	-	-
NO_3-N	7.8	9.0	-	-
pH	7.1	7.0	7.1	7.0
Suspended - (mg/l) Solids	884	771	450	-
Temperature ^oC	28	28	29	28

Where

BOD_5 = The 5-Day Biochemical Oxygen Demand,mg./l.

COD = Chemical Oxygen Demand,mg./l.

D.O = Dissolved Oxygen,mg./l.

NH_3-N = Ammonia-Nitrogen,mg./l as N.

NO_3-N = Nitrate-Nitrogen,mg./l as N.

Table 1

COD REMOVAL CHARACTERISTICS

SAMPLE NO. 1

t	Sa.t	C	%COD Removal	%COD Remaining
0	0	3475		
2	3140	2616	24.8	75.2
4	6280	1752	49.6	50.4
6	9420	904	74.0	26.0
8	12560	413	88.1	11.9
10	15700	295	91.5	8.5
12	18840	288	91.7	8.3
24	37680	268	92.3	7.7

Where:

C = COD concentration at time t. , mg./l.

Sa = The Average Sludge Concentration over the Range under Consideration = 1570 mg./l. as VSS. (From Fig. 3)

t = Time of Aeration , hr.

Table 2

COD REMOVAL CHARACTERISTICS

SAMPLE NO. 2

t	Sa. t	C	%COD Removal	%COD Remaining
0	0	2140		
2	3000	1358	36.8	63.2
4	6000	834	61.5	38.5
6	9000	371	82.2	17.8
8	12000	223	89.6	10.4
10	15000	199	90.7	9.3
12	18000	197	90.8	9.2
24	36000	195	90.9	9.1

Where:

C = COD concentration at Time t., mg./1.

Sa = The Average Sludge Concentration over the Range under Consideration = 1500 mg/1. as VSS. (From. Fig. 4)

t = Time of Aeration, hr.

Table 3

CONCENTRATION OF SOLIDS AT VARIOUS TIME OF AERATION AT 28 °C

SAMPLE NO. 1

t hr.	Volatile Solids mg./l.	Fixed Solids mg./l.	Total Solids mg./l.
0	1222	961	2183
2	1365	995	2340
4	1403	1110	2513
6	1476	1115	2591
8	1563	1204	2767
10	1552	1194	2746
12	1449	1113	2562
24	1306	1225	2531

Where:

t = Time of Aeration, hr.

From Fig. 3

The Average Sludge Concentration (Sa) over the Range under Consideration = 1570 mg/l. as VSS.

Table 4

CONCENTRATION OF SOLIDS AT VARIOUS TIME OF AERATION AT 28 °C

SAMPLE NO. 2

t hr.	Volatile Solids mg./l.	Fixed Solids mg./l.	Total Solids mg./l.
0	1063	801	1864
2	1175	869	2044
4	1296	1058	2354
6	1402	1183	2585
8	1486	1381	2867
10	1493	1372	2865
12	1430	1383	2813
24	1229	1254	2483

Where:

t = Time of Aeration, hr.

From Fig. 4

The Average Sludge Concentration (Sa) over the Range under Consideration = 1500 mg./l. as VSS.

Table 5

CONCENTRATION OF SOLIDS AT VARIOUS TIME OF AERATION

SAMPLE NO. 1

t hr.	Fat Skimmed off mg./l.	Suspended Solids mg./l.		Dissolved Solids mg./l.		Total Solids mg./l.
		Fat	Total S.S.	Fat	Total D.S.	
0	178	28	771	114	1270	2183
2	Skimmed	29	907	46	1358	2340
4	"	36	1008	44	1425	2513
6	"	45	1101	32	1413	2591
8	-	58	1189	28	1492	2767
10	-	54	1182	27	1483	2746
12	-	56	1165	24	1317	2562
24	-	49	1053	24	1405	2531

Where:

D.S = Dissolved Solids, mg./l.

S.S = Suspended Solids, mg./l.

t = Time of Aeration, hr.

Fat Skimmed off = Fat that skimmed off from the aeration tank after aeration time t., mg./l.

Table 6

CONCENTRATION OF SOLIDS AT VARIOUS TIME OF AERATION

SAMPLE NO. 2

t hr.	Fat Skimmed off mg./l.	Suspended Solids mg./l.		Dissolved Solids mg./l.		Total Solids mg./l.
		Fat	Total S.S	Fat	Total D.S	
0	116	19	884	78	883	1864
2	Skimmed	22	1003	24	995	2044
4	"	34	1177	21	1122	2354
6	"	35	1359	23	1168	2585
8	-	46	1561	25	1235	2867
10	-	49	1583	20	1213	2865
12	-	51	1573	16	1173	2813
24	-	43	1390	15	1035	2483

Where:

D.S = Dissolved Solids, mg./l.

S.S = Suspended Solids, mg./l.

t = Time of Aeration, hr.

Fat skimmed off = Fat that skimmed off from the aeration tank after aeration time t.

Table 7

CALCULATION OF ORGANIC REMOVAL RATE, m BY ASSIMILATION

SAMPLE NO. 1

t hr.	Co mg./l.	C mg./l.	C/Co	So mg/l.	1 - C/Co	i=Co/(So.t) hr^{-1}
0	3475			1222		
2	3475	2616	0.752	1222	0.248	1.413
4	3475	1752	0.504	1222	0.496	0.706
6	3475	904	0.260	1222	0.740	0.469
8	3475	413	0.119	1222	0.881	0.354
10	3475	295	0.085	1222	0.915	0.287
12	3475	288	0.083	1222	0.917	0.234

Where

C = Concentration of Organics at Time t, mg./l.

Co = Initial Concentration of Organics, mg./l.

i = Organic Loading Intensity = Co/ (So.t)

m = Constant

So = Initial Concentration of Activated Sludge, mg./l.

t = time, hr. .

Table 8

CALCULATION OF ORGANIC REMOVAL RATE, m BY ASSIMILATION

SAMPLE NO. 2

t hr.	Co mg/l.	C mg/l.	C/Co	So mg/l.	1- C/Co	i=Co/(So.t) hr.$^{-1}$
0	2140			1063		
2	2140	1358	0.635	1063	0.365	1.010
4	2140	834	0.389	1063	0.611	0.502
6	2140	371	0.172	1063	0.828	0.367
8	2140	223	0.102	1063	0.898	0.252
10	2140	199	0.093	1063	0.907	0.199
12	2140	197	0.092	1063	0.908	0.168

Where

C = Concentration of Organics at Time t, mg./l.

Co = Initial Concentration of Organics, mg./l.

i = Organic Loading Intensity = Co/ (So.t)

m = Constant

So = Initial Concentration of Activated Sludge,mg./l.

t = time, hr. .

Table 9.

DETERMINATION OF BOD_5: COD RATIO AT 28 °C

Sample NO.	Time of Aera-tion hr.	COD mg./l.	BOD_5 mg./l.	BOD_5/COD
1	0	3475	2328	0.67
	2	2616	1739	0.68
	4	1752	1174	0.67
	6	904	597	0.66
	8	413	268	0.65
	10	295	201	0.68
	12	288	190	0.66
	24	268	182	0.68
2	0	2140	1412	0.66
	2	1358	910	0.67
	4	834	543	0.65
	6	371	252	0.68
	8	223	147	0.66
	10	199	135	0.68
	12	197	132	0.67
	24	195	127	0.65
			ΣX	10.67

Where $\sum x$ = BOD_5/COD

N = Number of Tests

$$\text{Mean} = \sum x/N$$

$$= 10.67/16$$

$$= 0.667.$$

Table 10.

BOD$_5$-COD REMOVAL AND REMAINING AT VARIOUS TIME OF AERATION

SAMPLE NO. 1

Time of Aeration hr.	COD mg/l.	%COD Removal	%COD Remaining	BOD$_5$ mg/l.	%BOD$_5$ Removal	%BOD$_5$ Remaining
0	3475			2328		
2	2616	24.8	75.2	1739	25.5	74.5
4	1752	49.6	50.4	1174	50.4	49.6
6	904	74.0	26.0	597	74.3	25.7
8	413	88.1	11.9	268	87.6	12.4
10	295	91.5	8.5	201	91.4	8.6
12	288	91.7	8.3	190	91.8	8.2
24	268	92.3	7.7	182	92.2	7.8

Start with Dairy Waste 40 liters Sample.

Percent Sludge Return = 30 %

pH = 7.1

Temperature = 28 °C.

Table 11.

BOD_5-COD REMOVAL AND REMAINING AT VARIOUS TIME OF AERATION

SAMPLE NO. 2

Time of Aeration hr.	COD mg/l.	%COD Removal	%COD Remaining	BOD_5 mg/l.	%BOD_5 Removal	%BOD_5 Remaining
0	2140			1412		
2	1358	36.8	63.2	910	35.6	64.4
4	834	61.5	38.5	543	59.0	41.0
6	371	82.2	17.8	252	82.2	17.8
8	223	89.6	10.4	147	89.6	10.4
10	199	90.7	9.3	135	90.4	9.6
12	197	90.8	9.2	132	90.7	9.3
24	195	90.9	9.1	127	91.1	8.9

Start with Dairy Waste 40 liters Sample

Percent Sludge Return = 35 %

pH = 7.0

Temperature = 28 °C.

Table 12.

BOD_5-COD REMOVAL AND REMAINING AT VARIOUS TIME OF AERATION

SAMPLE NO. 3

Time of Aeration Days.	COD mg/l.	%COD Removal	%COD Remaining	BOD_5 mg/l.	%BOD_5 Removal	%BOD_5 Remaining
0	7077			4671		
1	1643	76.8	23.2	1117	76.3	23.7
2	848	88.1	11.9	551	88.2	11.8
3	817	88.8	11.2	547	88.4	11.9
4	534	92.4	7.6	363	92.3	7.7
5	332	95.3	4.7	219	95.3	4.7
6	329	95.4	4.6	217	95.4	4.6
7	283	96.0	4.0	192	95.9	4.1

Start with Dairy Waste 60 liters Sample; without Returned Sludge

pH = 7.1

Temperature = 29 °C

Daily Seeding :

1. $CaCl_2$ = 30.0 mg./l.
2. $FeCl_3$ = 0.5 mg./l.

Table 13.

BOD_5-COD REMOVAL AND REMAINING AT VARIOUS TIME OF AERATION

SAMPLE NO. 4

Time of Aeration Days	COD mg/l.	%COD Removal	%COD Remaining	BOD_5 mg/l.	%BOD_5 Removal	%BOD_5 Remaining
0	2334			1555		
1	831	64.4	35.6	554	64.4	35.6
2	487	79.1	20.9	325	79.1	20.9
3	308	86.8	13.2	205	86.8	13.2
4	268	88.5	11.5	178	88.5	11.5
5	194	90.7	8.3	129	90.7	8.3
6	179	92.3	7.7	119	92.3	7.7
7	158	93.2	6.8	105	93.2	6.8

Start with Dairy Waste 55 liters Sample, without Returned Sludge.

pH = 7.0

Temperature = 28 °C

Daily Seeding : Fe Cl_3 = 0.5 mg./l.

Remark : BOD_5 = 0.667 (COD)

From Table. 9 BOD_5/COD = 0.667.

Table 14.

VARIATION OF pH AND SUSPENDED SOLIDS

SAMPLE NO. 3

t	pH	Adjust pH to 7.0 by	Suspended Solids
0	7.1	KH_2PO_4	450
1	7.8	KH_2PO_4	690
2	7.6	KH_2PO_4	750
3	8.1	KH_2PO_4	870
4	7.5	KH_2PO_4	1110
5	7.7	KH_2PO_4	1470
6	7.7	KH_2PO_4	1710
7	7.4	KH_2PO_4	1830

Where

t = Time of Aeration , days

Remark : Suspended Solids were determined by Centrifuge Method.

Table 15.

VARIATION OF pH AND SUSPENDED SOLIDS

SAMPLE NO. 4

t	pH	Adjust pH to 7.0 by	Suspended Solids
0	7.0	-	-
1	6.1	K_2HPO_4	-
2	7.1	-	510
3	7.2	-	730
4	6.8	K_2HPO_4	750
5	7.0	-	810
6	7.5	KH_2PO_4	1050
7	7.1	-	1350

Where

t = Time of Aeration, days.

Remark : Suspended Solids were determined by Centrifuge Method.

Table 16.

DETERMINATION OF NITROGEN REQUIREMENTS BASED ON COD

SAMPLE NO. 1

t	C	Cr	N	Nr	100 Nr/Cr	% COD Removed
0	3475		544			
2	2616	859	526	18	2.09	24.8
4	1752	1723	502	42	2.43	49.6
6	904	2571	474	70	2.72	74.0
8	413	3062	447	97	3.16	88.1
10	295	3180	432	112	3.52	91.5
12	288	3187	418	126	3.96	91.7
24	268	3207	391	153	4.76	92.3

Where :

C = COD at Time t , mg./l.

Cr = COD Removed , mg./l.

N = Ammonia - Nitrogen , mg./l. as N.

Nr = Ammonia - Nitrogen Removed, mg./l. as N.

t = Time of Aeration, hr.

From Fig. 14

Ammonia - Nitrogen Requirements = 3.65 lb.N./100 lb.COD Removed.

Table 17.

DETERMINATION OF NITROGEN REQUIREMENTS BASED ON COD

SAMPLE NO. 2

t	C	Cr	N	Nr	100 Nr/Cr	% COD Removed
0	2140		523	|		
2	1358	782	502	21	2.68	36.8
4	834	1306	485	38	2.82	61.5
6	371	1769	466	57	3.22	82.2
8	223	1917	455	68	3.55	89.6
10	199	1941	447	76	3.90	90.7
12	197	1943	444	79	4.06	90.8
24	195	1945	436	87	4.47	90.9

Where :

C = COD at Time t , mg./l.

Cr = COD Removed , mg./l.

N = Ammonia - Nitrogen Present at Time t, mg./l. as N.

Nr = Ammonia - Nitrogen Removed, mg./l. as N.

t = Time of Aeration , hr.

From Fig. 15

Ammonia - Nitrogen Requirements = 3.80 lb.N/100 lb. COD Removed.

Table 18

DETERMINATION OF NITROGEN REQUIREMENTS BASED ON BOD_5

SAMPLE NO. 1

t	Le	Lr	N	Nr	100 Nr/Lr	% BOD_5 Removed
0	2328		544			
2	1739	589	526	18	3.06	25.5
4	1174	1154	502	42	3.64	50.4
6	597	1731	474	70	4.04	74.3
8	268	2060	447	97	4.71	87.6
10	201	2127	432	112	5.32	91.4
12	190	2138	418	126	5.90	91.8
24	182	2146	391	153	7.13	92.2

Where :

Le = 5 - Day BOD at Time t , mg./l.

Lr = 5 - Day BOD Removed , mg./l.

N = Ammonia-Nitrogen , mg./l. as N.

Nr = Ammonia-Nitrogen Removed, mg./l. as N.

t = Time of Aeration, hr.

From Fig. 16

Ammonia-Nitrogen Requirements = 6.10 lb.N./100 lb.BOD_5 Removed.

Table 19.

DETERMINATION OF NITROGEN REQUIREMENTS BASED ON BOD_5

SAMPLE NO. 2

t hr.	Le	Lr	N	Nr	100 Nr/Lr	% BOD_5 Removed
0	1412		523			
2	910	502	502	21	4.18	35.6
4	543	869	485	38	4.37	59.0
6	252	1160	466	57	4.92	82.2
8	147	1265	455	68	5.38	89.6
10	135	1277	447	76	5.95	90.4
12	132	1280	444	79	6.17	90.7
24	127	1285	436	87	6.77	91.1

Where :

Le = 5- Day BOD at Time t ; mg./l.

Lr = 5- Day BOD Removed ; mg./l.

N = Ammonia-Nitrogen ; mg./l. as N.

Nr = Ammonia-Nitrogen Removed ; mg./l. as N.

t = Time of Aeration , hr.

From Fig. 18

Ammonia-Nitrogen Requirements = 6.35 lb.N./100 lb.BOD_5 Removed.

Table 20.

AMMONIA - NITROGEN AND NITRATE - NITROGEN

SAMPLE NO. 1

Time of Aeration hr.	Ammonia-Nitrogen mg./l. as N.	Nitrate-Nitrogen mg./l. as N.
0	544	7.8
2	526	10.2
4	502	11.9
6	474	13.1
8	447	17.8
10	432	18.3
12	418	26.7
24	391	60.7

Table 21

AMMONIA - NITROGEN AND NITRATE - NITROGEN

SAMPLE NO. 2

Time of Aeration hr.	Ammonia-Nitrogen mg./l. as N.	Nitrate-Nitrogen mg./l. as N.
0	523	9.0
2	502	10.4
4	485	11.2
6	466	12.8
8	455	13.5
10	447	19.6
12	444	25.9
24	436	57.1

Table 22.

DISSOLVED OXYGEN DURING PERIOD OF AERATION

SAMPLE NO. 1

Time of Aeration hr.	Dissolved Oxygen mg./l.
0	0.4
2	5.8
4	5.9
6	6.2
8	6.6
10	6.7
12	6.8
24	6.8

Table 23.

DISSOLVED OXYGEN DURING PERIOD OF AERATION

SAMPLE NO. 2

Time of Aeration hr.	Dissolved Oxygen mg./l.
0	0.2
2	5.7
4	6.0
6	6.2
8	6.5
10	6.7
12	6.7
24	6.7

Table 24.

DISSOLVED OXYGEN DURING PERIOD OF AERATION

SAMPLE NO. 3

Time of Aeration Days.	Dissolved Oxygen mg./l.
0	0
1	6.7
2	6.7
3	6.8
4	6.7
5	6.8
6	6.9
7	6.9

Table 25.

DISSOLVED OXYGEN DURING PERIOD OF AERATION

SAMPLE NO. 4

Time of Aeration Days.	Dissolved Oxygen mg./l.
0	0
1	6.6
2	6.6
3	6.7
4	6.8
5	6.8
6	6.8
7	6.8

Table 26.

DETERMINATION OF LOGARITHMIC GROWTH RATE (k_1, K_1) FOR THE LOG-GROWTH PHASE

SAMPLE NO. 1

t hr.	S mg./l.	Δ S mg./l.	S_o mg./l.	$\frac{S + \Delta S}{S_o}$	$\log_{10} (\frac{S + \Delta S}{S_o})$
0	771	0	771	1.000	0
2	907	136	771	1.355	0.132
4	1008	237	771	1.615	0.208
6	1101	330	771	1.858	0.269
8	1189	418	771	2.081	0.319
10	1182	411	771	2.070	0.316
12	1165	394	771	2.021	0.306
24	1053	282	771	1.731	0.238

Where :

S = Suspended Solids, mg./l. (The Sludge Concentration)

S_o = The Initial Sludge Mass Per Unit Volume, mg./l.

t = Time of Aeration, hr.

Table 27.

DETERMINATION OF LOGARITMIC BOD REMOVAL RATE $(-k_2, -K_2)$

SAMPLE NO. 1

t	Le	Lo	Le/Lo	$\log_{10}$ (Le/Lo)
0	2328	2328	1.0	0
2	1729	2328	0.743	- 0.129
4	1174	2328	0.504	- 0.297
6	597	2328	0.256	- 0.691
8	268	2328	0.115	- 0.939
10	201	2328	0.086	- 1.063
12	190	2328	0.082	- 1.088
24	182	2328	0.078	- 1.107

Where :

Le = Oxidizable BOD Remaining , mg./l.

Lo = Total Amount of Initial BOD that can be oxidized , mg./l.

t = Time of Aeration , hr.

Table 28.

DETERMINATION OF LOGARITHMIC GROWTH RATE (k_1.K_1) FOR THE LOG - -GROWTH PHASE

SAMPLE NO. 2

t hr.	S mg./l.	$\triangle$ S mg./l.	So mg./l.	$\frac{S + \triangle S}{So}$	$\log_{10}(\frac{S + \triangle S}{So})$
0	884	0	884	1.000	0.0
2	1003	119	884	1.271	0.105
4	1177	293	884	1.665	0.222
6	1359	475	884	2.078	0.318
8	1561	677	884	2.530	0.403
10	1583	699	884	2.588	0.412
12	1573	689	884	2.506	0.399
24	1390	506	884	2.143	0.332

Where :

S = Suspended Solids, mg./l. (The Sludge Concentration)

So = The Initial Sludge Mass Per Unit Volume, mg./l.

t = Time of Aeration, hr.

Table 29.

DETERMINATION OF LOGARITHMIC BOD REMOVAL RATE ($-k_2$, $-K_2$)

SAMPLE NO. 2

t	Le	Lo	Le/Lo	$\log_{10}$(Le/Lo)
0	1412	1412	1.0	0
2	910	1412	0.644	- 0.191
4	543	1412	0.584	- 0.416
6	252	1412	0.178	- 0.731
8	147	1412	0.104	- 0.983
10	135	1412	0.0955	- 1.021
12	132	1412	0.0934	- 1.030
24	127	1412	0.0899	- 1.047

Where :

Le = Oxidizable BOD Remaining, mg./l.

Lo = Total Amount of Initial BOD that can be oxidized , mg./l.

t = Time of Aeration, hr.