APPENDIX H

DETERMINATION OF KINETIC COEFFICIENTS

Values for the parameters Y, k, K_s, and k_d must be available to use biological kinetic models. To determine these coefficients, bench-scale reactors, such as those shown in Figs. H-1 and H-2, or pilot-scale systems are used.

In determining these coefficients, the usual procedure is to operate the units over a range of effluent substrate concentrations; therefore, several different θ_c (at least five) should be selected for operation ranging from 1 to 10 days. Using the data collected at steady-state conditions, mean values should be determined for Q, S_o, S, X, and r_{su}. Equating the value of r_{su} given by Eq. 8-8 to the value of r_{su} given by Eq. 8-41 results in the following expression:

$$r_{su} = -\frac{kXS}{K_s + S} = -\frac{S_o - S}{\theta} \tag{H-1}$$

Dividing by X yields

$$\frac{kS}{K_s + S} = \frac{S_o - S}{\theta X} \tag{H-2}$$

The linearized form of Eq. H-2, obtained by taking its inverse, is

$$\frac{X\theta}{S_o - S} = \frac{K_s}{k}\frac{1}{S} + \frac{1}{k} \tag{H-3}$$

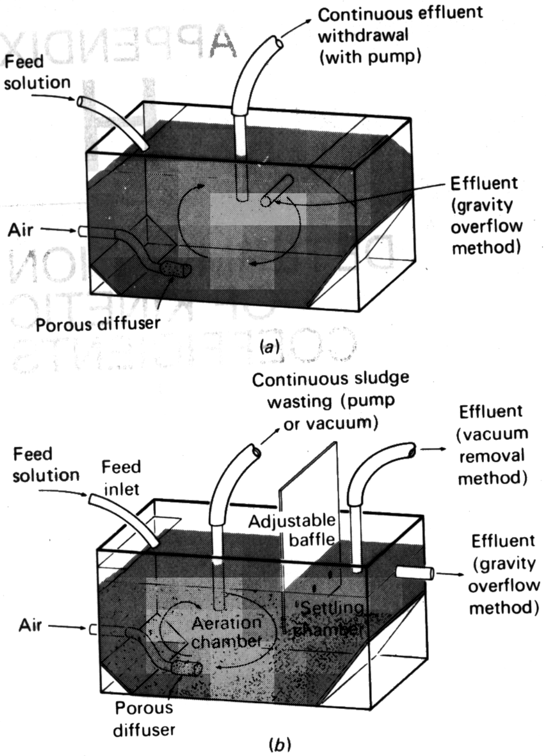


FIGURE H-1
Bench-scale complete-mix reactors used for the determination of kinetic coefficients (*a*) without solids recycle and (*b*) with solids recycle.

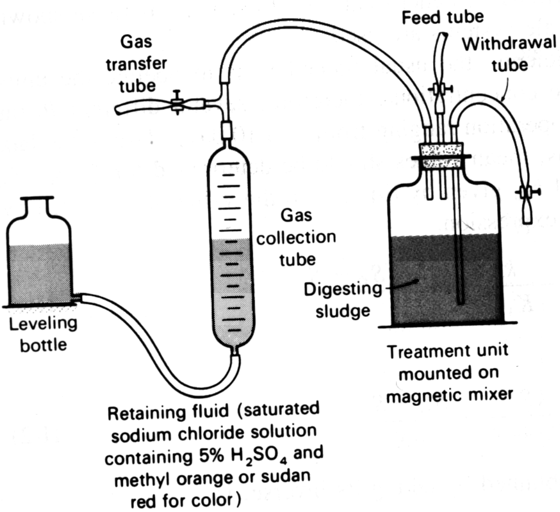


FIGURE H-2
Laboratory reactor used for the conduct of anaerobic treatment studies.

The values of K_s and k can be determined by plotting the term $[X\theta/(S_0 - S)]$ versus $(1/S)$. The values of Y and k_d may be determined using Eq. 8-40, by plotting $(1/\theta_c)$ versus $(-r_{su}/X)$.

$$\frac{1}{\theta_c} = -Y\frac{r_{su}}{X} - k_d \tag{8-40}$$

The slope of the straight line passing through the plotted experimental data points is equal to Y, and the intercept is equal to k_d. The procedure is illustrated in the following example.

Example H-1 Determination of kinetic coefficients from laboratory data. Determine the values of the coefficients k, K_s, μ_m, Y, and k_d using the following data derived from a bench-scale activated-sludge complete-mix reactor without recycle (see Fig. H-1a).

Unit no.	S_0, mg/L BOD_5	S, mg/L BOD_5	$\theta = \theta_c$, d	X, mg VSS/L
1	300	7	3.2	128
2	300	13	2.0	125
3	300	18	1.6	133
4	300	30	1.1	129
5	300	41	1.1	121

Solution

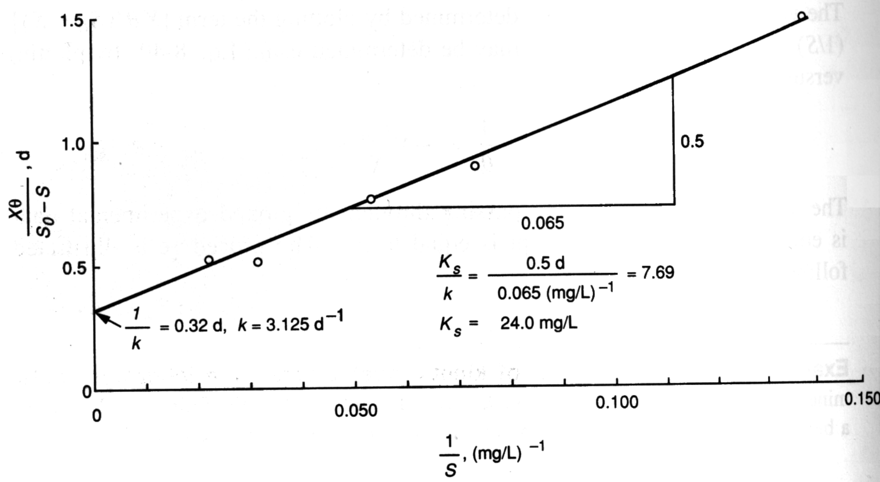
1. Determine the coefficients K_s and k.

(*a*) Set up a computation table to determine the coefficients K_s and k using Eq. H-3.

$$\frac{X\theta}{S_0 - S} = \frac{K_s}{k}\frac{1}{S} + \frac{1}{k}$$

S_0-S, mg/L	$X\theta$, mg VSS/d · L	$X\theta/(S_0-S)$, d	$1/S$, $(mg/L)^{-1}$
293	409.6	1.398	0.143
287	250.0	0.865	0.077
282	212.8	0.755	0.056
270	141.9	0.526	0.033
259	133.1	0.514	0.024

(*b*) Plot the term $(X\theta/S_0 - S)$ versus $(1/S)$, as shown in the figure at the top of the following page.



i. From Eq. H-3, the y intercept equals $(1/k)$.

$$\frac{1}{k} = 0.32 \text{ d}, \ k = 3.125 \text{ d}^{-1}$$

ii. From Eq. H-3, the slope of the curve in Fig. H-1 equals K_s/k.

$$\frac{K_s}{k} = \frac{0.5 \text{ d}}{0.065(\text{mg/L})^{-1}} = 7.692 \text{ mg/L} \cdot \text{d}$$

$$K_s = 7.692 \text{ mg/L} \cdot \text{d} \times 3.125 \text{ d}^{-1}$$
$$= 24.0 \text{ mg/L}$$

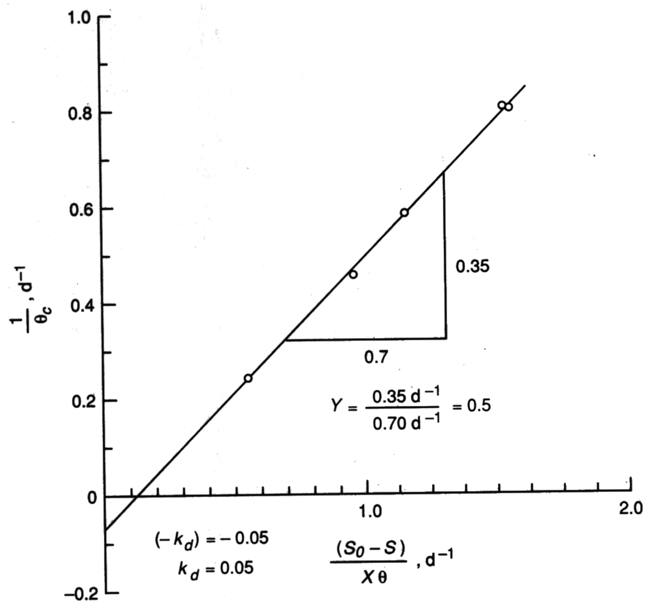
2. Determine the coefficients Y and k_d.
(*a*) Set up a computation to determine the coefficients using Eq. 8-40.

$$\frac{1}{\theta_c} = -Y\frac{r_{su}}{X} - k_d$$

$$\frac{1}{\theta_c} = Y\frac{S_0 - S}{X\theta} - k_d$$

Unit no.	$1/\theta_c$, d^{-1}	$(S_0 - S)/\theta X$, d^{-1}
1	0.313	0.715
2	0.500	1.156
3	0.625	1.325
4	0.909	1.901
5	0.909	1.946

(*b*) Plot the term $(1/\theta_c)$ versus $(S_0 - S)/X\theta$, as shown in the accompanying figure.



i. The *y* intercept equals $(-k_d)$.

$$-k_d = -0.05\ \text{d}^{-1}$$

$$k_d = 0.05\ \text{d}^{-1}$$

ii. The value of the slope of the curve equals Y.

$$Y = \frac{0.35\ \text{d}^{-1}}{0.70\ \text{d}^{-1}} = 0.5$$

3. Determine the value of the coefficient μ_m using Eq. 8-7.

$$\begin{aligned}\mu_m &= kY \\ &= 3.125\ \text{d}^{-1} \times 0.5 \\ &= 1.563\ \text{d}^{-1}\end{aligned}$$

Comment. In this example, the kinetic coefficients were derived from data obtained using bench-scale, complete-mix reactors without recycle. Similar data can be obtained using complete-mix reactors with recycle. An advantage of using reactors with recycle is that the mean cell-residence time can be varied independently of the hydraulic detention time. A disadvantage is that small bench-scale reactors operated with solids recycle are difficult to control.