16.5. For the activated-sludge unit shown in Fig. 16.7, the specific growth rate of cells is given by

$$\mu_{\text{net}} = \frac{\mu_m S}{K_s + S} - k_d$$

The following parameter values are known: $F = 500$ 1/h, $\alpha = 0.4$, $\gamma = 0.1$, $X_e = 0$, $V = 1500$ l, $K_s = 10$ mg/l, $\mu_m = 1\ \text{h}^{-1}$, $k_d = 0.05\ \text{h}^{-1}$, $S_0 = 1000$ mg/l, $Y^M_{X/S} = 0.5$ g dw/g substrate.

a. Calculate the substrate concentration (S) in the reactor at steady state.

b. Calculate the cell concentration(s) in the reactor.

c. Calculate X_r and S_r in the recycle stream.

16.6. In a trickling biological filter, the BOD value of the feed stream is $S_{0i} = 500$ mg/l with a feed flow of $F = 10^3$ l/h. The effluent BOD value is desired to be $S_0 = 10$ mg/l. The following kinetic parameters for the biocatalysts are known: $r_m = 20$ mg/S/l · h and $K_s = 200$ mg S/l. The biofilm thickness is $L = 0.1$ mm. The cross-sectional area of the filter is $A = 2\ \text{m}^2$, and the biofilm surface area per unit volume of the bed is $a = 500\ \text{cm}^2/\text{cm}^3$. Assume that dissolved oxygen is the rate-limiting substrate and the diffusion coefficient of oxygen is $D_{O_2} = 2 \times 10^{-5}\ \text{cm}^2/\text{s}$. Determine the required height of the bed. You can assume first-order bioreaction kinetics.

16.7. An activated-sludge waste treatment system is required to reduce the amount of BOD_5 from 1000 mg/l to 20 mg/l at the exit. The sedimentation unit concentrates biomass by a factor of 3. Kinetic parameters are $\mu_m = 0.2\ \text{h}^{-1}$, $K_s = 80$ mg/l, $k_d = 0.01\ \text{h}^{-1}$, and $Y^M_{X/S} = 0.5$ g MLVSS/g BOD_5. The flow of waste water is 10000 l/h and the size of the treatment basin is 50,000 l.

a. What is the value of the solids residence time (i.e., θ_c)?

b. What value of the recycle ratio must be used?

16.8. Consider a well-mixed waste treatment system for a small-scale system. The system is operated with a reactor of 1000 l and flow rate of 100 l/h. The separator concentrates biomass by a factor of 2. The recycle ratio is 0.7. The kinetic parameters are $\mu_m = 0.5\ \text{h}^{-1}$, $K_s = 0.2$ g/l, $Y^M_{X/S} = 0.5$ g/g, and $k_d = 0.05\ \text{h}^{-1}$. What is the exit substrate concentration?

16.9. Redo Example 16.4 if the Contois equation for growth applies. In this case

$$\mu_{\text{net}} = \frac{\mu_m S}{K_{sx} X + S} - k_d$$

The values of μ_m and k_d are the same as for Example 16.4, but K_s no longer applies. Assume $K_{sx} = 0.02$ g BOD_5/g MLVSS.