2-14-08

Add nutrient and e^- acceptor equations

to chemostat model

In general

$$r_n = \gamma_n r_{ut} Y \frac{(1+(1-f_d)b\theta_x)}{1+b\theta_x}$$

↑ new parameter

← Y_{obs} or Y_n — the yield we can actually measure in VSS. Includes active and inert fractions of biomass

for N $\gamma_N = \frac{.124\ gN}{gVSS}$

for P $\gamma_P = \frac{.025\ gP}{gVSS}$

$$C_n = C_n^0 + r_n V$$

these ratios are based on a cell formulation of $C_5H_7O_2N$ with mass of P = .2 times mass of N

different ratios would be required if our biomass formulation were defined differently.

for electron acceptors

$$\frac{\Delta S_a}{\Delta t} = \gamma_a Q\left[\overbrace{S^0 + 1.42X_v^0}^{\text{acceptor demand in}} - \overbrace{S - SMP - 1.42X_v}^{\text{acceptor demand out}}\right]$$

← this equation based on substrate balance

units of mass per time → ; ↑ the mass rate of acceptor utilization

$$\Rightarrow \frac{\Delta S_a}{\Delta t} = Q\left[S_a^0 - S_a\right] - R_a$$

← this equation based on acceptor balance

↑ R_a: acceptor applied mass per time

the new parameters for acceptor analysis are $\frac{\Delta S_a}{\Delta t}$, γ_a and R_a

$$\gamma_a = \frac{g\ \text{acceptor}}{g\ \text{oxygen demand of "substrate"}} \qquad \gamma_{O_2} = \frac{1\,gO_2}{gCOD}, \qquad \gamma_{NO_3^- - N} = \frac{0.35\,g\,NO_3\text{-}N}{gCOD}$$

↑ note biomass exerts an oxygen demand

to calculate γ_a for any acceptor use ½ rxn from Ch 2 tables to find moles acceptor per 1 e^- equivalent

for example

$\frac{1}{5}$ moles NO_3^- per e^- equivalent

$$\frac{\frac{1}{5} \text{ mol } NO_3^- \times \frac{14 \text{ g N}}{\text{mol } NO_3^-}}{1 e^- \text{ eq} \times \frac{8 \text{ g COD}}{1 e^- \text{ eq}}} = .35 \frac{\text{g } NO_3^- \text{-N}}{\text{g COD}}$$

$$\frac{\frac{1}{8} \text{ mol } SO_4^{2-} \times \frac{96 \text{ g } SO_4^{2-}}{\text{mol } SO_4^{2-}}}{1 e^- \text{ eq} \times \frac{8 \text{ g COD}}{1 e^- \text{ eq}}} = 1.5 \frac{\text{g } SO_4^{2-}}{\text{g COD}}$$

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So let's extend previous example to include nutrients and acceptor analysis

let $C_N^0 = 50 \frac{mg}{L} NH_4^+\text{-N}$, $C_P^0 = 10 \frac{mg}{L} P$ ← measured

$S_a^0 = 6 \frac{mg}{L} O_2$, $S_a = 2 \frac{mg}{L} O_2$ ← set by operator

↑ measured

$$C_N = 50 \frac{g}{m^3} N - \underbrace{\frac{.124 \text{ gN}}{\text{gVSS}} \frac{.42 \text{ gVSS}}{\text{g BOD}_L} \left(.249 \frac{\text{g BOD}_L}{m^3\text{-d}}\right) (.815)^* 2d}_{21.2 \frac{gN}{m^3}}$$

$$= 28.8 \frac{g}{m^3} N$$

$$^* \frac{1 - (1 - .8) \frac{.15}{d} 2d}{1 + \frac{.15}{d} 2d} = .815$$

$$C_P = 10\ \frac{g}{m^3}P - .2\ \frac{gP}{gN}\ r_N = 10\ \frac{g}{m^3}P - 4.2\ \frac{gP}{m^3} = 5.8\ \frac{gP}{m^3}$$

$$\frac{\Delta S_a}{\Delta t} = \frac{1\,gO_2}{g(OD)}\left(\frac{1000\ m^3}{d}\right) \times$$

$$\left[(500 - 1.7 - 31.8)\ \frac{g(OD)}{m^3} + 1.42\ \frac{g(OD)}{gVSS}(50 - 221)\frac{gVSS}{m^3}\right.$$

$$= 2.24 \times 10^5\ \frac{gO_2}{d}$$

$$R_a = 2.24 \times 10^5\ \frac{gO_2}{d} - 1000\frac{m^3}{d}(6 - 2)\frac{gO_2}{m^3} = 2.2 \times 10^5\ \frac{gO_2}{d}$$

↑ small effect of influent & effluent O_2