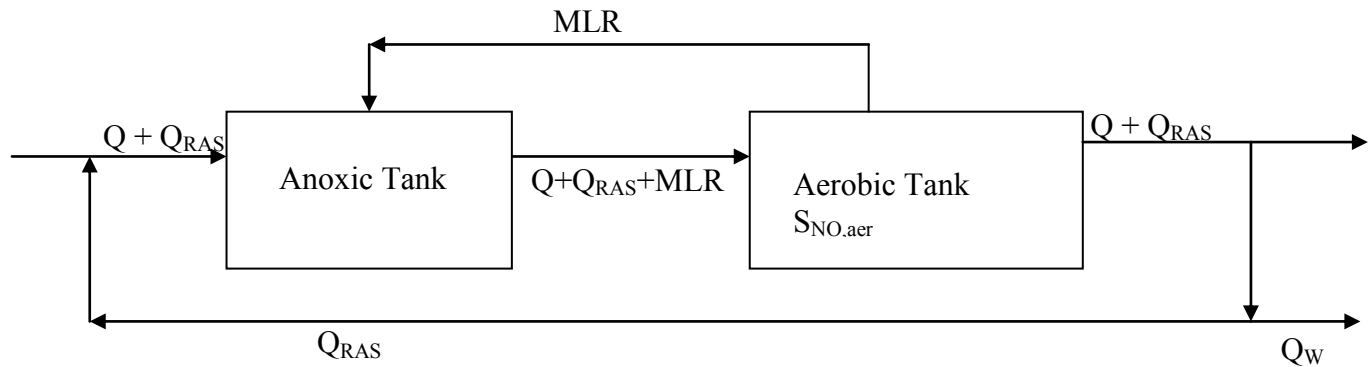


MODIFIED LUDZACK ETTINGER NITROGEN REMOVAL PROCESS EXAMPLE

GIVEN:



Wastewater average flow rate, $Q = 40,000 \text{ m}^3/\text{d}$

Influent	concentration
Soluble COD (S_{SO})	150 mg/l
Particulate COD (X_{SO})	115 mg/l
Soluble ammonia-N (S_{NH_4})	25 mg-l N
Soluble organic N (S_{NSO})	6.5 mg/l
Particulate organic N (X_{NSO})	8.5 mg/l

Parameters

$\hat{\mu}_H$	6 d^{-1}
$\hat{\mu}_A$	0.77 d^{-1}
b_H	0.18 d^{-1}
b_A	0.1 d d^{-1}
K_S	20 mg/l COD
K_{NH}	1 mg/l $\text{NH}_4\text{-N}$
Y_H	0.6 g-COD cells/g-substrateCOD
Y_A	0.24 mg COD cells/g- $\text{NH}_4\text{-N}$
f_D	0.2 g debrisCOD/g cells COD decayed
i_{NXB}	0.087 g-N/g-cell COD

Objectives:

Effluent COD = $S_S < 10 \text{ mg/l}$

Effluent ammonia nitrogen = $S_{NH} < 0.3 \text{ mg/l}$

Effluent total inorganic nitrogen (TIN) = 10 mg/l

For adequate settling MLSS = $X_T < 3,000 \text{ mg/l}$ or $4,260 \text{ mg/l}$ as COD

Step 1. Find Θ_{aer} for aeration basin – nitrification will control

$$\Theta_{aer} = \frac{K_{NH} + S_{NH}}{(S_{NH}(\hat{\mu}_A - b_A) - K_{NH} b_A)} = \frac{1 + 0.3}{0.3(0.77 - 0.1) - 1(0.1)} = 13 \text{ days}$$

Check S_s .

$$S_s = \frac{K_s(1 + b_H \Theta)}{(\hat{\mu}_H \Theta - (1 + b_H \Theta))} = \frac{20(1 + 0.18(13))}{(6(13) - (1 + 0.18(13)))} = 0.9 \text{ mg / l COD} \ll 10 \text{ mg / l COD}$$

Nitrogen available for nitrification, NO^*/Q

* Changed notation from “ S_{NO}/Q ” to make it less confusing

$$NO/Q = (S_{NHO} + S_{NSO} + X_{NSO}) - (i_{NXB} Y_{obs}(S_{SO} + X_{SO})) - S_{NH}$$

(assuming both soluble and particulate COD in influent is degraded and neglecting $S_s \ll S_{SO} + X_{SO}$)

$$Y_{H,obs} = (1 + 0.2(0.18)13)0.6 / (1 + 0.18(13)) = 0.26 \text{ g-cell-COD/g-substrate-COD}$$

$$NO/Q = (25 + 6.5 + 8.5) - (0.087(115 + 150)0.26) - 0.3 \text{ mg/L N}$$

$$NO/Q = 33.6 \text{ mg/l N}$$

$$NO = 40,000 \text{ m}^3/\text{d}(33.6 \text{ g/m}^3) = 1.4 \times 10^6 \text{ g-N/day available for denitrification}$$

For denitrification design:

Assume $\Theta_{anox} = 3 \text{ d}$ (influent is dilute, maximize available substrate and denitrification by using generation of COD from decay)

$$\text{MLE process: } \Theta_{sys} = 13 + 3 = 16 \text{ days}$$

$$\begin{aligned} X_T V_{sys} &= \Theta_{sys} (Q) (1 + f_D b_H \Theta_{sys}) \frac{Y_H (S_{SO} - S_s)}{(1 + b_H \Theta)} \\ &= 13 \text{ d} (40,000 \text{ m}^3 / \text{d}) (1 + 0.2(0.18)16) \frac{0.6(150 + 115)}{(1 + 0.18(16))} = 4 \times 10^7 \text{ g - MLSS as COD} \end{aligned}$$

$$X_T V_{aer} = (\Theta_{aer} / \Theta_{sys}) X_T V_{sys} = (13/16) 4 \times 10^7 = 3 \times 10^7 \text{ g MLSS as COD}$$

$$X_T V_{anox} = (\Theta_{anox} / \Theta_{sys}) X_T V_{sys} = (3/16) 4 \times 10^7 = 7.5 \times 10^6 \text{ g MLSS as COD}$$

Apply constraint: $MLSS < 4,260 \text{ mg/l COD}$ and assume $MLSS$ equal in anoxic and aerobic tanks:

$$V_{aer} = 3 \times 10^7 / 4260 = 7,000 \text{ m}^3$$

$$V_{\text{anox}} = 7.5 \times 10^6 / 4260 = 1,800 \text{ m}^3$$

$$V_{\text{sys}} = 7,000 + 1,800 = 8,800 \text{ m}^3$$

$$\Delta N / \Delta S_{\text{S,N}} = (1 + 0.18(3) - 0.6(1 + 0.2(0.18)3)) / (2.86(1 + 0.18(3))) = 0.2 \text{ g NO}_3\text{-N/g-COD}$$

$$\Delta N = 0.2(40000)(150) = 1.2 \times 10^6 \text{ g NO}_3\text{-N/d}$$

where ΔN = max amount of nitrate-nitrogen that can be denitrified as limited by available influent soluble COD

$$f_{\text{NO,D}} = \Delta N / (\text{NO})$$

$$f_{\text{NO,D}} = 1.2 \times 10^6 / 1.4 \times 10^6 = 0.86$$

$$\alpha + \beta = 0.86 / (1 - 0.86) = 6$$

$$\text{Let } \alpha = 0.5$$

$$\beta = 6 - 0.5 = 5.5$$

$$\text{MLR} = \beta Q = 5.5(40,000) \text{ m}^3/\text{d} = 220,000 \text{ m}^3/\text{d}$$

$$Q_{\text{RAS}} = \alpha Q = 0.5(40,000) \text{ m}^3/\text{d} = 20,000 \text{ m}^3/\text{d}$$

$$\text{Effluent nitrate nitrogen} = S_{\text{NO}} = (1 - f_{\text{NO,D}})\text{NO}/Q = 0.14(33.6) = 4.7 \text{ mg/L NO}_3\text{-N}$$

$$\text{effluent TIN} = \text{NH}_4\text{-N} + \text{NO}_3\text{-N} = 0.3 + 4.7 = 5 \text{ mg-TIN/L (meets permit)}$$