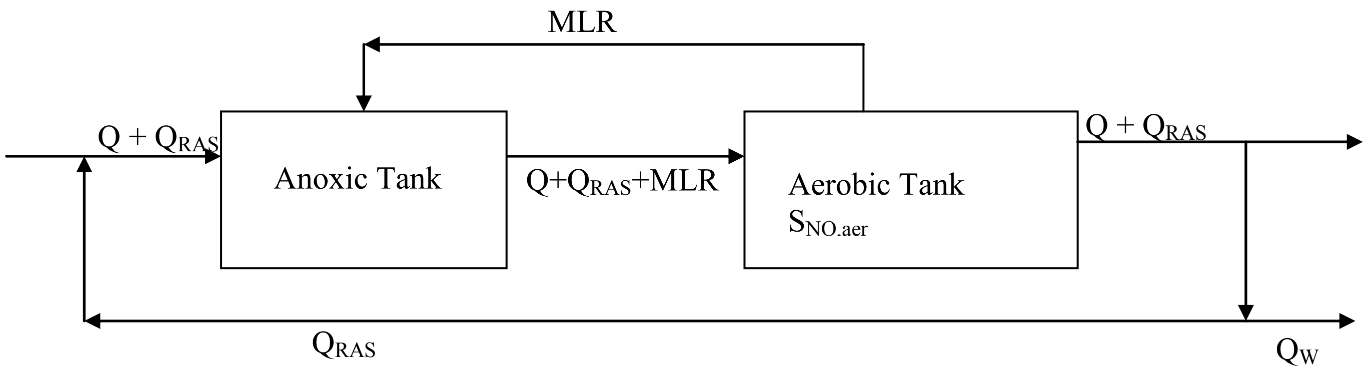
MODIFIED LUDZACK ETTINGER NITROGEN REMOVAL PROCESS EXAMPLE

GIVEN:



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

Influent	concentration
Soluble COD (S_{SO})	150 mg/l
Particulate COD (X_{SO})	115 mg/l
Soluble ammonia-N (S_{NHO})	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 NH_4-N
Y_H	0.6 g-COD cells/g-substrateCOD
Y_A	0.24 mg COD cells/g-NH_4-N
f_D	0.2 g debrisCOD/g cells COD decayed
i_{NXB}	0.087 g-N/g-cell COD

Objectives:
Effluent COD = $S_S < 10$ mg/l
Effluent ammonia nitrogen = $S_{NH} < 0.3$ mg/l
Effluent total inorganic nitrogen (TIN) = 10 mg/l
For adequate settling MLSS = $X_T < 3{,}000$ mg/l or 4,260 mg/l as COD

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

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

Check S_s.

$$S_S = \frac{K_S(1+b_H\Theta)}{(\hat{\mu}_H\Theta - (1+b_H\Theta))} = \frac{20(1+0.18(13))}{(6(13)-(1+0.18(13)))} = 0.9 mg/lCOD << 10 mg/LCOD$$

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 $S_S << S_{SO}+X_{SO}$)

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

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

NO/Q = 33.6 mg/l N

NO = 40,000 m^3/d(33.6 g/m^3) = 1.4 x 10^6 g-N/day available for denitrification

For denitrification design:

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

MLE process: Θ_{sys} = 13 + 3 = 16 days

$$X_T V_{sys} = \Theta_{sys}(Q)(1+f_D b_H \Theta_{sys})\frac{Y_H(S_{SO}-S_S)}{(1+b_H\Theta)}$$

$$= 13d(40{,}000 m^3/d)(1+0.2(0.18)16)\frac{0.6(150+115))}{(1+0.18(16))} = 4x10^7 g - MLSSasCOD$$

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

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

Apply constraint: MLSS < 4,260 mg/l COD and assume MLSS equal in anoxic and aerobic tanks:

V_{aer} = 3 x 10^7/4260 = 7,000 m^3

V_{anox} = 7.5 x 10^6/4260 = 1,800 m^3

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

$\Delta N/\Delta S_{S,N}$ = (1+0.18(3)-0.6(1+0.2(0.18)3))/(2.86(1+0.18(3)) = 0.2 g NO_3-N/g-COD

ΔN = 0.2(40000)(150) = 1.2 x 10^6 g NO_3-N/d

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

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

$f_{NO,D}$ = 1.2 x 10^6/1.4 x 10^6 = 0.86

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

Let $\alpha = 0.5$

$\beta = 6 - 0.5 = 5.5$

MLR = βQ = 5.5(40,000) m^3/d = 220,000 m^3/d

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

Effluent nitrate nitrogen = S_{NO} = (1 - $f_{NO,D}$)NO/Q= 0.14(33.6) = 4.7 mg/L NO_3-N

effluent TIN = NH_4-N+NO_3-N = 0.3+4.7 = 5 mg-TIN/L (meets permit)