Example 4.5

Determine the denitrification capacity of the activated sludge process of Example 4.1, assuming $f_{sb} = 0.20$.

Solution:

The composition of the organic material can be calculated from the influent and effluent COD and the concentration of volatile sludge X_v in Table 4.1. With $S_{ti} = 477$ mg COD.l^{-1}, $S_{te} = 18$ mg COD.l^{-1} and $X_v = 2,469$ mg VSS.l^{-1}, the following values are calculated:

$f_{ns} = S_{te}/S_{ti} = 18/477 = 0.04$

$mX_v = MX_v/MS_{ti} = V_r \cdot X_v/(Q_i \cdot S_{ti})$

For the applied sludge age $R_s = 18$ days and a temperature of 21.6°C the values of C_r and b_h are calculated as:

$C_r = Y \cdot R_s/(1 + b_h \cdot R_s) = 0.45 \cdot 18/(1 + 0.24 \cdot (1.04)^{1.6} \cdot 18) = 1.45$ mg VSS.mg^{-1} COD.d^{-1}

$b_h = 0.24 \cdot (1.04)^{1.6} = 0.26$ d^{-1}

Using the data from Table 4.1 and Eq. (3.69):

$mX_v = 25 \cdot 2469/(40 \cdot 477) = 3.23$ mg VSS.mg^{-1} COD.d^{-1}
$= (1 - f_{ns} - f_{np}) \cdot (1 + f \cdot b_h \cdot R_s) \cdot C_r + f_{np} \cdot R_s/f_{xv}$
$= (1 - 0.04 - f_{np}) \cdot (1 + 0.2 \cdot 0.26 \cdot 18) \cdot 1.45 + f_{np} \cdot 18/1.5)$
$= (0.96 - f_{np}) \cdot 2.78 + f_{np} \cdot 0.12$, or $f_{np} = 0.06$

Now, knowing the total non-biodegradable COD fraction the biodegradable COD concentration is calculated as:

$S_{bsi} = (1 - f_{ns} - f_{np}) \cdot S_{ti} = (1 - 0.04 - 0.06) \cdot 477 = 430$ mg COD.l^{-1}

$S_{bs} = f_{sb} \cdot S_{bi} = 86$ mg COD.l^{-1}

Using Eq. (4.48), the values of the denitrification rate constants are calculated as:

$K_2 = 0.1 \cdot (1.08)^{T-20} = 0.1 \cdot (1.08)^{1.6} = 0.113$ mg N.mg^{-1} X_a.d^{-1}

$K_3 = 0.08 \cdot (1.03)^{T-20} = 0.08 \cdot (1.03)^{1.6} = 0.084$ mg N.mg^{-1} X_a.d^{-1}

The anoxic sludge mass fraction $f_{x1} = V_1/V_r = 5/25 = 0.2$. This is much larger than the minimum anoxic sludge mass fraction required for the removal of easily biodegradable organic material:

$f_{min} = 0.114 \cdot f_{sb}/(K_1 \cdot C_r) = 0.12 \cdot 0.25/(0.72 \cdot (1.2)^{1.6} \cdot 1.45) = 0.02$

Hence, Eq.(4.62) can be applied:

$D_{c1} = (0.114 \cdot f_{sb} + K_2 \cdot C_r \cdot f_{x1}) \cdot S_{bi}$
$= (0.114 \cdot 0.20 + 0.113 \cdot 1.45 \cdot 0.2) \cdot (1 - 0.04 - 0.06) \cdot 477 = 24.3$ mg N.l^{-1}