4.6

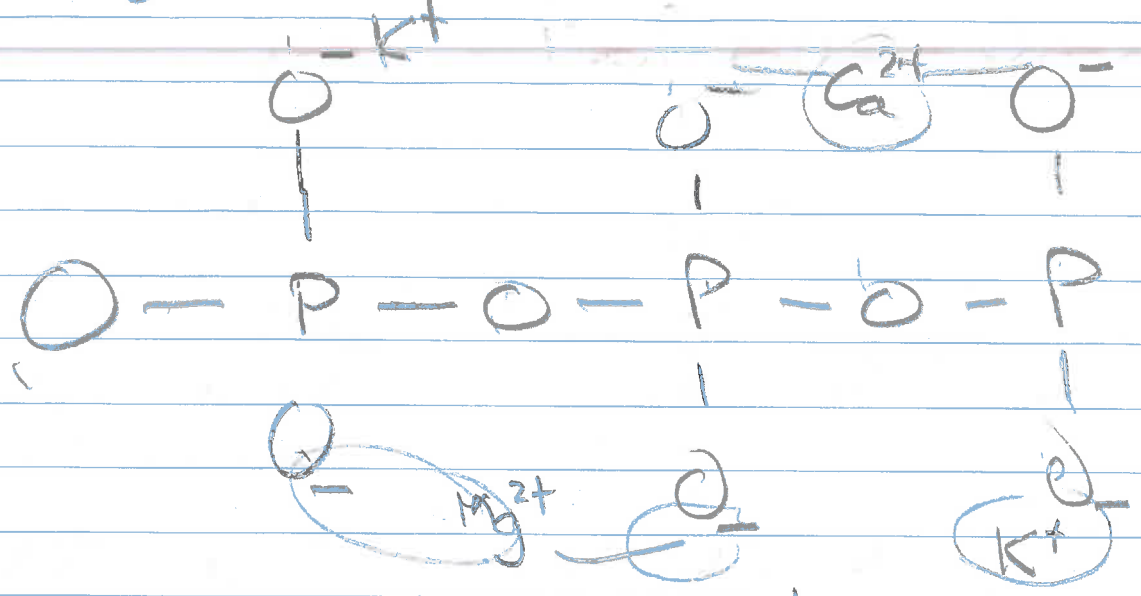
$$MX_{IO} = FX_{IOi} R_S + f_{iCHO} MX_{BH} + f_{iPAO} MX_{PAO}$$

(ISS, 0,15)

$$f_{iPAO} = 0,15 + 3,268 f_{PP,PAO}$$

$\frac{mg\,ISS}{mg\,PAO_{VSS}}$ (0,43)

$MePO_3$



$$MePO_3 + H_2O \rightarrow MMe^+ + H_2PO_4^-$$

P uptake ← → P release

$Mg_{0,27}K_{0,22}Ca_{0,12}PO_3$

PA

PolyP

$0,27 \times 2 + 0,22 \times 1 + 0,12 \times 2 = 1,000$

$0,27 \times 24 + 0,22 \times 39 + 0,12 \times 40 + 48 + 31 = 98,86$ g/mol

ISS ↔ 98,86 g/mol

$$ISS/P = \frac{98,86}{31} = 3,186 \frac{g\,ISS}{g\,PolyP-P}$$

$$f_{iPAO} = 0,15 + 3,268 \times 0,175 \quad (0,43)$$

$$= 0,725\ g\,ISS/g\,PAO_{VSS}$$

ISS Influent OHO PAO

$MX_{ID} = 5597 + 0{,}15 \times 11276 + 0{,}725 \times 15003$

$= 5597 + 1691 + 10850$

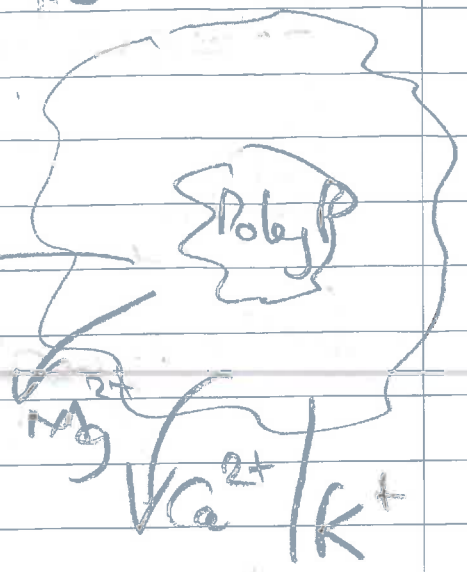
$= 18190$ kg ISS

MX_t TSS $= MX_V$ (VSS) $+ MX_{ID}$ (ISS)

$= 38052 + 18190$

$= 56242$ kg TSS

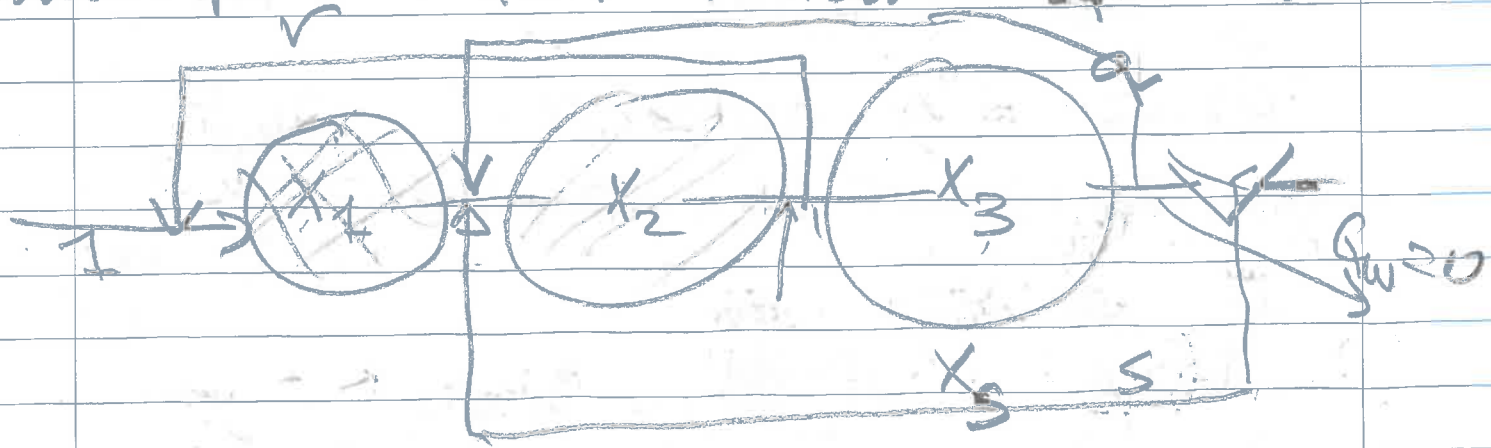
(MLE 38130 kg TSS)



$\frac{VSS}{TSS} = f_i = \frac{MX_V}{MX_t} = \frac{38052}{56242} = 0{,}677 \frac{gVSS}{gTSS}$

4.7

	Anaerobic	Anoxic	Aerobic	Total
Mass fraction	0.15	0,39	0.46	1,000
Mass	8436	21934	25871	56242
g TSS/ℓ X_t	2,25	4,5	4.5	
Volume m^3	3749	4874	5749	14373 m^3
Volume fraction	0261	0,339	0,400	1,000



Mass TSS balance: TSS in = TSS out

$0 \times 1 + r X_2 = (1+r) X_1$

$X_1 = \frac{r}{1+r} X_2$ $\quad r = 1$ $\quad X_1 = \frac{X_2}{2}$

Mass balance of anoxic

$$(1+r)X_1 + sX_3 + aX_3 = (a+r+s+1)X_2$$

Balance SST: $(1+s)X_3 = sX_3$

$$X_3 = \frac{1+s}{s} X_3$$

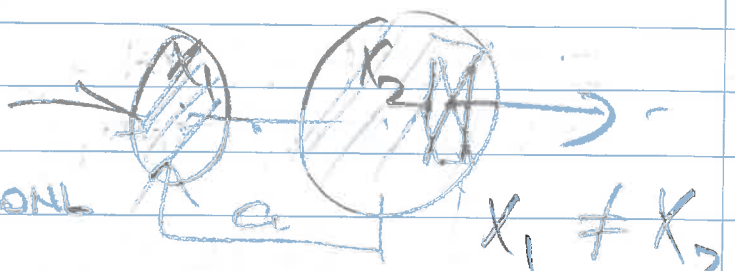
$$(1+r)X_1 + (1+s)X_3 + aX_3 = (a+r+s+1)X_2$$

$$(1+s+a)X_3 = (a+r+s+1)X_2 - (1+r)X_2$$

$$X_3 = X_2$$

c. Volume fractions ≠ mass fractions

4/09h30NL



4.8

Flux TSS wasted/d FX_t

$$= \frac{mX_t}{R_s} = \frac{562,42}{15} = 3749 \frac{kg\,TSS}{d}$$

$$FX_t = Q_w X_t = 3749$$

$$Q_w = 3749/4,5 = 833\ m^3/d$$

Now $Q_w \neq \frac{V}{R_s}$! because TSS conc is not same in each reactor

$Q_w = V/R_s$ is only true for TSS conc the same in all reactor!

4.9 $f_{bt} = 0,54 = f_{bea} + f_{bf} < f_{bem}$

$f_{bea} = 0,15$ $f_{bf} = 0,39$ $f_{bem} = 0,548$

~~$N_{ae} = \frac{K_{NT}}{SF=1}$~~ because $f_{bt} < f_{bem}$

$$N_{ae} = \frac{K_{NT}(b_{HT} + 1/R_s)}{(1-f_{bt})\mu_{AMT} - (b_{AT} + 1/R_s)}$$

$$N_{oe} = \frac{0,629\,(40,36 + 1,15)}{(1-0,54)\,0,283 - (40,36 + 1,15)}$$

$= 2,31$ mg FSA-N/ℓ

$f_{bt} = 0,54$

$$N_{oo} = \frac{K_{nc}}{S_f - 1} = \frac{0,629}{1,25-1} = 2,52$$

$f_{bm} = 0,48$

$N_{te} = N_{oa\,se} + N_{oe}$ (org N, FSA)

$= 1,1 + 2,31 = 3,4$ mg N/ℓ

$N_c = N_{ti} - N_s - N_{te}$

$= 50,0 - 10,2 - 3,4$

$= 36,4$ mg NO_3-N/ℓ

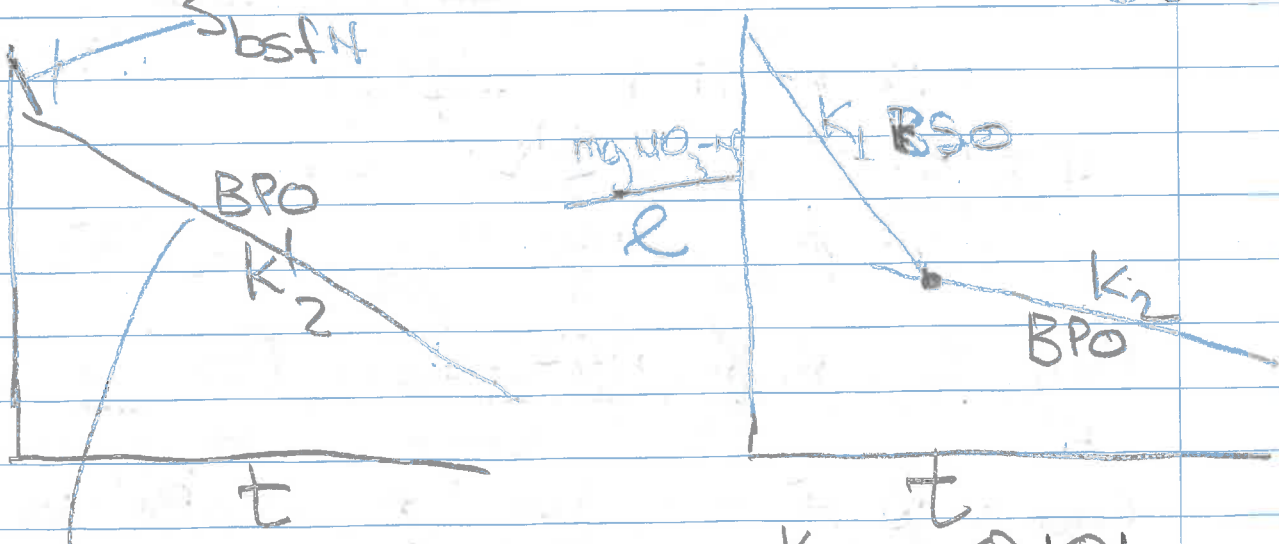
$$N_s = f_{bm}\frac{MX_v}{R_s Q_i} = 0,10\,\frac{3805,2}{15 \times 24,375} = 10,2 \text{ mg N/ℓ}$$

(MLE $N_s = 8,0$)

$FO_n = 4,57\,N_c\,Q_i$

$= 4,57 \times 36,4 \times 24,375 = 4141$ kgO/d

4.10



$K_{20} = 0,255$ mg NO_3-N / mg OHO VSS.d

ASM2 $\eta_{C+OHO} = 0,60$

$K_{21} = K_{20}(1,08)^{15-20} = 0,255\,(1,08)^{-1}$

$= 0,1874$ mg NO_3-N/(mg OHO VSS.d)

$K_{22} = 0,101$ mg NO_3-N / mg OHO VSS

ASM1 $\eta_{C+OHO} = 0,33$

$$D_{PI} = S_{bo} f_3 \left(1 + r\left(\frac{1 - f_{CV}\gamma_{HV}}{2,86}\right)\right) + \frac{FS_{bOHU}}{a_i} K_{2T} \frac{\gamma_{HV} R_S}{1 + b_{HT} R_S} f_{x1}$$

$$= 13,9(1+1)\frac{0334}{2,86} + \frac{7034}{24,875} 0,1874 \times 1.603 \times 0,39$$

$$= 3,2 + 33,1 = 36,4 \text{ mg } NO_3^- N/\ell \text{ influent}$$

So for UCT can we same a_{opt} eq as for MLE?

$$a_{opt} = \frac{-B + \sqrt{B^2 + 4AC}}{2A}$$ not ewa!

$$A = O_a/2,86 = 2/2,86 = 0,7$$

$$B = N_C - D_{PI} + \frac{(S+1)O_a + SO_S}{2,86}$$

$$= 36.4 - 36.4 + \frac{2 \times 2 + 1 \times 1}{2,86} = 1,81$$

$$C = (S+1)\left(D_{PI} - \frac{SO_S}{2,86}\right) - S N_C$$

$$= (1+1)\left(36.4 - \frac{1 \times 1}{2,86}\right) - 1 \times 36.4 = 35.7$$

$$a_{opt} = \frac{-1,81 + \sqrt{1.81^2 + 4 \times 0,7 \times 35.7}}{2 \times 0,7}$$

$$= 5,95 : 1$$

If a_{prac} is 6:1 then a_{opt} of 5.95 is close to 6:1 and so SRT is close to Balanced SRT for UCT system.

MLE
Balanced SRT = 10
$f_{xt} = f_{cm} = 0,39$

UCT
15d
$f_{xt} = f_{cm} - f_{ca}$
$0,39 = 0,54 - 0,15$

AE

$$N_{re} = \frac{N_c}{a+1} = \frac{36.4}{5.85+1+1}$$

$$= 4.7 \text{ mg N/l}$$

$$\%\text{ N removal} = \frac{N_{ti} - (N_{te} + N_{re})}{N_{ti}}$$

$$= (50 - (3.4+4.7))/50 \times 100$$

$$= 83.8\%$$

$$FO_d = 2.86\, Q_w (N_c - N_{re}) = 2.86 \times 24.875 (36.4 - 4.7)$$

$$= 2255 \text{ kgO/d}$$

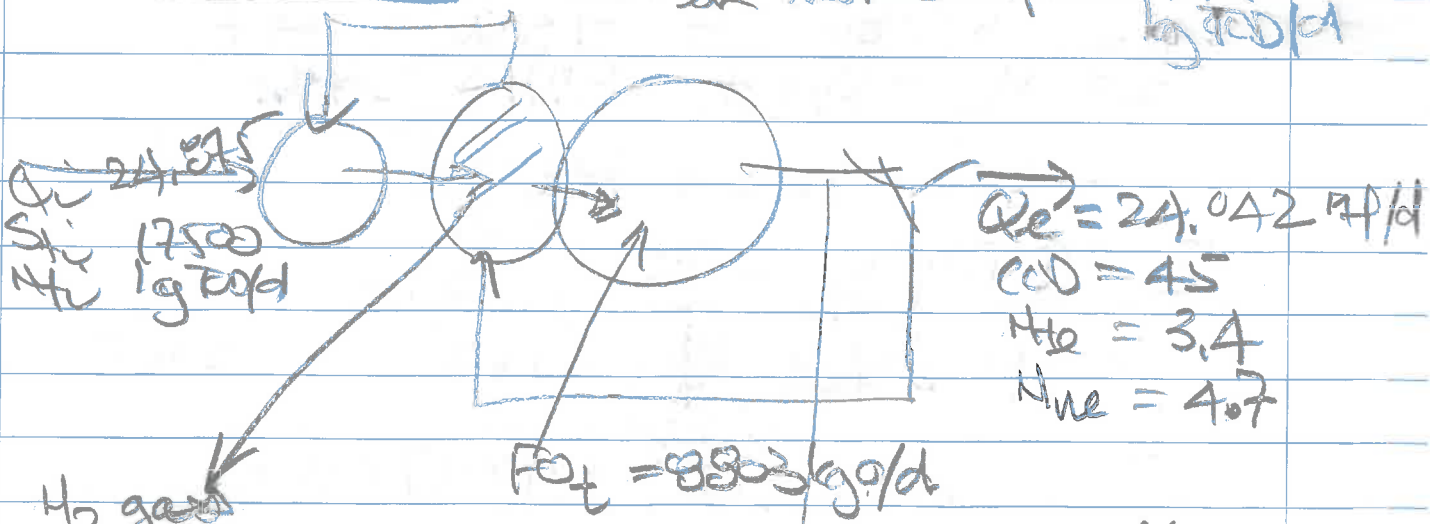
$$FO_t = FO_c + FO_n - FO_d$$

$$= 6939 + 4141 - 2255 = 8803 \text{ kgO/d}$$

(ALE 9817) 4/10h30 NL

4.12 TOD Balance

TOD en some b/o = 17500 kg TOD/d



$$TOD = Q_i \times (N_c - N_{re})$$

$$= 24.875 \times (36.4 - 4.7)$$

$$= 788.5 \text{ kg } N_2\text{-N/d}$$

$$TOD_{effluent} = Q_e (COD + 4.57 \times TKN)$$

$$= 24.042 (45 + 4.57 \times 3.4)$$

$$= 1455.2 \text{ kg TOD/d}$$

$$TOD_{in} Q_{in} = Q_{in}\left(\underbrace{COD}_{Dissolved} + 4.57 \times TKN + \underbrace{(VA)}_{Particulate} + 4.57 \times TKN\right)$$

$$= 8833\left[45 + 4.57 \times 34 + (f_{bv} + 4.57 f_n) X_v\right]$$

$$= 0.833\left[60.6 + (1.42 + 4.57 \times 0.1) 3047\right]$$

$$= 0.833\,(60.6 + 5905.1) = 4969.4 \ \frac{kg\ TOD}{d}$$

$$\text{Total TOD out} = \text{Effluent} + \text{waste flow} + H_2 + FO_L$$

$$= 1455.5 + 4969.4 + 788.5 \times 2.86 + 8803$$

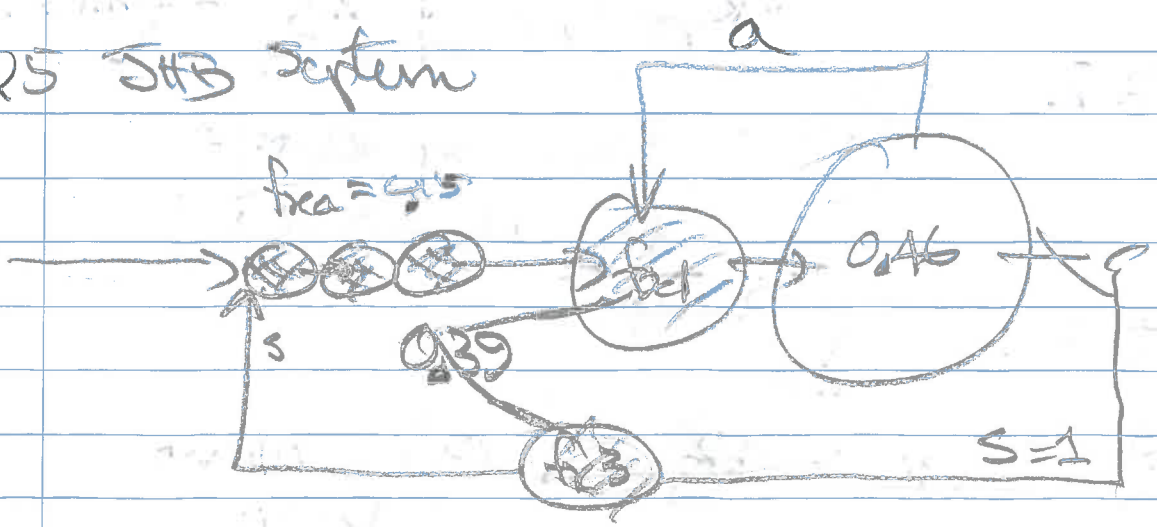
$$= 17483 \ kg\ TOD/d$$

$$\text{TOD Balance} = \frac{TOD_{out}}{TOD_{in}} \frac{100}{1} = \frac{17483}{17500}$$

$$= 99.9 \quad \text{Error} \leq \pm 1\% \ \therefore \text{OK}.$$

$$OUR = \frac{FO_L}{V_{aer}\,24} = \frac{8803}{24 \times 5,749\ m^3} = 63.8 \ \frac{mgO}{L.h}$$

Q5 SHB system



5.1 } Same as VCT $S_{bsfN} = 13.97$ mg cod/L

5.9 } 5.2 $P_{MX} = 39052$

5.3 $P_{te} = 0$ $f_{pi\,PAO} = 0.175$

5.4 FO_L = same 6939 kgO/d

5.5 COD Balanced - same

3.6 ISS same M_{XT} = 56242 kgTSS

VSS/TSS 0,677 same

3.8 same as VCT Q_w = 833 m^3 because X_t=4.5 FX_t=3749 kgTSS/d kgTSS/d

5.1 & 5.1 all same as VCT system Q 4.1 to 4.9

4.8 same SRT, f_{rd}, T°C, U_{mm20}, K_{n20} all same. Nitrification same

N_{ae} = 2,31, N_o = 3,4, N_c = 36.4

FO_N = 4141 kgO/d.

5.2 JHB (5.10 for VCT) How things get different process in f_{R1}+f_{R3} together

D_{pH} = D_{pSSc} + D_{pSPO} ≡ D_{pH} VCT

= $S_{bsfH}(1+Y)\left(\frac{1-f_{cv}Y_{HV}}{2.86}\right)$ 0,39 all det

$+K_{2T}\left(f_{xct}\frac{Y_W P_S}{1+b_{HT}R_S}\right)\frac{FS_{bodeg}}{Q_i}$

= 3,2 + 33,1 = 36,4 mg NO_3-N/l (same as VCT)

$$Q_{opt} = \frac{-B+\sqrt{B^2+4AC}}{2A}$$

$A = Q_a/2.86 = 3/2.86 = 0.7$ same

$B = N_e - D_{pp} + (1+S)\frac{Q_a}{3.86} + S\left(\frac{K_2}{K_3}\right)\frac{O_s}{2.86}$

$K'_{3T} = K_{320}(1.029)^{T-20}$

$= 0.114(1.029)^{4} = 0.1017 \frac{mg\ NO_3\text{-}N}{mgO_2 VSS.d}$

$$B = 36{,}4 - 36{,}4 + (1+1)\frac{2}{2{,}86} + 1 \times 1{,}834 \times \frac{1}{2{,}86}$$

$$\frac{K_{2T}'}{K_{3T}'} = \frac{0{,}1574}{0{,}1017} = 1{,}543$$

$$= 2{,}08$$

$$C = (1+S)\left[D_{fp} - S\left(\frac{K_{2T}'}{K_{3T}'}\frac{O_2}{2{,}86}\right)\right] - S\frac{K_{2T}'}{K_{3T}'}N_c$$

a if $\frac{K_{2T}'}{K_{3T}'} = 1$ B & C are = for UCT system

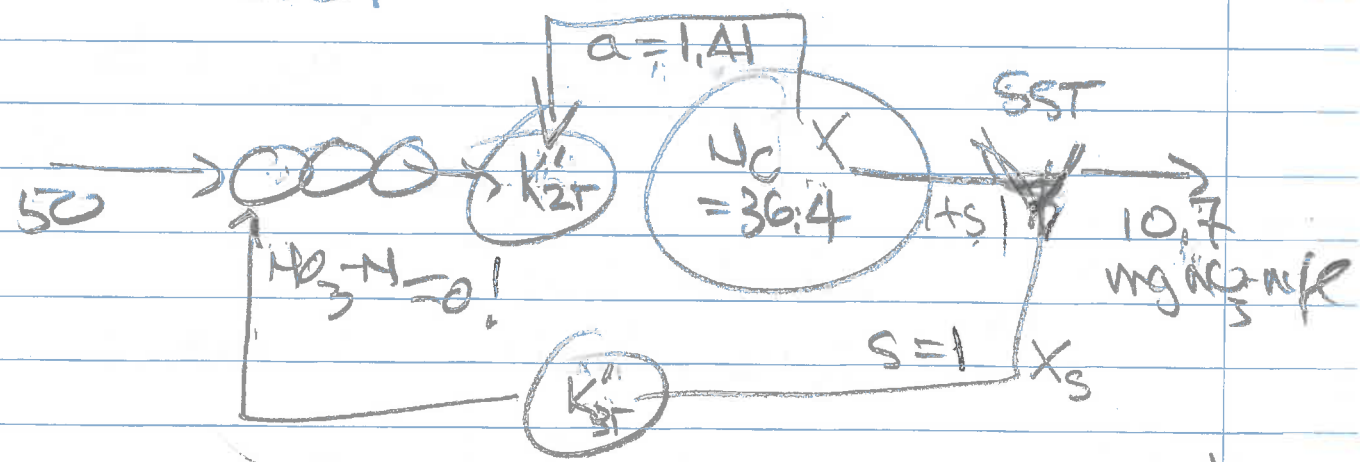
$$C = (1+1)\left(36{,}4 - 1 \times 1{,}843\,\frac{1}{2{,}86}\right) - 1 \times 1{,}343 \times 36{,}4$$

$$= 4{,}34$$

$$q_{pt_{SRT}} = \frac{-2{,}08 + \sqrt{2{,}08 + 4 \times 0{,}7 \times 4{,}34}}{2 \times 0{,}7}$$

$$= 1{,}41$$

$$N_{re} = \frac{N_c}{a+1} = \frac{36{,}4}{1{,}41+1+1} = 10{,}67 \text{ mg N/l}$$



$$f_{bI} = \frac{\left[\frac{N_c}{a+S+1} + \frac{O_2}{2{,}86}\right]a - (1+S)S_{bSFN}\frac{(1-f_{cv}i_{HV})}{2{,}86}}{K_{2T}'\frac{i_{HVFS}}{i_{bulk}} + \frac{S_{bOHO}}{a_i}}$$

$$= \frac{\left[\frac{36{,}4}{1{,}41+2} + \frac{2}{2{,}86}\right]1{,}41 - (1+1)1{,}89\,\frac{4{,}34}{3{,}86}}{0{,}1574 \times 1{,}603 \times \frac{7{,}034}{24{,}375}}$$

$= 22{,}2$ g/g COD

$f_{x1} = 0.151$

$$f_{x3} = \frac{\left(\frac{N_c}{9+5+1} + \frac{Q_s}{2.86}\right) S}{K_{3T} \frac{Y_{HV} R_s}{1 + b_{3T} R_s} \frac{F S_{bOHO}}{Q_i}}$$

$$= \frac{\left(\frac{36.4}{1.4+2} + \frac{1}{2.86}\right) 1}{4107 \times 1.603 \times 282.8 \quad \frac{703.4}{24.87}}$$

$= 0.239$

$f_{ct} = f_{x1} + f_{x3} = 4151 + 9239 = 0.390$ ✓

ie correct - used to find D_{pp}.

4/11h35 NL

$$D_{p3} = \frac{F S_{bOHO}}{Q_i} f_{x3} K_{3T} \frac{Y_{HV} R_s}{1 + b_{3T} R_s} - \frac{M X_{BH} OHO}{Q_i}$$

$= 282.8 \times 0.239 \times 4107 \times 1.603$

$= 11.02$ mg NO_3-N/l

Nitrate on predenit reactor $= S\left(N_{re} + \frac{Q_s}{2.86}\right)$

$= 1\left(10.67 + \frac{1}{2.86}\right) = 11.02$ mg NO_3-N/l

∴ D_{p3} = nitrate load

∴ zero nitrate to anaerobic

5.3 Volumes

	Anaerobic	Primary Anoxic	Aerobic	Underflow anoxic	Total
Mass fractions	0.15	0.151	0.46	0.239	1.000
Mass kg	8443	8503	25893	13450	56289
Conc Kt	4.5	4.5	4.5	9.0	5.11
Volume m^3	1876	1890	5754	1494	11014
Volume fraction	0.170	0.172	0.522	0.136	1.000

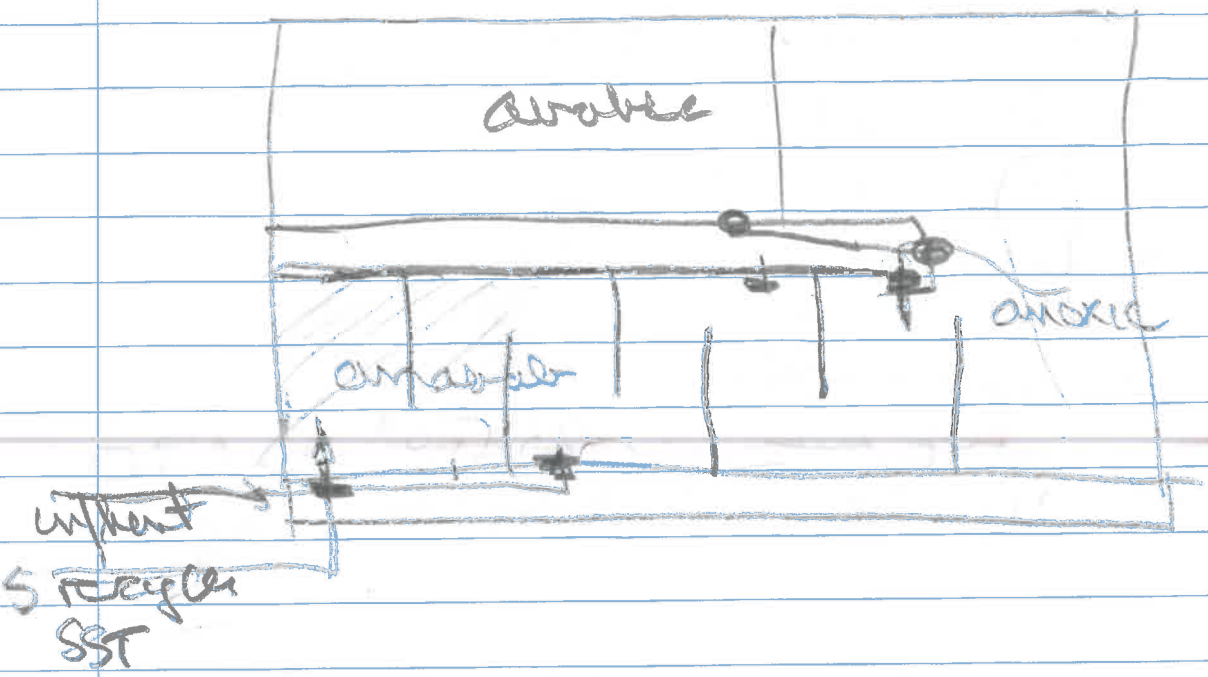
$$FO_d = 2{,}86\, Q_i (H_c - H_{re})$$
$$= 2{,}86 \times 24.375 (36.4 - 10{,}7)$$
$$= 1828 \text{ kgO/d}$$

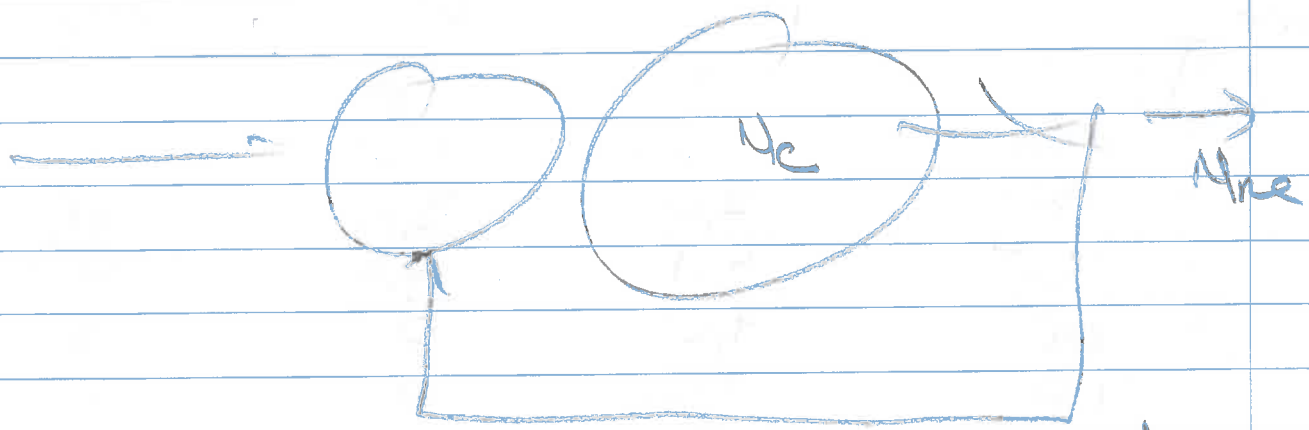
$$FO_t = FO_c + FO_n - FO_d$$
$$= 6939 + 4141 - 1828$$
(UCT) (UCT) JHB
$$= 9252 \text{ kgO/d}$$

$$OUR_t = \frac{FO_t \times 1000}{V_{aer}\, 24} = \frac{9252 \times 10^3}{5754 \times 24} = 67{,}0 \text{ mgO/l.h}$$

5.6

	MLE	UCT	JHB
q/l CO	45	45	45
" FSA	0,92	2,31	2,31
" TKH	2,0	3,4	3,4
" NO_3^-	5,4	4,6	10,7
" OP^3	7,62	0	0
" TP	7,62	0	0
SRT	15d	15d	15d
Reactor gTSS/l	4,5	4,5	4,5
FO_t	9920	8817	9251
OUR_t avalle	79,1	63,8	67,0
FX_t kgTSS/d	2543	3753	3753
S recycle	1	1	1
a "	5,4	5,86	1,41
r "	—	1,0	—
Volume m^3	8476	14385	11014
Balance SRT	10,0	14,1	16,8
a_{gt}	6:1	6:1	6:1





N_c = mg NO_3-N produced / l effluent

N_{re} = N_2 in effluent mg NO_3-N / l influent

Flux N_2 gas = $Q_i (N_c - N_{re})$

= 24.87 (40.0 − 5.4) kg N_2-N/d

= 860.7 kg N_2-N/d

1 mol gas = 22.4 l at STP

mol N_2 = $\frac{860.7}{2 \times 14}$ = 30.7 kmol/d

Volume = 30.7 × 22.4 = kl N_2 gas/d at STP

= 687 kl N_2 gas/d at STP 0°C 1 atm

(m^3) N = 20°C 1 atm.

end 4/12h30 PL