Electronic Supplementary Material (ESI) for Environmental Science: Water Research & Technology.

Supporting information for:

Integrated Shortcut Nitrogen and Biological Phosphorus Removal from Mainstream Wastewater: Process Operation and Modeling

Paul Roots, Fabrizio Sabba, Alex F. Rosenthal, Yubo Wang, Quan Yuan, Leiv Rieger, Fenghua Yang, Joseph A. Kozak, Heng Zhang, George F. Wells

S1. Methods

S1.1 Process Modeling

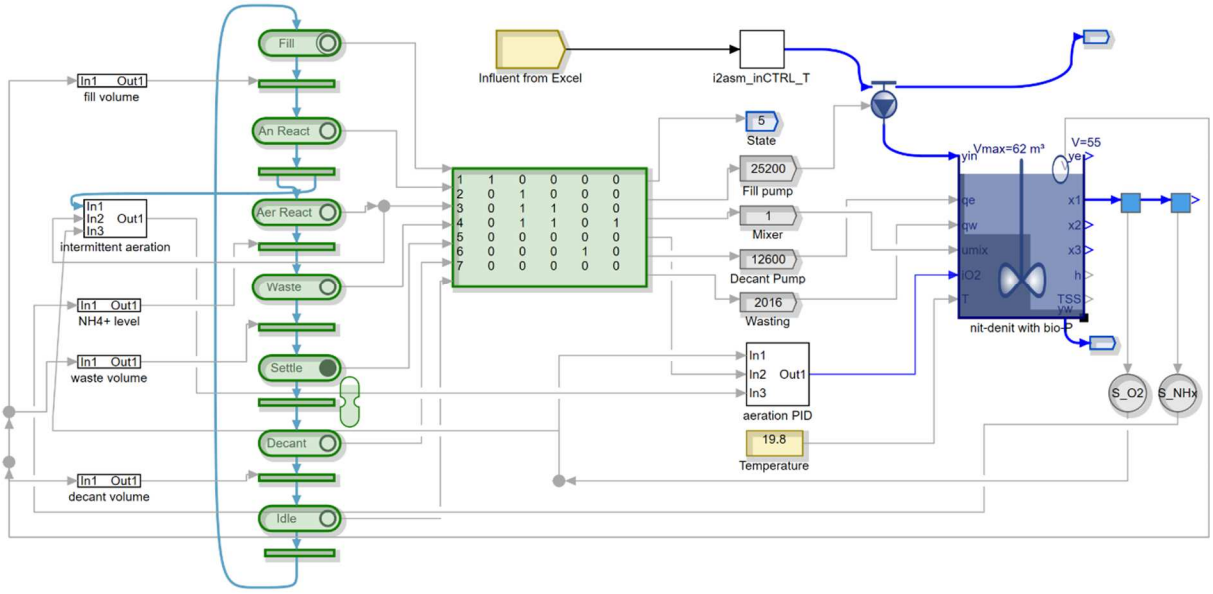

Figure S1. Process representation in the Simba# 3.0 software.

Modeled specific growth rates for AOO, NOO, and PAOs were quantified throughout the SBR cycles with rate equations and parameter values from the Simba# inCTRL ASM matrix. Rate equations and parameters values (at 20°C) discussed in the text are as follows:

$$\boldsymbol{net\ specific\ growth\ rate\ of\ AOO\ (d^{-1})} = \boldsymbol{\mu_{AOO}}$$
$$= \hat{\mu}_{AOO}\frac{S_{NHx}}{S_{NHx}+K_{NHx,AOO}}\frac{S_{O2}}{S_{O2}+K_{O2,AOO}}\frac{S_{PO4}}{S_{PO4}+K_{PO4,ANO}}\frac{S_{ALK}}{S_{ALK}+K_{ALK,AOO}}$$
$$-\hat{b}_{AOO,O2}\frac{S_{O2}}{S_{O2}+K_{O2,AOO}}-\hat{b}_{AOO,NOx}\frac{S_{NO3}+S_{NO2}}{S_{NO3}+S_{NO2}+K_{NOx,ANO}}\frac{K_{O2,AOO}}{S_{O2}+K_{O2,AOO}}$$
$$-\hat{b}_{AOO,ANA}\frac{K_{NOx,ANO}}{S_{NO3}+S_{NO2}+K_{NOx,ANO}}\frac{K_{O2,AOO}}{S_{O2}+K_{O2,AOO}}$$

Where:

$$\hat{\mu}_{AOO} = maximum\ specific\ growth\ rate\ of\ AOO\ (d^{-1}) = 0.9$$
$$S_{NHx} = concentration\ of\ NH_4^+ + NH_3\ \left(\frac{mgN}{L}\right)$$
$$K_{NHx,AOO} = AOO\ half\ saturation\ coefficient\ for\ (NH_4^+ + NH_3)\left(\frac{mgN}{L}\right) = 0.7$$
$$S_{O2} = concentration\ of\ dissolved\ O_2\ \left(\frac{mgO_2}{L}\right)$$
$$K_{O2,AOO} = AOO\ half\ saturation\ coefficient\ for\ dissolved\ O_2\ \left(\frac{mgO_2}{L}\right) = 0.25$$

$$S_{PO4} = concentration\ of\ PO_4^{3-}\ \left(\frac{mgP}{L}\right)$$

$$K_{PO4,ANO} = nitrifier\ nutrient\ half\ saturation\ coefficient\ for\ PO_4^{3-}\ \left(\frac{mgP}{L}\right) = 0.001$$

$$S_{ALK} = concentration\ of\ alkalinity\ \left(\frac{meq}{L}\right)$$

$$K_{ALK,AOO} = AOO\ half\ saturation\ coefficient\ for\ alkalinity\ \left(\frac{meq}{L}\right) = 0.5$$

$$\hat{b}_{AOO,O2} = maximum\ specific\ aerobic\ decay\ rate\ of\ AOO\ (d^{-1}) = 0.17$$

$$\hat{b}_{AOO,NOx} = maximum\ specific\ anoxic\ decay\ rate\ of\ AOO\ (d^{-1}) = 0.1$$

$$S_{NO3} = concentration\ of\ NO_3^-\ \left(\frac{mgN}{L}\right)$$

$$S_{NO2} = concentration\ of\ NO_2^-\ \left(\frac{mgN}{L}\right)$$

$$K_{NOx,ANO} = nitrifier\ half\ saturation\ for\ anoxic\ conditions\ \left(\frac{mgN}{L}\right) = 0.03$$

$$\hat{b}_{AOO,ANA} = maximum\ specific\ anaerobic\ decay\ rate\ of\ AOO\ (d^{-1}) = 0.05$$

$$\boldsymbol{net\ specific\ growth\ rate\ of\ NOO\ (d^{-1}) = \mu_{NOO}}$$

$$= \hat{\mu}_{NOO}\frac{S_{NO2}}{S_{NO2}+K_{NO2,NOO}}\frac{S_{O2}}{S_{O2}+K_{O2,NOO}}\frac{S_{NHx}}{S_{NHx}+K_{NHx,ANO}}\frac{S_{PO4}}{S_{PO4}+K_{PO4,ANO}}\frac{S_{ALK}}{S_{ALK}+K_{ALK,NOO}}$$
$$-\hat{b}_{NOO,O2}\frac{S_{O2}}{S_{O2}+K_{O2,NOO}} - \hat{b}_{AOO,NOx}\frac{S_{NO3}+S_{NO2}}{S_{NO3}+S_{NO2}+K_{NOx,ANO}}\frac{K_{O2,NOO}}{S_{O2}+K_{O2,NOO}}$$
$$-\hat{b}_{NOO,ANA}\frac{K_{NOx,ANO}}{S_{NO3}+S_{NO2}+K_{NOx,ANO}}\frac{K_{O2,NOO}}{S_{O2}+K_{O2,NOO}}$$

Where (in addition to above):

$$\hat{\mu}_{NOO} = maximum\ specific\ growth\ rate\ of\ NOO\ (d^{-1}) = 0.7$$

$$K_{NO2,NOO} = NOO\ half\ saturation\ coefficient\ for\ (NO_2^-)\left(\frac{mgN}{L}\right) = 0.1$$

$$K_{O2,NOO} = NOO\ half\ saturation\ coefficient\ for\ dissolved\ O_2\left(\frac{mgO_2}{L}\right) = 0.1$$

$$K_{NHx,ANO} = Nitrifier\ nutrient\ half\ saturation\ coefficient\ for\ (NH_4^+ + NH_3)\left(\frac{mgN}{L}\right) = 0.001$$

$$K_{ALK,NOO} = NOO\ half\ saturation\ coefficient\ for\ alkalinity\ \left(\frac{meq}{L}\right) = 0.5$$

$$\hat{b}_{NOO,O2} = maximum\ specific\ aerobic\ decay\ rate\ of\ NOO\ (d^{-1}) = 0.15$$

$$\hat{b}_{NOO,NOx} = maximum\ specific\ anoxic\ decay\ rate\ of\ NOO\ (d^{-1}) = 0.07$$

$$\hat{b}_{NOO,ANA} = maximum\ specific\ anaerobic\ decay\ rate\ of\ NOO\ (d^{-1}) = 0.04$$

AOO and NOO washout SRT calculation

The modeled SRT to avoid washout for NOO was calculated by taking the inverse of average modeled $\boldsymbol{\mu_{NOO}}$ values (as shown above, calculated approximately every minute) over one cycle, i.e.:

$$\text{washout } SRT_{NOO} = \frac{1}{mean(\mu_{NOO})}$$

A similar calculation was done for AOO to affirm that modeled SRT was sufficiently high to retain AOO. The aerobic fraction of the resulting SRT for AOO and NOO was then calculated by assuming that 48% of the intermittently aerated react phase was aerobic – see Section 2.1 for details.

$$SRT_{AER} = SRT * \frac{0.48(t_{AER})}{t_{AN} + t_{AER}} = SRT * 0.399$$

Where:

$SRT_{AER} = aerobic\ SRT$

$t_{AER} = length\ of\ modeled\ intermittently\ aerated\ react\ phase\ (minutes)$
$= 222$ (variable in the actual reactor)

$t_{AN} = length\ of\ anaerobic\ react\ phase\ (minutes)$
$= 45$ (same in the actual reactor)

PAO-Related Rate Equations

$$\boldsymbol{specific\ growth\ rate\ of\ PAOs\ on\ PHA\ and\ O_2\ (d^{-1}) = \mu_{PAO,O2}}$$
$$= \hat{\mu}_{PAO} \frac{\frac{X_{PHA}}{X_{PAO}}}{\frac{X_{PHA}}{X_{PAO}} + K_{PHA}} \frac{S_{O2}}{S_{O2} + K_{O2,OHO}} \frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}} \frac{S_{PO4}}{S_{PO4} + K_{PO4,PAO}} \frac{S_{ALK}}{S_{ALK} + K_{ALK}}$$

Where (in addition to above):

$\hat{\mu}_{PAO} = maximum\ specific\ growth\ rate\ of\ PAOs\ (d^{-1}) = 0.95$

$X_{PHA} = concentration\ of\ polyhydroxyalkanoates - PHAs\ \left(\frac{mgCOD}{L}\right)$

$X_{PAO} = concentration\ of\ PAOs\ \left(\frac{mgCOD}{L}\right)$

$K_{PHA} = half\ saturation\ coefficient\ for\ PHA\ \left(\frac{mgCOD}{L}\right) = 0.1$

$K_{O2,OHO} = OHO\ and\ PAO\ half\ saturation\ coefficient\ for\ dissolved\ O_2\ \left(\frac{mgO_2}{L}\right) = 0.05$

$K_{NHx,OHO} = OHO\ and\ PAO\ nutrient\ half\ saturation\ coefficient\ for\ (NH_4^+ + NH_3)\left(\frac{mgN}{L}\right) = 0.001$

$K_{PO4,PAO} = PAO\ half\ saturation\ coefficient\ for\ PO_4^{3-}\ \left(\frac{mgP}{L}\right) = 0.15$

$K_{ALK} = PAO\ half\ saturation\ coefficient\ for\ alkalinity\ \left(\frac{meq}{L}\right) = 0.1$

$$\textbf{specific growth rate of PAOs on PHA and } NO_2^- \ (d^{-1}) = \ \boldsymbol{\mu_{PAO,NO2}}$$

$$= \ \hat{\mu}_{PAO}\, \eta_{anox,PAO} \frac{\frac{X_{PHA}}{X_{PAO}}}{\frac{X_{PHA}}{X_{PAO}} + K_{PHA}} \frac{S_{NO2}}{S_{NO2} + K_{NO2,OHO}} \frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}} \frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}$$

$$\frac{S_{PO4}}{S_{PO4} + K_{PO4,PAO}} \frac{S_{ALK}}{S_{ALK} + K_{ALK}}$$

Where (in addition to above):

$$\eta_{anox,PAO} = PAO\ anoxic\ growth\ factor = 0.33$$

$$K_{NO2,OHO} = OHO\ and\ PAO\ half\ saturation\ coefficient\ for\ NO_2^- \left(\frac{mgN}{L}\right) = 0.05$$

$$\textbf{specific growth rate of PAOs on PHA and } NO_3^- \ (d^{-1}) = \ \boldsymbol{\mu_{PAO,NO3}}$$

$$= \ \hat{\mu}_{PAO}\, \eta_{anox,PAO} \frac{\frac{X_{PHA}}{X_{PAO}}}{\frac{X_{PHA}}{X_{PAO}} + K_{PHA}} \frac{S_{NO3}}{S_{NO3} + K_{NO3,OHO}} \frac{K_{NO2,OHO}}{S_{NO2} + K_{NO2,OHO}} \frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}$$

$$\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}} \frac{S_{PO4}}{S_{PO4} + K_{PO4,PAO}} \frac{S_{ALK}}{S_{ALK} + K_{ALK}}$$

Where (in addition to above):

$$K_{NO3,OHO} = OHO\ and\ PAO\ half\ saturation\ coefficient\ for\ NO_3^- \left(\frac{mgN}{L}\right) = 0.1$$

Additional Equations Governing PHA in the Model

While the three equations above govern PAO growth on PHA associated with P uptake, there are three additional equations that govern PAO growth in PO_4^{3-}-limited conditions. These three equations are identical to those listed above (i.e. one each for aerobic, NO_2^- and NO_3^-) aside from the following changes:

Substitute $\hat{\mu}_{PAO} with\ \hat{\mu}_{PAO,LIM} = maximum\ specific\ growth\ rate\ of\ PAOs,$
$P - limited\ (d^{-1}) = 0.42$

Substitute $K_{PHA} with\ K_{PHA,lim}$

$$= half\ saturation\ coefficient\ for\ PHA, P - limited \left(\frac{mgCOD}{L}\right) = 0.05$$

And add the following Monod term: $\frac{X_{PP,LO}}{X_{PP,LO} + K_{PP,lim}}$

Where: $X_{PP,LO} = releasable\ stored\ polyphosphate \left(\frac{mgP}{L}\right)$

$$K_{PP,lim} = polyphosphate\ limitation\ half-saturation\ \left(\frac{mgP}{L}\right) = 0.001$$

PHA production is modeled via the following equation:

Specific PHA storage rate from VFAs by PAOs ($\boldsymbol{d^{-1}}$):

$$= q_{PAO,PHA} \frac{\frac{X_{PP,LO}}{X_{PAO}}}{\frac{X_{PP,LO}}{X_{PAO}} + K_{PP,LO}} \frac{S_{VFA}}{S_{VFA} + K_{STORE,VFA}} \frac{S_{ALK}}{S_{ALK} + K_{ALK}}$$

Where (in addition to above):

$$q_{PAO,PHA} = PHA\ storage\ rate\ by\ PAOs\ (d^{-1}) = 6$$

$$K_{PP,LO} = polyphosphate\ half-saturation\ for\ storage\ \left(\frac{mgP}{mgCOD}\right) = 0.01$$

$$S_{VFA} = concentration\ of\ volatile\ fatty\ acids\ \left(\frac{mgCOD}{L}\right)$$

$$K_{STORE,VFA} = VFA\ half-saturation\ for\ storage\ \left(\frac{mgCOD}{L}\right) = 1$$

Aside from the equations above, modeling of PHA in the inCTRL ASM matrix is affected only by the aerobic, anoxic and anaerobic PAO decay rate equations, which causes PHA release proportional to the PHA content of the PAO biomass.

S1.2. Solids Retention Time (SRT) Control

SRT was controlled via timed mixed liquor wasting after the aerated react period and before settling. A maximum wasting pump time was set on the PLC, and the actual pumping time for each cycle varied depending on the length of the aerated react phase. For example, if the maximum wasting pump time was set to 1 minute, the maximum aeration time was set to 300 minutes, and the actual aeration time for a given cycle was 150 minutes, the actual pumping time would be $1\ minute \times \frac{150\ minutes}{300\ minutes} = 0.5\ minutes$. Because the aeration time varied on a cycle-by-cycle basis according to the influent strength and the target effluent NH_4^+ level, the dynamic SRT value was calculated for each individual cycle, as adapted from (Laureni et al., 2019) and Takács et al., (2008). SRT for each cycle was calculated according to the equation below (Laureni et al., 2019).

$$SRT_{t+\Delta t} = SRT_t \left(1 - \frac{X_E V_E + X_R V_W}{X_R V_R}\right) + \Delta t$$

Where:

$SRT_{t+\Delta t}$ = Solids retention time of cycle under analysis (days)
SRT_t = Solids retention time of previous cycle (days)
V_R = Volume of reactor (L)

X_E = Effluent VSS concentration for the cycle under analysis (mg/L)
V_E = Effluent volume for the cycle under analysis (L)
X_R = Reactor MLVSS concentration for the cycle under analysis (mg/L)
V_W = Mixed liquor wasting volume for the cycle under analysis (L)
Δt = React time of the cycle under analysis, not including settling and decant (days)

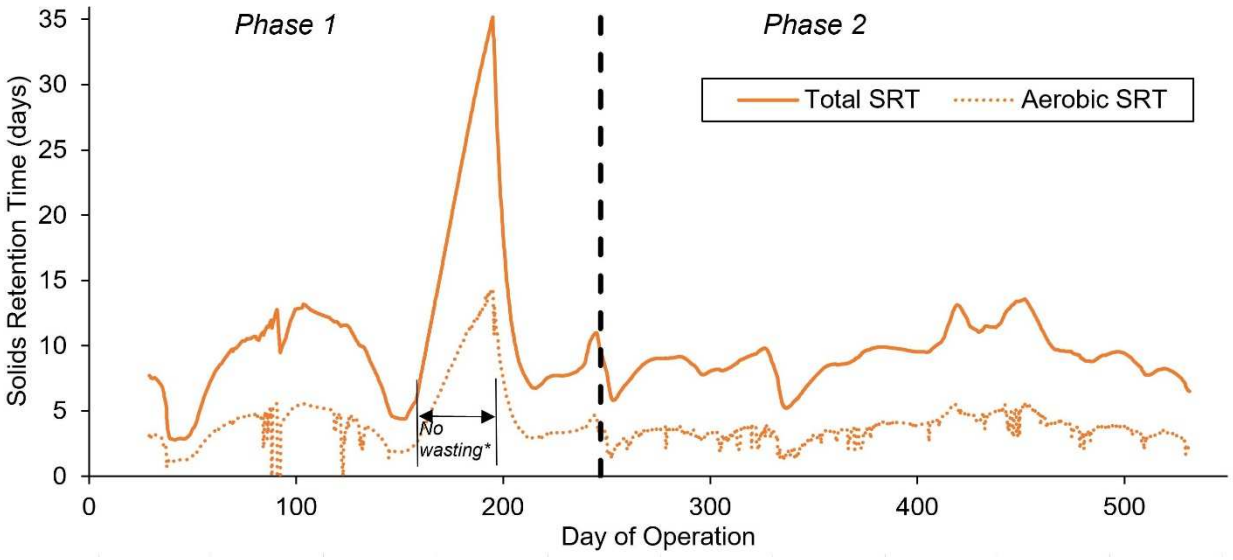

Figure S2. Total and aerobic dynamic SRT over time in the SBR. The average total and aerobic SRT during Phase 1 was 11 ± 7 and 4.5 ± 3.0 days, and the average total and aerobic SRT during Phase 2 was 9.2 ± 1.8 and 3.6 ± 0.9 days, respectively. *Mixed liquor wasting was suspended from days 158 – 195 to recover AOO activity.

S1.3. 16S rRNA Gene Amplicon Sequencing

16S rRNA gene amplicon library preparations were performed using a two-step PCR protocol using the Fluidigm Biomark: Multiplex PCR Strategy as previously described (Griffin and Wells, 2017). In the first round of PCR, each 20 uL reaction contained 10 µL of FailSafe PCR 2X PreMix F (Epicentre, Madison, WI), 0.63 units of Expand High Fidelity PCR Taq Enzyme (Sigma-Aldrich, St. Louis, MO), 0.4 µM of forward primer and reverse primer modified with Fluidigm common sequences at the 5' end of each primer, 1 µL of gDNA (approximately 100 ng) and the remaining volume molecular biology grade water. The V4-V5 region of the 16S rRNA gene was amplified in duplicate from 10 samples collected over the course of reactor operation using the 515F-Y (5'-GTGYCAGCMGCCGCGGTAA-3') and 926R (5'-CCGYCAATTYMTTTRAGTTT-3') (Parada et al., 2016) primer set. Thermocycling conditions for the 515F-Y/926R primer set were 95°C for 5 minutes, then 28 cycles of 95°C for 30 seconds, 50°C for 45 seconds, and 68°C for 30 seconds, followed by a final extension of 68°C for 5 minutes. Specificity of amplification was checked for all samples via agarose gel electrophoresis.

Samples were then barcoded by sample via a second stage PCR amplification using Access Array Barcodes (Fluidigm, South San Francisco, CA) (Griffin and Wells, 2017). Each 20 uL PCR reaction consisted of 10 µL of FailSafe PCR 2X PreMix F, 0.63 units of Expand High Fidelity PCR Taq Enzyme, 2 µL of template from the first round of PCR, 4 µL of sample-specific barcode primers and the remaining volume molecular biology grade water. The conditions for the second round of PCR were 95°C for 5 minutes, then 8 cycles of 95°C for 30 seconds, 60°C for 30 seconds, and 68°C for 30 seconds. Agarose gel electrophoresis was run again after the second round of PCR to verify correct amplification. Sequencing was performed on an Illumina Miseq sequencer (Illumina, San Diego, CA) using Illumina V2 (2x250 paired end) chemistry.

For amplicon sequence analysis, sequence quality control was performed through DADA2 (Callahan et al., 2016) integrated in QIIME2 version qiime2-2018.8 (Bolyen et al., 2018), which included quality-score-based sequence truncation, primer trimming, merging of paired-end reads, and removal of chimeras. Taxonomy was assigned to each individual sequence variation using the Silva database, release 132.

S1.4 qPCR supermix and reaction conditions

Bio-Rad iQ SYBR Green Supermix (Bio-Rad, Hercules, CA, USA) containing 50 U/ml iTaq DNA polymerase, 0.4 mM dNTPs, 100 mM KCl, 40 mM Tris-HCl, 6 mM MgCl2, 20 mM fluorescein, and stabilizers was used for two qPCR assays. Target genes included ammonia oxidizing bacterial *amoA* via the *amoA*-1F and *amoA*-2R primer set (Rotthauwe et al., 1997) and total bacterial (universal) 16S rRNA genes via the Eub519/Univ907 primer set (Burgmann et al., 2011). The final volume of the reaction mix for each PCR and qPCR reaction was 20 µl, in which the DNA template was ~1 ng, and the primer concentrations were 0.2 µM. All assays were performed in triplicate. For each assay, triplicate standard series were generated by tenfold serial dilutions (10^2-10^8 gene copies/µl).

S2. Process Modeling Reproduces Key Elements of Process Performance

Agreement between the process model and our experimental results suggest that the trends in N and P removal from mainstream wastewater that we observed are likely generally applicable to other locations. By closely modeling the influent (primary effluent), reactor control, aeration control and SRT (model SRT 9.5 days, reactor SRT 9.2 ± 1.8 days) from Phase 2, the resulting model performance closely matched that of the reactor (Figure 5): modeled HRT was 7.2 hours (reactor HRT 6.8 ± 2.8 hours), modeled VSS was 1,245 mg/L (reactor VSS 1,344 ± 226 mg/L) and Figure 2, Figure 4, and Table 3 demonstrate that both in-cycle nutrient dynamics and effluent concentrations were well-matched between the model and reactor performance. Importantly, this was done via a commercially available wastewater process modeling software without modification to the inCTRL ASM matrix.

S3. Supporting Table and Figures

Table S1. Sampling frequency and target analytes (per APHA, 2005) for daily composite samples. All samples listed are of reactor influent and effluent except NO_2^--N (effluent only) and mixed liquor TSS and VSS (sampled in-reactor).

Analyte	Samples per week

Total COD	3
Filtered COD (1.2 µm filter)	3
Alkalinity	3
Total Kjeldahl Nitrogen	3
NH_4^+-N	3
NO_X^--N [1]	3
NO_2^--N (effluent only)	3
Total Phosphorus	3
Ortho-Phosphate	2
TSS [2] & VSS [3]	1
Mixed Liquor TSS [2] & VSS [3]	2

[1] *NO_X^--N = NO_2^--N + NO_3^--N*

[2] *TSS = total suspended solids*

[3] *VSS = volatile suspended solids*

Table S2. Influent (primary effluent) COD fractionation and COD-to-nutrient ratios.

	Primary Effluent	As percent of total COD
Total COD (mgCOD/L)[a]	164.4 ± 46.2	---
Particulate COD (mgCOD/L)	61.7 ± 23.8	37%
Colloidal COD (mgCOD/L)	28.6 ± 18.1	17%
Soluble COD not including VFA (mgCOD/L)	56.4 ± 19.4	34%
VFA (mgCOD/L)	18.8 ± 8.9	11%
COD:TP[b] (gCOD/gP)	67:1	---
COD:TKN[b] (gCOD/gN)	8.3:1	---

[a]Primary effluent COD fractionation was performed weekly from days 114 - 515 (n = 50).

[b]COD:Nutrient ratios are taken from average of all samples from days 27 - 519 (n = 192).

Table S3. N_2O emissions test results for 8 cycles during Phase 2.

Day of cycle tested	N_2O emitted/ influent TKN	N_2O emitted/ TIN removed	influent TKN (mgN/L)	influent COD (mg/L)	COD/ TKN	Effluent NO_2^- (mgN/L)	Average temp (°C)
414	3.8%	11.4%	23	206	9	2.9	20.5
426	6.2%	12.0%	20	204	10	2.7	20.3
428	1.0%	2.3%	12	140	12	1.2	20.5
475	1.0%	2.6%	13	64	5	2.0	20.4
489	2.2%	4.3%	19	183	10	2.4	20.3
503	0.2%	0.2%	14	160	11	0.4	19.4
517	0.8%	1.6%	21	147	7	1.9	19.4
531	1.56%	7.36%	13	144	11	2.1	19.4

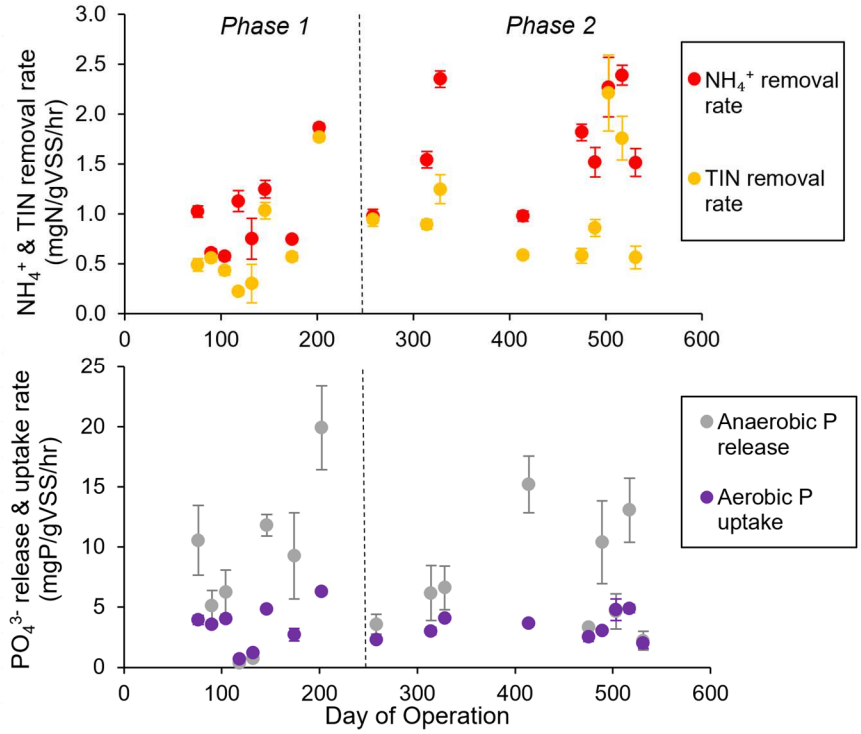

Figure S3. In-cycle N and P removal rates from least-squares regression of the linear portions of in-cycle grab samples for NH_4^+, NO_2^-, NO_3^-, and PO_4^{3-}. Error bars represent standard errors of the slopes.

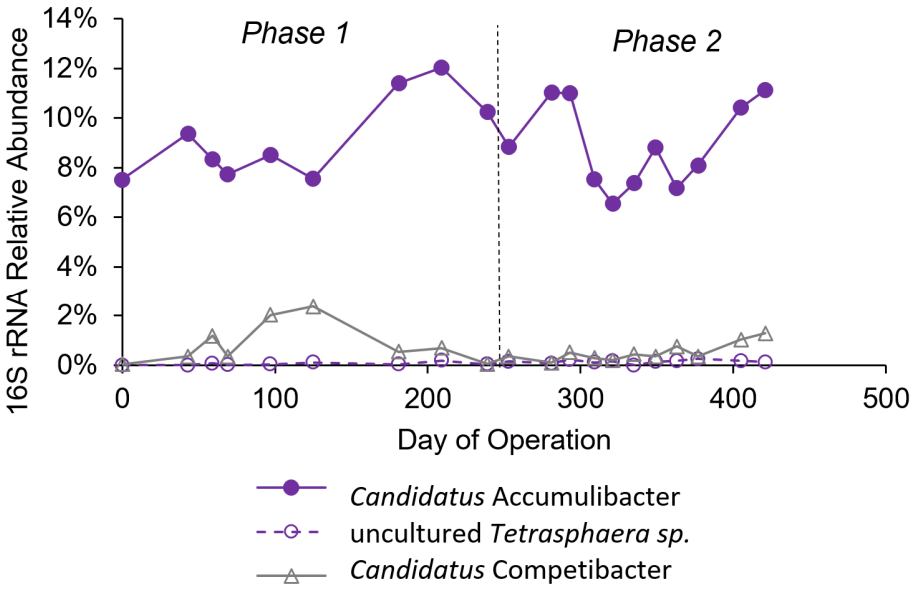

Figure S4. Relative *Accumulibacter*, *Tetrasphaera*, and *Competibacter* abundance through the first 421 days of reactor operation according to 16S rRNA gene sequencing. Day "0" represents the inoculum, which was sampled before reactor operation began.

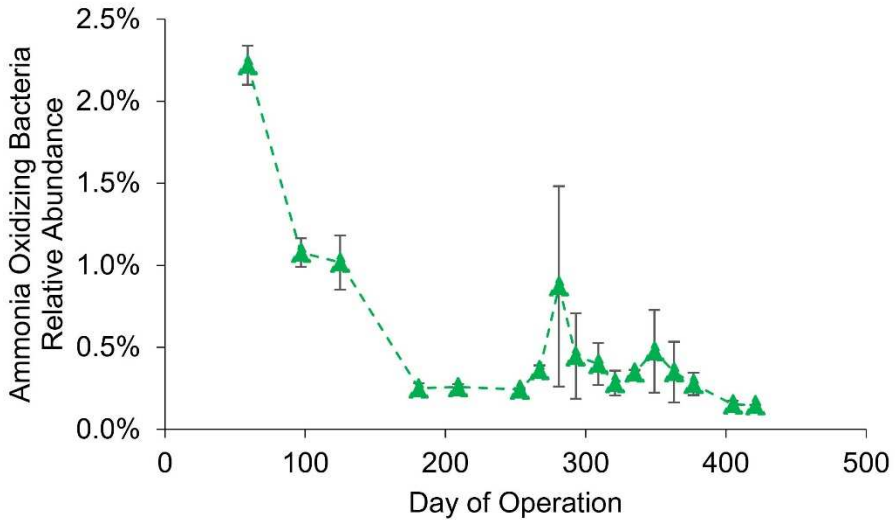

Figure S5. Ammonia oxidizing bacterial *amoA* gene abundance normalized to total bacterial 16S rRNA genes through the first 421 days of reactor operation according to qPCR.

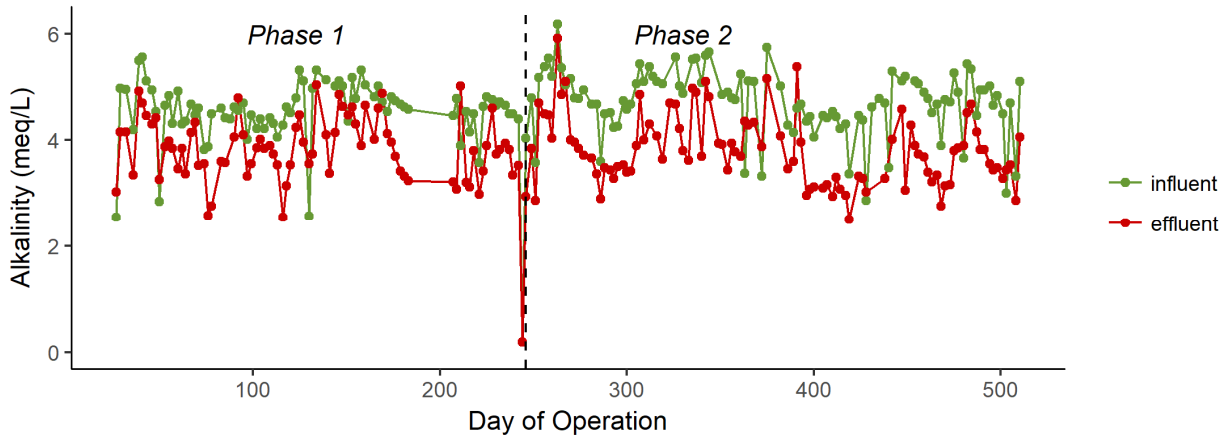

Figure S6. Reactor influent and effluent alkalinity concentrations from composite sampling

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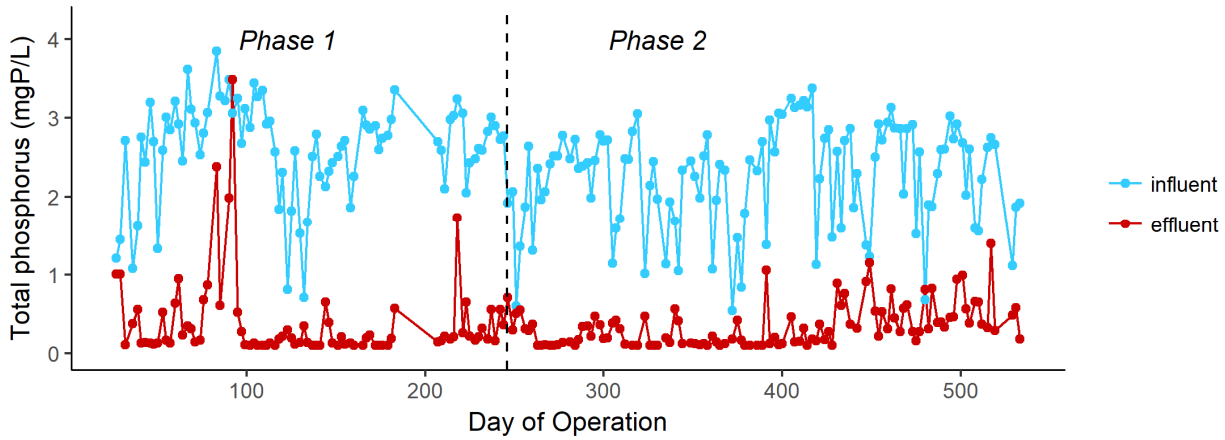

Figure S7. Reactor influent and effluent total phosphorus concentrations from composite sampling.

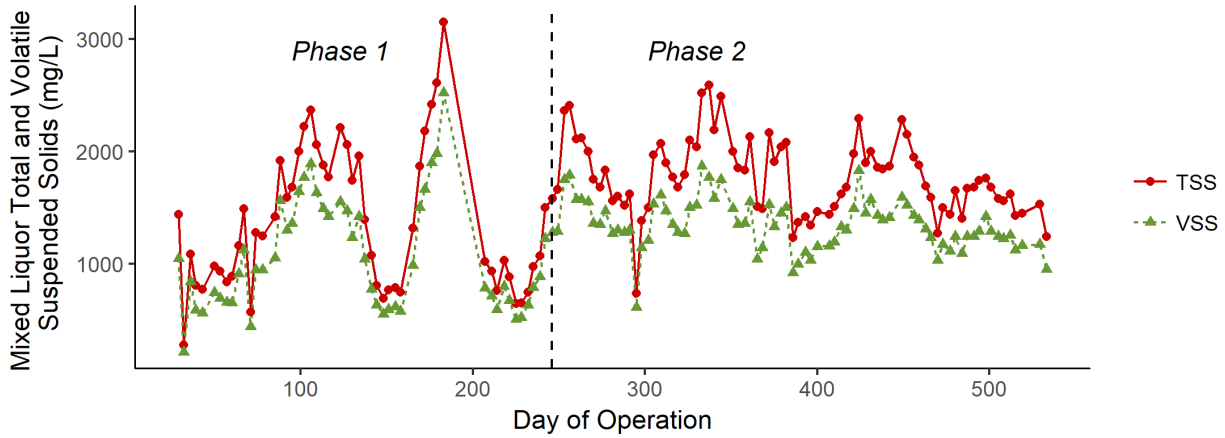

Figure S8. Reactor mixed liquor TSS and VSS concentrations.

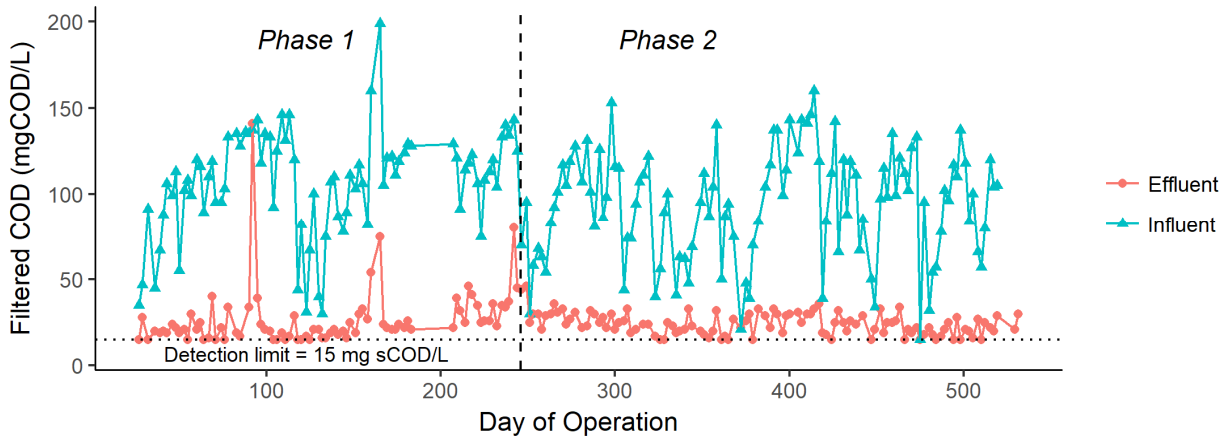

Figure S9. Reactor influent and effluent filtered COD from composite sampling. Samples were filtered through a 1.2 µm pore size membrane.

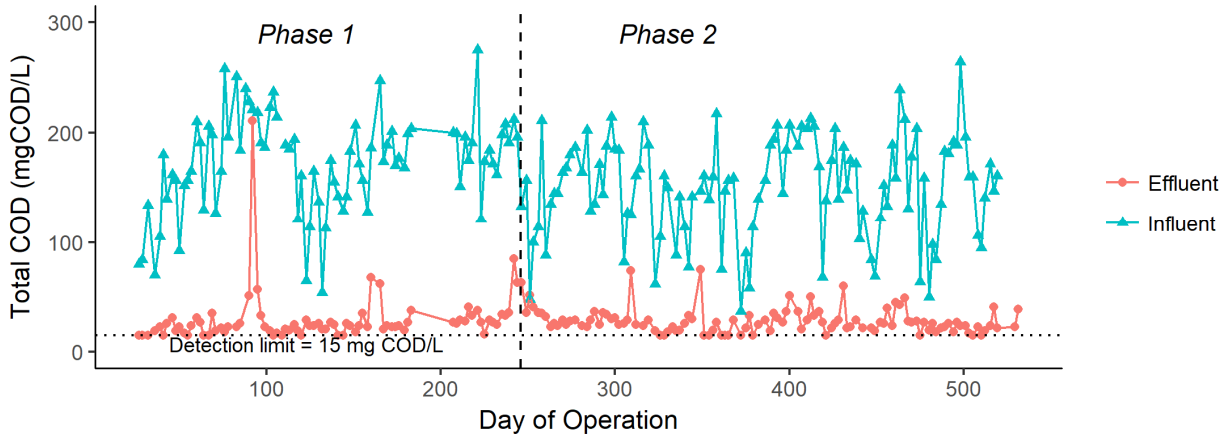

Figure S10. Reactor influent and effluent total COD concentrations from composite sampling.

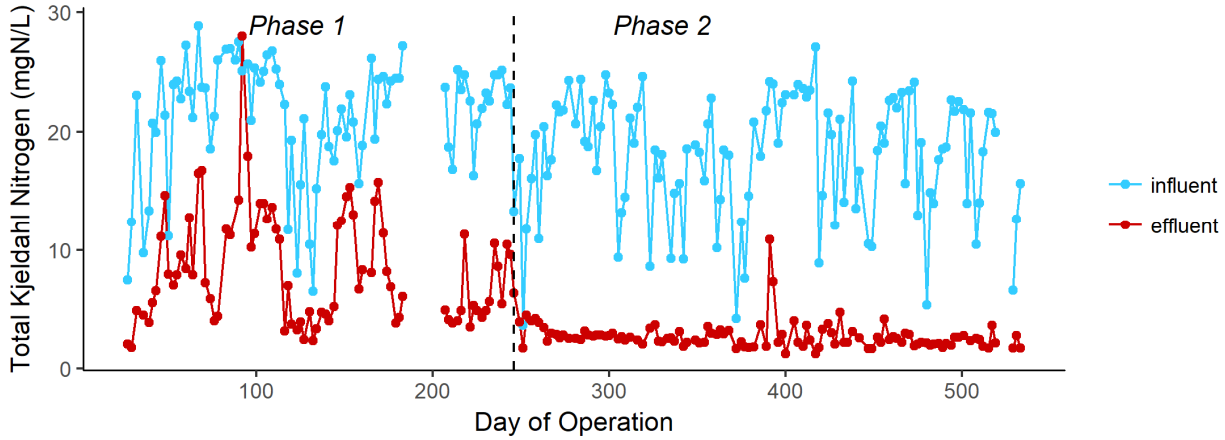

Figure S11. Reactor influent and effluent TKN concentrations from composite sampling.

S3. References for Supporting Information

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Table S4: Stoichiometric Matrix for inCTRL ASM model implemented in the Simba# process simulator

	S_{VFA}	S_F	S_{MEOL}	C_B	X_B	S_U	C_U	X_U	X_{PHA}	X_E	X_{OHO}	X_{MEOLO}
r1	$\frac{-1}{Y_{OHO,VFA,O2}}$	0	0	0	0	0	0	0	0	0	1	0
r2	$\frac{-1}{Y_{OHO,VFA,NOx}}$	0	0	0	0	0	0	0	0	0	1	0
r3	$\frac{-1}{Y_{OHO,VFA,NOx}}$	0	0	0	0	0	0	0	0	0	1	0
r4	0	$\frac{-1}{Y_{OHO,SF,O2}}$	0	0	0	0	0	0	0	0	1	0
r5	0	$\frac{-1}{Y_{OHO,SF,NOx}}$	0	0	0	0	0	0	0	0	1	0
r6	0	$\frac{-1}{Y_{OHO,SF,NOx}}$	0	0	0	0	0	0	0	0	1	0
r7	$\frac{1 - Y_{OHO,SF,ANA} - Y_{OHO,H2,ANA}}{Y_{OHO,SF,ANA}}$	$\frac{-1}{Y_{OHO,SF,ANA}}$	0	0	0	0	0	0	0	0	1	0
r8	0	0	$\frac{-1}{Y_{OHO,SMEOL,O2}}$	0	0	0	0	0	0	0	1	0
r9	0	0	0	0	$1 - f_E$	0	0	0	0	f_E	-1	0
r10	0	0	0	0	$1 - f_E$	0	0	0	0	f_E	-1	0
r11	0	0	0	0	$1 - f_E$	0	0	0	0	f_E	-1	0
r12	0	0	$\frac{-1}{Y_{MEOLO}}$	0	0	0	0	0	0	0	0	1
r13	0	0	$\frac{-1}{Y_{MEOLO}}$	0	0	0	0	0	0	0	0	1
r14	0	0	0	0	$1 - f_E$	0	0	0	0	f_E	0	-1
r15	0	0	0	0	$1 - f_E$	0	0	0	0	f_E	0	-1
r16	0	0	0	0	$1 - f_E$	0	0	0	0	f_E	0	-1
r17	0	0	0	0	0	0	0	0	$\frac{-1}{Y_{PAO,PHA,O2}}$	0	0	0
r18	0	0	0	0	0	0	0	0	$\frac{-1}{Y_{PAO,PHA,NO2}}$	0	0	0
r19	0	0	0	0	0	0	0	0	$\frac{-1}{Y_{PAO,PHA,NO3}}$	0	0	0
r20	0	0	0	0	0	0	0	0	$\frac{-1}{Y_{PAO,PHA,O2}}$	0	0	0
r21	0	0	0	0	0	0	0	0	$\frac{-1}{Y_{PAO,PHA,NO2}}$	0	0	0
r22	0	0	0	0	0	0	0	0	$\frac{-1}{Y_{PAO,PHA,NO3}}$	0	0	0
r23	-1	0	0	0	0	0	0	0	$f_{PHA,VFA}$	0	0	0
r24	0	0	0	0	$1 - f_E$	0	0	0	0	f_E	0	0
r25	0	0	0	0	$1 - f_E$	0	0	0	0	f_E	0	0
r26	0	0	0	0	$1 - f_E$	0	0	0	0	f_E	0	0
r27	1	0	0	0	0	0	0	0	-1	0	0	0
r28	0	0	0	0	0	0	0	0	0	0	0	0
r29	0	0	0	0	0	0	0	0	0	0	0	0
r30	1	0	0	0	0	0	0	0	-1	0	0	0
r31	0	0	0	0	0	0	0	0	0	0	0	0
r32	0	0	0	0	0	0	0	0	0	0	0	0
r33	1	0	0	0	0	0	0	0	-1	0	0	0
r34	0	0	0	0	0	0	0	0	0	0	0	0
r35	0	0	0	0	0	0	0	0	0	0	0	0
r36	0	0	0	0	0	0	0	0	0	0	0	0
r37	0	0	0	0	0	0	0	0	0	0	0	0
r38	0	0	0	0	$1 - f_E$	0	0	0	0	f_E	0	0
r39	0	0	0	0	$1 - f_E$	0	0	0	0	f_E	0	0
r40	0	0	0	0	$1 - f_E$	0	0	0	0	f_E	0	0
r41	0	0	0	0	0	0	0	0	0	0	0	0
r42	0	0	0	0	$1 - f_E$	0	0	0	0	f_E	0	0
r43	0	0	0	0	$1 - f_E$	0	0	0	0	f_E	0	0
r44	0	0	0	0	$1 - f_E$	0	0	0	0	f_E	0	0
r45	0	0	0	-1	1	0	0	0	0	0	0	0
r46	0	0	0	0	0	0	-1	1	0	0	0	0
r47	0	1	0	0	-1	0	0	0	0	0	0	0
r48	0	1	0	0	-1	0	0	0	0	0	0	0
r49	0	1	0	0	-1	0	0	0	0	0	0	0
r50	0	0	0	0	0	0	0	0	0	0	0	0
r51	0	0	0	0	0	0	0	0	0	0	0	0
r52	0	0	0	0	0	0	0	0	0	0	0	0
r53	0	0	0	0	0	0	0	0	0	0	0	0
r54	0	0	0	0	1	0	0	0	0	-1	0	0
r55	0	0	0	0	0	0	0	0	0	0	$-1\,EEQ_{NO2}$	0
r56	0	0	0	0	0	0	0	0	0	0	$-1\,EEQ_{NO3}$	0
r57	0	0	0	0	0	0	0	0	0	0	0	0
r58	0	0	0	0	0	0	0	0	0	0	0	0
r59	0	0	0	0	0	0	0	0	0	0	0	0
	S_{VFA}	S_F	S_{MEOL}	C_B	X_B	S_U	C_U	X_U	X_{PHA}	X_E	X_{OHO}	X_{MEOLO}
ThOD	1	1	1	1	1	1	1	1	1	1	1	1
ThN	0	0	0	$i_{N,C,B}$	0	0	$i_{N,C,U}$	0	0	$i_{N,Bio}$	$i_{N,Bio}$	$i_{N,Bio}$
P	0	0	0	$i_{P,C,B}$	0	0	$i_{P,C,U}$	0	0	$i_{P,Bio}$	$i_{P,Bio}$	$i_{P,Bio}$
Charge	$\frac{-1}{4\,M_O}$	0	0	0	0	0	0	0	0	0	0	0
Metal	0	0	0	0	0	0	0	0	0	0	0	0
C	0	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0	0
TSS	0	0	0	0	$\frac{1}{i_{CV,B}}$	0	0	$\frac{1}{i_{CV,U}}$	$\frac{1}{i_{CV,PHA}}$	$\frac{1}{i_{CV,E}}$	$\frac{1}{i_{CV,BIO}} + \frac{i_{IG}}{i_{CV,BIO}}$	$\frac{1}{i_{CV,BIO}} + \frac{i_{IG}}{i_{CV,BIO}}$
VSS	0	0	0	0	$\frac{1}{i_{CV,B}}$	0	0	$\frac{1}{i_{CV,U}}$	$\frac{1}{i_{CV,PHA}}$	$\frac{1}{i_{CV,E}}$	$\frac{1}{i_{CV,BIO}}$	$\frac{1}{i_{CV,BIO}}$
ISS	0	0	0	0	0	0	0	0	0	0	$\frac{i_{IG}}{i_{CV,BIO}}$	$\frac{i_{IG}}{i_{CV,BIO}}$
N	0	0	0	$i_{N,C,B}$	0	0	$i_{N,C,U}$	0	0	$i_{N,Bio}$	$i_{N,Bio}$	$i_{N,Bio}$
TKN	0	0	0	$i_{N,C,B}$	0	0	$i_{N,C,U}$	0	0	$i_{N,Bio}$	$i_{N,Bio}$	$i_{N,Bio}$
N_fil	0	0	0	$i_{N,C,B}$	0	0	$i_{N,C,U}$	0	0	0	0	0
N_sol	0	0	0	0	0	0	0	0	0	0	0	0
NOx	0	0	0	0	0	0	0	0	0	0	0	0
COD	1	1	1	1	1	1	1	1	1	1	1	1
COD_fil	1	1	1	1	0	1	1	0	0	0	0	0
COD_sol	1	1	1	0	0	1	0	0	0	0	0	0
BOD5	$1 - Y_{VFA,BOD} + (1 - f_{BOD})\,Y_{VFA,BOD}\left(1 - e^{-1\,b_{OHO,BOD}\,d_{BOD}}\right)$	$1 - Y_{OHO,BOD} + (1 - f_{BOD})\,Y_{OHO,BOD}\left(1 - e^{-1\,b_{OHO,BOD}\,d_{BOD}}\right)$	$1 - Y_{MEOLO,BOD} + (1 - f_{BOD})\,Y_{MEOLO,BOD}\left(1 - e^{-1\,b_{MEOLO,BOD}\,d_{BOD}}\right)$	$1 - Y_{OHO,BOD} + (1 - f_{BOD})\,Y_{OHO,BOD}\left(1 - e^{-1\,b_{OHO,BOD}\,d_{BOD}}\right)$	$(1 - Y_{OHO,BOD})\left(1 - e^{-1\,k_{BOD}\,d_{BOD}}\right) - (1 - f_{BOD})\,\frac{Y_{OHO,BOD}}{b_{OHO,BOD} - k_{BOD}}\left(k_{BOD}\left(1 - e^{-1\,b_{OHO,BOD}\,d_{BOD}}\right) - b_{OHO,BOD}\left(1 - e^{-1\,k_{BOD}\,d_{BOD}}\right)\right)$	0	0	0	$(1 - Y_{OHO,BOD})\left(1 - e^{-1\,k_{BOD}\,d_{BOD}}\right) - (1 - f_{BOD})\,\frac{Y_{OHO,BOD}}{b_{OHO,BOD} - k_{BOD}}\left(k_{BOD}\left(1 - e^{-1\,b_{OHO,BOD}\,d_{BOD}}\right) - b_{OHO,BOD}\left(1 - e^{-1\,k_{BOD}\,d_{BOD}}\right)\right)$	0	$(1 - f_{BOD})\left(1 - e^{-1\,b_{OHO,BOD}\,d_{BOD}}\right)$	$(1 - f_{BOD})\left(1 - e^{-1\,b_{MEOLO,BOD}\,d_{BOD}}\right)$
BOD5_fil	$1 - Y_{VFA,BOD} + (1 - f_{BOD})\,Y_{VFA,BOD}\left(1 - e^{-1\,b_{OHO,BOD}\,d_{BOD}}\right)$	$1 - Y_{OHO,BOD} + (1 - f_{BOD})\,Y_{OHO,BOD}\left(1 - e^{-1\,b_{OHO,BOD}\,d_{BOD}}\right)$	$1 - Y_{MEOLO,BOD} + (1 - f_{BOD})\,Y_{MEOLO,BOD}\left(1 - e^{-1\,b_{MEOLO,BOD}\,d_{BOD}}\right)$	$1 - Y_{OHO,BOD} + (1 - f_{BOD})\,Y_{OHO,BOD}\left(1 - e^{-1\,b_{OHO,BOD}\,d_{BOD}}\right)$	0	0	0	0	0	0	0	0
BOD5_sol	$1 - Y_{VFA,BOD} + (1 - f_{BOD})\,Y_{VFA,BOD}\left(1 - e^{-1\,b_{OHO,BOD}\,d_{BOD}}\right)$	$1 - Y_{OHO,BOD} + (1 - f_{BOD})\,Y_{OHO,BOD}\left(1 - e^{-1\,b_{OHO,BOD}\,d_{BOD}}\right)$	$1 - Y_{MEOLO,BOD} + (1 - f_{BOD})\,Y_{MEOLO,BOD}\left(1 - e^{-1\,b_{MEOLO,BOD}\,d_{BOD}}\right)$	0	0	0	0	0	0	0	0	0
sPS	0	0	0	0	1	0	0	1	1	1	1	1
Vtss	0	0	0	0	0	0	0	0	0	0	0	0
Vvss	0	0	0	0	0	0	0	0	0	0	0	0
C_VSS	0	0	0	$\frac{1}{i_{CV,B}}$	0	0	$\frac{1}{i_{CV,U}}$	0	0	0	0	0
XC_TSS	0	0	0	$\frac{1}{i_{CV,B}}$	$\frac{1}{i_{CV,B}}$	0	$\frac{1}{i_{CV,U}}$	$\frac{1}{i_{CV,U}}$	$\frac{1}{i_{CV,PHA}}$	$\frac{1}{i_{CV,E}}$	$\frac{1}{i_{CV,BIO}} + \frac{i_{IG}}{i_{CV,BIO}}$	$\frac{1}{i_{CV,BIO}} + \frac{i_{IG}}{i_{CV,BIO}}$
SX	1	1	1	4	2	1	4	2	2	2	2	2
aTS	0	0	0	0	0.5555555555555558	0	0	0.7692307692307692	0.5988023952095809	0.7042253521126761	0.8098591549295775	0.8098591549295775
Diff	0.000107	0.000107	0.000138	2.68E-05	0	6.05E-05	1.51E-05	0	0	0	0	0
Default	1	5	0.1	1	50	25	0.1	700	200	500	500	0.1

	X_{PAO}	X_{AOO}	X_{NOO}	S_{NHx}	S_{NO2}	S_{NO3}	S_{N2}	$S_{N,F}$	$X_{N,B}$	$S_{N,U}$	$X_{N,U}$	S_{PO4}
r1	0	0	0	$-1\,i_{N,Bio}$	0	0	0	0	0	0	0	$-1\,i_{P,Bio}$
r2	0	0	0	$-1\,i_{N,Bio}$	$\frac{1 - Y_{OHO,VFA,NOx}}{EEQ_{NO2,NO3}\,Y_{OHO,VFA,NOx}}$	$\frac{-1\,(1 - Y_{OHO,VFA,NOx})}{EEQ_{NO2,NO3}\,Y_{OHO,VFA,NOx}}$	0	0	0	0	0	$-1\,i_{P,Bio}$
r3	0	0	0	$-1\,i_{N,Bio}$	$\frac{-1\,(1 - Y_{OHO,VFA,NOx})}{EEQ_{N2,NO2}\,Y_{OHO,VFA,NOx}}$	0	$\frac{1 - Y_{OHO,VFA,NOx}}{EEQ_{N2,NO2}\,Y_{OHO,VFA,NOx}}$	0	0	0	0	$-1\,i_{P,Bio}$
r4	0	0	0	$-1\,i_{N,Bio}$	0	0	0	0	0	0	0	$-1\,i_{P,Bio}$
r5	0	0	0	$-1\,i_{N,Bio}$	$\frac{1 - Y_{OHO,SF,NOx}}{EEQ_{NO2,NO3}\,Y_{OHO,SF,NOx}}$	$\frac{-1\,(1 - Y_{OHO,SF,NOx})}{EEQ_{NO2,NO3}\,Y_{OHO,SF,NOx}}$	0	0	0	0	0	$-1\,i_{P,Bio}$
r6	0	0	0	$-1\,i_{N,Bio}$	$\frac{-1\,(1 - Y_{OHO,SF,NOx})}{EEQ_{N2,NO2}\,Y_{OHO,SF,NOx}}$	0	$\frac{1 - Y_{OHO,SF,NOx}}{EEQ_{N2,NO2}\,Y_{OHO,SF,NOx}}$	0	0	0	0	$-1\,i_{P,Bio}$
r7	0	0	0	$-1\,i_{N,Bio}$	0	0	0	0	0	0	0	$-1\,i_{P,Bio}$
r8	0	0	0	$-1\,i_{N,Bio}$	0	0	0	0	0	0	0	$-1\,i_{P,Bio}$
r9	0	0	0	0	0	0	0	0	$(1 - f_E)\,i_{N,Bio}$	0	0	0
r10	0	0	0	0	0	0	0	0	$(1 - f_E)\,i_{N,Bio}$	0	0	0
r11	0	0	0	0	0	0	0	0	$(1 - f_E)\,i_{N,Bio}$	0	0	0
r12	0	0	0	$-1\,i_{N,Bio}$	$\frac{1 - Y_{MEOLO}}{EEQ_{NO2,NO3}\,Y_{MEOLO}}$	$\frac{-1\,(1 - Y_{MEOLO})}{EEQ_{NO2,NO3}\,Y_{MEOLO}}$	0	0	0	0	0	$-1\,i_{P,Bio}$
r13	0	0	0	$-1\,i_{N,Bio}$	$\frac{-1\,(1 - Y_{MEOLO})}{EEQ_{N2,NO2}\,Y_{MEOLO}}$	0	$\frac{1 - Y_{MEOLO}}{EEQ_{N2,NO2}\,Y_{MEOLO}}$	0	0	0	0	$-1\,i_{P,Bio}$
r14	0	0	0	0	0	0	0	0	$(1 - f_E)\,i_{N,Bio}$	0	0	0
r15	0	0	0	0	0	0	0	0	$(1 - f_E)\,i_{N,Bio}$	0	0	0
r16	0	0	0	0	0	0	0	0	$(1 - f_E)\,i_{N,Bio}$	0	0	0
r17	1	0	0	$-1\,i_{N,Bio}$	0	0	0	0	0	0	0	$\frac{-1\,f_{PHA,PP,O2}}{Y_{PAO,PHA,O2}} - i_{P,Bio}$
r18	1	0	0	$-1\,i_{N,Bio}$	$\frac{-1\,(1 - Y_{PAO,PHA,NO2})}{EEQ_{N2,NO2}\,Y_{PAO,PHA,NO2}}$	0	$\frac{1 - Y_{PAO,PHA,NO2}}{EEQ_{N2,NO2}\,Y_{PAO,PHA,NO2}}$	0	0	0	0	$\frac{-1\,f_{PHA,PP,NOx}}{Y_{PAO,PHA,NO2}} - i_{P,Bio}$
r19	1	0	0	$-1\,i_{N,Bio}$	$\frac{1 - Y_{PAO,PHA,NO3}}{EEQ_{NO2,NO3}\,Y_{PAO,PHA,NO3}}$	$\frac{-1\,(1 - Y_{PAO,PHA,NO3})}{EEQ_{NO2,NO3}\,Y_{PAO,PHA,NO3}}$	0	0	0	0	0	$\frac{-1\,f_{PHA,PP,NOx}}{Y_{PAO,PHA,NO3}} - i_{P,Bio}$
r20	1	0	0	$-1\,i_{N,Bio}$	0	0	0	0	0	0	0	0
r21	1	0	0	$-1\,i_{N,Bio}$	$\frac{-1\,(1 - Y_{PAO,PHA,NO2})}{EEQ_{N2,NO2}\,Y_{PAO,PHA,NO2}}$	0	$\frac{1 - Y_{PAO,PHA,NO2}}{EEQ_{N2,NO2}\,Y_{PAO,PHA,NO2}}$	0	0	0	0	0
r22	1	0	0	$-1\,i_{N,Bio}$	$\frac{1 - Y_{PAO,PHA,NO3}}{EEQ_{NO2,NO3}\,Y_{PAO,PHA,NO3}}$	$\frac{-1\,(1 - Y_{PAO,PHA,NO3})}{EEQ_{NO2,NO3}\,Y_{PAO,PHA,NO3}}$	0	0	0	0	0	0
r23	0	0	0	0	0	0	0	0	0	0	0	$f_{P,VFA}$
r24	-1	0	0	0	0	0	0	0	$(1 - f_E)\,i_{N,Bio}$	0	0	0
r25	-1	0	0	0	0	0	0	0	$(1 - f_E)\,i_{N,Bio}$	0	0	0
r26	-1	0	0	0	0	0	0	0	$(1 - f_E)\,i_{N,Bio}$	0	0	0
r27	0	0	0	0	0	0	0	0	0	0	0	0
r28	0	0	0	0	0	0	0	0	0	0	0	1
r29	0	0	0	0	0	0	0	0	0	0	0	1
r30	0	0	0	0	0	0	0	0	0	0	0	0
r31	0	0	0	0	0	0	0	0	0	0	0	1
r32	0	0	0	0	0	0	0	0	0	0	0	1
r33	0	0	0	0	0	0	0	0	0	0	0	0
r34	0	0	0	0	0	0	0	0	0	0	0	1
r35	0	0	0	0	0	0	0	0	0	0	0	1
r36	0	0	0	0	0	0	0	0	0	0	0	1
r37	0	1	0	$\frac{-1}{Y_{AOO}} - i_{N,Bio}$	$\frac{1}{Y_{AOO}}$	0	0	0	0	0	0	$-1\,i_{P,Bio}$
r38	0	-1	0	0	0	0	0	0	$(1 - f_E)\,i_{N,Bio}$	0	0	0
r39	0	-1	0	0	0	0	0	0	$(1 - f_E)\,i_{N,Bio}$	0	0	0
r40	0	-1	0	0	0	0	0	0	$(1 - f_E)\,i_{N,Bio}$	0	0	0
r41	0	0	1	$-1\,i_{N,Bio}$	$\frac{-1}{Y_{NOO}}$	$\frac{1}{Y_{NOO}}$	0	0	0	0	0	$-1\,i_{P,Bio}$
r42	0	0	-1	0	0	0	0	0	$(1 - f_E)\,i_{N,Bio}$	0	0	0
r43	0	0	-1	0	0	0	0	0	$(1 - f_E)\,i_{N,Bio}$	0	0	0
r44	0	0	-1	0	0	0	0	0	$(1 - f_E)\,i_{N,Bio}$	0	0	0
r45	0	0	0	0	0	0	0	0	$i_{N,C,B}$	0	0	0
r46	0	0	0	0	0	0	0	0	0	0	$i_{N,C,U}$	0
r47	0	0	0	0	0	0	0	0	0	0	0	0
r48	0	0	0	0	0	0	0	0	0	0	0	0
r49	0	0	0	0	0	0	0	0	0	0	0	0
r50	0	0	0	0	0	0	0	1	-1	0	0	0
r51	0	0	0	0	0	0	0	0	0	0	0	0
r52	0	0	0	1	0	0	0	-1	0	0	0	0
r53	0	0	0	0	0	0	0	0	0	0	0	1
r54	0	0	0	0	0	0	0	0	$i_{N,Bio}$	0	0	0
r55	0	0	0	$1 + EEQ_{NO2}\,i_{N,Bio}$	-1	0	0	0	0	0	0	$EEQ_{NO2}\,i_{P,Bio}$
r56	0	0	0	$1 + EEQ_{NO3}\,i_{N,Bio}$	0	-1	0	0	0	0	0	$EEQ_{NO3}\,i_{P,Bio}$
r57	0	0	0	0	0	0	0	0	0	0	0	$-1\,f_{P,Me}$
r58	0	0	0	0	0	0	0	0	0	0	0	$f_{P,Me}$
r59	0	0	0	0	0	0	0	0	0	0	0	0
	X_{PAO}	X_{AOO}	X_{NOO}	S_{NHx}	S_{NO2}	S_{NO3}	S_{N2}	$S_{N,F}$	$X_{N,B}$	$S_{N,U}$	$X_{N,U}$	S_{PO4}
ThOD	1	1	1	0	$-3\,\frac{M_O}{M_N}$	$-4\,\frac{M_O}{M_N}$	$-3\,\frac{M_O}{2\,M_N}$	0	0	0	0	0
ThN	$i_{N,Bio}$	$i_{N,Bio}$	$i_{N,Bio}$	1	1	1	1	1	1	1	1	0
P	$i_{P,Bio}$	$i_{P,Bio}$	$i_{P,Bio}$	0	0	0	0	0	0	0	0	1
Charge	0	0	0	$\frac{1}{M_N}$	$\frac{-1}{M_N}$	$\frac{-1}{M_N}$	0	0	0	0	0	$\frac{-1.5}{M_P}$
Metal	0	0	0	0	0	0	0	0	0	0	0	0
C	0	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0	0
TSS	$\frac{1}{i_{CV,BIO}} + \frac{i_{IG}}{i_{CV,BIO}}$	$\frac{1}{i_{CV,BIO}} + \frac{i_{IG}}{i_{CV,BIO}}$	$\frac{1}{i_{CV,BIO}} + \frac{i_{IG}}{i_{CV,BIO}}$	0	0	0	0	0	0	0	0	0
VSS	$\frac{1}{i_{CV,BIO}}$	$\frac{1}{i_{CV,BIO}}$	$\frac{1}{i_{CV,BIO}}$	0	0	0	0	0	0	0	0	0
ISS	$\frac{i_{IG}}{i_{CV,BIO}}$	$\frac{i_{IG}}{i_{CV,BIO}}$	$\frac{i_{IG}}{i_{CV,BIO}}$	0	0	0	0	0	0	0	0	0
N	$i_{N,Bio}$	$i_{N,Bio}$	$i_{N,Bio}$	1	1	1	0	1	1	1	1	0
TKN	$i_{N,Bio}$	$i_{N,Bio}$	$i_{N,Bio}$	1	0	0	0	1	1	1	1	0
N_fil	0	0	0	1	1	1	0	1	0	1	0	0
N_sol	0	0	0	1	1	1	0	1	0	1	0	0
NOx	0	0	0	0	1	1	0	0	0	0	0	0
COD	1	1	1	0	0	0	0	0	0	0	0	0
COD_fil	0	0	0	0	0	0	0	0	0	0	0	0
COD_sol	0	0	0	0	0	0	0	0	0	0	0	0
BOD5	$(1 - f_{BOD})\left(1 - e^{-1\,b_{PAO,BOD}\,d_{BOD}}\right)$	$(1 - f_{BOD})\left(1 - e^{-1\,b_{AOO,BOD}\,d_{BOD}}\right)$	$(1 - f_{BOD})\left(1 - e^{-1\,b_{NOO,BOD}\,d_{BOD}}\right)$	0	0	0	0	0	0	0	0	0
BOD5_fil	0	0	0	0	0	0	0	0	0	0	0	0
BOD5_sol	0	0	0	0	0	0	0	0	0	0	0	0
sPS	1	1	1	0	0	0	0	0	1	0	1	0
Vtss	0	0	0	0	0	0	0	0	0	0	0	0
Vvss	0	0	0	0	0	0	0	0	0	0	0	0
C_VSS	0	0	0	0	0	0	0	0	0	0	0	0
XC_TSS	$\frac{1}{i_{CV,BIO}} + \frac{i_{IG}}{i_{CV,BIO}}$	$\frac{1}{i_{CV,BIO}} + \frac{i_{IG}}{i_{CV,BIO}}$	$\frac{1}{i_{CV,BIO}} + \frac{i_{IG}}{i_{CV,BIO}}$	0	0	0	0	0	0	0	0	0
SX	2	2	2	1	1	1	1	1	3	1	3	1
aTS	0.8098591549295775	0.8098591549295775	0.8098591549295775	0	0	0	0	0	0	0	0	0
Diff	0	0	0	0.000173	0.000147	0.000171	0.000164	0.000107	0	6.05E-05	0	0.000173
Default	300	50	30	3	0.2	15	16	0.5	4	2	50	1

	$X_{PP,LO}$	$X_{PP,HI}$	$S_{P,F}$	$X_{P,B}$	$S_{P,U}$	$X_{P,U}$	S_{O2}	X_{IG}	X_{MeOH}	X_{MeP}	S_{ALK}	Rate
r1	0	0	0	0	0	0	$\frac{-1\,(1 - Y_{OHO,VFA,O2})}{Y_{OHO,VFA,O2}}$	0	0	0	$\frac{-1}{Y_{OHO,VFA,O2}}\,CH_{VFA} - i_{N,Bio}\,CH_{NHx} - i_{P,Bio}\,CH_{PO4}$	$\mu_{OHO,T}\,\frac{S_{VFA}}{S_{VFA} + K_{VFA}}\,X_{OHO}\,\frac{S_{O2}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}\,\frac{S_{PO4}}{S_{PO4} + K_{PO4,OHO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r2	0	0	0	0	0	0	0	0	0	0	$\frac{-1}{Y_{OHO,VFA,NOx}}\,CH_{VFA} - \frac{1 - Y_{OHO,VFA,NOx}}{EEQ_{NO2,NO3}\,Y_{OHO,VFA,NOx}}\,CH_{NO3} + \frac{1 - Y_{OHO,VFA,NOx}}{EEQ_{NO2,NO3}\,Y_{OHO,VFA,NOx}}\,CH_{NO2} - i_{N,Bio}\,CH_{NHx} - i_{P,Bio}\,CH_{PO4}$	$\mu_{OHO,T}\,\eta_{anox,OHO}\,\frac{S_{VFA}}{S_{VFA} + K_{VFA}}\,X_{OHO}\,\frac{S_{NO3}}{S_{NO3} + K_{NO3,OHO}}\,\frac{K_{NO2,OHO}}{S_{NO2} + K_{NO2,OHO}}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}\,\frac{S_{PO4}}{S_{PO4} + K_{PO4,OHO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r3	0	0	0	0	0	0	0	0	0	0	$\frac{-1}{Y_{OHO,VFA,NOx}}\,CH_{VFA} - \frac{1 - Y_{OHO,VFA,NOx}}{EEQ_{N2,NO2}\,Y_{OHO,VFA,NOx}}\,CH_{NO2} - i_{N,Bio}\,CH_{NHx} - i_{P,Bio}\,CH_{PO4}$	$\mu_{OHO,T}\,\eta_{anox,OHO}\,\frac{S_{VFA}}{S_{VFA} + K_{VFA}}\,X_{OHO}\,\frac{S_{NO2}}{S_{NO2} + K_{NO2,OHO}}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}\,\frac{S_{PO4}}{S_{PO4} + K_{PO4,OHO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r4	0	0	0	0	0	0	$\frac{-1\,(1 - Y_{OHO,SF,O2})}{Y_{OHO,SF,O2}}$	0	0	0	$-1\,i_{N,Bio}\,CH_{NHx} - i_{P,Bio}\,CH_{PO4}$	$\mu_{OHO,T}\,\frac{S_F}{S_F + K_{SF}}\,X_{OHO}\,\frac{K_{VFA}}{S_{VFA} + K_{VFA}}\,\frac{S_{O2}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}\,\frac{S_{PO4}}{S_{PO4} + K_{PO4,OHO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r5	0	0	0	0	0	0	0	0	0	0	$\frac{-1\,(1 - Y_{OHO,SF,NOx})}{EEQ_{NO2,NO3}\,Y_{OHO,SF,NOx}}\,CH_{NO3} + \frac{1 - Y_{OHO,SF,NOx}}{EEQ_{NO2,NO3}\,Y_{OHO,SF,NOx}}\,CH_{NO2} - i_{N,Bio}\,CH_{NHx} - i_{P,Bio}\,CH_{PO4}$	$\mu_{OHO,T}\,\eta_{anox,OHO}\,\frac{S_F}{S_F + K_{SF}}\,X_{OHO}\,\frac{K_{VFA}}{S_{VFA} + K_{VFA}}\,\frac{S_{NO3}}{S_{NO3} + K_{NO3,OHO}}\,\frac{K_{NO2,OHO}}{S_{NO2} + K_{NO2,OHO}}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}\,\frac{S_{PO4}}{S_{PO4} + K_{PO4,OHO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r6	0	0	0	0	0	0	0	0	0	0	$\frac{-1\,(1 - Y_{OHO,SF,NOx})}{EEQ_{N2,NO2}\,Y_{OHO,SF,NOx}}\,CH_{NO2} - i_{N,Bio}\,CH_{NHx} - i_{P,Bio}\,CH_{PO4}$	$\mu_{OHO,T}\,\eta_{anox,OHO}\,\frac{S_F}{S_F + K_{SF}}\,X_{OHO}\,\frac{K_{VFA}}{S_{VFA} + K_{VFA}}\,\frac{S_{NO2}}{S_{NO2} + K_{NO2,OHO}}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}\,\frac{S_{PO4}}{S_{PO4} + K_{PO4,OHO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r7	0	0	0	0	0	0	0	0	0	0	$\frac{1 - Y_{OHO,SF,ANA}}{Y_{OHO,SF,ANA}}\,CH_{VFA} - i_{N,Bio}\,CH_{NHx} - i_{P,Bio}\,CH_{PO4}$	$\mu_{FERM,OHO,T}\,\frac{S_F}{S_F + K_{SF,ANA}}\,X_{OHO}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{K_{NOx,OHO}}{S_{NO2} + S_{NO3} + K_{NOx,OHO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}\,\frac{S_{PO4}}{S_{PO4} + K_{PO4,OHO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK,FERM}}$
r8	0	0	0	0	0	0	$\frac{-1\,(1 - Y_{OHO,SMEOL,O2})}{Y_{OHO,SMEOL,O2}}$	0	0	0	$-1\,i_{N,Bio}\,CH_{NHx} - i_{P,Bio}\,CH_{PO4}$	$\mu_{OHO,T}\,\eta_{S,MEOL}\,\frac{S_{MEOL}}{S_{MEOL} + K_{MEOL,OHO}}\,X_{OHO}\,\frac{S_{O2}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}\,\frac{S_{PO4}}{S_{PO4} + K_{PO4,OHO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r9	0	0	0	$(1 - f_E)\,i_{P,Bio}$	0	0	0	0	0	0	0	$b_{OHO,O2,T}\,X_{OHO}\,\frac{S_{O2}}{S_{O2} + K_{O2,OHO}}$
r10	0	0	0	$(1 - f_E)\,i_{P,Bio}$	0	0	0	0	0	0	0	$b_{OHO,NOx,T}\,X_{OHO}\,\frac{S_{NO2} + S_{NO3}}{S_{NO2} + S_{NO3} + K_{NOx,OHO}}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}$
r11	0	0	0	$(1 - f_E)\,i_{P,Bio}$	0	0	0	0	0	0	0	$b_{OHO,ANA,T}\,X_{OHO}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{K_{NOx,OHO}}{S_{NO2} + S_{NO3} + K_{NOx,OHO}}$
r12	0	0	0	0	0	0	0	0	0	0	$\frac{-1\,(1 - Y_{MEOLO})}{EEQ_{NO2,NO3}\,Y_{MEOLO}}\,CH_{NO3} + \frac{1 - Y_{MEOLO}}{EEQ_{NO2,NO3}\,Y_{MEOLO}}\,CH_{NO2} - i_{N,Bio}\,CH_{NHx} - i_{P,Bio}\,CH_{PO4}$	$\mu_{MEOLO,T}\,\frac{S_{MEOL}}{S_{MEOL} + K_{MEOL}}\,X_{MEOLO}\,\frac{S_{NO3}}{S_{NO3} + K_{NO3,OHO}}\,\frac{K_{NO2,OHO}}{S_{NO2} + K_{NO2,OHO}}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}\,\frac{S_{PO4}}{S_{PO4} + K_{PO4,OHO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK,MEOLO}}$
r13	0	0	0	0	0	0	0	0	0	0	$\frac{-1\,(1 - Y_{MEOLO})}{EEQ_{N2,NO2}\,Y_{MEOLO}}\,CH_{NO2} - i_{N,Bio}\,CH_{NHx} - i_{P,Bio}\,CH_{PO4}$	$\mu_{MEOLO,T}\,\frac{S_{MEOL}}{S_{MEOL} + K_{MEOL}}\,X_{MEOLO}\,\frac{S_{NO2}}{S_{NO2} + K_{NO2,OHO}}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}\,\frac{S_{PO4}}{S_{PO4} + K_{PO4,OHO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK,MEOLO}}$
r14	0	0	0	$(1 - f_E)\,i_{P,Bio}$	0	0	0	0	0	0	0	$b_{MEOLO,O2,T}\,X_{MEOLO}\,\frac{S_{O2}}{S_{O2} + K_{O2,OHO}}$
r15	0	0	0	$(1 - f_E)\,i_{P,Bio}$	0	0	0	0	0	0	0	$b_{MEOLO,NOx,T}\,X_{MEOLO}\,\frac{S_{NO3} + S_{NO2}}{S_{NO3} + S_{NO2} + K_{NOx,OHO}}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}$
r16	0	0	0	$(1 - f_E)\,i_{P,Bio}$	0	0	0	0	0	0	0	$b_{MEOLO,ANA,T}\,X_{MEOLO}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{K_{NOx,OHO}}{S_{NO2} + S_{NO3} + K_{NOx,OHO}}$
r17	$Y_{PPLO}\,\frac{f_{PHA,PP,O2}}{Y_{PAO,PHA,O2}}$	$(1 - Y_{PPLO})\,\frac{f_{PHA,PP,O2}}{Y_{PAO,PHA,O2}}$	0	0	0	0	$\frac{-1\,(1 - Y_{PAO,PHA,O2})}{Y_{PAO,PHA,O2}}$	0	0	0	$\left(\frac{-1\,f_{PHA,PP,O2}}{Y_{PAO,PHA,O2}} - i_{P,Bio}\right) CH_{PO4} - i_{N,Bio}\,CH_{NHx}$	$\mu_{PAO,T}\,\frac{\frac{X_{PHA}}{X_{PAO}}}{\frac{X_{PHA}}{X_{PAO}} + K_{PHA}}\,X_{PAO}\,\frac{S_{O2}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}\,\frac{S_{PO4}}{S_{PO4} + K_{PO4,PAO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r18	$Y_{PPLO}\,\frac{f_{PHA,PP,NOx}}{Y_{PAO,PHA,NO2}}$	$(1 - Y_{PPLO})\,\frac{f_{PHA,PP,NOx}}{Y_{PAO,PHA,NO2}}$	0	0	0	0	0	0	0	0	$\left(\frac{-1\,f_{PHA,PP,NOx}}{Y_{PAO,PHA,NO2}} - i_{P,Bio}\right) CH_{PO4} - i_{N,Bio}\,CH_{NHx} - \frac{1 - Y_{PAO,PHA,NO2}}{EEQ_{N2,NO2}\,Y_{PAO,PHA,NO2}}\,CH_{NO2}$	$\mu_{PAO,T}\,\eta_{anox,PAO}\,\frac{\frac{X_{PHA}}{X_{PAO}}}{\frac{X_{PHA}}{X_{PAO}} + K_{PHA}}\,X_{PAO}\,\frac{S_{NO2}}{S_{NO2} + K_{NO2,OHO}}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}\,\frac{S_{PO4}}{S_{PO4} + K_{PO4,PAO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r19	$Y_{PPLO}\,\frac{f_{PHA,PP,NOx}}{Y_{PAO,PHA,NO3}}$	$(1 - Y_{PPLO})\,\frac{f_{PHA,PP,NOx}}{Y_{PAO,PHA,NO3}}$	0	0	0	0	0	0	0	0	$\left(\frac{-1\,f_{PHA,PP,NOx}}{Y_{PAO,PHA,NO3}} - i_{P,Bio}\right) CH_{PO4} - i_{N,Bio}\,CH_{NHx} - \frac{1 - Y_{PAO,PHA,NO3}}{EEQ_{NO2,NO3}\,Y_{PAO,PHA,NO3}}\,CH_{NO3} + \frac{1 - Y_{PAO,PHA,NO3}}{EEQ_{NO2,NO3}\,Y_{PAO,PHA,NO3}}\,CH_{NO2}$	$\mu_{PAO,T}\,\eta_{anox,PAO}\,\frac{\frac{X_{PHA}}{X_{PAO}}}{\frac{X_{PHA}}{X_{PAO}} + K_{PHA}}\,X_{PAO}\,\frac{S_{NO3}}{S_{NO3} + K_{NO3,OHO}}\,\frac{K_{NO2,OHO}}{S_{NO2} + K_{NO2,OHO}}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}\,\frac{S_{PO4}}{S_{PO4} + K_{PO4,PAO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r20	$-1\,i_{P,Bio}$	0	0	0	0	0	$\frac{-1\,(1 - Y_{PAO,PHA,O2})}{Y_{PAO,PHA,O2}}$	0	0	0	$-1\,i_{N,Bio}\,CH_{NHx}$	$\mu_{PAO,LIM,T}\,\frac{\frac{X_{PHA}}{X_{PAO}}}{\frac{X_{PHA}}{X_{PAO}} + K_{PHA,lim}}\,X_{PAO}\,\frac{S_{O2}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}\,\frac{K_{PO4,PAO}}{S_{PO4} + K_{PO4,PAO}}\,\frac{X_{PP,LO}}{X_{PP,LO} + K_{PP,lim}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r21	$-1\,i_{P,Bio}$	0	0	0	0	0	0	0	0	0	$\frac{-1\,(1 - Y_{PAO,PHA,NO2})}{EEQ_{N2,NO2}\,Y_{PAO,PHA,NO2}}\,CH_{NO2} - i_{N,Bio}\,CH_{NHx}$	$\mu_{PAO,LIM,T}\,\eta_{anox,PAO}\,\frac{\frac{X_{PHA}}{X_{PAO}}}{\frac{X_{PHA}}{X_{PAO}} + K_{PHA,lim}}\,X_{PAO}\,\frac{S_{NO2}}{S_{NO2} + K_{NO2,OHO}}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}\,\frac{K_{PO4,PAO}}{S_{PO4} + K_{PO4,PAO}}\,\frac{X_{PP,LO}}{X_{PP,LO} + K_{PP,lim}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r22	$-1\,i_{P,Bio}$	0	0	0	0	0	0	0	0	0	$-1\,i_{N,Bio}\,CH_{NHx} - \frac{1 - Y_{PAO,PHA,NO3}}{EEQ_{NO2,NO3}\,Y_{PAO,PHA,NO3}}\,CH_{NO3} + \frac{1 - Y_{PAO,PHA,NO3}}{EEQ_{NO2,NO3}\,Y_{PAO,PHA,NO3}}\,CH_{NO2}$	$\mu_{PAO,LIM,T}\,\eta_{anox,PAO}\,\frac{\frac{X_{PHA}}{X_{PAO}}}{\frac{X_{PHA}}{X_{PAO}} + K_{PHA,lim}}\,X_{PAO}\,\frac{S_{NO3}}{S_{NO3} + K_{NO3,OHO}}\,\frac{K_{NO2,OHO}}{S_{NO2} + K_{NO2,OHO}}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,OHO}}\,\frac{K_{PO4,PAO}}{S_{PO4} + K_{PO4,PAO}}\,\frac{X_{PP,LO}}{X_{PP,LO} + K_{PP,lim}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r23	$-1\,f_{P,VFA}$	0	0	0	0	0	0	0	0	0	$-1\,CH_{VFA} + f_{P,VFA}\,CH_{PO4}$	$q_{PAO,PHA,T}\,X_{PAO}\,\frac{S_{VFA}}{S_{VFA} + K_{STORE,VFA}}\,\frac{\frac{X_{PP,LO}}{X_{PAO}}}{\frac{X_{PP,LO}}{X_{PAO}} + K_{PP,LO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r24	0	0	0	$(1 - f_E)\,i_{P,Bio}$	0	0	0	0	0	0	0	$b_{PAO,O2,T}\,X_{PAO}\,\frac{S_{O2}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r25	0	0	0	$(1 - f_E)\,i_{P,Bio}$	0	0	0	0	0	0	0	$b_{PAO,NOx,T}\,X_{PAO}\,\frac{S_{NO3} + S_{NO2}}{S_{NO3} + S_{NO2} + K_{NOx,OHO}}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r26	0	0	0	$(1 - f_E)\,i_{P,Bio}$	0	0	0	0	0	0	0	$b_{PAO,ANA,T}\,X_{PAO}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{K_{NOx,OHO}}{S_{NO2} + S_{NO3} + K_{NOx,OHO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r27	0	0	0	0	0	0	0	0	0	0	CH_{VFA}	$r24\,\frac{X_{PHA}}{X_{PAO}}$
r28	-1	0	0	0	0	0	0	0	0	0	CH_{PO4}	$r24\,\frac{X_{PP,LO}}{X_{PAO}}$
r29	0	-1	0	0	0	0	0	0	0	0	CH_{PO4}	$r24\,\frac{X_{PP,HI}}{X_{PAO}}$
r30	0	0	0	0	0	0	0	0	0	0	CH_{VFA}	$r25\,\frac{X_{PHA}}{X_{PAO}}$
r31	-1	0	0	0	0	0	0	0	0	0	CH_{PO4}	$r25\,\frac{X_{PP,LO}}{X_{PAO}}$
r32	0	-1	0	0	0	0	0	0	0	0	CH_{PO4}	$r25\,\frac{X_{PP,HI}}{X_{PAO}}$
r33	0	0	0	0	0	0	0	0	0	0	CH_{VFA}	$r26\,\frac{X_{PHA}}{X_{PAO}}$
r34	-1	0	0	0	0	0	0	0	0	0	CH_{PO4}	$r26\,\frac{X_{PP,LO}}{X_{PAO}}$
r35	0	-1	0	0	0	0	0	0	0	0	CH_{PO4}	$r26\,\frac{X_{PP,HI}}{X_{PAO}}$
r36	-1	0	0	0	0	0	0	0	0	0	CH_{PO4}	$b_{PP,LO,ANA,T}\,X_{PAO}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{K_{NOx,OHO}}{S_{NO2} + S_{NO3} + K_{NOx,OHO}}\,\frac{X_{PP,LO}}{X_{PP,LO} + K_{PP,LO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r37	0	0	0	0	0	0	$\frac{-1\,(EEQ_{NO2} - Y_{AOO})}{Y_{AOO}}$	0	0	0	$\left(\frac{-1}{Y_{AOO}} - i_{N,Bio}\right) CH_{NHx} + \frac{1}{Y_{AOO}}\,CH_{NO2} - i_{P,Bio}\,CH_{PO4}$	$\mu_{AOO,T}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,AOO}}\,X_{AOO}\,\frac{S_{O2}}{S_{O2} + K_{O2,AOO}}\,\frac{S_{PO4}}{S_{PO4} + K_{PO4,AOO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK,AOO}}$
r38	0	0	0	$(1 - f_E)\,i_{P,Bio}$	0	0	0	0	0	0	0	$b_{AOO,O2,T}\,X_{AOO}\,\frac{S_{O2}}{S_{O2} + K_{O2,AOO}}$
r39	0	0	0	$(1 - f_E)\,i_{P,Bio}$	0	0	0	0	0	0	0	$b_{AOO,NOx,T}\,X_{AOO}\,\frac{S_{NO3} + S_{NO2}}{S_{NO3} + S_{NO2} + K_{NOx,ANO}}\,\frac{K_{O2,AOO}}{S_{O2} + K_{O2,AOO}}$
r40	0	0	0	$(1 - f_E)\,i_{P,Bio}$	0	0	0	0	0	0	0	$b_{AOO,ANA,T}\,X_{AOO}\,\frac{K_{O2,AOO}}{S_{O2} + K_{O2,AOO}}\,\frac{K_{NOx,ANO}}{S_{NO2} + S_{NO3} + K_{NOx,ANO}}$
r41	0	0	0	0	0	0	$\frac{-1\,(EEQ_{NO2,NO3} - Y_{NOO})}{Y_{NOO}}$	0	0	0	$\frac{-1}{Y_{NOO}}\,CH_{NO2} + \frac{1}{Y_{NOO}}\,CH_{NO3} - i_{N,Bio}\,CH_{NHx} - i_{P,Bio}\,CH_{PO4}$	$\mu_{NOO,T}\,\frac{S_{NO2}}{S_{NO2} + K_{NO2,NOO}}\,X_{NOO}\,\frac{S_{O2}}{S_{O2} + K_{O2,NOO}}\,\frac{S_{NHx}}{S_{NHx} + K_{NHx,ANO}}\,\frac{S_{PO4}}{S_{PO4} + K_{PO4,ANO}}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK,NOO}}$
r42	0	0	0	$(1 - f_E)\,i_{P,Bio}$	0	0	0	0	0	0	0	$b_{NOO,O2,T}\,X_{NOO}\,\frac{S_{O2}}{S_{O2} + K_{O2,NOO}}$
r43	0	0	0	$(1 - f_E)\,i_{P,Bio}$	0	0	0	0	0	0	0	$b_{NOO,NOx,T}\,X_{NOO}\,\frac{S_{NO3} + S_{NO2}}{S_{NO3} + S_{NO2} + K_{NOx,ANO}}\,\frac{K_{O2,NOO}}{S_{O2} + K_{O2,NOO}}$
r44	0	0	0	$(1 - f_E)\,i_{P,Bio}$	0	0	0	0	0	0	0	$b_{NOO,ANA,T}\,X_{NOO}\,\frac{K_{O2,NOO}}{S_{O2} + K_{O2,NOO}}\,\frac{K_{NOx,ANO}}{S_{NO2} + S_{NO3} + K_{NOx,ANO}}$
r45	0	0	0	$i_{P,C,B}$	0	0	0	0	0	0	0	$q_{ads,T}\,C_B\,X_{BIO}\,\frac{K_{ads}}{\frac{X_B}{X_{BIO}} + K_{ads}}$
r46	0	0	0	0	0	$i_{P,C,U}$	0	0	0	0	0	$q_{ads,T}\,C_U\,X_{BIO}\,\frac{K_{ads}}{\frac{X_U}{X_{BIO}} + K_{ads}}$
r47	0	0	0	0	0	0	0	0	0	0	0	$q_{HYD,T}\,\frac{\frac{X_B}{X_{HETO}}}{\frac{X_B}{X_{HETO}} + K_{HYD}}\,\frac{S_{O2}}{S_{O2} + K_{O2,OHO}}\,X_{HETO}$
r48	0	0	0	0	0	0	0	0	0	0	0	$q_{HYD,T}\,\eta_{HYD,NOx}\,\frac{\frac{X_B}{X_{HETO}}}{\frac{X_B}{X_{HETO}} + K_{HYD}}\,\frac{S_{NO3} + S_{NO2}}{S_{NO3} + S_{NO2} + K_{NOx,OHO}}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,X_{HETO}$
r49	0	0	0	0	0	0	0	0	0	0	0	$q_{HYD,T}\,\eta_{HYD,ANA}\,\frac{\frac{X_B}{X_{HETO}}}{\frac{X_B}{X_{HETO}} + K_{HYD}}\,\frac{K_{O2,OHO}}{S_{O2} + K_{O2,OHO}}\,\frac{K_{NOx,OHO}}{S_{NO2} + S_{NO3} + K_{NOx,OHO}}\,X_{HETO}$
r50	0	0	0	0	0	0	0	0	0	0	0	$\frac{X_{N,B}}{X_B}\,(r47 + r48 + r49)$
r51	0	0	1	-1	0	0	0	0	0	0	0	$\frac{X_{P,B}}{X_B}\,(r47 + r48 + r49)$
r52	0	0	0	0	0	0	0	0	0	0	CH_{NHx}	$q_{AMMON,T}\,S_{N,F}\,X_{BIO}$
r53	0	0	-1	0	0	0	0	0	0	0	CH_{PO4}	$q_{PO4com,T}\,S_{P,F}\,X_{BIO}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r54	0	0	0	$i_{P,Bio}$	0	0	0	0	0	0	0	$q_{Eb,T}\,X_E$
r55	0	0	0	0	0	0	0	0	0	0	$(1 + EEQ_{NO2}\,i_{N,Bio})\,CH_{NHx} - CH_{NO2} + EEQ_{NO2}\,i_{P,Bio}\,CH_{PO4}$	$q_{ASSIM,T}\,\frac{S_{NO2}}{S_{NO2} + K_{NO2,ASSIM}}\,\frac{K_{NHx,ASSIM}}{S_{NHx} + K_{NHx,ASSIM}}\,\frac{X_{OHO}}{X_{OHO} + K_{OHO,ASSIM}}\,X_{BIO}$
r56	0	0	0	0	0	0	0	0	0	0	$(1 + EEQ_{NO3}\,i_{N,Bio})\,CH_{NHx} - CH_{NO3} + EEQ_{NO3}\,i_{P,Bio}\,CH_{PO4}$	$q_{ASSIM,T}\,\frac{S_{NO3}}{S_{NO3} + K_{NO3,ASSIM}}\,\frac{K_{NO2,ASSIM}}{S_{NO2} + K_{NO2,ASSIM}}\,\frac{K_{NHx,ASSIM}}{S_{NHx} + K_{NHx,ASSIM}}\,\frac{X_{OHO}}{X_{OHO} + K_{OHO,ASSIM}}\,X_{BIO}$
r57	0	0	0	0	0	0	0	0	-1	1	$-1\,f_{P,Me}\,CH_{PO4}$	$q_{PREC}\,S_{PO4}\,X_{MeOH}$
r58	0	0	0	0	0	0	0	0	1	-1	$f_{P,Me}\,CH_{PO4}$	$q_{DISSOL}\,X_{MeP}\,\frac{S_{ALK}}{S_{ALK} + K_{ALK}}$
r59	0	0	0	0	0	0	1	0	0	0	0	$\frac{kO2}{V}\,1000$
	$X_{PP,LO}$	$X_{PP,HI}$	$S_{P,F}$	$X_{P,B}$	$S_{P,U}$	$X_{P,U}$	S_{O2}	X_{IG}	X_{MeOH}	X_{MeP}	S_{ALK}	
ThOD	0	0	0	0	0	0	-1	0	0	0	0	total theoretical oxygen demand
ThN	0	0	0	0	0	0	0	0	0	0	0	total theoretical total N content
P	1	1	1	1	1	1	0	0	0	$f_{P,Me}$	0	TP: Total Phosphorus
Charge	0	0	0	0	0	0	0	0	0	0	-1	Ionic charge
Metal	0	0	0	0	0	0	0	0	1	1	0	Total metal content
C	0	0	0	0	0	0	0	0	0	0	0	total C content
S	0	0	0	0	0	0	0	0	0	0	0	Total S content
TSS	$i_{SS,PP}$	$i_{SS,PP}$	0	0	0	0	0	1	$f_{MeOOH,Me} + f_{H2O,Me}$	$f_{MeP,Me}$	0	TSS: Total Suspended Solids
VSS	0	0	0	0	0	0	0	0	$f_{H2O,Me}$	0	0	VSS: Volatile Suspended Solids
ISS	$i_{SS,PP}$	$i_{SS,PP}$	0	0	0	0	0	1	$f_{MeOOH,Me}$	$f_{MeP,Me}$	0	ISS: Inorganic Suspended Solids
N	0	0	0	0	0	0	0	0	0	0	0	TN: Total Nitrogen
TKN	0	0	0	0	0	0	0	0	0	0	0	TKN: Total Kjeldahl Nitrogen
N_fil	0	0	0	0	0	0	0	0	0	0	0	N_fil: Filtered Nitrogen (incl. colloidals)
N_sol	0	0	0	0	0	0	0	0	0	0	0	N_sol: Soluble Nitrogen (w/o colloidals)
NOx	0	0	0	0	0	0	0	0	0	0	0	NOx-N: Sum of NO2 and NO3
COD	0	0	0	0	0	0	0	0	0	0	0	COD: Total Chemical Oxygen Demand
COD_fil	0	0	0	0	0	0	0	0	0	0	0	COD_fil: Filtered Chemical Oxygen Demand (incl. colloidals)
COD_sol	0	0	0	0	0	0	0	0	0	0	0	COD_sol: Soluble Chemical Oxygen Demand (w/o colloidals)
BOD5	0	0	0	0	0	0	0	0	0	0	0	cBOD5: Total Carbonaceous Biological Oxygen Demand within 5 days
BOD5_fil	0	0	0	0	0	0	0	0	0	0	0	cBOD5_fil: Filtered Carbonaceous Biological Oxygen Demand within 5 days
BOD5_sol	0	0	0	0	0	0	0	0	0	0	0	cBOD5_sol: Soluble Carbonaceous Biological Oxygen Demand within 5 days
sPS	1	1	0	1	0	1	0	1	1	1	0	Setteability in primary clarifier (0-1)
Vtss	0	0	0	0	0	0	0	0	0	0	0	Volumen of total suspended solids
Vvss	0	0	0	0	0	0	0	0	0	0	0	Volumen of volatile suspended solids
C_VSS	0	0	0	0	0	0	0	0	0	0	0	Colloidal VSS (passes through filter)
XC_TSS	$i_{SS,PP}$	$i_{SS,PP}$	0	0	0	0	0	1	$f_{MeOOH,Me} + f_{H2O,Me}$	1	0	TSS including colloidal matter
SX	2	2	1	3	1	3	1	2	2	2	1	
aTS	3.5	3.5	0	0	0	0	0	1	1.7523391499999998	2.70062427	0	
Diff	0	0	0.000107	0	6.05E-05	0	0.000216	1.24E-08	0	0	0.000173	
Default	200	50	0.1	0.2	0.2	4	2	500	0.1	0.1	4	

Fractions

Name	Description	Unit
S_{VFA}	VFAs	g COD/m^3
S_F	Fermentable substrate	g COD/m^3
S_{MEOL}	Methanol	g COD/m^3
C_B	Colloidal biodegradable substrate	g COD/m^3
X_B	Slowly biodegradable substrate	g COD/m^3
S_U	Soluble unbiodegradable organics	g COD/m^3
C_U	Colloidal unbiodegradable organics	g COD/m^3
X_U	Particulate unbiodegradable organics	g COD/m^3
X_{PHA}	Stored PHA	g COD/m^3
X_E	Endogenous decay products	g COD/m^3
X_{OHO}	Ordinary heterotrophs	g COD/m^3
X_{MEOLO}	Anoxic methanol utilizers	g COD/m^3
X_{PAO}	Phosphorus accumulating organisms	g COD/m^3
X_{AOO}	Aerobic ammonia oxidizers	g COD/m^3
X_{NOO}	Nitrite oxidizing organisms	g COD/m^3
S_{NHx}	Total ammonia	g N/m^3
S_{NO2}	Nitrite	g N/m^3
S_{NO3}	Nitrate	g N/m^3
S_{N2}	Dissolved Nitrogen	g N/m^3
$S_{N,F}$	Soluble biodegradable organic N (from S_F)	g N/m^3
$X_{N,B}$	Particulate biodegradable organic N	g N/m^3
$S_{N,U}$	Soluble unbiodegradable organic N	g N/m^3
$X_{N,U}$	Particulate unbiodegradable organic N	g N/m^3
S_{PO4}	Orthophosphate	g P/m^3
$X_{PP,LO}$	Releasable stored polyphosphate	g P/m^3
$X_{PP,HI}$	Non-releasable stored polyphosphate	g P/m^3
$S_{P,F}$	Soluble biodegradable organic P (from S_F)	g P/m^3
$X_{P,B}$	Particulate biodegradable organic P	g P/m^3
$S_{P,U}$	Soluble unbiodegradable organic P content	g P/m^3
$X_{P,U}$	Particulate unbiodegradable organic P content	g P/m^3
S_{O2}	Dissolved oxygen	g O2/m^3
X_{IG}	Inorganic suspended solids	g TSS/m^3
X_{MeOH}	Metal hydroxide compounds	g Me/m^3
X_{MeP}	Metal phosphate compounds	g Me/m^3
S_{ALK}	Alkalinity	eq/m^3

Parameters

	Name	Default	Description	Unit
From Influent Fractionation				
	$i_{CV,B}$	1.8	Xb XCOD/VSS ratio	g COD/g VSS
	$i_{CV,U}$	1.3	Xu XCOD/VSS ratio	g COD/g VSS
	$i_{N,C,B}$	0.03	N content of biodegradable colloids	g N/g COD
	$i_{N,C,U}$	0.03	N content of unbiodegradable colloids	g N/g COD
	$i_{P,C,B}$	0.01	P content of biodegradable colloids	g P/g COD
	$i_{P,C,U}$	0.005	P content of unbiodegradable colloids	g P/g COD
Heterotrophic kinetics				
	μ_{OHO}	3.2	Maximum specific growth rate of OHOs	1/d
	$\mu_{FERM,OHO}$	0.4	Fermentation rate coefficient (anaerobic OHO growth)	1/d
	$K_{ALK,FERM}$	1	Alkalinity half saturation coefficient for fermentation	eq/m^3
	K_{VFA}	0.5	VFA half saturation for OHOs	g COD/m^3
	K_{SF}	5	Substrate half saturation for OHOs	g COD/m^3
	$K_{SF,ANA}$	5	Substrate half saturation during fermentation	g COD/m^3
	$K_{MEOL,OHO}$	1	Methanol half saturation for OHOs (aerobic)	g COD/m^3
	$K_{O2,OHO}$	0.05	O2 half saturation for OHOs	g O2/m^3
	$\eta_{anox,OHO}$	0.6	Anoxic growth reduction for OHOs	-
	$\eta_{S,MEOL}$	1	Growth reduction for OHOs on S_MEOL	-
	$K_{NO3,OHO}$	0.1	NO3 half saturation for OHOs	g N/m^3
	$K_{NO2,OHO}$	0.05	NO2 half saturation for OHOs	g N/m^3
	$K_{NOx,OHO}$	0.03	NOx half saturation for OHOs	g N/m^3
	$K_{NHx,OHO}$	0.001	NHx half saturation for OHOs	g N/m^3
	$K_{PO4,OHO}$	0.002	PO4 half saturation for OHOs	g P/m^3
	$b_{OHO,O2}$	0.62	Aerobic decay rate coefficient for OHOs	1/d
	$b_{OHO,NOx}$	0.4	Anoxic decay rate coefficient for OHOs	1/d
	$b_{OHO,ANA}$	0.2	Anaerobic decay rate coefficient for OHOs	1/d
Methylotroph kinetics				
	μ_{MEOLO}	1.3	Methylotroph maximum specific growth rate	1/d
	K_{MEOL}	0.5	Methanol half saturation coefficient	g COD/m^3
	$K_{ALK,MEOLO}$	0.1	Alkalinity half saturation coefficient for Methylotrophs	eq/m^3
	$b_{MEOLO,O2}$	0.05	Aerobic decay rate coefficient for methylotrophs	1/d
	$b_{MEOLO,NOx}$	0.03	Anoxic decay rate coefficient for methylotrophs	1/d
	$b_{MEOLO,ANA}$	0.02	Anaerobic decay rate coefficient for methylotrophs	1/d
Ammonia oxidizer kinetics				
	μ_{AOO}	0.9	Maximum specific growth rate of AOOs	1/d
	$K_{NHx,AOO}$	0.7	Ammonia half saturation for AOOs	g N/m^3
	$K_{O2,AOO}$	0.25	Oxygen half saturation for AOOs	g O2/m^3
	$b_{AOO,O2}$	0.17	Aerobic decay rate coefficient for AOOs	1/d
	$b_{AOO,NOx}$	0.1	Anoxic decay rate coefficient for AOOs	1/d
	$b_{AOO,ANA}$	0.05	Anaerobic decay rate coefficient for AOOs	1/d
	$K_{ALK,AOO}$	0.5	Alkalinity half saturation for AOOs	eq/m^3
Nitrite oxidizer kinetics				
	μ_{NOO}	0.7	Maximum specific growth rate of NOOs	1/d
	$K_{O2,NOO}$	0.15	Oxygen half saturation for NOOs	g O2/m^3
	$K_{NO2,NOO}$	0.1	NO2 half saturation for NOOs	g N/m^3
	$b_{NOO,O2}$	0.15	Aerobic decay rate coefficient for NOOs	1/d
	$b_{NOO,NOx}$	0.07	Anoxic decay rate coefficient for NOOs	1/d
	$b_{NOO,ANA}$	0.04	Anaerobic decay rate coefficient for NOOs	1/d
	$K_{ALK,NOO}$	0.5	Alkalinity half saturation for NOOs	eq/m^3
Nitrifier kinetics				
	$K_{NO2,ANO}$	0.01	NO2 half saturation for anoxic conditions	g N/m^3
	$K_{NO3,ANO}$	0.1	NO3 half saturation for anoxic conditions	g N/m^3
	$K_{NOx,ANO}$	0.03	Half saturation for anoxic conditions	g N/m^3
	$K_{NHx,ANO}$	0.001	Nutrient NHx half saturation for nitrifiers	g N/m^3
	$K_{PO4,ANO}$	0.001	Nutrient PO4 half saturation for nitrifiers	g P/m^3
Phosphorus accumulating kinetics				
	μ_{PAO}	0.95	Maximum specific growth rate of PAOs	1/d
	$\mu_{PAO,LIM}$	0.42	Maximum specific growth rate of PAOs, P limited	1/d
	$b_{PPLO,ANA}$	0.03	Anaerobic maintenance PP cleavage	1/d
	K_{PHA}	0.1	PHA half saturation coefficient	g COD/m^3
	$K_{PHA,lim}$	0.05	PHA half saturation coefficient	g COD/m^3
	$\eta_{anox,PAO}$	0.33	PAO anoxic growth factor	-
	$q_{PAO,PHA}$	6	PHA storage rate	1/d
	$K_{STORE,VFA}$	1	VFA half saturation for storage	g COD/m^3
	$K_{PP,LO}$	0.01	PP-low half saturation for storage	g P/m^3
	$K_{PO4,PAO}$	0.15	PO4 half saturation for PAOs	g P/m^3
	$K_{PP,lim}$	0.001	PP limitation as nutrient	g P/m^3
	$b_{PAO,O2}$	0.2	Aerobic decay rate coefficient for PAOs	1/d
	$b_{PAO,NOx}$	0.07	Anoxic decay rate coefficient for PAOs	1/d
	$b_{PAO,ANA}$	0.02	Anaerobic decay rate coefficient for PAOs	1/d
Conversion kinetics				
	q_{ads}	0.15	Maximum specific adsorption rate of colloidal matter	m^3/(g COD*d)
	K_{ads}	1	Threshold ratio of adsorbed colloidal matter to OHOs	g COD/g COD
	q_{HYD}	2	Hydrolysis rate coefficient	1/d
	K_{HYD}	0.05	Hydrolysis half saturation coefficient	-
	$\eta_{HYD,NOx}$	0.28	Anoxic hydrolysis factor	-
	$\eta_{HYD,ANA}$	0.14	Anaerobic hydrolysis factor	-
	q_{AMMON}	0.05	Ammonification rate coefficient	1/d
	$q_{PO4conv}$	0.5	Phosphate release rate coefficient	1/d
	q_{EtoB}	0.007	Endogenous residue conversion rate coefficient	1/d
	q_{ASSIM}	1	Assimilative NHx production rate coefficient	1/d
	$K_{NHx,ASSIM}$	0.0005	Assimilative NHx half saturation	g N/m^3
	$K_{NO2,ASSIM}$	0.001	Assimilative NO2 half saturation	g N/m^3
	$K_{NO3,ASSIM}$	0.001	Assimilative NO3 half saturation	g N/m^3
	$K_{OHO,ASSIM}$	0.001	Assimilative OHO half saturation	g COD/m^3
	q_{PREC}	1	Precipitation rate coefficient	1/d
	q_{DISSOL}	0.6	Precipitate dissolution rate coefficient	1/d
	K_{ALK}	0.1	Alkalinity half saturation	eq/m^3
Arrhenius coefficients				
	$\theta_{mu,OHO}$	1.072	Arrhenius coefficient	-
	$\theta_{FERM,OHO}$	1.072	Arrhenius coefficient	-
	$\theta_{b,OHO,O2}$	1.03	Arrhenius coefficient	-
	$\theta_{b,OHO,NOx}$	1.03	Arrhenius coefficient	-
	$\theta_{b,OHO,ANA}$	1.03	Arrhenius coefficient	-
	$\theta_{mu,MEOLO}$	1.09	Arrhenius coefficient	-
	$\theta_{b,MEOLO,O2}$	1.03	Arrhenius coefficient	-
	$\theta_{b,MEOLO,NOx}$	1.03	Arrhenius coefficient	-
	$\theta_{b,MEOLO,ANA}$	1.03	Arrhenius coefficient	-
	$\theta_{mu,PAO}$	1.072	Arrhenius coefficient	-
	$\theta_{mu,PAO,LIM}$	1.072	Arrhenius coefficient	-
	$\theta_{q,PAO,PHA}$	1.072	Arrhenius coefficient	-
	$\theta_{b,PAO,O2}$	1.03	Arrhenius coefficient	-
	$\theta_{b,PAO,NOx}$	1.03	Arrhenius coefficient	-
	$\theta_{b,PAO,ANA}$	1.03	Arrhenius coefficient	-
	$\theta_{b,PPLO,ANA}$	1.03	Arrhenius coefficient	-
	$\theta_{mu,AOO}$	1.072	Arrhenius coefficient	-
	$\theta_{b,AOO,O2}$	1.03	Arrhenius coefficient	-
	$\theta_{b,AOO,NOx}$	1.03	Arrhenius coefficient	-
	$\theta_{b,AOO,ANA}$	1.03	Arrhenius coefficient	-
	$\theta_{mu,NOO}$	1.06	Arrhenius coefficient	-
	$\theta_{b,NOO,O2}$	1.03	Arrhenius coefficient	-
	$\theta_{b,NOO,NOx}$	1.03	Arrhenius coefficient	-
	$\theta_{b,NOO,ANA}$	1.03	Arrhenius coefficient	-
	$\theta_{q,ads}$	1.03	Arrhenius coefficient for adsorption	-
	$\theta_{q,HYD}$	1.03	Arrhenius coefficient	-
	$\theta_{q,AMMON}$	1.03	Arrhenius coefficient	-
	$\theta_{q,PO4conv}$	1.03	Arrhenius coefficient	-
	$\theta_{q,EtoB}$	1.03	Arrhenius coefficient	-
	$\theta_{q,ASSIM}$	1.072	Arrhenius coefficient	-
Heterotrophic stoichiometry				
	$Y_{OHO,VFA,O2}$	0.6	Aerobic yield of OHOs on VFA	g COD/g COD
	$Y_{OHO,VFA,NOx}$	0.43	Anoxic yield of OHOs on VFA	g COD/g COD
	$Y_{OHO,SF,O2}$	0.666	Aerobic yield of OHOs on substrate	g COD/g COD
	$Y_{OHO,SF,NOx}$	0.54	Anoxic yield of OHOs on substrate	g COD/ g COD
	$Y_{OHO,SF,ANA}$	0.1	Anaerobic yield of OHOs on substrate	g COD/g COD
	$Y_{OHO,H2,ANA}$	0.35	Anaerobic yield of H2 production in fermentation	g COD/g COD
	$Y_{OHO,SMEOL,O2}$	0.4	Aerobic yield of OHOs on methanol	g COD/g COD
Methylotroph stoichiometry				
	Y_{MEOLO}	0.4	MEOLO yield	g COD/g COD
Ammonia oxidizer stoichiometry				
	Y_{AOO}	0.15	AOO yield	g COD/g N
Nitrite oxidizer stoichiometry				
	Y_{NOO}	0.09	NOO yield	g COD/g N
Phosphorus accumulating stoichiometry				
	$Y_{PAO,PHA,O2}$	0.639	Aerobic yield of PAOs on PHA	g COD/g COD
	$Y_{PAO,PHA,NO2}$	0.52	Anoxilic yield of PAOs on PHA	g COD/g COD
	$Y_{PAO,PHA,NO3}$	0.52	Anoxalic yield of PAOs on PHA	g COD/g COD
	Y_{PPLO}	0.94	PPlow yield on PP storage (rest goes to PPhigh)	g P/g P
	$f_{PHA,PP,O2}$	0.95	PHA to PP ratio, aerobic	g COD/g P
	$f_{PHA,PP,NOx}$	0.35	PHA to PP ratio, anoxic	g COD/g P
	$f_{P,VFA}$	0.49	P release to VFA ratio	g P/g COD
	$f_{PHA,VFA}$	1	PHA sequestration from VFA (1=no COD loss)	g COD/g COD
	$i_{ISS,PP}$	3.5	ISS content of PP	g TSS/g P
General stoichiometry				
	$i_{N,Bio}$	0.07	N content of biomasses	g N/g COD
	$i_{P,Bio}$	0.022	P content of biomasses	g P/g COD
	$f_{P,Me}$	0.55463806	g P per g Me in MeP	g P/g Me
	$f_{MeOOH,Me}$	1.59104199	g MeOOH per g Me	g MeOOH/g Me
	$f_{MeP,Me}$	2.70062427	g MeP per g Me	g MeP/g Me
	$f_{H2O,Me}$	0.16129716	H2O loss in VSS test per Me (2MeOOH -> Me2O3 + H2O)	g H2O/g MeOH
	$i_{CV,BIO}$	1.42	Biomass XCOD/VSS ratio	g COD/g VSS
	$i_{CV,PHA}$	1.67	PHA XCOD/VSS ratio	g COD/g VSS
	$i_{CV,E}$	1.42	Xe XCOD/VSS ratio	g COD/g VSS
	f_{E}	0.08	Endogenous fraction (death-regeneration)	g COD/g COD
	i_{IG}	0.15	Synthesis inorganics in active biomass	g TSS/g VSS
Diffusion parameters				
	η_{D}	0.5	Reduction of diffusivity in biofilm	-
Atomic masses				
	M_{O}	15.9994	Atomic mass of oxygen	g/mol
	M_{N}	14.0067	Atomic mass of nitrogen	g/mol
	M_{H}	1.00794	Atomic mass of hydrogen	g/mol
	M_{C}	12.0107	Atomic mass of carbon	g/mol
	M_{Fe}	55.845	Atomic mass of iron	g/mol
	M_{Al}	26.9815	Atomic mass of aluminium	g/mol
	M_{P}	30.9737622	Atomic mass of phosphorus	g/mol
BOD calculations				
	$Y_{OHO,BOD}$	0.666	Y_OHO for BOD5 calculations	g COD/g COD
	$Y_{VFA,BOD}$	0.6	Y_VFA for BOD calculations	g COD/g COD
	$Y_{MEOLO,BOD}$	0.5	Y_MEOLO for BOD calculations	g COD/g COD
	$b_{OHO,BOD}$	0.24	b_OHO for BOD5 calculations	1/d
	f_{BOD}	0.2	Factor for BOD calculations	-
	d_{BOD}	5	Days for BOD	d
	k_{BOD}	0.4	Factor for BOD calculations	-
	$b_{AOO,BOD}$	0.15	b_AOO for BOD5 calculations	1/d
	$b_{NOO,BOD}$	0.16	b_NOO for BOD5 calculations	1/d
	$b_{MEOLO,BOD}$	0.05	b_MEOLO for BOD5 calculations	1/d
	$b_{PAO,BOD}$	0.2	b_PAO for BOD5 calculations	1/d
Physical properties				
	$Tbase$	20	Base temperature for conversion	degC

Variables

Variable	Description	Unit
Pre-defined variables		
V	Volume	m^3
External variables		
$iO2$	oxygen input	kg/d
T	Temperature	degC
Instrumental variables		
$EEQ_{N2} = 3 \frac{M_O}{2\ M_N}$	Electron equivalence of N2	g COD/g N
$EEQ_{NO2} = 3 \frac{M_O}{M_N}$	Electron equivalence of NO2	g COD/g N
$EEQ_{NO3} = 4 \frac{M_O}{M_N}$	Electron equivalence of NO3	g COD/g N
$EEQ_{NO2,NO3} = \frac{M_O}{M_N}$	Electron equivalence of NO2 to NO3	g COD/g N
$EEQ_{N2,NO2} = 3 \frac{M_O}{2\ M_N}$	Electron equivalence of N2 to NO2	g COD/g N
$CH_{VFA} = \frac{-1}{4\ M_O}$	Charge of VFA	e-/g COD
$CH_{NO2} = \frac{-1}{M_N}$	Charge of NO2	e-/g N
$CH_{NO3} = \frac{-1}{M_N}$	Charge of NO3	e-/g N
$CH_{NHx} = \frac{1}{M_N}$	Charge of NHx	e-/g N
$CH_{PO4} = \frac{-1.5}{M_P}$	Charge of PO4	e-/g P
$X_{BIO} = X_{OHO} + X_{PAO} + X_{MEOLO} + X_{AOO} + X_{NOO}$	COD of all biomasses	g COD/m^3
$X_{HETO} = X_{OHO} + X_{PAO} + X_{MEOLO}$	COD of all heterotrophic biomasses	g COD/m^3
$X_{COD} = X_{BIO} + X_B + X_U + X_{PHA} + X_E$	Particulate COD	g COD/m^3
$X_{VSS,BIO} = \frac{X_{OHO} + X_{PAO} + X_{MEOLO} + X_{AOO} + X_{NOO}}{i_{CV,BIO}}$	VSS of all biomasses	g VSS/m^3
$X_{VSS} = X_{VSS,BIO} + \frac{X_B}{i_{CV,B}} + \frac{X_U}{i_{CV,U}} + \frac{X_{PHA}}{i_{CV,PHA}} + \frac{X_E}{i_{CV,E}} + f_{H2O,Me}\ X_{MeOH}$	VSS	g VSS/m^3
$X_{TSS} = X_{VSS} + X_{IG} + f_{MeOOH,Me}\ X_{MeOH} + f_{MeP,Me}\ X_{MeP} + i_{ISS,PP}\ \left(X_{PP,LO} + X_{PP,HI}\right)$	TSS	g TSS/m^3
$\mu_{OHO,T} = \mu_{OHO}\ Arrh\left(\theta_{mu,OHO}, T, Tbase\right)$		1/d
$\mu_{FERM,OHO,T} = \mu_{FERM,OHO}\ Arrh\left(\theta_{FERM,OHO}, T, Tbase\right)$		1/d
$b_{OHO,O2,T} = b_{OHO,O2}\ Arrh\left(\theta_{b,OHO,O2}, T, Tbase\right)$		1/d
$b_{OHO,NOx,T} = b_{OHO,NOx}\ Arrh\left(\theta_{b,OHO,NOx}, T, Tbase\right)$		1/d
$b_{OHO,ANA,T} = b_{OHO,ANA}\ Arrh\left(\theta_{b,OHO,ANA}, T, Tbase\right)$		1/d
$\mu_{MEOLO,T} = \mu_{MEOLO}\ Arrh\left(\theta_{mu,MEOLO}, T, Tbase\right)$		1/d
$b_{MEOLO,O2,T} = b_{MEOLO,O2}\ Arrh\left(\theta_{b,MEOLO,O2}, T, Tbase\right)$		1/d
$b_{MEOLO,NOx,T} = b_{MEOLO,NOx}\ Arrh\left(\theta_{b,MEOLO,NOx}, T, Tbase\right)$		1/d
$b_{MEOLO,ANA,T} = b_{MEOLO,ANA}\ Arrh\left(\theta_{b,MEOLO,ANA}, T, Tbase\right)$		1/d
$\mu_{PAO,T} = \mu_{PAO}\ Arrh\left(\theta_{mu,PAO}, T, Tbase\right)$		1/d
$\mu_{PAO,LIM,T} = \mu_{PAO,LIM}\ Arrh\left(\theta_{mu,PAO,LIM}, T, Tbase\right)$		1/d
$q_{PAO,PHA,T} = q_{PAO,PHA}\ Arrh\left(\theta_{q,PAO,PHA}, T, Tbase\right)$		1/d
$b_{PAO,O2,T} = b_{PAO,O2}\ Arrh\left(\theta_{b,PAO,O2}, T, Tbase\right)$		1/d
$b_{PAO,NOx,T} = b_{PAO,NOx}\ Arrh\left(\theta_{b,PAO,NOx}, T, Tbase\right)$		1/d
$b_{PAO,ANA,T} = b_{PAO,ANA}\ Arrh\left(\theta_{b,PAO,ANA}, T, Tbase\right)$		1/d
$b_{PPLO,ANA,T} = b_{PPLO,ANA}\ Arrh\left(\theta_{b,PPLO,ANA}, T, Tbase\right)$		1/d
$\mu_{AOO,T} = \mu_{AOO}\ Arrh\left(\theta_{mu,AOO}, T, Tbase\right)$		1/d
$b_{AOO,O2,T} = b_{AOO,O2}\ Arrh\left(\theta_{b,AOO,O2}, T, Tbase\right)$		1/d
$b_{AOO,NOx,T} = b_{AOO,NOx}\ Arrh\left(\theta_{b,AOO,NOx}, T, Tbase\right)$		1/d
$b_{AOO,ANA,T} = b_{AOO,ANA}\ Arrh\left(\theta_{b,AOO,ANA}, T, Tbase\right)$		1/d
$\mu_{NOO,T} = \mu_{NOO}\ Arrh\left(\theta_{mu,NOO}, T, Tbase\right)$		1/d
$b_{NOO,O2,T} = b_{NOO,O2}\ Arrh\left(\theta_{b,NOO,O2}, T, Tbase\right)$		1/d
$b_{NOO,NOx,T} = b_{NOO,NOx}\ Arrh\left(\theta_{b,NOO,NOx}, T, Tbase\right)$		1/d
$b_{NOO,ANA,T} = b_{NOO,ANA}\ Arrh\left(\theta_{b,NOO,ANA}, T, Tbase\right)$		1/d
$q_{ads,T} = q_{ads}\ Arrh\left(\theta_{q,ads}, T, Tbase\right)$	Maximum specific adsorption rate at liquid temperature	1/d
$q_{HYD,T} = q_{HYD}\ Arrh\left(\theta_{q,HYD}, T, Tbase\right)$		1/d
$q_{AMMON,T} = q_{AMMON}\ Arrh\left(\theta_{q,AMMON}, T, Tbase\right)$		1/d
$q_{PO4conv,T} = q_{PO4conv}\ Arrh\left(\theta_{q,PO4conv}, T, Tbase\right)$		1/d
$q_{EtoB,T} = q_{EtoB}\ Arrh\left(\theta_{q,EtoB}, T, Tbase\right)$		1/d
$q_{ASSIM,T} = q_{ASSIM}\ Arrh\left(\theta_{q,ASSIM}, T, Tbase\right)$		1/d