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**AEROBIC DIGESTION OF WASTE ACTIVATED SLUDGE
FROM BIOLOGICAL NUTRIENT REMOVAL
ACTIVATED SLUDGE SYSTEMS**

BY

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A thesis submitted in partial fulfilment of the requirement for the degree of Master of Science
in Civil Engineering

**University of Cape Town
Faculty of Engineering and the Built Environment
Department of Civil Engineering**

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DECLARATION

I hereby declare that this thesis is my original work and has not been presented for a degree in any other university. All sources of information have been acknowledged.

Signed by candidate

Michael Kidāne Mebrahtu

Feb. 16, 2007

Date

DEDICATION

This work is dedicated to my family
for their love.

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First and foremost, I thank the Almighty God, Jehovah, for enabling me to finish this work in time.

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LIST OF ABBREVIATIONS

Item	Description
ADM	Anaerobic Digestion Model
ANO	Autotrophic nitrifying organisms
AOB	Ammonia oxidizing bacteria
AS	Activated sludge
ASM	Activated sludge model
AVSS	Active volatile suspended solids
BRM	Batch Reactor model
BEPR	Biological excess phosphorus removal
BNR	Biological nutrient removal
BOD ₅	Biochemical oxygen demand
BT	Batch test
bVSS	Biodegradable volatile suspended solids
CMAD	Completely mixed aerobic digester
COD	Chemical oxygen demand
DO	Dissolved oxygen
DSVI	Diluted sludge volume index
FSA	Free and saline ammonia
FSS	Fixed suspended solids
IDS	Inorganic dissolved solids
IIDS	Intracellular inorganic dissolved solids
ISS	Inorganic suspended solids
IWA	International Water Association
MB	Mass balance
MBR	Membrane
MLSS	Mixed liquor suspended solids
MLVSS	Mixed liquor volatile suspended solids
ND	Nitrification denitrification
NDBEPR	Nitrification denitrification biological excess phosphorus removal
NOB	Nitrate oxidizing bacteria
OHO	Ordinary heterotrophic organisms
OP	Ortho phosphate

OP _i	Ortho phosphate concentration at time t
OU	Oxygen utilized
OU _H	Oxygen utilized by OHOs
OU _G	Oxygen utilized by PAOs
OUR	Oxygen utilization rate
PAO	Phosphorus accumulating organisms
PC	Personal computer
PHA	Polyhydroxyalkanoates
PHB	Poly-β-hydroxybutyrate
PP	Poly phosphate
PS	Primary sludge
PVC	Polyvinyl chloride
RAS	Returned activated sludge
RBCOD	Readily biodegradable chemical oxygen demand
rpm	Revolutions per minute
SB	Sewage batch
SBCOD	Slowly biodegradable chemical oxygen demand
SOUR	Specific oxygen utilization rate
SRT	Solids retention time
SSM	Steady state model
TKN	Total kjeldahl nitrogen
TP	Total phosphate
TSS	Total suspended solids
UCT	University of Cape Town
UCTPHO	University of Cape Town model
VFA	Volatile fatty acid
VSS	Volatile suspended solids
WAS	Waste activated sludge
WRC	Water Research Commission
WWTP	Wastewater treatment plant

LIST OF SYMBOLS

Symbol	Unit	Name
A/O		Anaerobic oxic
b_H	d^{-1}	OHO endogenous respiration rate
b_H'	d^{-1}	Death rate of OHOs
b_{HT}	d^{-1}	OHO endogenous respiration rate at temperature T
b_G	d^{-1}	Death rate of PAOs
b_{G20}	d^{-1}	Death rate of PAOs at 20°C
$CaCO_3$		Calcium carbonate
CO_2		Carbon dioxide
$C_5H_7NO_2$		Component formula of an activated sludge cell
D		Fraction of degradable active biomass in the influent that appears as degradable active biomass in the effluent
f		Fraction of active volatile material degraded
f_{ac}		Fraction of acetate with respect to RBCOD
f_{aGTe}	$mgPAOTSS\ mgTSS^{-1}$	Effluent active fraction of the PAOTSS
f_{aGTi}	$mgPAOTSS\ mgTSS^{-1}$	Initial/influent active fraction of the PAOTSS
f_{aHTe}	$mgOHOTSS\ mgTSS^{-1}$	Effluent active fraction of the OHOTSS
f_{aHTi}	$mgOHOTSS\ mgTSS^{-1}$	Initial/influent active fraction of the OHOTSS
f_{aGVe}	$mgPAOVSS\ mgVSS^{-1}$	Effluent active fraction of the PAOVSS
f_{aGVi}	$mgPAOVSS\ mgVSS^{-1}$	Initial/influent active fraction of the PAOVSS
f_{aHVe}	$mgOHOVSS\ mgVSS^{-1}$	Effluent active fraction of the OHOVSS
f_{aHVi}	$mgOHOVSS\ mgVSS^{-1}$	Initial/influent active fraction of the OHOVSS
f_{aT}	$mgTSS\ mgTSS^{-1}$	TSS active fraction
f_{aTe}	$mgTSS\ mgTSS^{-1}$	Effluent TSS active fraction
f_{aTi}	$mgTSS\ mgTSS^{-1}$	Initial/influent TSS active fraction
f_{aV}	$mgVSS\ mgVSS^{-1}$	VSS active fraction
f_{aVe}	$mgVSS\ mgVSS^{-1}$	Effluent VSS active fraction
f_{aVi}	$mgVSS\ mgVSS^{-1}$	Initial/influent VSS active fraction

f_{bs}		Fraction of biodegradable soluble COD with respect to biodegradable COD
f_{cv}	mgCOD mgVSS^{-1}	COD/VSS ratio
f_{cvH}	$\text{mgCOD mgOHVSS}^{-1}$	COD/VSS ratio for OHOs
f_{cvG}	$\text{mgCOD mgPAOVSS}^{-1}$	COD/VSS ratio for PAOs
f_{eG}		Endogenous residue of the PAOs
f'_{eG}		Unbiodegradable VSS in PAOs
f_{eH}		Endogenous residue of the OHOs
f'_{eH}		Unbiodegradable VSS in OHOs
$\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2$		Ferrous ammonium sulphate
f_G		Fraction of the endogenous residue of the PAOs
f_{GVt}	%	Fraction of PAOVSS removed at time t
f_H		Fraction of the endogenous residue of the OHOs
f_{HVt}	%	Fraction of OHOVSS removed at time t
f_i	mgVSS mgTSS^{-1}	VSS/TSS ratio
f_{ie}	mgVSS mgTSS^{-1}	Effluent VSS/TSS ratio
f_{ii}	mgVSS mgTSS^{-1}	Influent VSS/TSS ratio
f_{iOHO}	$\text{mgISS mgOHVSS}^{-1}$	Inorganic suspended solids content of OHOs
f_{iPAO}	$\text{mgISS mgPAOVSS}^{-1}$	Inorganic suspended solids content of PAOs
f_{iPAOBM}	$\text{mgISS mgPAOVSS}^{-1}$	P content of PAO cell mass
f_n	mgN mgVSS^{-1}	Nitrogen content of the VSS
f_p	mgP mgVSS^{-1}	Phosphorus content of the VSS
f_{pG}	mgP mgVSS^{-1}	Phosphorus content of the OHOs
f_{pH}	mgP mgVSS^{-1}	Phosphorus content of the PAOs
$f_{s'up}$	mgCOD mgCOD^{-1}	Fraction of unbiodegradable particulate COD
$f_{s'us}$	mgCOD mgCOD^{-1}	Fraction of unbiodegradable soluble COD
f_T		Fraction of nondegradable active TSS unaffected by digestion
f_{Tt}	%	Fraction of total suspended solids removed at time t
f_{Tsr}	%	Fraction of solids removed (with respect to TSS)
f_{Vr}	%	Fraction of volatile suspended solids removed
f_{Vt}	%	Fraction of volatile suspended solids removed at time t

f_{Vsr}	%	Fraction of solids removed (with respect to VSS)
f_{xa}		Anaerobic mass fraction
f_{XBGP}	mgP mgPAOVSS ⁻¹	Total P content of PAOs
f_{XBGPBM}	mgISS mgPAOVSS ⁻¹	Inorganic suspended solids content of PAO cell mass
f_{XBGPp}	mgP mgPAO ⁻¹	Polyphosphate content of PAOs
H^+		Hydrogen ion
HAc		Undissociated acetic acid
H ₂ O		Water
H ₂ SO ₄		Sulphuric acid
H ₃ BO ₃		Boric acid
HCO_3^-		Bicarbonate
H_2CO_3		Carbonic acid
$H_2CO_3^*$		Carbonic acid and aqueous (molecularly dissolved) carbon dioxide
HgSO ₄		Mercuric sulphate
HNO_3		Nitric acid
i_{NBM}		Nitrogen content of biomass
i_{NSf}		Nitrogen content of F-RBCOD
i_{NSi}		Nitrogen content of inert soluble COD
i_{NXi}		Nitrogen content of inert particulate COD
i_{NXs}		Nitrogen content of particulate COD
i_{PBM}		Phosphorus content of the biomass
i_{PSf}		Phosphorus content of F-RBCOD
i_{PSi}		Phosphorus content of inert soluble COD
i_{PXi}		Phosphorus content of inert particulate COD
i_{PXs}		Phosphorus content of particulate COD
(i)		Compound (in a matrix representation)
(j)		Process (in a matrix representation)
v_{ij}		Stoichiometric coefficient (in a matrix representation)
K ₂ Cr ₂ O ₇		Potassium dichromate

K_2HPO_4		Di-potassium hydrogen orthophosphate
K_{CT}		First order rate constant for conversion of F-RBCOD to SCFA RBCOD at temperature T (0.06 day ⁻¹ at 20°C)
k_d	d ⁻¹	Aerobic digestion reaction rate constant
K_{La}	d ⁻¹	Oxygen mass transfer coefficient
$K_{La(s)}$	d ⁻¹	Oxygen mass transfer coefficient for sample
$K_{La(w)}$	d ⁻¹	Oxygen mass transfer coefficient for water
k_{sp}		Solubility product
Mg^{2+}		Magnesium ion
$MgNH_4PO_4$		Magnesium ammonium phosphate (struvite)
MN_{te}		Mass of effluent nitrogen in the effluent
MN_{ti}		Mass of influent nitrogen in the influent
MN_w		Mass of organic nitrogen in the waste sludge
$MN_{w(s)}$		Mass of soluble nitrogen in the waste sludge
MO_c	mgO d ⁻¹	Mass of carbonaceous oxygen demand per day
MO_d	mgO d ⁻¹	Mass of denitrification oxygen demand
MO_n	mgO d ⁻¹	Mass of nitrification oxygen demand per day
MO_T	mgO d ⁻¹	Total oxygen demand per day
MO_{Ti}	mgO d ⁻¹	Mass oxygen demand at any time
MP_{te}	mgP d ⁻¹	Mass of phosphorus in the effluent
MP_{ti}	mgP d ⁻¹	Mass of phosphorus in the influent
MP_{tw}	mgP d ⁻¹	Mass of organic phosphorus in the waste sludge
$MP_{tw(s)}$	mgP d ⁻¹	Mass of ortho phosphate in the waste sludge
MS_{bi}	mgCOD d ⁻¹	Mass of biodegradable substrate in the influent
MS_{CON}	mgCOD d ⁻¹	Fermentable RBCOD (F-RBCOD) converted to SCFA
MS_H	mgCOD d ⁻¹	Mass of biodegradable substrate available to OHOs
MS_{seq}	mgCOD d ⁻¹	Mass of substrate sequestered by the PAOs in the anaerobic reactor in the BEPR AS system
MS_{te}	mgCOD d ⁻¹	Mass of effluent COD
MS_{ti}	mgCOD d ⁻¹	Mass of influent COD
MS_{tw}	mgCOD d ⁻¹	Mass of particulate COD in the waste sludge

$MS_{tw(s)}$	$mgCOD\ d^{-1}$	Mass of soluble COD in the waste sludge
MX_{cG}	$mgPAOVSS\ d^{-1}$	Endogenous mass of PAOs
MX_{cH}	$mgOHOVSS\ d^{-1}$	Endogenous mass of OHOs
MX_G	$mgAPAOVSS\ d^{-1}$	Biological active mass of the PAOs generated in the BEPR AS system
MX_{Gi}	$mgAPAOVSS\ d^{-1}$	Active mass of PAOs in the influent
MX_H	$mgAOHOVSS\ d^{-1}$	Active mass of the OHOs generated in the BEPR AS system, forming the influent mass of active OHOs to the aerobic digester
MX_{Hi}	$mgAOHOVSS\ d^{-1}$	Influent active OHO mass
MX_I	$mgISS\ d^{-1}$	Mass of inert material
MX_{Ii}	$mgISS\ d^{-1}$	Mass of ISS in the activated sludge system
MX_{Io}	$mgISS\ d^{-1}$	Mass of influent inert organic material
MX_{Ioi}	$mgISS\ d^{-1}$	Mass of influent ISS into aerobic digester
MX_{Vi}	$mgVSS\ d^{-1}$	Mass of influent VSS
N		Nitrogen
N_{ae}	$mgN\ l^{-1}$	Effluent ammonia concentration
$NaHCO_3$		Sodium bicarbonate
NaOH		Sodium hydroxide
NH_3		Ammonia
$NH_{4(eff)}$		FSA concentration in the effluent
NH_4^+		Ammonium
N_{ne}	$mgN\ l^{-1}$	Effluent nitrate concentration
N_{ni}	$mgN\ l^{-1}$	Effluent nitrate concentration at time t
NO_2^-		Nitrite
NO_3		Nitrate
$NO_{3(eff)}$	$mgN\ l^{-1}$	Nitrate concentration in the effluent
NO_{3i}	$mgNO_3-N\ l^{-1}$	Nitrate in the influent to the anaerobic reactor of the BEPR AS system
NO_3-N	$mgNO_3-N\ l^{-1}$	Nitrate nitrogen
NO_{3r}	$mgNO_3-N\ l^{-1}$	Nitrate recycled to the anaerobic reactor of the BEPR AS system
NO_{3t}	$mgNO_3-N\ l^{-1}$	Nitrate concentration at time t

N_{ousi}	mgN l^{-1}	Influent organic unbiodegradable soluble nitrogen
N_{ouse}	mgN l^{-1}	Effluent organic unbiodegradable soluble nitrogen
N_r		Total number of anaerobic reactors of equal volume in series $n = 1, 2, \dots N$ in the BEPR AS system
N_{ti}	mgN l^{-1}	Influent nitrogen concentration
N_2		Nitrogen gas
O		Oxygen
O_c	$\text{mgO l}^{-1} \text{ h}^{-1}$	Carbonaceous OUR
O_{ct}	$\text{mgO l}^{-1} \text{ h}^{-1}$	Carbonaceous OUR at time t
O_e	$\text{mgO l}^{-1} \text{ h}^{-1}$	OUR for endogenous respiration
O_{eG}	$\text{mgO l}^{-1} \text{ h}^{-1}$	OUR for endogenous respiration due to PAOs
O_{eH}	$\text{mgO l}^{-1} \text{ h}^{-1}$	OUR for endogenous respiration due to OHOs
O_{Gt}	$\text{mgO l}^{-1} \text{ h}^{-1}$	OUR for PAOs at time t
OH^-		Hydroxide
O_{Ht}	$\text{mgO l}^{-1} \text{ h}^{-1}$	OUR for OHOs at time t
O_i	mgO l^{-1}	Oxygen in the influent to the anaerobic reactor of the BEPR AS system
O_n	$\text{mgO l}^{-1} \text{ h}^{-1}$	Nitrification OUR
O_{nt}	$\text{mgO l}^{-1} \text{ h}^{-1}$	Nitrification OUR at time t
OP_{eff}	mgP l^{-1}	Effluent orthophosphate concentration
O_r	mgO l^{-1}	Oxygen recycled to the anaerobic reactor of the BEPR AS system
O_T	$\text{mgO l}^{-1} \text{ h}^{-1}$	Total OUR
O_{Tt}	$\text{mgO l}^{-1} \text{ h}^{-1}$	Total OUR at time t
OU_G	mgO l^{-1}	Oxygen utilized by PAOs
OU_H	mgO l^{-1}	Oxygen utilized by OHOs
P		Phosphorus
P_i	mgP l^{-1}	Influent phosphorus concentration
pK		Dissociation constant (negative log of ionization constant)
PO_4^{3-}		Orthophosphate
P_{se}	mgP l^{-1}	Effluent phosphorus concentration
P_{sGt}	mgP l^{-1}	Concentration of phosphorus at time t due to PAOs

P_{sIt}	mgP l^{-1}	Concentration of phosphorus at time t due to OHOs
P_{st}	mgP l^{-1}	Concentration of phosphorus at time t
P_{ti}	mgP l^{-1}	Influent phosphorus
q_{Fe}	gCOD gCOD^{-1}	Anaerobic RBCOD fermentation rate
Q_i	l day^{-1}	Influent flow to the BEPR AS system
Q_w	l day^{-1}	Waste flow
q_{pp}	$\text{gPP gPAO}^{-1} \text{ d}^{-1}$	Rate constant for storage of poly-P
r		Recycle ratio to the anaerobic reactor with respect to the influent flow of the BEPR AS system
R_h		Hydraulic retention time
R_s	d	Sludge age
S_{be}	mgCOD l^{-1}	Effluent biodegradable COD
S_{bi}	mgCOD l^{-1}	Influent biodegradable COD
S_{bsai}	mgCOD l^{-1}	SCFA in the influent to the BEPR AS system
S_{bsfi}	mgCOD l^{-1}	Influent F-RBCOD concentration to the BEPR AS system
S'_{bsfi}	mgCOD l^{-1}	F-RBCOD available for conversion per litre of influent
S_{bsfN}	mgCOD l^{-1}	RBCOD concentration leaving the n^{th} anaerobic reactor in the series of N anaerobic reactors of the BEPR AS system
S_A	mgCOD l^{-1}	Acetate concentration
S_F	mgCOD l^{-1}	Fermentable RBCOD
S_F_{eff}	mgCOD l^{-1}	Effluent Fermentable RBCOD
S_I	mgCOD l^{-1}	Unbiodegradable soluble COD
S_{ti}	mgCOD l^{-1}	Influent COD
t		Time
t_d	d^{-1}	Digestion time
V_{acr}	m^3	Volume of aerobic reactor
V_d	m^3	Volume of aerobic digester
X	mgVSS l^{-1}	VSS concentration
X_a	mgVSS l^{-1}	VSS that is active
X_{ai}	mgVSS l^{-1}	Influent/initial VSS that is active

X_{at}	mgVSS l ⁻¹	VSS that is active at time t
X_c	mgVSS l ⁻¹	Fixed VSS
X_d	mgVSS l ⁻¹	Degradable VSS
X_{di}	mgVSS l ⁻¹	Initial degradable VSS
X_{dt}	mgVSS l ⁻¹	Degradable VSS remaining after batch aeration time t
X_e	mgVSS l ⁻¹	VSS that is endogenous residue
X_{eG}	mgPAOVSS l ⁻¹	Endogenous residue of the PAOs
X_{eGe}	mgPAOVSS l ⁻¹	Effluent concentration of endogenous residue of the PAOs
X_{eGt}	mgPAOVSS l ⁻¹	Endogenous residue of the PAOs at time t
X_{eH}	mgOHOVSS l ⁻¹	Endogenous residue of the OHOs
X_{eHe}	mgOHOVSS l ⁻¹	Effluent concentration of endogenous residue of the OHOs
X_{eHt}	mgOHOVSS l ⁻¹	Endogenous residue of the OHOs at time t
X_{et}	mgVSS l ⁻¹	VSS that it endogenous residue at time t
X_{eT}	mgVSS l ⁻¹	Effluent total VSS remaining at time t
X_{eTe}	mgVSS l ⁻¹	Effluent concentration of total endogenous residue
X_G	mgPAOVSS l ⁻¹	Concentration of the PAOs
X_{Ge}	mgPAOVSS l ⁻¹	Effluent concentration of the PAOs
X_{Gi}	mgPAOVSS l ⁻¹	Initial/influent concentration of the PAOs
X_{Gt}	mgPAOVSS l ⁻¹	Concentration of the PAOs at time t
X_H	mgOHOVSS l ⁻¹	Concentration of the OHOs
X_{He}	mgOHOVSS l ⁻¹	Effluent concentration of the OHOs
X_{Hi}	mgOHOVSS l ⁻¹	Initial/influent concentration of the OHOs
X_{Ht}	mgOHOVSS l ⁻¹	Concentration of the OHOs at time t
X_i	mgVSS l ⁻¹	Initial VSS concentration
X_l	mgVSS l ⁻¹	Inert organic material
X_{le}	mgVSS l ⁻¹	Effluent VSS that is inert material
X_{li}	mgVSS l ⁻¹	Influent VSS that is inert material
X_{lo}	mgVSS l ⁻¹	Inert inorganic material
X_{loc}	mgISS l ⁻¹	Concentration of inert inorganic material in the effluent

ABSTRACT

Waste activated sludge (WAS) is a biological sludge that contains biodegradable and non-biodegradable volatile suspended solids (VSS) and non-volatile inorganic suspended solids (ISS). Stabilization for safe disposal of the WAS is a process of paramount importance at wastewater treatment plants (WWTPs). Hence, aerobic digestion of the WAS from biological nutrient removal (BNR) activated sludge (AS) systems was carried out under batch conditions to (1) measure changes in nitrogen and phosphorus concentrations in solid and liquid phases during aerobic batch digestion tests (2) simulate the parent system with Activated Sludge Model No. 2 (ASM-2) in AQUASIM computer program to obtain the initial conditions for batch test simulation (3) simulate the batch aerobic digestion process with ASM-2 and compare with experimental data (4) develop VSS-based and total suspended solids (TSS) (with the addition of ISS to the VSS-based) batch reactor and steady state models for aerobic digestion of nitrification denitrification biological excess phosphorus removal (NDBEPR) WAS based on the individual biomass die-off rates of phosphorus accumulating organisms (PAOs) and ordinary heterotrophic organisms (OHOs), and (5) evaluate the ASM-2 simulation results with steady state aerobic batch digestion model.

The aerobically digested WAS was harvested from a University of Cape Town (UCT) configuration membrane (MBR) system which was fed raw wastewater taken from the Mitchell's plain WWTP in Cape Town (South Africa) which treats primarily domestic wastewater. The MBR UCT system, which had 140 l d^{-1} of influent flow and 20 days sludge age, comprised an anaerobic-anoxic-aerobic sequence of reactors with volumes of 25, 19 and 35 l respectively with mixed liquor recycled from the anoxic to anaerobic, and aerobic to anoxic reactors at ratios of 1:1 and 3:1 of the influent flow respectively. The batch aerobic digestion reactor was a 5 l cylindrical Perspex vessel with graduations for measuring the level of the sludge in the reactor. The concentration of the dissolved oxygen (DO) in the reactor was automatically controlled, within the range of 2 to 5 mgO l^{-1} , by a DO controller/oxygen utilization rate (OUR) meter which also concomitantly measures the OUR. Eight aerobic digestion batch tests (BT) with detention times ranging from 6 to 25 days were carried out at regulated pH (7.20) and temperature (20°C).

The sewage batch (SB) average results of the parent system and the batch digestion results were both simulated with ASM-2 in the computer program AQUASIM. The predicted results

X_{loi}	mgISS l ⁻¹	Influent ISS concentration
X_{lot}	mgISS l ⁻¹	Concentration of inert inorganic material at time t
X_{lw}		Concentration of unbiodegradable particulate COD in the waste sludge
X_n	mgVSS l ⁻¹	VSS that is non-degradable residue
X_s	mgVSS l ⁻¹	Slowly biodegradable particulate COD
X_{sw}		Concentration of slowly biodegradable particulate COD in the waste sludge
X_t	mgVSS l ⁻¹	VSS at time t
X_{Tadi}	mgTSS l ⁻¹	Degradable portion of the active fraction of the influent TSS concentration
X_{Tae}	mgTSS l ⁻¹	Active fraction of the effluent TSS concentration
X_{Tai}	mgTSS l ⁻¹	Active fraction of the influent TSS concentration
X_{Tanoi}	mgTSS l ⁻¹	Non-degradable portion of the inactive fraction of the influent TSS concentration
X_{Taoi}	mgTSS l ⁻¹	Non-degradable portion of the active fraction of the influent TSS concentration
X_{Te}	mgTSS l ⁻¹	Effluent TSS concentration
X_{Ti}	mgTSS l ⁻¹	Initial/influent TSS concentration
X_{Tne}	mgTSS l ⁻¹	Inactive fraction of the effluent TSS concentration
X_{Tni}	mgTSS l ⁻¹	Inactive fraction of the influent TSS concentration
X_{Tt}	mgTSS l ⁻¹	TSS concentration at time t
X_v	mgVSS l ⁻¹	Total VSS concentration
X_{vt}	mgVSS l ⁻¹	Total VSS concentration at time t
Y_G	d ⁻¹	Yield of PAOs
Y_H	d ⁻¹	Yield of OHOs

digestion period indicates that the source of the released N was the solubilization of the organic N in the sludge mass. The SOUR observed at the end of the batch tests were all below the $\text{SOUR} < 1 \text{ mgO gVSS}^{-1} \text{ h}^{-1}$ threshold value signifying that the aerobically digested waste activated sludge was well stabilized.

Acrobic digestion, modified to include intermittent aeration to promote denitrification and lime addition to enhance mineral precipitation, is a simple stabilization system for NDBEPR WAS producing a low N and P dewatering liquor for recycle to the biological reactor.

X_{loi}	mgISS l^{-1}	Influent ISS concentration
X_{lot}	mgISS l^{-1}	Concentration of inert inorganic material at time t
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X_{Tanoi}	mgTSS l^{-1}	Non-degradable portion of the inactive fraction of the influent TSS concentration
X_{Taoi}	mgTSS l^{-1}	Non-degradable portion of the active fraction of the influent TSS concentration
X_{Te}	mgTSS l^{-1}	Effluent TSS concentration
X_{Ti}	mgTSS l^{-1}	Initial/influent TSS concentration
X_{Tne}	mgTSS l^{-1}	Inactive fraction of the effluent TSS concentration
X_{Tni}	mgTSS l^{-1}	Inactive fraction of the influent TSS concentration
X_{Tt}	mgTSS l^{-1}	TSS concentration at time t
X_V	mgVSS l^{-1}	Total VSS concentration
X_{Vt}	mgVSS l^{-1}	Total VSS concentration at time t
Y_G	d^{-1}	Yield of PAOs
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X_{Tadi}	mgTSS l^{-1}	Degradable portion of the active fraction of the influent TSS concentration
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X_{Te}	mgTSS l^{-1}	Effluent TSS concentration
X_{Ti}	mgTSS l^{-1}	Initial/influent TSS concentration
X_{Tne}	mgTSS l^{-1}	Inactive fraction of the effluent TSS concentration
X_{Tni}	mgTSS l^{-1}	Inactive fraction of the influent TSS concentration
X_{Ti}	mgTSS l^{-1}	TSS concentration at time t
X_V	mgVSS l^{-1}	Total VSS concentration
X_{Vi}	mgVSS l^{-1}	Total VSS concentration at time t
Y_G	d^{-1}	Yield of PAOs
Y_H	d^{-1}	Yield of OHOs

of the parent system provided initial condition input data for the batch test simulations with ASM-2. The batch test simulation results were then compared with those measured. The ISS model, developed by Ekama and Wentzel (2004) was incorporated into the ASM-2. The ASM-2 was calibrated by using the measured SB average data of the MBR UCT system and COD, N and P mass balances of the simulated results were checked. Moreover, based on the aerobic digestion steady state model (SSM) of Marais and Ekama (1976), VSS-based and TSS (adding ISS to the VSS-based) batch reactor and steady state models for aerobic digestion of WAS from BEPR AS systems were developed.

During the aerobic digestion process the VSS, TSS and COD concentrations decreased whereas the P release increased almost linearly with time. For all the batch tests the ISS decreased with some undulations, especially at the beginning of the digestion period. The appearance of nitrate on the second day of digestion indicated the immediate commencement of nitrification and the low FSA concentrations, well below 1 mg l^{-1} , maintained during the end of the digestion period showed the occurrence of complete nitrification. The release of ortho phosphate (OP) into the bulk liquid was directly related to the initial concentration of the suspended solids. Curiously, significantly less P was released to the bulk liquid than expected from the P content of the polyphosphate accumulating organisms (PAOs) in the concentrated TSS batch tests than in the diluted one. This indicated the mineral precipitation of P was taking place in the concentrated TSS batch tests, which was confirmed with supplementary experiments.

For the batch aerobic digestion, generally, the measured COD concentrations dropped faster than those simulated with ASM-2. With regard to the OUR there was marked deviation of the predicted from the measured values. Similar trends of decrease of VSS and TSS concentrations with retention time were observed with ASM-2 and the batch reactor model (BRM). Except for the slightly higher levels of nitrate computed with the BRM, the increase in nitrate concentrations as simulated with ASM-2 and computed with BRM was almost the same during the aerobic digestion process. The endogenous respiration (b) rates of the OHOs and PAOs determined from the computed OUR using the BRM were 0.23 and 0.04 d^{-1} respectively.

The almost identical TKN reductions with respect to VSS destruction and TSS reduction and linear increase in nitrate concentration with cumulative total oxygen utilized during the

CHAPTER 1

INTRODUCTION

1.1 General

Wastewater is basically the water supply of the community after it has been used in a variety of applications. Wastewater is a combination of the liquid or water-carried wastes removed from residences, institutions, and commercial and industrial establishments. Wastewater is a highly turbid liquid, consisting of a dilute complex mixture of mineral and organic matter in many forms, including: (a) large and small particles of solid matter floating and in suspension, (b) substances in true solution, and (c) extremely finely divided 'colloidal' substances between these two categories.

Wastewater contains living organisms such as bacteria, viruses and protozoa; it is an excellent medium for the development of bacteria, containing several million per millilitre. The organic substances present in wastewater include carbohydrates, lignins, fats, soaps and synthetic detergents, and proteins. Ammonia and ammonium salts are always present, some derived from the decomposition of urine. In addition, untreated wastewater contains numerous pathogenic micro-organisms that dwell in the human intestinal tract. Wastewater also contains nutrients, such as nitrogen and phosphorus, which can stimulate the growth of aquatic plants, and may contain potentially toxic compounds that may damage the receiving water courses.

When wastewater or other organic wastes are discharged to a watercourse there is a reduction in the concentration of dissolved oxygen in the receiving water owing to its utilization by bacteria in the presence of organic matter. The bacteria utilize this organic matter as food for their growth, causing it to be broken down into simpler organic and inorganic compounds and development of disease vectors. The objectionable character of sewage is, mainly, due to the presence of organic matter which, in the absence of dissolved oxygen, soon putrefies, with the formation of foul-smelling compounds. If the organic pollution load is sufficiently great, the stream may lose all its dissolved oxygen resulting in putrefaction and foul odours due to liberation of hydrogen sulphide gas.

If pollution of these watercourses is to be avoided so that they can be used for their many requirements, then the organic matter in sewage must be converted to stable substances permitting a reasonably clean effluent to be discharged. To protect public health and the environment, the immediate and nuisance-free removal of wastewater from its sources of generation, followed by treatment and disposal into the environment becomes a necessity.

The treatment of wastewater produces a significant quantity of residual suspended solids that must be further processed prior to disposal. Invariably, the processing stages involve the separation of liquids from the suspended solids and, in doing so; change the characteristics of the residual matter. Furthermore, processing changes the solids/water mixture to cakes of high concentration and, ultimately, to minimal moisture content at the ultimate solids concentration. The constituents removed in wastewater treatment plants (WWTPs) include screenings, grit, scum and sludge. The solids in the waste sludge flow represent the unbiodegradable organics and the net growth of biological cells that have been synthesized in the utilization of the incoming organic material to the WWTP.

The objective of the WWTP, therefore, is to convert the wastewater into a stable sludge for disposal and an effluent suitable for discharge to the local watercourse. The amount and quality of the sludges produced depend entirely on the origin of the wastewater, the type of treatment plant and, perhaps even more important, on the method of plant operation. The whole treatment plant must be operated efficiently and without nuisance or offense to surrounding public and land uses.

Generally, the liquid part of sewage can be treated satisfactorily. Of the constituents removed from the wastewater at the different stages, biosolids (primary and/or secondary sludges) are by far the largest in volume and mass, and its stabilization and disposal present perhaps the most complex problem and high operation cost in the whole WWTP.

The complexity of dealing with the produced and wasted sludge arises from (1) the composition of the sludge in that it mainly consists of the substances responsible for the offensive character of untreated wastewater; (2) the decomposing nature, depending on its active fraction, of the organic matter contained in the waste activated sludge (WAS); and (3) the fact that the greater part of the WAS is organic matter.

The WAS is a biological sludge that contains biodegradable and non-biodegradable volatile suspended solids (VSS) and non-volatile inorganic suspended solids (ISS). Its characteristics differ greatly from primary sludge (PS) and so, too, does its behaviour. The VSS fraction of untreated WAS ranges from 60 to 80 percent without primary clarification at the WWTP and from 75 to 85 percent with primary clarification.

Waste activated sludges are treated to (1) reduce pathogens (disinfection), (2) eliminate offensive odours, and (3) inhibit, reduce, or eliminate the potential for putrefaction by oxidizing the biodegradable organics (stabilization). The success in achieving these objectives is related to the effects of the stabilization operation or process on the volatile or organic fraction of the suspended solids. Die-off of pathogens, release of odours, and putrefaction occur when micro-organisms are allowed to flourish in the biodegradable organic fraction of the sludge. The means to eliminate these nuisance conditions is mainly related to the biological reduction of the biodegradable organic content of the sludge to render them unsuitable for further growth of the micro-organisms. In addition to the health and aesthetic reasons, stabilization is also used for organic solids reduction with or without energy recovery.

The principal methods used for stabilization of sludge are (1) alkaline stabilization, usually with lime; (2) anaerobic digestion; (3) aerobic digestion, and (4) composting. Digestion is a commonly used biological process for the stabilization of sludges from WWTPs and trickling filters.

Aerobic digestion is the aerobic biological stabilization of wastewater sludge. During aerobic digestion the biodegradable organics of the biomass are utilized with oxygen because the wastewater organics have been completely degraded. This 'auto' biodegradation can be visualized in two ways. The first way is as endogenous respiration in which micro-organisms metabolize their own cellular mass when the external substrate available is inadequate. In this model, as the biodegradable portion of organic part of sludge continuously decrease, a living cell consumes its own protoplasm and cellular matter in order to obtain the energy required for the metabolism. Through this endogenous respiration process, the mass of biodegradable solids decreases resulting in the required stabilization of the WAS.

The second way of visualizing the 'auto' oxidation of biomass biodegradable organics is as death-regeneration. In this model, a fraction of the live cells die and release the biodegradable organics to the bulk liquid. The remaining live organisms use these biodegradable organics in normal growth process of anabolism (cell mass generation) and catabolism (energy generation) as they would any biodegradable organics. Fewer new cells grow due to the catabolic energy loss resulting in oxygen utilization for growth. Provided the correct endogenous respiration or death rates and unbiodegradable residue fractions are chosen for each model, both models give the same results. Generally, the endogenous respiration model is used in steady state activated sludge (AS) and aerobic digestion models (ADMs) because it leads to simpler equations. The death-regeneration model is incorporated into activated sludge simulation models, such as activated sludge model No. 1 (ASM-1) and ASM-2 (Henze *et al.*, 1987, 1995).

Advantages of aerobic digestion as compared to anaerobic digestion are:

- (a) Volatile solids reduction in a well-operated aerobic digester can be equal to that obtained anaerobically,
- (b) Low chemical oxygen demand (COD) concentration in supernatant liquor
- (c) Production of an odourless, humus-like, biologically stable digested sludge
- (d) Operation is relatively easy with low operational problems
- (e) Lower capital cost
- (f) Suitability for digesting nutrient-rich WAS

The major disadvantages of the aerobic digestion process are:

- (a) Requirement of high power cost associated with supplying the required oxygen, and
- (b) Non-recovery of energy in methane to reduce power consumption at the WWTP.

Though the basic composition of the sludge remains relatively unchanged, the bio-oxidation that occurs during aerobic digestion changes the characteristics of the treated sludges affecting its characteristics such as volatile suspended solids to total suspended solids (VSS/TSS) ratio and dewaterability.

Important parameters for measuring the degree of aerobic (or anaerobic) treatment for sludge stability are:

- Odour production – in addition to hydrogen sulphide, many other chemicals either in or produced by sludge may create odours.
- Reduction in volatile suspended solids (e.g., > 38% VSS removal)
- Change in the rate of oxygen utilization by aerobic organisms as an indication of aerobic activity (e.g., < 1.0 mgO gVSS⁻¹ h⁻¹)
- COD of the supernatant
- Dewaterability

1.2 Rationale for the Study

The AS process is widely used to treat various organic wastewaters. However, the materials removed during treatment process are often left in a sludge, which must be further treated before disposal. Waste activated sludges from biological nutrient removal (BNR) plants, even those with extended aeration, are not stable enough to be dewatered and disposed of into the environment. Stabilization for safe disposal of the WAS, therefore, is a process of paramount importance at WWTPs.

With the recent goals on developing simulation models for the whole WWTP, including the sludge stabilization systems (Copp *et al.*, 2003), it is necessary to know how nitrogen (N) and phosphorus (P) are released from WAS under aerobic (and anaerobic) digestion conditions, in particular the P from biological excess phosphorus removal (BEPR) sludges.

Research into aerobic digestion of fully aerobic or N removal system WAS showed that the N release could be modelled as a co-process of the endogenous respiration or death regeneration models (e.g. Warner *et. al.*, 1985); as the biodegradable organics of the biomass was degraded so its N and P components added to the bulk liquid N and P concentrations. In biological excess phosphorus removal, the process of P release under anaerobic conditions is much faster than the die-off or endogenous respiration rates of the phosphorus accumulating organisms (PAOs). Does this also apply to aerobic conditions? In this respect, the ASM-2 model kinetics may not apply because under aerobic digestion conditions, the PAOs receive no influent biodegradable organics. Under these prolonged substrate limited conditions do

their die-off and P-release rates change? The objectives of this thesis is to examine these questions and to investigate whether or not the BEPR/PAO kinetics in the ASM-2 can also be used for modelling aerobic digestion of WAS from BEPR plants, as ASM-1 can be used for modelling aerobic digestion of WAS from fully aerobic or nitrification-denitrification (ND) plants.

1.3 Objectives of the Study

The objectives of the study are to: -

- conduct aerobic digestion batch tests on WAS harvested from a parent laboratory scale nitrification-denitrification biological excess phosphorus removal (NDBEPR) system,
- measure changes in nitrogen and phosphorus concentrations in solid and liquid phases during aerobic batch digestion tests,
- simulate the parent system with ASM-2 in AQUASIM computer program to obtain the initial conditions for batch test simulation,
- simulate the batch aerobic digestion process with ASM-2 and compare with experimental data,
- develop VSS-based and TSS (with the addition of ISS to the VSS-based) batch reactor and steady state models for aerobic digestion of NDBEPR WAS based on the individual biomass die-off rates of PAOs and ordinary heterotrophic organisms (OHOs), and
- evaluate the ASM-2 simulation results with steady state aerobic batch digestion model.

CHAPTER 2

LITERATURE REVIEW

2.1 General Description

For fully aerobic or N removal AS, aerobic digestion of the WAS is nothing more than a continuation of the AS process. Aerobic digestion is a metabolic process in which “endogenous” respiration prevails over biosynthesis activity of micro-organisms because of the almost complete exhaustion of the influent wastewater food supply. Once the external wastewater source of organic material has been exhausted, the micro-organisms will enter into endogenous respiration where cellular material is oxidized to satisfy the energy of maintenance, i.e., energy for life support requirement. Due to the presence of a heterogeneous population of micro-organisms and an extremely complex ecosystem, various microbial species may serve as food sources for other members of the population (Adam *et al.*, 1974). Under these conditions, whether they are visualized as endogenous respiration or death regeneration, the concentration of biomass will continuously decrease and the remaining portion will present such a low utilizable energy content as to be considered biologically stable and suitable for disposal in the environment.

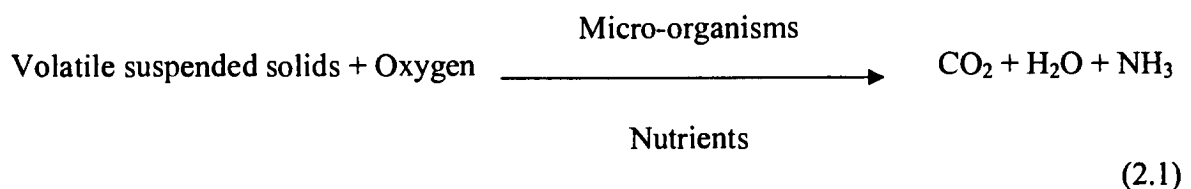
One of the major objectives of wastewater treatment is the removal of solids that otherwise might damage the water quality in the recipient water body. These solids are generally referred to as sludge and exist in many forms and various quantities. Obviously the amount and quality of sludge depends entirely on the origin of the waste, the type of treatment plant and, perhaps even more important, on the method of plant operation.

In spite of many research works conducted, no uniform parameter has been found to determine unequivocally the degree of stabilization and digestion time (Barbusinski and Koscielniak, 1997). The stability of the sludge required at a particular installation depends on the method of ultimate disposal and the local restraints on disposal (Ahlberg and Boyko, 1972).

2.2 Stoichiometry

Aerobic digestion is similar to the AS process. For an unlimited supply of usable organics and nutrients, the micro-organisms undergo log growth and the activity of the organism per unit mass is at a maximum. As the supply of available substrate becomes limiting the micro-organisms begin to consume their own protoplasm to obtain energy for cell maintenance reactions. During this phase, the organisms' activity becomes less than maximum resulting in declining growth. When energy is obtained from cell tissue the micro-organisms are said to be in the endogenous phase. Cell tissue is oxidized aerobically to carbon dioxide, water and ammonia.

The oxidation of biomass VSS to carbon dioxide and water through microbial metabolism, during the aerobic digestion process can, generally, be represented by the following equation:



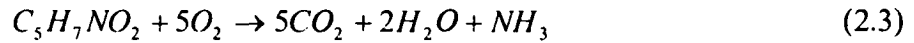
In the above equation the heterotrophic micro-organisms both participate and are produced in the reaction.

Actually, only about 75 to 80 percent of the cell tissue can be oxidized; the remaining 20 to 25 percent is composed of inert components and organic compounds that are not biodegradable. Non-biodegradable VSS, called endogenous residue, will remain in the final product from aerobic digestion.

The basic principle of aerobic sludge digestion is usually illustrated as follows:

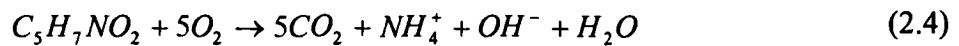


Considering the biomass wasted to a digester and the formula $\text{C}_5\text{H}_7\text{NO}_2$ represents cell mass of micro-organisms, the stoichiometry of Equation (2.2), when applied to the degradable portion of the sludge, will be:



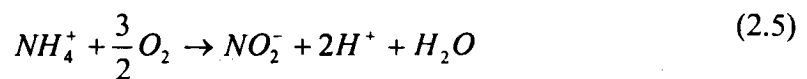
During the AS process the influent nitrogen is either incorporated into the AS, or escapes as nitrogen gas to the environment, or exits through the effluent as nitrate or ammonia. Most of the nitrogen in the WAS is organically bound in the sludge cells, though a significant amount of nitrogen may also be present as ammonia and nitrate. During aerobic digestion several different biologically mediated reactions may take place changing the forms of nitrogen both in solid form and in solution. The important reactions are ammonification, nitrification, and denitrification. Ammonification is the change from organic nitrogen to ammonium. Nitrification describes the biological oxidation of ammonium to nitrate; and denitrification describes the reduction of nitrate or nitrite to nitrogen gas. Sometimes denitrification may be encountered during aerobic digestion due to under aeration where some organisms are at zero dissolved oxygen (DO) concentration.

In the process of aerobic digestion, endogenous hydrolysis causes the release of nitrogen contained in the AS mass into the bulk liquid as organic nitrogen. The organic nitrogen is, then converted to ammonia. This ammonification process is expressed as follows,

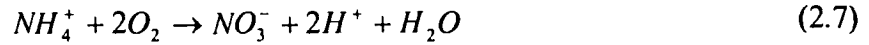


where $C_5H_7NO_2$ is the component formula of an activated sludge cell.

The ammonium is oxidized to nitrite or nitrate by nitrifying bacteria. The biological nitrification of ammonium by ammonia oxidizing bacteria (AOB) is considered a two-step reaction. The first step involves oxidation of ammonium to nitrite by AOB, while the second step is oxidation of nitrite to nitrate by nitrate oxidizing bacteria (NOB). Both of these groups are autotrophic, deriving energy for metabolism from inorganic nitrogen. These two-step reactions of nitrification of released ammonia nitrogen are described as:



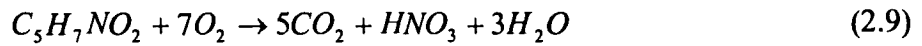
The net stoichiometric relationship for the oxidation of ammonium to nitrate by autotrophic nitrifying bacteria can be represented by the sum of Equations (2.5 and 2.6),



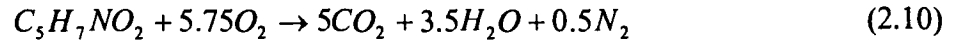
In the aquatic environment of an aerobic digester the production of free hydrogen ions generally results in reaction with bicarbonate ions (Bishop and Farmer, 1978). Equation (2.7) can be modified to show this:



The overall equation with complete nitrification:



With complete nitrification/denitrification:



As given by Equations (2.7) to (2.9), the conversion of organic nitrogen to nitrate, results in an increase in the concentration of hydrogen ions. For every molecule of nitrate (NO_3^-) formed from soluble ammonia (NH_4^+) two molecules of H^+ are generated. Hence, approximately 7 kg of alkalinity, expressed as $CaCO_3$, is destroyed per each kg N of NH_4^+ oxidized. As a result, the pH decreases. In the absence of sufficient buffering capacity, if the pH drops too low, nitrification is inhibited and eventually may stop. Moreover, if the DO concentration is kept very low (less than 1 mg l^{-1}) nitrification will not occur.

Thus, the theoretical oxygen demand for the aerobic sludge digestion process can be determined from Equation (2.3) as follows:

$$C_5H_7NO_2 = (5 \times 12) + (7 \times 1) + (2 \times 16) = 113 \text{ g organisms (VSS)}$$

$$\text{Oxygen utilized, } 5O_2 = (5 \times 2 \times 16) = 160 \text{ g oxygen (COD)}$$

Therefore, $1 \text{ g VSS} = (160/113) = 1.42 \text{ g COD}$

Hence, theoretically, the aerobic sludge digestion process requires approximately 1.42 g O to oxidize 1 g of cell material (VSS). The theoretical oxygen demand to oxidize 1 g VSS would be 1.98 g O (COD) with complete nitrification, and 1.77 g O (COD) with complete nitrification and denitrification. From the stoichiometric relations it can be seen that H^+ is consumed and released resulting in pH changes during digestion (Brink *et al.*, 2006). This aspect is discussed in detail in Section 2.3.1.

2.3 Factors Affecting Digestion Kinetics

Like any other biological process, the kinetics of aerobic digestion process is influenced by a number of factors as discussed below.

2.3.1 pH

pH is one of the most important parameters affecting the stoichiometry and kinetics of the biological aerobic digestion process. A pH close to a neutral level ($\text{pH} = 7$) provides a good environment for the oxidative micro-organisms, thus enhancing aerobic digestion efficiency through enhanced endogenous metabolism (Anderson and Mavinic, 1984). Moreover, keeping the pH at ~ 7.20 provides the optimum nitrification rate, which is expected to fall in the range of 7 to 8 (Ekama, 2005). Hence to provide a better environment for microbial metabolism, monitoring and regulating the pH has become one of the main parameter of concern during aerobic digestion process.

In their study of aerobic digestion of non-BEPR WAS with pH control, Anderson and Mavinic (1984) observed a trend of increase in digestion efficiency with pH increase to 7.0. When investigating the fate of nitrogen during aerobic digestion, Mavinic and Koers (1982) reported that a pH as low as 4.0 did not seem to impede the nitrification or denitrification processes. In their examination of the effects of detention time and pH on the performance of continuous flow aerobic digestion, Randall *et al.* (1974) reported that a pH of 6.5 gave the maximum value of decay coefficient, followed in order by values of 8.0, 5.0, and 3.5.

However, at pH values less than 5.7, Randall *et al.* (1969) experienced retardation of biological activity in some of their aerobic digesters. Moore (1970) evaluated the effect of pH on aerobic digestion of WAS and stated that the aerobic digestion efficiency, as measured by solids reduction, was relatively insensitive to different test pH conditions (3.5, 5.0, 7.0, and 9.0) but was always greater in pH-controlled units. Coackley *et al.* (1966), however, noted that pH values less than 4.0 would inhibit the microbial activity.

2.3.2 Temperature

Temperature will affect the biological system in two ways: first, temperature will affect the enzymatic reactions that are responsible for the reductions of VSS; second, the temperature will influence the diffusion of substrate to the organisms (Eikum *et al.*, 1974).

The effect of temperature on the decay coefficient usually has been represented by a modified Arrhenius relationship (Grady and Lim, 1980):

$$k_1 = k_2 \theta^{(T_1 - T_2)} \quad (2.11)$$

where

k_1 and k_2 = reaction rate coefficients at temperature T_1 and T_2 respectively; and

θ = thermal coefficient.

Marais and Ekama (1976) reported that the temperature dependency of the OHO endogenous respiration rate, b_H could be expressed in terms of a simplified Arrhenius equation:

$$b_{HT} = b_{H20} \theta^{(T-20)} \quad (2.12)$$

where

b_{HT} = value at $t^\circ\text{C}$

b_{H20} = value at $20^\circ\text{C} = 0.24 \text{ mgOHOVSS mgOHOVSS}^{-1} \text{ d}^{-1}$

θ = constant = 1.029

t = temperature in degree C

That is,

$$b_{HT} = 0.24 (1.029)^{(T-20)}$$

Randall *et al.* (1975) stated that an Arrhenius relationship might not be valid above 20°C, whereas Matsch and Drnevich (1977) verified this relationship up to about 60°C with acclimated systems. In their study of aerobic digestion of WAS at low temperatures, Mavinic and Koers (1979) observed that temperature had a significant effect on oxygen uptake at all sludge ages and VSS reduction increased with increasing temperature. While Marais and Ekama (1976) worked in the temperature range 8 to 20°C, van Haandel *et al.* (1998) worked in the temperature range 20 to 30°C and confirmed that $b_{H20} = 0.24 \text{ d}^{-1}$ but found a slightly higher temperature sensitivity coefficient, $\theta = 1.04$.

2.3.3 Initial concentration of suspended solids

The effect of the initial concentration of suspended solids on the kinetics of aerobic digestion is mainly related to its influence on oxygen transfer rate.

The extent to which the oxygen mass transfer rate, $k_L a$ value of an aeration system is influenced by the presence of dissolved or suspended solids is generally expressed in terms of a factor, α , defined as follows:

$$\alpha = \frac{k_L a_{(s)}}{k_L a_{(w)}} \quad (2.13)$$

where $k_L a_{(s)}$ relates to the aqueous suspension and $k_L a_{(w)}$ relates to distilled water or tap water.

The presence of solids in suspension may affect oxygen transfer through (Casey and Karmo, 1974):

- (a) their influence on the bulk characteristics of the air-water mixture, i.e. on its effective density and viscosity
- (b) their effect on air-water interface conditions

Quoting on the work of Rogers and Vernimmen (1964) on the influence of suspensions of diatomaceous earth, AS, ferric hydroxide and aluminium hydroxide on the rate of oxygen transfer in aeration columns, Casey and Karmo (1974) stated that AS was found to reduce the rate of oxygen transfer with increasing solids concentration up to about 2.5 g l^{-1} , at which the value of α was about 0.4; at higher concentrations the effect became less marked. This solids concentration and α values are very low compared with the solids concentration considered in the membrane (MBR) University of Cape Town (UCT) system which is about 7, 13 and 15 g l^{-1} in the anaerobic, anoxic and aerobic reactors, respectively, with α value of 0.75. On their work of the influence of suspended solids on oxygen transfer in aeration systems Casey and Karmo (1974) noted that non-flocculent suspensions within concentration range of 0 – 10 g l^{-1} had a negligible influence on the overall transfer coefficient. However, organic flocculent suspensions (i.e. AS and synthetic suspensions) had a significant effect on oxygen transfer rate.

An inverse relationship has been observed in several studies between initial solids concentration and the first-order decay coefficient, k_d (Reynolds, 1973; Ganczarczyk *et al.*, 1980; d'Antonio and Gigliani, 1984; Krishnamoorthy and Loehr, 1989; and Khalili *et al.*, 2000).

Randal *et al.* (1969) carried out laboratory batch digestion tests on non-BEPR WAS having initial suspended solids concentrations in the ranges of $11,000 - 26,000 \text{ mg l}^{-1}$ and reported that the rate of destruction of sludge solids by aerobic digestion increased with the increase in solids concentration. When conducting aerobic stabilization of non-BEPR WAS, Abramov (1975) associated a more concentrated sludge with somewhat lower VSS degradation rate, while sludge concentrations from $7,500 - 20,000 \text{ mg l}^{-1}$ did not affect the first-order decay coefficient.

Since increasing the sludge age increases the nonactive volatile solids accumulation in the AS system, Upadhyaya and Eckenfelder (1975) indicated that an increase in mixed liquor volatile suspended solids (MLVSS) could cause a decrease in AS active mass, even under conditions of similar sludge ages. In their study of aerobic digestion of thickened non-BEPR WAS to determine reaction rate constants, D'Antonio, (1983) observed that the destruction rate constant values decreased as the initial solids concentration increased. For the same duration, less concentrated sludges exhibited higher VSS percent destructions than did the more

thickened samples; however, at the end of the test, the latter reached higher destruction values with longer aeration periods. Moreover, he reported the need for longer digestion time for sludges with higher initial concentration of solids.

2.3.4 Sludge Age (in Prior Activated Sludge Process)

Owing to the different substrate types on which the activated sludges were grown, various studies on the influence of sludge age in prior AS process on the kinetics of aerobic digestion showed differing results. Generally, the unbiodegradable VSS fraction of the WAS generated from AS process with longer sludge ages will be higher as a result of the accumulation of biologically inert volatile matter (endogenous residue). Hence increasing the sludge age increases the inert volatile solids accumulation in the system because in effect the endogenous process has continued for longer in the AS reactor at longer sludge ages.

In their study of aerobic digestion of non-BEPR WAS, Reece *et al.* (1979) found that the solids retention time (SRT) at which the sludge was grown did not significantly affect the first order rate constant. Hence, they concluded that the degradable solids in an AS grown at a long SRT could be destroyed just as rapidly as those in a sludge grown at a short SRT.

A decrease of the first order decay coefficient with an increase in prior sludge age have been reported by Abramov (1975), Krishnamoorthy and Loehr (1989), and Goodman and Englande (1974). However, Marais and Ekama (1976) showed that, while the decay rate constant, k_b , based on VSS, decreases with parent system sludge age, the endogenous respiration rate, b_H based on ordinary heterotrophic organisms volatile suspended solids (OHOVSS), is not affected by sludge age.

2.3.5 Type of Sludge and Detention Time

Matsch and Drnevlch (1977) stated that the rate of digestion is a function of the past history of the sludge and that, in general, WAS will require less time to digest aerobically than PS. This is because in the WAS the external substrate is almost completely exhausted, especially for long sludge ages, as a result the micro-organisms will 'immediately' undergo an endogenous mass loss, perceived as endogenous respiration or death-regeneration, with the

lysis of cell material to obtain the energy required for maintenance. The presence of external substrate in the PS enhances growth of the micro-organisms thereby delaying the endogenous mass loss of the micro-organisms until the depletion of the external substrate. Ganczarczyk *et al.* (1980) noted that the decay coefficients of WAS were, in general, lower than those of PS.

In their study of the variations in sludge metabolic activity and viable micro-organism percentage as a function of growth rate, Weddle and Jenkins (1971) observed that metabolic activity was directly proportional to the number of viable micro-organisms present in the system. Similarly, when investigating the microbial activity in aerobic sludge digestion, Droste and Sanchez (1983) noted that the rate of substrate removal and the decrease of endogenous mass were ultimately dependent on the active cell mass concentration within the reactor.

In their study of aerobic stabilization of primary and mixed primary chemical (alum) sludge, Eikum *et al.* (1974) reported a decrease in the rate of reduction of volatile organic solids as the detention time in the reactor increased. Similarly, when conducting aerobic digestion of non-BEPR WAS at low temperatures, Koers and Mavinic, (1977) noted a decrease of biodegradability of digested sludge with increased in detention time. In their evaluation of the aerobic digestion of WAS at variable temperature and loading rates, Mavinic and Koers (1979), however, observed increase of VSS reduction with increasing detention time.

Rich (1982) observed that the magnitude of the decay coefficient was dependent on the aeration period used to determine its value, while Abramov (1975) observed that DO concentrations of 1.0 – 8.5 mg l⁻¹ did not affect the value of the decay coefficient.

From the above, the sludge type, its microbial content, the physiological condition, characteristics of the influent wastewater where the sludge is grown, the concentration of nutrients, and mixing affect the kinetics of sludge digestion.

2.4 Transformations of Nutrients during Aerobic Digestion

The nitrogen and phosphorus entering a biological nutrient removal plant either are in solution or associated with the suspended and colloidal solids. While portions of the feed

nitrogen and phosphorus are removed during primary sedimentation, the rest enters the BNR reactor. During aerobic digestion, nitrogen and phosphorus are released from the decomposed sludge biomass.

Most research to date on aerobic digestion has been concerned with the rate and extent of solids reduction, and the effect of digestion on the settleability and drainability of sludges. In only a few cases have researchers reported data concerning the fate of nutrients during digestion. It is, generally, concluded that aerobic digestion produces a supernatant substantially lower in nitrogen and phosphorus than supernatant produced from anaerobic digestion (Bishop and Farmer, 1978).

2.4.1 Nitrogen

Eckenfelder (1956) was one of the first to investigate the changes in nutrient forms during aerobic digestion process. He noted an increase in soluble nitrogen at approximately stoichiometric ratio to the sludge oxidized.

When evaluating the fate of nutrients during aerobic digestion of non-BEPR WAS, Bishop and Farmer (1978) noted that, as much as 41% of the nitrogen in the feed sludge remained in the supernatant of the digested sludge, while the percentage of nitrogen in the sludge solids remained fairly constant. The percentage of nitrogen released to the liquid phase was roughly equivalent to the percentage of VSS destroyed.

Mavinic and Koers (1982) stated that, in the absence of organic N in the supernatants, and the constant organic nitrogen content of the cell mass, the volatile solids destruction, in aerobic digestion, results in almost 100 percent mineralization of organic nitrogen to ammonia in solution. Moreover, they reported that the organic nitrogen content for the digested sludges and feed sludges was practically constant, with an overall value of $0.08 \text{ gN gVSS}^{-1}$. Hence they concluded that the amount of nitrogen converted from the solid phase to the liquid phase in aerobically digested AS should then be proportional to the amount of VSS destroyed.

In their study of aerobic digestion of non-BEPR WAS with different initial solids concentrations, Ganczarczyk *et al.* (1980) observed that the rate and degree of nitrification

were lower for sludges having higher solids concentration. Based on these observations together with those made on pH changes during aerobic digestion they suggested that there was some inhibition of nitrification during the digestion of the more concentrated sludges or that a simultaneous denitrification occurred. From Ganczarczyk *et al.* (1980) above, such differences are possible and appear to be associated with the N content of the aerobically digested organics. If the organics are largely proteins then a high bulk liquid ammonia concentration will be observed, if largely carbohydrates, then a low bulk liquid ammonia concentration will be observed. Aerobic digestion models can take this into account through the N content (f_n) of the biodegradable organics. Matsuda *et al.* (1988) studied the behaviour of nitrogen during aerobic digestion of BEPR WAS with continuous and intermittent aeration and pH range of 4 to 6 for detention time of 30 days. In their aerobic batch digestion of BEPR WAS, Matsuda *et al.* (1988) noted an almost linear decrease of TKN from about 560 to 225 mgN l⁻¹, while the corresponding increase of nitrate (NO₃) and ammonia (NH₄) was up to 175 and 125 mg l⁻¹ with 30 days of detention time respectively. The high ammonia concentration Matsuda *et al.* (1988) obtained at the end of their 30 days of aerobic digestion, however, casts doubt on the existence of complete nitrification. In the aerobic digestion test of WAS from three BNR plants (Anglesea, Ballarat South and Bendigo) with continuous and intermittent aeration for 7 days of detention time, Tonkovic (1999) observed that a significant reduction of organic nitrogen, particularly with continuous aeration, with 23, 8 and 27% destruction of organic nitrogen and 6, 0 and 14% of overall nitrogen removal respectively. For the BEPR WAS with 14% total nitrogen removal, Tonkovic (1999) asserted that there was occurrence of a significant simultaneous nitrification and denitrification.

2.4.2 Phosphorus

In the BEPR system the influent phosphorus is mainly incorporated into the AS via the BEPR process mediated by the PAOs while the rest exits through the effluent as orthophosphate (OP). Normal biological uptake during the AS process usually accounts for a removal of only about 20% of the total phosphorus (TP) in the plant influent. BEPR seeks to increase this to 100%. Aerobic and ND activated sludge contains approximately 2% to 3% phosphorus on a dry weight basis (Bishop and Farmer, 1978). The enhanced PAO cultures of Wentzel *et al.* (1988) contained 0.38 mgP mgPAOVSS⁻¹ or equivalently 30 to 35% P biomass or 300 to 350 mgP gVSS⁻¹ at 10 to 20 days sludge age. In the NDBEPR system with real wastewater the

PAOs are diluted into the 2 to 3% P OHOs and unbiodegradable VSS organics with the result that the P VSS content of NDBEPR systems varies between 5 to 15% P depending on the P removal. Whatever the P content, aerobic digestion of NDBEPR WAS can result in 3 to 5 times more P being released to the bulk liquid. Most of this will be released as OP from the internally stored polyphosphate (PP) of the PAOs. During the aerobic digestion process, through endogenous hydrolysis the solid phase phosphorus of the WAS is solubilized into organic phosphorus, and the organic phosphorus does change into ortho phosphate (OP).

Because the PAO PP is stabilized with cations such as magnesium, potassium and calcium, during the aerobic digestion process these cations are released as a result of solids degradation. If the combined molar concentration of magnesium (Mg^{2+}), ammonium (NH_4^+) and phosphate (PO_4^{3-}) exceeds the solubility product, K_{sp} of struvite, then struvite precipitation occurs. Struvite is magnesium ammonium phosphate ($MgNH_4PO_4$), which forms a hard crystalline deposit blocking aerators, pipes and pumps of sludge treatment facilities. The formation of struvite can be represented as:



The approximate minimum concentration required for struvite precipitation to occur is at a molar ratio of $Mg:NH_4:PO_4$ of 1:1:1, i.e. at concentrations of 27 mg l⁻¹ Mg^{2+} , 20 mg l⁻¹ NH_4^+ and 106 mg l⁻¹ PO_4^{3-} . Struvite precipitation is highly pH dependent. As the pH increases from 7 to 9 the percent of total ammoniacal nitrogen present as NH_4^+ decreases from 99 to 64% while the fraction of total PO_4 -P present as the PO_4^{3-} anion increases 250 fold (Stum and Morgan, 1970).^{*} In this respect nitrification during aerobic digestion of BEPR WAS is beneficial because it keeps the free ammonia concentration very low and so reduces the potential to precipitate struvite. The problem associated with struvite precipitation is most pronounced in anaerobic digestion process.

During the aerobic digestion of non-BEPR WAS, Irgens and Halvorson (1965) observed very low levels of phosphorus in aerobic digester supernatant. In their study of aerobic digestion of both primary and mixed sludges, Eikum, *et al.* (1975) found no significant solubilization of solid phase phosphorus. However, when tracking nutrient changes during aerobic digestion

of non-BEPR WAS, Bishop and Farmer (1978) stated that 37% of the phosphorus in the feed sludge remained in the supernatant of the digested sludge. Moreover, they noted that the phosphorus was released in approximately a stoichiometric ratio to the volatile solids destroyed, producing a stabilized sludge with a phosphorus content of about 2% of the suspended solids.

Matsuda *et al.* (1988) studied the behaviour of phosphorus during aerobic digestion of BEPR WAS with continuous and intermittent aeration and pH range of 4 to 6 for detention time of 30 days. They observed a decrease of TSS and VSS with detention time while the fixed suspended solids (FSS) were roughly constant ($1000 - 3000 \text{ mg l}^{-1}$), and the reduction rate of VSS was proportional to biodegradable volatile suspended solids (bVSS) with a rate constant of about 0.15 d^{-1} . They also noted that the concentration of phosphorus in liquid phase increased considerably and stated that biomass with low phosphorus content are decomposed in the first stage of aerobic digestion and that with high phosphorus content are decomposed thereafter. The percentage of biomass phosphorus of the total phosphorus (TP) decreased from 99 to 30%. The OP concentration increased from 2 to 45 mg l^{-1} , i.e., showing an increase of 70% in 30 days of detention time. Moreover, they observed that after 30 days of digestion 30% of the initial VSS and 40% of the initial TSS remained. From this it can be seen that the 70% increase of the liquid phase phosphorus was accompanied by 70% decrease of VSS, indicating that the P release during the digestion process was as a result of VSS degradation.

Tonkovic (1999) undertook aerobic digestion of WAS from three BNR and four conventional plants with continuous and intermittent aeration for 7 days of detention time. He stated that the VSS content of the BNR sludges from treatment plants with relatively long sludge ages was high, while plants with a lower operating sludge age produced less stable sludges having a high VSS/TSS ratio and a high specific oxygen utilization rate (SOUR) value. Besides, he noted that intermittent aeration resulted in slightly greater VSS destruction than continuous aeration. For the WAS harvested from three BNR plants (Anglesea, Ballarat South and Bendigo) with continuous aeration, the COD/VSS ratio decreased from 1.40, 1.44 and $1.31 \text{ mgCOD mgVSS}^{-1}$ to 1.23, 1.36 and $1.13 \text{ mgCOD mgVSS}^{-1}$ respectively, during the 7 days of aerobic digestion. For these three BNR plants, the VSS/TSS ratio changed from initial values of 0.59, 0.73 and $0.81 \text{ mgVSS mgTSS}^{-1}$ to final values of 0.63, 0.70 and $0.78 \text{ mgVSS mgTSS}^{-1}$ respectively. The final SOUR values of these BNR sludges after 7 days of digestion

were 0.9, 3.0 and 1.5 mgO (gTSS.h)⁻¹. Moreover, Tonkovic (1999) stated that intermittent aeration reduced phosphorus leaching by 50% or more, and biosolids from BNR treatment plants operating under long sludge ages leached very little phosphorus even under continuous aeration conditions. He ascribed this to the phosphorus being in a mineralized form contained within the lysed cell wall or as inorganic granules (polymer metal phosphorus complexes) within the cell proper.

Ju *et al.* (2005) conducted aerobic batch digestion tests of secondary sludges from a conventional and BNR WWTPs. From the conventional plant, they harvested fresh sludge from the returned activated sludge (RAS) of a secondary clarifier and digested the sludge within one hour of harvesting. The conventional WWTP, which used aeration ditches for the secondary biological treatment to remove ammonium and organic substances, had an average influent flow of ~3000-3500 l s⁻¹ (70-80 mgd) with biochemical oxygen demand (BOD₅), TSS and total kjeldahl nitrogen (TKN) concentrations of 100-110, 160 and 20 mg l⁻¹ respectively. The BOD₅ of the influent to the secondary treatment was 70-90 mg l⁻¹. The BNR WWTP, of an anaerobic/oxic (A/O) ditch process that consisted of a three-stage anaerobic selector (including a RAS denitrification stage and two subsequent anaerobic stages) and a single oxidation ditch, had a design capacity of 1.75 mgd (77 l s⁻¹). The typical influent TSS and TKN concentrations were 350 mg l⁻¹ and 40 mg l⁻¹ respectively. The sludge harvested from the BNR plant was shipped to the laboratory where the aerobic batch digestion tests were conducted. To remedy the extensive P release encountered in the anaerobic conditions during the shipment, samples of WAS and of the influent to the secondary treatment were shipped separately in ice packs. The sludge was reacclimatized in the laboratory using a sequential batch operation to simulate the plant condition. The sludge was mixed with the influent water at a ratio of 1:2 (the average ratio used in the plant) and the resultant mixed liquor was subjected to 1.5 h of gentle mixing without aeration, 26 h of aeration and 7 h of sludge settling. The settled sludge was then remixed with the influent sample from the BNR plant and the cycle of acclimation repeated. The sludge was acclimatized for 3-5 cycles before being collected for the digestion tests. The WAS from the conventional and BNR plants were batch digested under a combination of low aeration (DO: 0.8-2 mgO l⁻¹), high aeration (DO: 3-4 mgO l⁻¹) and cyclic aeration, and without and with pH control (@ 5.0, 5.5, 6.5, 6.8, and 7.0) in six runs at a room temperature (22 ± 2°C).

Ju *et al.* (2005) observed appreciable amounts of phosphorus release into the water along with the sludge digestion. Generally, they noted that the OP concentrations of the BNR WAS ($60 - 130 \text{ mg l}^{-1}$) were higher than that of the conventional WAS ($20 - 80 \text{ mg l}^{-1}$). For the conventional WAS, the OP concentrations under fully aerobic conditions with initial phosphorus content of the TSS ($(\text{P/TSS})_i$) of 2% and pH of 7.0 and 7.5 were ~ 29.9 and $\sim 28.8 \text{ mgOP l}^{-1}$ respectively, at the end of 16 days of detention time. For the BNR WAS, the OP concentrations under fully aerobic conditions with $(\text{P/TSS})_i$ of $\sim 3.6\%$ and pH of 6.5 was 82.4 mgOP l^{-1} while that with $(\text{P/TSS})_i$ of $\sim 7.3\%$ and pH of 7.0 was $102.9 \text{ mgOP l}^{-1}$. Besides, they reported that the initial phosphorus content of the TSS were higher for the BNR WAS (6 – 7%) than those of the conventional WAS (2 – 3.5%), and that the OP concentrations of the low DO ($0.8 - 2 \text{ mgO l}^{-1}$) and intermittent aerations were comparable, and were lower than those of the fully aerobic (DO of $3 - 4 \text{ mgO l}^{-1}$). The reaction rate constants, k_d , they obtained were lower for the conventional WAS ($0.006 - 0.024 \text{ h}^{-1}$) than for the BNR WAS ($0.002 - 0.008 \text{ h}^{-1}$), while for the BNR WAS at pH of 7.20 the k_d was 0.008 h^{-1} . For the conventional WAS, they stated that the pH decreased with increased DO, due to nitrification, and increased with decreasing DO, due to slower nitrification and occurrence of denitrification, in that the supernatant phosphorus profiles mirrored the profiles of the pH change. The formation of inorganic phosphorus precipitates they ascribed to the effect of pH. Moreover, they asserted that the P release from organic phosphorus was accompanied with VSS degradation.

2.5 Historical Developments

In view of WAS being predominantly biological solids, the most important reaction controlling the digestion of organic solids would be the microbial decay. It has been shown that the rate and extent of biological stabilization in aerobic digesters are significantly influenced by the operation conditions such as mixing rate, aeration time, reactor temperature, mean residence time of sludge, and oxygen uptake rate (Khalili *et al.*, 2000).

The rate at which biodegradable volatile solids are oxidized is a function of many factors such as (Kambhu and Andrews, 1969):

1. Concentration of biodegradable volatile solids
2. Temperature

3. Mixing
4. Oxygen transfer rate
5. Composition of solids
6. Concentration of nutrients
7. Concentration of micro-organisms
8. Type of micro-organisms
9. Physiological condition of micro-organisms

A number of batch aerobic digestion tests have been carried out to determine the reaction rate constant, k_d $\text{mgVSS}^{-1} \text{mgVSS}^{-1} \text{d}^{-1}$. As a result, varying values of reaction rate constants have been reported, in particular lower rates at longer sludge ages. For example, Krishnamoorthy and Loehr (1989) obtained values of decay coefficients for WAS ranging from 0.016 to 0.426 day^{-1} . Moreover, Mavinic and Koers (1979) reported that the endogenous decay rates based on VSS were not adequately described by a single k_d value. Instead, they found that two k_d values better fitted their data. These global (VSS specific) reaction rate constants, however, do not explicitly portray the decay rate of the OHOs which form part of the VSS. The unbiodegradable components of the VSS clearly can not be degraded further.

Marais and Ekama (1976) found the decay rate for OHOs, b_H to be 0.24 d^{-1} at 20°C . This rate is specific to the OHO biomass and has units $\text{mgOHOVSSdegraded} (\text{mgOHOVSSpresent})^{-1} \text{d}^{-1}$. From a number of tests on sludge samples from plants with sludge ages ranging from 2.5 to 20 days, but at the same temperatures, they found that b_H is constant and independent of sludge age. This resolved the long discussion in the literature in the 1970s on the variation of k_d with sludge age; while k_d based on VSS changes, b_H based on only the OHO part of the VSS does not. This, therefore, opened the way for developing general AS simulation models. Repeating the tests at 14°C and 8°C , they showed that b_H is not very temperature sensitive, i.e. $b_{HT} = 0.24 (1.029)^{(T-20)}$. Van Haandel *et al.* (1998) provided independent validation of a constant b_H value with sludge age and determined $b_{HT} = 0.24 (1.04)^{(T-20)}$ over the 20 to 30°C temperature range.

Dold *et al.* (1980) developed the death regeneration approach to modelling OHO loss. In this approach some OHOs actually die and lyse their biodegradable organics (which are slowly biodegradable particulate organics, SBCOD) to the bulk liquid. The surviving OHOs utilize this SBCOD as they would any SBCOD from the influent wastewater. They showed that

identical simulation results are obtained for the endogenous respiration and death-regeneration approaches if

$$b_H' = b_H \frac{(1 - f_{eH} f_{cv} Y_H)}{(1 - f_{cv} Y_H)} \quad (2.15)$$

$$f_{eH}' = f_{eH} \frac{(1 - f_{cv} Y_H)}{(1 - f_{eH} f_{cv} Y_H)} \quad (2.16)$$

where

b_H = OHO endogenous respiration rate (d^{-1})
= 0.24 at 20°C

b_H' = OHO death rate (d^{-1})
= 0.62 at 20°C

f_{eH} = endogenous residue of OHOs
= 0.20 in endogenous respiration model

f_{eH}' = unbiodegradable VSS in OHOs
= 0.92 in death regeneration model

Y_H = OHO yield coefficient
= 0.45 mgVSS mgCOD $^{-1}$

f_{cv} = OHO COD/VSS ratio
= 1.48 mgCOD mgVSS $^{-1}$

Van Haandel *et al.* (1981) extended the model of Dold *et al.* (1980) to include biological denitrification. With some further modifications to the kinetic equations describing the enmeshment, hydrolysis and utilization of SBCOD this model was adopted by the International Water Association (IWA) as ASM-1 (Henze *et al.*, 1987). Warner *et al.* (1986) applied the ND simulation model of van Haandel *et al.* (1981) and a steady state simplification of it, to anoxic-aerobic digestion and found that these models predicted the behaviour of the system very well. The recommended air off time for complete N removal in the intermittently aerated digester was 50% of the time in 4 to 6 hour cycles. Apart from N removal this mode of operation also obviated the need for lime addition to control pH (Warner *et al.*, 1985).

To include BEPR by PAOs into ASM-1, Wentzel *et al.* (1988) developed and tested enhanced PAO cultures in laboratory scale 3-stage Bardenpho and UCT BNR systems. These enhanced PAO cultures exhibited predominantly aerobic P uptake BEPR, and had negligibly little capacity for denitrification. From aerobic digestion batch tests on sludge harvested from these systems, they determined the PAO endogenous respiration rate at 20°C, b_{G20} to be 0.04 mgPAOVSS mgPAOVSS⁻¹ d⁻¹. This is very low – 1/6th of the OHOs. Due to the complexities and uncertainties of what happens to the internally stored substrate (polyhydroxyalkanoates, PHAs) and polyphosphate (PP) during death regeneration, the net effect endogenous respiration approach was maintained^a. The loss of PAO biomass results in a release of P to the bulk liquid but because the b_G rate is so slow, this release of P is small relative to the P uptake resulting from replenishment of internally stored PP chains in the “surviving” and newly grown PAO biomass. However, under aerobic digestion conditions in the absence of PHA formation and growth, the P release due to endogenous respiration will cause significant increase in bulk liquid P concentration.

The kinetics of P release, P uptake, growth and endogenous respiration of PAOs were included in the ND model of van Haandel *et al.* (1981) to form The University of Cape Town (UCT) model (UCTPHO, Wentzel *et al.*, 1992). The details of this model are described by Wentzel *et al.* (1988, 1992); suffice to say that the BEPR kinetics of these models are based exclusively on aerobic P uptake PAO behaviour. The aerobic P uptake BEPR kinetics were also included into ASM-1 to form ASM-2 (Henze *et al.*, 1995). This ASM-2 model will form the modelling basis of this investigation on aerobic digestion of BEPR WAS. A review of the Dold *et al.* (1980), van Haandel *et al.* (1981) and ASM-1 and ASM-2 simulation models is given by Hu *et al.* (2003) and is, therefore, not repeated here.

2.6 Steady State Models of Aerobic Digestion

During aerobic sludge stabilization, the biodegradable organic matter is stabilized to a point that it can be safely discharged to the environment. Generally, a significant percentage (40 to 60%) of the original organic residue remains after biological degradation (Higgins *et al.*,

^a It is suspected that the same complexities faced the developers of ASM-3 which considers that all substrate is first internally stored before utilization, and so applied the net effect endogenous respiration to OHOs, instead of death-regeneration model of biomass loss.

1982) since all the organic matter in wastewater sludges is ordinarily not susceptible to total oxidation.

Since the extent of the organic solid removal and effectiveness of aerobic digestion are controlled by the kinetics of the biological processes, most of the studies have attempted to identify the best proper kinetics of biodegradation for aerobic digesters. Consequently, there has been considerable interest in the development of kinetic equations that can be used to determine the reactor-residence times required to achieve a desired degree of solids destruction.

With the introduction of a term for the inert organic residue by Eckenfelder *et al.* (1961), most of the studies have concluded that the rate of destruction of biomass may be expressed as a first order function of the concentration of biodegradable biomass present. The first-order decay coefficient is recognized as a “pseudo-constant” whose value is affected by many factors.

Four models have been proposed to describe the kinetic behaviour of aerobic digestion of non-BEPR WAS: Adams *et al.* (1974), Marais and Ekama (1976), Benefield and Randall (1978), and Ekama *et al.* (2006).

2.6.1 Model of Adams, Eckenfelder and Stein (1974)

Adams *et al.* (1974) considered digestion of biological sludge only, that is, sludges derived from wastage of mixed liquor from the AS process, and sludges naturally wasted from trickling filters. This is the classical k_d model which considers a certain fraction of the measured VSS to be biodegradable. It does not include endogenous residue generation during aerobic digestion and so is not a true AS model derivative. The model assumes that only the VSS content of the sludge will decrease during digestion without loss of non-volatile (inorganic) suspended solids (ISS). Interestingly Ekama *et al.* (2006) show that the assumption of constant ISS during digestion is not correct (see below).

Based on observations of Eckenfelder and Ford (1970) and Benedek *et al.* (1972), Adams *et al.* (1974) approximated the destruction of volatile degradable organics in batch-fed reactors or continuously-fed plug flow systems by first order kinetics as follows^b:

$$\frac{X_{dt}}{X_{di}} = e^{-k_d t} \quad (2.17)$$

where:

X_{dt} = degradable VSS remaining after batch aeration time, t (mg l^{-1})

X_{di} = initial degradable VSS at time, 0 (mg l^{-1})

k_d = batch reaction rate for degradable VSS destruction (day^{-1})

t = time of aeration (days)

Therefore, under batch conditions, the degradable VSS at time t will be:

$$X_{dt} = X_{di} e^{-k_d t} \quad (2.18)$$

By incorporating the non-degradable residue, X_n they expressed the degradable VSS, X_d , as a function of total VSS, X_t :

$$X_{dt} = (X_e - X_n) \quad (2.19a)$$

$$X_{di} = (X_{oi} - X_n) \quad (2.19b)$$

where:

X_e = effluent total VSS remaining at time, t (mg l^{-1})

X_i = influent total VSS at time, 0 (mg l^{-1})

X_n = non-degradable portion of VSS, assumed constant throughout the aeration period (mg l^{-1})

Modifying Equation (2.17) to consider total VSS rather than degradable VSS by incorporating Equations (2.19a) and (2.19b):

^b For the sake of uniformity of notation the symbolic representations used by the authors is altered

$$\frac{(X_e - X_n)}{(X_i - X_n)} = e^{-k_d t} \quad (2.20)$$

The value of X_n was taken as that of the remaining VSS corresponding to that of zero degradable VSS value during the process of batch digestion.

Once the value of X_n is obtained, subtracting X_n from each X_e value at different specific times of the digestion process will give an estimate of the concentration of biodegradable material at the corresponding times. Plotting the $\log_{10}$ of X_e versus detention time would yield an approximate straight line with the intercept on the $\log_{10}$ axis giving an estimate of X_i , and the slope an estimate of k_d , i.e.

$$k_d = 2.303 * (\text{slope}).$$

2.6.2 Model of Marais and Ekama (1976)

The aerobic digestion model of Marais and Ekama (1976) is a particular application of their steady state model (SSM) for the AS process under purely aerobic conditions without influent feed. It is different to the Adams *et al.* (1974) model in that it included endogenous residue generation during digestion and in this respect is a true AS model derivative for aerobic digestion.

Based on the sub-division of the waste activated sludge fed into the aerobic digester into inert and active microbial masses, Marais and Ekama (1976) developed their aerobic digestion theory with the following four behavioural patterns:

- (i) Inert volatile material comprising endogenous residue and unbiodegradable particulate organics from the AS system, X_i (mgVSS l⁻¹), is unaffected by digestion
- (ii) Active volatile material (OHOs), X_a (mgAVSS l⁻¹), degrade at a specific endogenous respiration or mass loss rate of b_H in accordance with:

$$\frac{dX_a}{dt} = -b_H X_a \quad (2.21)$$

- (iii) A fraction of the active material that is degraded, f , remains as endogenous residue, X_e (mgVSS l⁻¹)

$$\frac{dX_e}{dt} = f\left(-\frac{dX_a}{dt}\right) = fb_H X_a \quad (2.22)$$

- (iv) The balance of the active material from (iii) above, $(1-f)X_a$ is utilized as substrate and oxidized with oxygen as electron acceptor. The COD (oxygen) equivalent of the VSS oxidized is $f_{cv} = 1.48$ mgCOD mgVSS⁻¹. Hence the oxygen demand for endogenous respiration,

$$O_e = f_{cv}\Delta VSS = f_{cv}(1-f)b_H X_a \quad (2.23)$$

During the aerobic batch digestion, the VSS at time t is

$$X_{vt} = X_{at} + X_{et} + X_{ft} \quad (2.24)$$

X_f remains constant and equal to X_{fi} , where as X_a and X_e are altered during the digestion process.

Equation (2.21) has the solution

$$X_{at} = X_{ai}e^{-b_H t} \quad (2.25)$$

From every unit of X_a that disappears, f units of X_e are generated, i.e.

$$X_{et} = f(X_{ai} - X_{at}) \quad (2.26)$$

Substituting X_{at} from Equation (2.25) into Equation (2.26)

$$X_{et} = fX_{ai}(1 - e^{-b_H t}) \quad (2.27)$$

The VSS at any time t , X_{vt} is given by

$$\begin{aligned}
X_{vt} &= X_{at} + X_{ct} + X_{li} \\
&= X_{ai}e^{-b_H t} + fX_{ai}(1 - e^{-b_H t}) + X_{li} \\
&= X_{ai}(1 - f)e^{-b_H t} + fX_{ai} + X_{li}
\end{aligned} \tag{2.28}$$

Rearranging and taking the natural log results in

$$\log_{10}(X_{vt} - fX_{ai} - X_{li}) = \log_{10}[X_{ai}(1 - f)] - b_H t \log_{10}e \tag{2.29}$$

In an aerobic batch digestion as the test proceeds X_a decreases and X_e increases at f (0.2) times the rate of decrease of X_a until eventually at $t = \infty$, $X_{a\infty} = 0$ and $X_{e\infty} = fX_{ai}$, and $X_{V\infty} = X_e + X_{li} = X_c$

Marais and Ekama (1976) proposed that a value of $X_c (= fX_{ai} + X_{li})$ be estimated and subtracted from X_{vt} and the difference plotted on $\log_{10}(X_{vt} - X_c)$ versus digestion time. If the value of X_c is selected too large the plot curves downwards, if too small it curves upwards and a lower linear least square regression coefficient would be obtained compared with the correct X_c which gives a straight line and minimizes the correlation coefficient (R^2). The slope of the line gives b_H and X_{ai} is determined from the intercept on the vertical axis.

For the determination of X_{ai} , citing the difficulty of measuring the mixed liquor volatile suspended solids (MLVSS) accurately, especially for sludges from plants with long sludge ages, Marais and Ekama (1976) proposed using the oxygen utilization rate (OUR).

The OUR for endogenous respiration, O_e is given by Equation (2.23). Substituting X_{at} from Equation (2.25) into Equation (2.23) gives

$$O_e = f_{cv}(1 - f)b_H X_{ai}e^{-b_H t} \quad (\text{mgO l}^{-1} \text{ d}^{-1}) \tag{2.30}$$

where $f_{cv} = \text{COD/VSS ratio} = 1.48 \text{ mgCOD mgVSS}^{-1}$.

Hence, a plot of $\log_{10}(O_e)$ versus time will give a linear line with the slope giving b_H , i.e.

$$b_H = 2.303 * (\text{slope})$$

And the intercept on the O_e axis (i.e. at $t = 0$) is the value $f_{cv}(1-f)b_H X_{ai}$. Hence, X_{ai} is determined from

$$X_{ai} = \frac{\text{Intercept}}{f_{cv}(1-f)b_H} \quad (2.31)$$

Marais and Ekama (1976) concluded that the OUR approach, as compared with using the VSS, is particularly useful because OUR can be measured much more accurately than VSS and can be automated with an online DO controller/OUR meter. Moreover, the batch volume does not decrease by sampling but evaporation water loss needs to be replaced daily.

Determination of b_H and X_{ai} by the OUR procedure requires that the value of f and f_{cv} be known. They, therefore, adopted a mean measured value of $1.48 \text{ mgCOD mgVSS}^{-1}$ for f_{cv} and 0.2 for f based on the findings of McKinney and Symons (1964).

With the occurrence of complete nitrification, they accounted the oxygen demand for nitrification by observing that a fraction, f_n with regard to the biodegradable material, i.e. $(1-f)$, is nitrogen released as ammonia and available for nitrification. This nitrogen fraction is then nitrified with the corresponding oxygen demand for nitrification. The nitrification oxygen demand is, then, given by

$$O_n = 4.57 f_n (1-f) b_H X_{ai} \quad (\text{mgO l}^{-1} \text{ d}^{-1}) \quad (2.32)$$

Substituting for X_{ai} from Equation (2.25)

$$O_n = 4.57 f_n (1-f) b_H X_{ai} e^{-b_H t} \quad (\text{mgO l}^{-1} \text{ d}^{-1}) \quad (2.33)$$

where

f_n = fraction of nitrogen in the active mass = $0.10 \text{ (mgN mgVSS}^{-1})$

4.57 = mass of oxygen required to nitrify 1 mg NH_3 to $\text{NO}_3\text{-N}$

The total oxygen demand at time t , O_{Tt} in a batch digester is therefore given by the sum of the carbonaceous and nitrification oxygen requirements

$$\begin{aligned}
 O_{Tt} &= O_c + O_n \\
 &= f_{cv}(1-f)b_H X_m e^{-b_H t} + 4.57 f_n (1-f)b_H X_{ai} e^{-b_H t} \\
 &= (f_{cv} + 4.57 f_n)(1-f)b_H X_{ai} e^{-b_H t}
 \end{aligned} \tag{2.34}$$

From Equation (2.33) it can be seen that nitrification does not affect the b_H determination because the slope of the $\log_{10}(O_{Tt})$ versus time remains unchanged, but the intercept on the vertical axis has increased. Nevertheless, the actual OHO concentration, X_{ai} can still be calculated from Equation (2.33).

The increase in the nitrate concentration in the digester as a result of complete nitrification is given by

$$\Delta N_{nt} = (X_{ai} - X_{at})(1-f)f_n \quad (\text{mgN l}^{-1}) \tag{2.35}$$

Substituting for X_{at} from Equation (2.25) into Equation (2.34) and simplifying yields

$$\Delta N_{nt} = X_{ai}(1 - e^{-b_H t})(1-f)f_n \quad (\text{mgN l}^{-1}) \tag{2.36}$$

Similarly, the phosphorus released through endogenous respiration, in the batch digester, will be

$$\Delta P_{st} = X_{ai}(1 - e^{-b_H t})(1-f)f_p \quad (\text{mgP l}^{-1}) \tag{2.37}$$

where f_p = fraction of phosphorus in the active mass (mgP mgVSS^{-1})

Utilization of the model for design hinges upon knowing the active and inert fractions of the feed sludge into the aerobic digester. This was obtained from the influent wastewater characteristics and design parameters of the AS system from which the WAS was harvested and their steady state AS model, of which the aerobic digester model is a subset. Marais and Ekama (1976) formulated, under steady state conditions, the following equation for the determination of the active fraction of the sludge,

$$X_a = \frac{Y_H \{S_{ii} (1 - f_{S'us} - f_{S'up}) - S_{be}\} \frac{R_s}{R_h}}{(1 + b_H R_s)} \quad \text{mgOHVSS l}^{-1} \quad (2.38)$$

where

- Y_H = growth yield coefficient (mgAVSS mgCOD⁻¹ utilized)
 S_{ii} = influent COD (mgCOD l⁻¹)
 S_{be} = effluent biodegradable COD, which is assumed zero (mgCOD l⁻¹)
 $f_{S'us}$ = unbiodegradable soluble COD fraction (mgCOD mgCOD⁻¹)
 $f_{S'up}$ = unbiodegradable particulate COD fraction (mgCOD mgCOD⁻¹)
 R_s = sludge age, in days
 R_h = hydraulic retention time, in days

The endogenous residue is given by

$$X_e = f b_H R_s X_a \quad \text{mgOHVSS l}^{-1} \quad (2.39)$$

and inert fraction is

$$X_i = X_{ii} \frac{R_s}{R_h} = \frac{f_{S'up} S_{ii}}{f_{cv}} \frac{R_s}{R_h} \quad \text{mgVSS l}^{-1} \quad (2.40)$$

The total VSS content of the sludge will, then, be

$$X_v = X_a + X_e + X_i \quad (2.41)$$

Substituting for X_a , X_e and X_i from Equations (2.38, 2.39 and 2.40) into Equation (2.41) and rearranging yields

$$X_v = \frac{Y_H \{S_{ii} (1 - f_{S'us} - f_{S'up}) - S_{be}\} \frac{R_s}{R_h}}{(1 + b_H R_s)} + f b_H R_s \left(\frac{Y_H \{S_{ii} (1 - f_{S'us} - f_{S'up}) - S_{be}\} \frac{R_s}{R_h}}{(1 + b_H R_s)} \right) + \frac{f_{S'up} S_{ii}}{f_{cv}} \frac{R_s}{R_h} \quad \text{mgVSS l}^{-1} \quad (2.42)$$

Simplifying and rearranging Equation (2.42) yields

$$X_v = \frac{S_{ii}}{R_h} \left\{ \frac{(1 - f_{S'us} - f_{S'up}) Y_H R_s}{(1 + b_H R_s)} (1 + f b_H R_s) + \frac{f_{S'up}}{f_{cv}} R_s \right\} \quad \text{mgVSS l}^{-1} \quad (2.43)$$

The OHO active fraction with respect to the VSS (f_{av}) is defined as

$$f_{av} = \frac{X_a}{X_v} \quad (2.44)$$

and

$$\frac{1}{f_{av}} = \frac{X_v}{X_a} \quad (2.45)$$

Hence from Equations (2.38) and (2.43):

$$\frac{1}{f_{av}} = \left[\frac{S_{ii}}{R_h} \left\{ \frac{(1 - f_{S'us} - f_{S'up}) Y_H R_s}{(1 + b_H R_s)} (1 + f b_H R_s) + \frac{f_{S'up}}{f_{cv}} R_s \right\} \right] \left[\frac{1}{\frac{Y_H \{S_{ii} (1 - f_{S'us} - f_{S'up}) - S_{be}\} R_s}{(1 + b_H R_s)} R_h} \right] \quad (2.46)$$

Simplifying and rearranging Equation (2.46) yields

$$\frac{1}{f_{av}} = (1 + f b_H R_s) + \frac{(1 + b_H R_s) f_{S'up}}{f_{cv} Y_H (1 - f_{S'us} - f_{S'up})} \quad (2.47)$$

2.6.3 Model of Benefield and Randall (1978)

Owing to the reported decrease in fixed (inorganic) suspended solids (ISS) during digestion of WAS by Randall *et al.* (1975), Benefield and Randall (1978) developed a model, based on TSS, for aerobic digestion process.

With the following assumptions:

- (1) the TSS are composed of an active fraction and an inactive fraction;

- (2) the inactive fraction of the influent TSS is nondegradable, that is, material which cannot be oxidized or solubilised through microbial activity;
- (3) the active fraction of the influent TSS is composed of nondegradable and degradable fractions where degradable describes material which can be oxidized or solubilised through microbial activity;
- (4) only the degradable active fraction of the total suspended solids decreases during digestion

they developed the following relationships^c:

$$X_{Tnoi} X_{Ti} + X_{Taoi} X_{Ti} - f_T X_{Taoi} X_{Ti} = X_{Tne} X_{Te} \quad (2.48)$$

$$f_T X_{Taoi} X_{Ti} + D X_{Tadi} X_{Ti} = X_{Tae} X_{Te} \quad (2.49)$$

$$X_{Tnoi} X_{Ti} = X_{Tni} X_{To} \quad (2.50)$$

$$X_{Tadi} X_{Ti} + X_{Taoi} X_{Ti} = X_{Tai} X_{Ti} \quad (2.51)$$

$$X_{Tai} X_{Ti} + X_{Tni} X_{Ti} = X_{Ti} \quad (2.52)$$

$$X_{Tne} X_{Te} + X_{Tae} X_{Te} = X_{Te} \quad (2.53)$$

where

X_{Ti} = TSS concentration in influent to digester

X_{Te} = TSS concentration in effluent from digester

X_{Tai} = active fraction of the TSS concentration in the influent

X_{Tni} = fraction of the TSS concentration in the influent which is inactive

X_{Tadi} = degradable portion of active fraction of the TSS concentration in the influent

X_{Taoi} = nondegradable portion of active fraction of the TSS concentration in the influent

X_{Tnoi} = nondegradable portion of the inactive fraction of the TSS concentration in the influent

X_{Tae} = active fraction of the TSS concentration in the effluent

X_{Tne} = fraction of the TSS concentration in the effluent which is inactive

f_T = fraction of nondegradable active biomass in the influent that passes through the digestion process and appears as active nondegradable biomass in the effluent

D = fraction of degradable active biomass in the influent that appears as degradable active biomass in the effluent

^c For the sake of uniformity of notation the symbolic representations used by the authors is altered

- K_d = decay rate of the degradable fraction of the active biomass approximated from the decrease in TSS
- t_d = digestion time

Defining K_d as the active degradable biomass lost per unit time of active degradable biomass in the system:

$$\begin{aligned} \text{Active degradable biomass lost through microbial activity} &= K_d t_d [DX_{Tadi} X_{Ti}] \\ &= X_{Tadi} X_{Ti} - DX_{Tadi} X_{Ti} \end{aligned} \quad (2.54)$$

which reduces to

$$K_d t_d = \frac{(1-D)}{D} \quad (2.55)$$

Equation (2.47) can be rearranged into the form

$$X_{Taoi} X_{Ti} - f_T X_{Taoi} X_{Ti} = X_{Tne} X_{Te} - X_{Tnoi} X_{Ti} \quad (2.56)$$

Substituting for $f_T X_{Taoi} X_{Ti}$ in Equation (2.48) from Equation (2.49) gives

$$X_{Taoi} X_{Ti} - (X_{Tae} X_{Te} - DX_{Taoi} X_{Ti}) = X_{Tne} X_{Te} - X_{Tnoi} X_{Ti} \quad (2.57)$$

A further substitution can be made for $X_{Taoi} X_{Ti}$ from Equation (2.51) and for $X_{Tnoi} X_{Ti}$ from Equation (2.50):

$$X_{Tai} X_{Ti} - X_{Tadi} X_{Ti} - X_{Tae} X_{Te} + DX_{Tadi} X_{Ti} = X_{Tne} X_{Te} - X_{Tni} X_{Ti} \quad (2.58)$$

Rearranging, this expression can be written as

$$(X_{Tai} + X_{Tni}) X_{Ti} + X_{Tadi} X_{Ti} (D-1) = (X_{Tae} + X_{Tne}) X_{Te} \quad (2.59)$$

From Equations (2.52) and (2.53) we see that

$$(X_{Tai} + X_{Tni}) = X_{Tae} + X_{Tne} = 1 \quad (2.60)$$

Thus, Equation (2.59) can be expressed as

$$X_{Ti} + X_{Tadi} X_{Ti} (D - 1) = X_{Te} \quad (2.61)$$

or

$$(1 - D) = \frac{X_{Ti} - X_{Te}}{X_{Ti} X_{Tadi}} \quad (2.62)$$

Substituting for (1-D) from Equation (2.55) into Equation (2.62) and solving for t_d yields

$$t_d = \frac{(X_{Ti} - X_{Te})}{K_d D X_{Tadi} X_{Ti}} \quad (2.63)$$

With the findings of Kountz and Forney (1959) that approximately 77 percent of a biological cell is degradable, Equation (2.63) can be modified as

$$t_d = \frac{(X_{Ti} - X_{Te})}{K_d 0.77 D X_{Tai} X_{Ti}} \quad (2.64)$$

The applicability of this TSS based aerobic digestion model to experimental data under completely mixed aerobic digestion conditions that are from sources other than Benefield and Randall (1978) was not explored in this review. This is because recently Ekama and Wentzel (2004) extended the steady state VSS based AS model to include the ISS and hence also the TSS for aerobic and N removal systems (based on OHOs) and BEPR systems (based on PAOs). This model extension is reviewed below because Ekama *et al.* (2006) used it to develop a TSS based aerobic digestion model for aerobic and N removal WAS (including OHOs only). This ISS AS model has not been applied to aerobic digestion of BEPR system WAS. This aspect will be explored in this investigation.

2.6.4 Aerobic Digestion Model of Ekama, Wentzel and Sötemann (2006)

Ekama and Wentzel (2004) developed a predictive model of the ISS concentration in the activated sludge reactor. This model is an extension of the Wentzel *et al.* (1990) VSS and COD based AS model for NDBEPR systems and considers accumulation of influent ISS in the reactor in proportion to sludge age and an OHO and PAO biomass ISS content. This biomass ISS content is not real, it consists of dissolved intracellular inorganics which precipitate in the drying step of the VSS-TSS test procedure. The OHO and PAO ISS content (f_{iOHO} and f_{iPAO}) were found to be

$$f_{iOHO} = 0.15 \text{ mgISS mgOHOVSS}^{-1} \quad (2.65)$$

$$f_{iPAO} = f_{iPAOBM} + 3.286(f_{XBGP} - f_{XBGPBM}) \quad (2.66)$$

$$f_{XBGP} = f_{XBGPBM} + f_{XBGP}$$

$$f_{XBGPBM} = 0.03 \text{ mgP mgPAOVSS}^{-1}$$

$$f_{iPAOBM} = 0.15 \text{ mgISS mgPAOVSS}^{-1} \text{ (without polyphosphate)}$$

where

f_{iOHO} = inorganic suspended solids content of OHO cell mass ($\text{mgISS mgOHOVSS}^{-1}$)

f_{iPAO} = inorganic suspended solids content of PAOs ($\text{mgISS mgPAOVSS}^{-1}$)

f_{iPAOBM} = ISS content of PAO cell mass ($\text{mgISS mgPAOVSS}^{-1}$)

f_{XBGP} = total P content of PAOs (mgP mgPAOVSS^{-1})

f_{XBGPBM} = P content of the PAO cell mass (mgP mgPAOVSS^{-1})

f_{XBGP} = polyphosphate content of PAOs ($\text{mgPP mgPAOVSS}^{-1}$)

3.286 = ISS content of the PAO intracellular polyphosphate (mgISS mgPP^{-1})

The model was validated with experimental data from 21 investigations collected over 15 years on 30 aerobic and anoxic-aerobic ND AS systems and 18 NDBEPR systems operated on artificial and real wastewater and at sludge ages from 3 to 20 days.

Ekama *et al.* (2006) included in the ISS model the steady state AS model for OHOs only and applied it to aerobic digestion of ND system WAS to produce a TSS based aerobic digester model using influent and effluent active fractions with respect to TSS as inputs. They also reworked the VSS based aerobic digester model of Marais and Ekama (1976) in terms of influent and effluent active fractions with respect to VSS. The model shows a decrease in ISS

with digestion time as OHO biomass decreases, as noted and modelled in a different way by Benefield and Randall (1978).

In the interest of brevity the derivation of these models are not presented here; the equations for the single reactor flow through aerobic digester are given in Table 2.1 (Ekama *et al.*, 2006).

As part of their SSM validation Ekama *et al.* (2006) also incorporated the OHO based ISS model into ASM-1. They found that the ASM-1 model predictions matched very closely the prediction of the SSM and the experimental data of van Haandel *et al.* (1998).

As indicated above, Ekama *et al.* (2006) applied their VSS-TSS aerobic digester models only to WAS from ND AS systems. They did not develop a OHO and PAO based steady state aerobic digestion model in terms of VSS and TSS applicable to NDBEPR system WAS. A SSM for aerobic digestion of NDBEPR sludge, therefore, does not exist. It is the intention in this investigation to develop such a model by considering the endogenous respiration process of PAOs. To provide a theoretical modelling basis to interpret experimental aerobic digestion data of NDBEPR WAS, the ISS model for OHOs and PAOs (Equation 2.65 and 2.66) will be integrated into ASM-2 in this investigation. The ISS ASM-2 model will then be used to simulate the parent NDBEPR system from which WAS will be harvested for batch aerobic digestion tests, and the batch digestion tests themselves.

Table 2.1. Equations of the steady state aerobic digestion model of Ekama, Wentzel and Sötteman (2006)

Parameter	Model in terms of VSS	Model in terms of TSS
Influent active fraction (f_{avi} , f_{ati})	$\beta = \frac{1}{f_{avi}} - (1 - f_{EH}) \dots (1)$	$\delta = \frac{1}{f_{ati}} - (1 - f_{iOHO}) \dots (11)$
Effluent active fraction (f_{ave} , f_{ate})	$\alpha = \frac{1}{f_{ave}} - (1 - f_{EH}) \dots (2)$	$\gamma = \frac{1}{f_{ate}} - (1 - f_{iOHO}) \dots (12)$
Retention time (R_h , d)	$R_h = \frac{1}{b_{HT}} \left[\frac{\alpha}{\beta} - 1 \right] \dots (3)$	$R_h = \frac{\gamma - \delta}{b_{HT}(\delta + f_{EH})} \dots (13)$
Effluent active fraction (f_{ave} , f_{ate})	$\alpha = \beta(1 + b_{HT}R_h) \dots (4)$	$\gamma = \delta + b_{HT}R_h(\delta + f_{EH}) \dots (14)$
Fraction of solids removed (f_{vst} , f_{tst})	$f_{vst} = f_{avi}(1 - f_{EH})(1 - \frac{\beta}{\alpha}) \dots (5)$	$f_{tst} = 1 - \frac{f_{ati}}{f_{ate}(1 + b_{HT}R_h)} \dots (15)$
Organic oxygen demand (kgO/d)	$V_d O_c = f_{cv} f_{vst} Q_i X_w \dots (6)$	$V_d O_c = f_{ct} Q_i X_w f_{tst} (1 - f_{EH}) / (1 + f_{iOHO} - f_{EH}) \dots (16)$
Nitrification oxygen demand (kgO/d)	$V_d O_n = 4.57 f_n f_{vst} Q_i X_w \dots (7)$	$V_d O_n = 4.57 f_n Q_i X_w f_{tst} (1 - f_{EH}) / (1 + f_{iOHO} - f_{EH}) \dots (17)$
Total oxygen demand (kgO/d)	$V_d O_t = (f_{cv} + 4.57 f_n) f_{vst} Q_i X_w \dots (8)$	$V_d O_t = (f_{ct} + 4.57 f_n) Q_i X_w f_{tst} (1 - f_{EH}) / (1 + f_{iOHO} - f_{EH}) \dots (18)$
Effluent ammonia concentration (mgN/l)	$N_{oe} = N_{ne} = f_n X_w f_{vst} \dots (9a \& 9b)$	$N_{oe} = N_{ne} = f_n X_w f_{tst} (1 - f_{EH}) / (1 + f_{iOHO} - f_{EH}) \dots (19a \& 19b)$
Effluent ortho-P concentration (mgP/l)	$P_{se} = f_p X_w f_{vst} \dots (10)$	$P_{se} = f_p X_w f_{tst} (1 - f_{EH}) / (1 + f_{iOHO} - f_{EH}) \dots (20)$
VSS/TSS ratio	$f_{ii} = \frac{f_{ati}}{f_{avi}} \dots (21)$ $f_{ie} = \frac{f_{ate}}{f_{ave}} \dots (22)$ $f_{ie} = \frac{(1 - f_{vst})}{(1 - f_{tst})} f_{ii} \dots (23a)$ $f_{ie} = \frac{f_{ii} [1/(b_H R_h) + 1] - f_{ati}(1 - f_{EH})}{[(1/(b_H R_h) + 1) - f_{ati}(1 + f_{iOHO} - f_{EH})]} \dots (23b)$	

Notes: (1) For known influent active fraction (f_{avi} , f_{ati}) if (i) effluent active fraction is specified (i.e. a level of sludge stability), then use Eqs. 2 or 12 to calculate α or γ and Eqs. 3 or 13 to calculate the required retention time (R_h) or (ii) if R_h is known, then use Eqs. 4 or 14 to calculate α or γ and Eqs. 2 or 12 to calculate the resulting effluent active fraction.

(2) Symbols: f_{avi} , f_{ati} , f_{ave} , f_{ate} = active fraction with respect to VSS (subscript v) and TSS (subscript t) for the influent (subscript i) and effluent (subscript e) sludges, f_{vst} , f_{tst} = fraction of VSS (subscript v) and TSS (subscript t) solids removed; f_{ii} , f_{ie} = VSS/TSS ratio of the influent (subscript i) and effluent (subscript e) solids; V_d = digester volume; Q_i = influent flow; O_c , O_n and O_t = organic, nitrification and total oxygen utilization rates – mgO(l.d)⁻¹; f_{EH} , and b_{HT} = unbiodegradable fraction and endogenous respiration rate of the OHOs in the endogenous respiration model (i.e. 0.20 and 0.24 d⁻¹ at 20°C); f_{iOHO} = ISS content of the OHOs = 0.15 mgISS mgOHOVSS⁻¹; N_{oe} , N_{ne} and P_{se} are the effluent ammonia (no nitrification, $N_{ne} = 0$), nitrate (complete nitrification, $N_{ne} = 0$) and phosphorus concentrations.

2.7 Model Validation

2.7.1 VSS-based

The models of Adams *et al.* (1974) and of Marais and Ekama (1976) are VSS-based, while the model of Ekama *et al.* (2006) is both VSS and TSS based. However, under batch conditions the models of Marais and Ekama (1976) and the VSS-based model of Ekama *et al.* (2006) are similar. Therefore, the results of the model of Marais and Ekama (1976) will apply to the VSS-based model of Ekama *et al.* (2006). The data of Adams *et al.* (1974) will be used for comparative validation of these models.

Table 2.2. Comparison of experimental batch aerobic digestion data of Adams *et al.* (1974) with the equivalent values computed with the models of Adams *et al.* (1974) and of Marais and Ekama (1976)

Retention Time (d)	VSS Remaining (mgVSS l ⁻¹)			Degradable VSS Remaining (mgVSS l ⁻¹)		
	Experiment	Adam's (X _n =1760)	Marais' (X _c =1820)	Experiment	Adam's	Marais'
0	6115.00	6115.00	6055.00	4355.00	4355.00	4235.00
1	4220.00	4024.93	4067.78	2460.00	2264.93	2247.78
3	2770.00	3184.68	3152.62	1010.00	1424.68	1332.62
5	2510.00	2656.14	2610.05	750.00	896.14	790.05
7	2280.00	2323.69	2288.39	520.00	563.69	468.39
9	1975.00	2114.57	2097.69	215.00	354.57	277.69
11	2105.00	1983.03	1984.63	345.00	223.03	164.63
13	1925.00	1900.29	1917.60	165.00	140.29	97.60
15	1760.00	1848.24	1877.86	0.00	88.24	57.86
17	1775.00	1815.51	1854.31	15.00	55.51	34.31

The models of Adams *et al.* (1974) and of Marais and Ekama (1976) are similar. The main difference lies in the way the X_n and X_c are determined. In the model of Adams *et al.* (1974) X_n is estimated as the VSS remaining at the end of 'complete' digestion of the degradable VSS. In the model of Marais and Ekama (1976) X_c is computed as the sum of the X_{li} (influent inert material) and the X_c (unbiodegradable residue accumulated during the digestion process). Apart for this difference in the calculation of the X_n and X_c, the simulated concentrations of the two models were equivalent.

2.7.2 TSS-based

The model of Benefield and Randall (1978) is TSS-based. Under batch conditions, unlike that of the model of Adams *et al.* (1974), the model of Benefield and Randall (1978) does not give a fixed unbiodegradable TSS except for the inclusion of the findings of Kountz and Forney where approximately 77 percent of a biological cell is degradable. Moreover, the model of Benefield and Randall (1978) considers, under completely mixed aerobic digester conditions, only the influent and effluent TSS with their respective various components. Though the model assumes that a portion of the active influent TSS is nondegradable, it does not assign a quantitative value to this nondegradable active TSS nor does it account for a generation of inert TSS (endogenous residue) concentration during aerobic digestion. Hence, determination of instantaneous TSS concentrations (TSS at time t) is not possible even if an assumed active fraction of the effluent TSS is assigned. As the model of Benefield and Randall (1978) cannot be employed under aerobic batch conditions its validation cannot be performed.

The model of Ekama *et al.* (2006) is both VSS and TSS based. These VSS and TSS based models were validated with aerobic digester data of van Haandel *et al.* (1998) and a very good correlation was obtained between predicted and measured results (Ekama *et al.*, 2006)

2.8 Closure

In this chapter the aerobic digestion process as mediated by the OHOs, PAOs and ANOs was described. The stoichiometric relations of the occurring biological process, the factors affecting the processes and the transformations occurring during the aerobic digestion process were explained. The historical development of understanding, explaining and representing the aerobic digestion process were presented. The refinement, through time, of the reaction rate constants and the specific death rate were addressed. Representation of the decay rate during the aerobic digestion process in terms of endogenous respiration and death regeneration models were discussed. Moreover, the historical development and comparison of the existing steady state aerobic digestion models were presented. Except for the different ways of determining the X_n (Adam *et al.*) and X_c (Marais and Ekama), the models of Adams, Eckenfelder and Stein (1974) and of Marais and Ekama (1976) are similar. Application of the

model of Benefield and Randall (1978) under aerobic batch digestion can not be realized since the model does not assign a quantitative value to the nondegradable active TSS though the model assumes that a portion of the active influent TSS is nondegradable; nor does the model of Benefield and Randall (1978) account for a generation of inert TSS (endogenous residue) concentration during aerobic digestion. From this review, pH and temperature have a major influence on the aerobic digestion process. Especially in the aerobic digestion of BEPR WAS, it became clear that pH change can result in precipitation of inorganic phosphorus. Hence, this study of aerobic digestion of BEPR WAS was conducted with controlled pH (7.20) and complete nitrification to keep the ammonia concentration low, to control inorganic phosphorus precipitation, and in a temperature-controlled laboratory (at 20°C), for optimum biological activity. Most of the aerobic digestion studies are conducted on non-BEPR WAS which in turn shows the necessity of conducting aerobic digestion of BEPR WAS.

CHAPTER 3

EXPERIMENTAL SET UP AND PROCEDURES

3.1 Experimental set up

3.1.1 Parent system

The generator reactor (parent system) from which the WAS that was tested under aerobic digestion conditions was harvested is a UCT configuration membrane (MBR) bioreactor BNR system. The influent raw wastewater fed to the MBR UCT system was collected from the Mitchell's Plain WWTP in Cape Town (South Africa) which treats primarily domestic wastewater, with a small (< 10%) industrial component. The MBR UCT system was fed 800 mgCOD l⁻¹ raw wastewater supplemented with 200 mgCOD l⁻¹ sodium acetate (to increase the biological P removal) and ammonium chloride and di-hydrogen potassium orthophosphate to increase the COD, TKN and phosphorus to 1000 mgCOD l⁻¹, 100 mgN l⁻¹ and 40 mgP l⁻¹ respectively.

The MBR UCT system comprised an anaerobic-anoxic-aerobic sequence of reactors with volumes of 25, 19 and 35 l and mass fractions of 0.126, 0.279 and 0.595 respectively (Figure 3.1). The system had a 20 days sludge age, was fed 140 l d⁻¹ influent flow and 2.9 l d⁻¹ waste sludge was taken directly from the aerobic reactor for sludge age control. Mixed liquor was recycled from the anoxic to anaerobic, and aerobic to anoxic reactors at ratios of 1:1 and 3:1 of the influent flow respectively. The mixed liquor suspended solids (MLSS) and MLVSS concentrations in the aerobic reactor were around 16800 mgTSS l⁻¹ and 13600 mgVSS l⁻¹ respectively, with lower concentrations in the anoxic and anaerobic reactors due to the lower concentration inflows to these reactors.

As the name implies, the MBR UCT system was equipped with five double-sided Kubota® panel membranes with total surface area of 0.586 m² acting as solid-liquid separators. The membranes were submerged in the aerobic reactor and scoured by a coarse bubble aeration system which also supplied the required oxygen demand for the biological reactions. The effluent flow through the membranes was collected via flexible silicone tubing connected to

the membrane outlets, into a common rigid polyvinyl chloride (PVC) pipe that exited through the reactor sidewall.

The sewage feed was collected from the WWTP in 2 m³ batches, trucked to the laboratory, macerated and stored in 400 l stainless steel drums refrigerated at 4°C. A sewage batch served as feed for approximately two weeks. Daily the raw sewage in one of the stainless steel tanks was thoroughly mixed, then the required volume withdrawn via a valve outlet pipe at the bottom of each tank and strained through a 1mm mesh. The appropriate volume of the screened sewage was then poured into a 200 l plastic drum where it was mixed with a tablespoon of sodium bicarbonate. The required volumes of sodium acetate, di-hydrogen potassium orthophosphate and ammonium chloride solutions were then added, and the volume made up to the required amount with tap water so that the final COD concentration was as close as possible to the target 800 mgCOD l⁻¹. Once the feed mix had been prepared in this manner, after taking a 200 ml sample, it was poured into the feed tank of the MBR UCT system. The feed bucket was maintained upright in a chest refrigerator at about 4 to 8°C and its content was gently stirred at about 10 rpm by paddle mixer to prevent sedimentation of particulates. The wastewater feed was continuously pumped for 24 h through an outlet at the bottom of the feed tank via silicon tubing.



Figure 3.1. Schematic diagram of the MBR UCT system

As part of a different research project the MBR UCT system was tested every 2nd day for all the required parameters such as influent, reactor and effluent COD, VSS, TSS, TKN, FSA, TP, OP, nitrite, nitrate, oxygen utilization rate (OUR), diluted sludge volume index (DSVI). The data collected in this way was averaged over a sewage batch (SB). The SB averages reflected the system performance over that SB. For details see du Toit *et al.* (2006). The SB average influent COD, TKN, FSA, TP, OP and measured readily biodegradable COD (RBCOD^a) concentrations and the system operating parameters constituted the input to ASM-2 simulation model to simulate the system performance. In the simulation model a number of influent wastewater characteristics and kinetic constants were adjusted so that the predicted performance matched that measured in the MBR UCT system. This was done for the SBs during which batch aerobic digestion tests were conducted to determine the theoretical initial concentrations for the batch tests. The batch tests themselves were also simulated with the calibrated ASM-2 model to compare predicted results with those measured in the batch tests. This procedure is described in greater detail below.

3.1.2 Batch aerobic reactor

The batch aerobic digestion reactor was a 5 l cylindrical Perspex vessel with graduations for measuring the level of the sludge in the reactor. The bottom of the reactor had a hole for coupling a tube for aeration. The removable top lid of the reactor had a hole for inserting DO and pH probes and for taking samples. The sludge was continuously mixed by paddle agitators driven by an electric motor mounted on top of the lid. The concentration of the DO in the reactor was controlled within the range of 2 to 5 mgO l⁻¹ by a DO controller/OUR meter. Low-pressure compressed air was used for aeration. The air was humidified by passing it through a flask partially filled with water and entered the reactor via a diffuser stone placed at the bottom of the reactor. The air supply was automatically switched on by the DO controller/OUR meter when the DO concentration drops below 2 and switches off when it reached 5 mgO l⁻¹.

The DO concentration, and concomitantly the OUR was measured continuously and automatically using a YSI Model 5739 DO probe and HiTech MicroSystem DO and OUR

^a Measured with a dedicated square wave fed RBCOD AS system fed the same wastewater and with floc-filtered influent and effluent COD concentrations (see du Toit *et al.*, 2006)

meter. The OUR is calculated with a statistical linear least-square regression analysis on the accumulated data pairs of DO and time during air-off period. The DO data stored in the DO and OUR meter over 24 h together with the OUR values and corresponding correlation coefficients were down loaded with a cable connection to a personal computer (PC) and copied into a spreadsheet program for further analysis.

The schematic set-up of the batch aerobic digestion reactor is given in Figure 3.2.

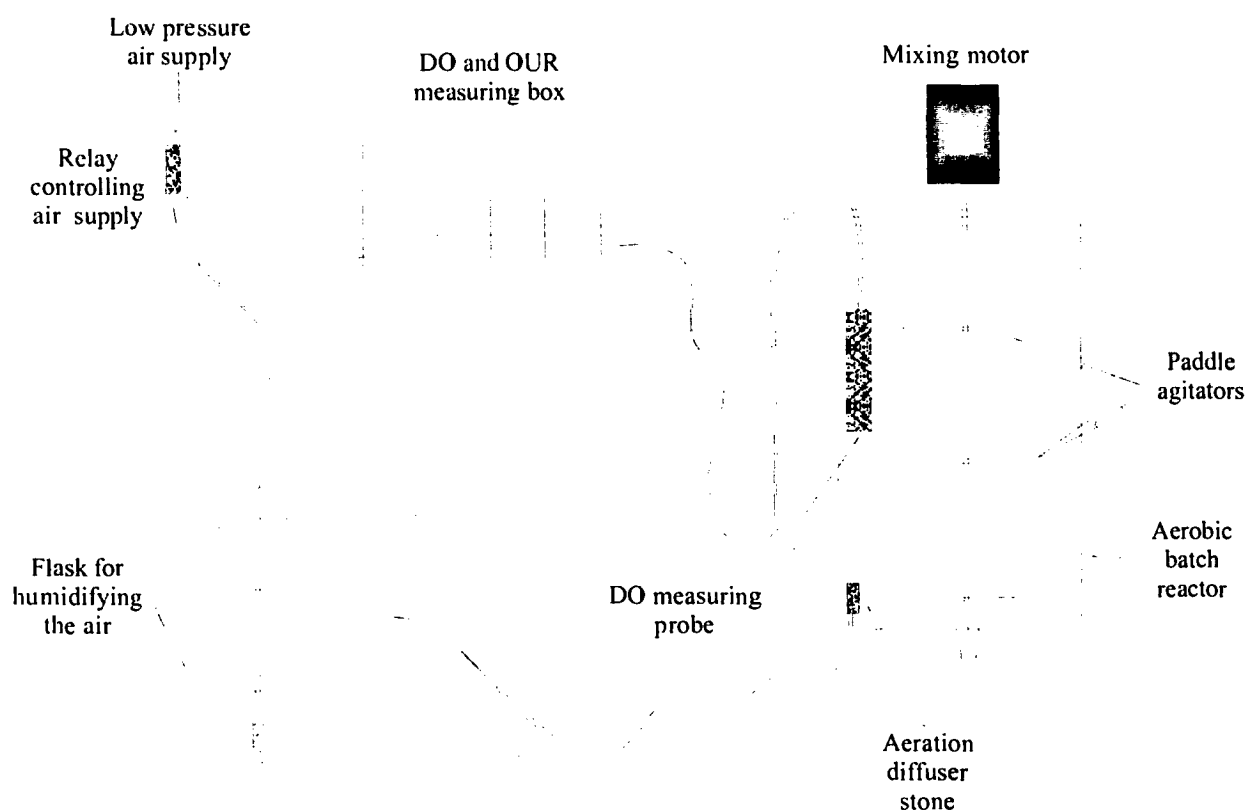


Figure 3.2. Schematic diagram of the batch aerobic digester reactor

3.2 Experimental Procedures

Eight aerobic digestion batch tests (BT) with detention times ranging from 6 to 25 days were carried out at 20°C. For the first six batch tests, 5 l of undiluted sludge was harvested from the aerobic reactor of the MBR UCT system and aerobically digested for about 20 days. These six batch test (BT-1 to BT-6) were done when the MBR UCT system was fed SBs 1, 2, 2, 5, 26, and 28. The last two batch tests, i.e. BT-7, with undiluted aerobic reactor sludge and

BT-8, with diluted aerobic reactor sludge, were done simultaneously during SB 30 to compare the effect of the initial concentration of the WAS on the aerobic digestion kinetics. These two batch tests had a volume of 3 l each. The source WAS for these two batch tests was taken as a single volume of sludge from the MBR UCT system. BT-7 was fed 3 l of undiluted sludge while 0.6 l of undiluted sludge diluted 5 times, i.e. 0.6 l of WAS plus 2.4 l of distilled water was fed into BT-8.

For batch tests 1, 2 and 3 the sludge harvested from the MBR UCT system was collected over several days and stored in a cold room at 4°C. Before feeding into the aerobic batch reactors, the harvested sludge was brought to a room temperature (20°C) by placing the container with the WAS in a warm water bath. After reaching 20°C the temperature was maintained at 20°C because the batch tests were conducted in the temperature-controlled laboratory of the Water Research Group at UCT. For batch tests 4, 5 and 6, only freshly harvested sludge was fed into the aerobic reactors. Similarly, only freshly wasted sludge was used for the last two batch tests 7 and 8.

Evaporation loss in the batch tests was minimized by using humidified air and was determined by measuring the level of the sludge in the reactor each day. The evaporation loss was then compensated by adding an equivalent amount of distilled water to the reactor. By regularly cleaning and brushing the sludge that got stuck on the side wall of the reactor, all the contents of the reactor was kept in solution/suspension during the batch tests.

At the beginning of each day during the batch test, 150 ml of sample was taken from the batch reactor for analysis. Prior to taking the sample, pH was measured and if below 7.2 adjusted to 7.2. This was done by adding a measured amount of sodium bicarbonate (NaHCO_3) from a prepared stock solution. The volume, and therefore, the concentration of the sodium bicarbonate added were recorded. The pH was measured with a calibrated pH probe immersed in the aerated sludge mass.

A sample was taken daily from the batch reactor. A drop of polyelectrolyte flocculant (1 g l^{-1}) was added to the samples to make subsequent filtering easier. The sample taken was centrifuged at 3500 rpm for 10 min. All the supernatant was retained for further analysis. Part of the supernatant was filtered through $0.45 \mu\text{m}$ membrane filters for filtered-sample analysis and the rest was used for unfiltered-sample analysis. The filtered and unfiltered sample

volumes remaining after performing some analysis were preserved by adding one drop of mercuric chloride (8 g l^{-1}) and kept in a cold room at 4°C .

After centrifugation, the centrifuged solids were placed in a crucible by rinsing all the solids content of the centrifuge tube into a crucible for VSS and TSS analysis. Before use, empty crucibles were cleaned, dried, labelled and weighed on an airtight digital scale with 0.1 mg resolution. The crucibles with solids were put in an oven for 12 hrs at 110°C . After removal from the oven, the crucibles containing the dried solids were put in a dessicator to cool down. The crucibles were weighed and incinerated in an oven for 20 min at 600°C . Thereafter, the crucibles were returned to the dessicator and their weights taken after cooling. From these measurements the VSS and TSS concentrations were calculated.

The COD, FSA, TKN, TP, OP, nitrite and nitrate analyses were carried out using standard procedures as set out in the Laboratory Procedures – Wastewater treatment laboratory manual (Lakay *et al.*, 2000) and Standard Methods (1995).

For filtered and unfiltered COD analyses, 10 ml duplicate samples of each were used with a pair of flasks with 10 ml distilled water serving as blanks. Into each 250 ml Erlenmeyer flask were added 10 ml of distilled water, approximately 0.04 mg of mercuric sulphate (HgSO_4) powder, 5 ml of potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) with normality of 0.25N and 15 ml of concentrated sulphuric acid (H_2SO_4) (37.52N , as supplied at 1840 g l^{-1}) with predissolved AgSO_4 . Following thorough mixing the flasks were placed on a heating pad for 2 hrs. Once they were cooled off, approximately 80 ml of distilled water was poured through the top opening of the condenser tubes to rinse the side walls. After adding 2 drops of ferroin indicator, each flask was titrated with standardized 0.05N ferrous ammonium sulphate ($\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2$). The COD concentration was calculated from the average of the sample and blank titration volumes. For high COD concentrations such as unfiltered samples, the samples were first diluted into the range of the above COD procedure ($0 - 1000 \text{ mgCOD l}^{-1}$).

For FSA and TKN analyses, 10 ml of filtered and unfiltered samples, respectively, were pipetted into 100 ml bulb TKN flasks. For TKN analysis, after adding 2 glass beads, 10 ml distilled water and a 10 ml of digestion mix into each flask, they were placed on a heating pad and boiled until the samples were clear ($\sim 2 \text{ hrs}$) and thereafter allowed to cool. After this digestion step, the flasks were fitted to a steam distillation unit. To each bulb flask about 10

ml of distilled water was added to dissolve the sediment. For FSA analysis the flasks were fitted into a distillation unit after the addition of filtered sample and 10 ml of distilled water. Conical flasks with 25 ml of boric acid (H_3BO_3) solution were placed at the receiving ends of the steam distillation apparatus. After adding 7 ml of 1N sodium hydroxide (NaOH), the contents of the bulb flasks were boiled until the volume of the conical flasks with boric acid reached about 50 ml. After steam distillation the conical flasks with boric acid were titrated with standard 0.001N sulphuric acid solution. The FSA and TKN concentrations were calculated from the titrant volumes. For high TKN and FSA concentrations, the samples were appropriately diluted so that the titrant volume would not exceed 50 ml.

Nitrite and nitrate analysis were done on a Technicon Auto Analyzer, in accordance with the testing procedure given in Technicon Auto-Analyser Methodology (Industrial Methods 33-69W), with the nitrate reduction to nitrite and formation of a soluble pink dye which is measured colorimetrically representing the original nitrite present plus that formed from nitrate. The filtered samples were appropriately diluted to ensure the nitrite and nitrate samples fell into the 0 to 2 mgN l⁻¹. The diluted samples were put in the auto analyser together with nine evenly spaced standards of nitrite and nitrate concentration solutions. Taking due account of the dilutions, the concentrations of the samples were determined from the plotted graphs in comparison with the standards.

For TP and OP analyses, 10 ml of unfiltered and filtered samples, respectively, were used. In separate boiling tubes 20 ml of distilled water, 20 ml of standard solutions of 5, 10, 15, 20 and 25 ppm, and 10 ml of sample and 10 ml of distilled water were pipetted. Into each tube 5 ml of potassium persulphate solution and 5 ml sulphuric acid solution were added. After closing with aluminium foil, the tubes were placed in a hot water bath (96°C) for 1h. After cooling down the samples were filtered and 5 ml of filtrate was placed in smaller tubes to which 5 ml of vanadomolybdate solution was added. The tubes were covered with 'parafilm' plastic and shaken for thorough mixing. After 20 minutes for colour development the samples were analysed with a UNICAM 8625 UV/VIS spectrometer at microwave length of 470 μm .

The inorganic carbon system alkalinity (H_2CO_3^*) analyses were carried out using the 5 pH point titration procedure of Moosbrugger *et al.* (1992). A beaker containing 10 ml of filtered sample diluted to 50 ml with distilled water was placed on a slow magnetic stirrer. A

calibrated pH probe was dipped into the solution. After recording the initial pH and temperature, the sample was titrated from its initial pH to four further pH points symmetrically spaced about the $H_2CO_3^*-HCO_3^-$ and $HA_C-A_C^-$ pK values, with dosing increments of 0.02 ml of titrant (hydrochloric acid). The pH, temperature and dosage of titrant added were recorded at each pH point. The alkalinity (and volatile fatty acids, VFA, which was zero) of the sample was computed by inserting the recorded pHs, temperature and titrant volumes into the computer program TITRA5.

The calcium and magnesium analyses were carried out in the Laboratory of the Department of Chemical Engineering to the University of Cape Town using atomic adsorption spectroscopy analysis with atomic-adsorption spectrometer Varian AA 110 Model.

3.3 Modelling and Simulation

The SB average results of the parent system and the batch digestion results were both simulated with ASM-2 in the computer program AQUASIM. All the compounds and system descriptions required by ASM-2, such as the measured characteristics of the influent, sizes of the anaerobic, anoxic and aerobic reactors, mixed liquor recycle ratios, along with the process configuration, of the MBR UCT system were written into the AQUASIM computer program. The ASM-2 simulated values were then compared with the measured mixed liquor, waste and effluent concentrations of the various parameters of the MBR UCT system. Some kinetic and stoichiometric constants were modified to achieve the best correlation between predicted and measured results (see below). The predicted results of the parent system provided initial condition input data for the batch test simulations with ASM-2. The batch test simulation results were then compared with those measured.

3.3.1 Model description

The mathematical description of the ASM-2 is presented in a matrix format in Appendix C1. The matrix contains fifteen compounds of interest and seventeen processes. The symbols of the compounds are placed on the head of the matrix identified with index "i" for the range of the compounds, i.e., 1 through 15. The biological processes occurring in the system, identified with the index "j", are listed on the left end column of the matrix. The

mathematical formulations of the process rates (denoted by ρ_j) are described on the right end column of the matrix. Along with the units of measurement, the compounds of interest are defined in their respective column at the bottom of the matrix. It is noteworthy to mention that all the compounds are measured in COD units, including the sludge organic solids, resulting in the ease of conservation, rate tracking and calculation.

The intersection of a pertinent compound (i) with a process (j) signifies the stoichiometric coefficient, denoted by v_{ij} . A specific stoichiometric coefficient could have a positive or negative sign depending on whether it represents growth/production or death/consumption, respectively. This, therefore, signifies the behaviour at a single point in the system. The matrix format enables the presentation of the lengthy and separate equations describing biological processes in a compact form and easy visualization of the flow and interaction of the different compounds and rates.

The different components of the VSS, TSS, COD, nitrogen, phosphorus and oxygen constitute the fifteen compounds. Similarly, the different processes of the OHOs, PAOs and autotrophic nitrifying organisms (ANOs) associated with growth and death, along with the hydrolysis of the particulate biodegradable substrate make up the seventeen processes of the ASM-2 model.

3.3.2 Inclusion of the ISS model into the ASM-2

In contrast to organic models, predictive models for the reactor ISS, and hence the TSS ($\text{TSS} = \text{VSS} + \text{ISS}$) concentrations have not been included in simulation models (Ekama and Wentzel, 2004). In ASM-1 the ISS is empirically calculated from an assumed VSS/TSS ratio, without inclusion of a fundamentally based predictive model for the accumulation of ISS in the reactor. The principle of Gujer (1993), i.e. calculating TSS from stoichiometric TSS/COD ratios for the individual mixed liquor organic compounds, is employed in ASM-2. Hence, the TSS concentration is computed via stoichiometric TSS/COD ratios for the active biomass (for OHO, PAO and ANO), $i_{\text{TSSBM}} = 0.90 \text{ mgTSS mgCOD}^{-1}$, for slowly biodegradable particulate substrate, $i_{\text{TSSX}_s} = 0.75 \text{ mgTSS mgCOD}^{-1}$, for unbiodegradable (inert) organic matter, $i_{\text{TSSX}_i} = 0.75 \text{ mgTSS mgCOD}^{-1}$ and for the polyphosphate (PP) content of the PAOs $3.23, \text{ mgISS (mgP-PP)}^{-1}$ (Henze *et al.*, 2000). The difference between TSS and VSS is then the ISS. The

model has no provision for including the ISS concentration in the influent. Therefore, the ISS model, developed by Ekama and Wentzel (2004), which recognizes influent and OHO and PAO biomass ISS, was incorporated into the ASM-2 to replace the TSS/COD ratios.

The ISS model of Ekama and Wentzel (2004) was reviewed in Chapter 2 and is readily incorporated into ASM-2. The influent ISS, X_{loi} accumulation in the reactor is proportional to sludge age (R_s) and inversely proportional to average nominal hydraulic retention time (R_h), the OHO ISS contribution is proportional to the OHO biomass concentration ($f_{\text{OHO}} = 0.15 \text{ mgISS mgOHOVSS}^{-1}$ or $0.10 \text{ mgISS mgOHOCOD}^{-1}$) and the PAO ISS contribution is proportional to the PAO biomass concentration (also $0.10 \text{ mgISS mgPAOCOD}^{-1}$) and the PAO P content (f_{XBGP}), which is obtained in the model from the simulated BEPR behaviour.

3.3.3 Model calibration

The ASM-2 was calibrated by using the measured SB average data of the MBR UCT system. First, the predicted P removal for the measured influent RBCOD concentration was reconciled with that measured. For all the SBs, the predicted P removal was higher than that measured. Because the P uptake behaviour in MBR UCT system was predominantly aerobic, as in the ASM-2 model, the predicted P removal was higher because (i) the P content of the PAO is higher than that measured due to a higher P uptake to poly- β -hydroxybutyrate (PHB) utilized (P uptake/PHB) ratio or (ii) the PAO concentration was lower because they did not take up all the influent RBCOD in the anaerobic reactor. So to match the predicted P removal to that measured for (i) the rate constant for storage of poly-P (q_{pp}) was decreased and for (ii) the anaerobic RBCOD fermentation rate (q_{Fe}) was decreased. Both options were simulated. Once the predicted and measured P removal matched by adjusting q_{pp} or q_{Fe} , the unbiodegradable particulate COD fraction ($f_{\text{S,up}}$) was varied until the predicted VSS matched that measured. Some very minor adjustment of q_{pp} and q_{Fe} was required to rematch the predicted and measured P removal because $f_{\text{S,up}}$ has a very small influence on P removal. Once the measured and predicted VSS matched, the influent ISS concentration was adjusted until the predicted and measured TSS matched. The infrequently measured influent ISS concentration matched this calibrated values quite closely. Once calibrated in this way, COD, N and P mass balances of the simulated results were checked.

Based on the average SB influent values, COD, N and P mass balances of the simulated values of the MBR UCT system were found to range from 99.8 to 100.5, 99.8 to 100.0 and 99.9 to 100.2%, respectively (Appendix A3 to A11), which is acceptable and an indication that the model was giving consistent and reliable results. Since the aerobic digestion tests were carried on the sludge harvested from the MBR UCT system, no further calibration was done on the ASM-2 model for simulating the aerobic batch digestion tests.

For the aerobic batch digestion simulations, the measured initial concentrations were taken as the initial values for simulation. For model parameters with no corresponding measured values, such as the concentration of poly phosphate (PP), the fraction of SBCOD, etc., the initial concentrations of the particulate components were determined from the ratios of the predicted VSS and TSS concentrations to the initial measured batch test concentrations. These ratios reflected the degree of dilution/concentration that took place between harvesting the sludge from the MBR UCT system and filling the batch reactor. The initial dissolved concentrations were not changed from those measured, or in the absence of measured data, those simulated for the particular SB were used. The batch test predicted and measured data were plotted graphically for each batch and evaluated. This is presented in Chapter 5.

CHAPTER 4

DEVELOPMENT OF BATCH REACTOR AND STEADY STATE MODELS FOR AEROBIC DIGESTION OF WAS FROM BEPR AS SYSTEMS

4.1 Batch Aerobic Digester (Batch Reactor Model)

4.1.1 VSS based

Based on the model of Marais and Ekama (1976), a VSS-based batch reactor model (BRM) for aerobic batch digestion of WAS from BEPR AS systems was developed.

In the development of the model the following assumptions were made:

- (i) Inert volatile material, X_I (mgVSS l^{-1}) is unaffected by digestion
- (ii) The active OHOs, X_H (mgAOHOVSS l^{-1}) degrade at a specific endogenous respiration or mass loss rate of b_H in accordance with:

$$\frac{dX_H}{dt} = -b_H X_H \quad (4.1)$$

where $b_H = 0.24 \text{ day}^{-1}$ at 20°C

- (iii) A fraction of the active OHOs that is degraded, f_H remains as endogenous residue, X_{eH} (mgVSS l^{-1})

$$\frac{dX_{eH}}{dt} = f_H \left(-\frac{dX_H}{dt} \right) = f_H b_H X_H \quad (4.2)$$

- (iv) The active PAOs, X_G (mgAPAOVSS l^{-1}) degrade at a specific endogenous respiration or mass loss rate of b_G in accordance with:

$$\frac{dX_G}{dt} = -b_G X_G \quad (4.3)$$

- (v) A fraction of the active PAOs that is degraded, f_G remains as endogenous residue, X_{eG} (mgVSS l⁻¹)

$$\frac{dX_{eG}}{dt} = f_G \left(-\frac{dX_G}{dt} \right) = f_G b_G X_G \quad (4.4)$$

- (vi) The balance of the active OHOs and PAOs from (iii) and (v) above, i.e. $(1 - f_H)b_H X_H$ and $(1 - f_G)b_G X_G$ are utilized catabolically as substrate and oxidized with oxygen as electron acceptor,

$$\frac{dOU_H}{dt} = O_{eH} = f_{cvH} (1 - f_H) b_H X_H \quad (\text{mgO l}^{-1} \text{ d}^{-1}) \quad (4.5)$$

$$\frac{dOU_G}{dt} = O_{eG} = f_{cvG} (1 - f_G) b_G X_G \quad (\text{mgO l}^{-1} \text{ d}^{-1}) \quad (4.6)$$

$$O_e = O_{eH} + O_{eG} \quad (\text{mgO l}^{-1} \text{ d}^{-1}) \quad (4.7)$$

where

- X_H = Concentration of active OHOs (mg l⁻¹)
- X_{eH} = Concentration of endogenous residue of the OHOs (mg l⁻¹)
- b_H = OHOs endogenous respiration rate, (day⁻¹)
- f_H = Fraction of endogenous residue of the OHOs
- f_{cvH} = COD/VSS ratio of the OHOs (mgCOD mgOH OVSS⁻¹)
- O_{eH} = OUR at any time t associated with the OHOs (mgO l⁻¹ d⁻¹)
- OU_H = Oxygen utilized by the OHOs (mgO d⁻¹)
- X_G = Concentration of active PAOs (mg l⁻¹)
- X_{eG} = Concentration of endogenous residue of the PAOs (mg l⁻¹)
- b_G = PAOs endogenous respiration rate, (day⁻¹)
- f_G = Fraction of endogenous residue of the PAOs
- f_{cvG} = COD/VSS ratio of the PAOs (mgCOD mgPAO VSS⁻¹)
- O_{eG} = OUR at any time t associated with the PAOs (mgO l⁻¹ d⁻¹)
- OU_G = Oxygen utilized by the PAOs (mgO d⁻¹)
- O_e = OUR for endogenous respiration (mgO l⁻¹ d⁻¹)

$f_H = 0.8$

During the aerobic batch digestion, the VSS at time t , X_{Vt} is

$$X_{Vt} = X_{Ht} + X_{Gt} + X_{eHt} + X_{eGt} + X_{It} \quad (4.8)$$

where

X_{Ht} = Concentration of active OHOs at time t (mg l^{-1})

X_{Gt} = Concentration of active PAOs at time t (mg l^{-1})

X_{eHt} = Concentration of endogenous residue of the OHOs at time t (mg l^{-1})

X_{eGt} = Concentration of endogenous residue of the PAOs at time t (mg l^{-1})

X_{It} = Concentration of inert material at time t (mg l^{-1})

The inert material, X_I remains constant and equal to the influent inert material, X_{Ii} whereas X_H , X_G , X_{eH} and X_{eG} are altered during the digestion process.

The degradation of the active OHOVSS, X_H is given by Equation (4.1) which has the solution

$$X_{Ht} = X_{Hi} e^{-b_H t} \quad (4.9)$$

where X_{Hi} = Initial concentration of active OHOs (mg l^{-1})

From every unit of X_H that disappears, f_H units of X_{eH} are generated, i.e.

$$X_{eHt} = f_H (X_{Hi} - X_{Ht}) \quad (4.10)$$

where $f_H = 0.20$

Substituting from Equation (4.9) into Equation (4.10) and simplifying yields

$$X_{eHt} = f_H X_{Hi} (1 - e^{-b_H t}) \quad \checkmark \quad (4.11)$$

The degradation of the active PAOVSS, X_G is given by Equation (4.3) which has the solution

$$X_{Gt} = X_{Gi} e^{-b_G t} \quad (4.12)$$

where X_{Gi} = Initial concentration of active PAOs (mg l^{-1})

From every unit of X_G that disappears, f_G units of X_{eG} are generated, i.e.

$$X_{eGt} = f_G (X_{Gi} - X_{Gt}) \quad (4.13)$$

where $f_G = 0.25$

Substituting from Equation (4.12) into Equation (4.13) and simplifying yields

$$X_{eGt} = f_G X_{Gi} (1 - e^{-b_G t}) \quad (4.14)$$

Hence, the total concentration of the endogenous residue at time t , X_{et} in the batch aerobic digester is given by

$$\begin{aligned} X_{et} &= X_{eHt} + X_{eGt} \\ &= f_H X_{Hi} (1 - e^{-b_H t}) + f_G X_{Gi} (1 - e^{-b_G t}) \end{aligned} \quad (4.15)$$

The VSS concentration at any time t , X_{vt} in the batch aerobic digester is given by Equation (4.8). Substituting from Equations (4.9), (4.12) and (4.15) into Equation (4.8) yields

$$X_{vt} = X_{Hi} e^{-b_H t} + X_{Gi} e^{-b_G t} + f_H X_{Hi} (1 - e^{-b_H t}) + f_G X_{Gi} (1 - e^{-b_G t}) + X_{li} \quad (4.16)$$

Simplifying and rearranging Equation (4.16) yields

$$X_{vt} = X_{li} \{ f_H + (1 - f_H) e^{-b_H t} \} + X_{Gi} \{ f_G + (1 - f_G) e^{-b_G t} \} + X_{li} \quad (4.17)$$

The change (reduction) in VSS concentration at any time t , ΔX_{vt} is given by

$$\Delta X_{vt} = X_{vi} - X_{vt} \quad (4.18)$$

where X_{Vi} = Initial concentration of the VSS (mg l^{-1})

Substituting from Equation (4.17) into Equation (4.18) yields

$$\Delta X_{Vi} = (X_{Hi} + X_{Gi} + X_H) - [X_{Hi} \{f_H + (1 - f_H)e^{-b_H t}\} + X_{Gi} \{f_G + (1 - f_G)e^{-b_G t}\} + X_H] \quad (4.19)$$

Simplifying and rearranging Equation (4.19) yields

$$\Delta X_{Vi} = \{X_{Hi}(1 - f_H)(1 - e^{-b_H t})\} + \{X_{Gi}(1 - f_G)(1 - e^{-b_G t})\} \quad (4.20)$$

The fraction of VSS removed (VSS destruction) at any time t , f_{Vrt} is given by

$$f_{Vrt} = \frac{\Delta X_{Vi}}{X_{Vi}} \quad (4.21)$$

Substituting from Equation (4.20) into Equation (4.21) yields

$$f_{Vrt} = \frac{X_{Hi}(1 - f_H)(1 - e^{-b_H t}) + X_{Gi}(1 - f_G)(1 - e^{-b_G t})}{X_{Vi}} \quad (4.22)$$

If $\frac{X_{Hi}}{X_{Vi}} = f_{aHVi}$ (initial active fraction of the OHOVSS) and $\frac{X_{Gi}}{X_{Vi}} = f_{aGVi}$ (initial active fraction of the PAOVSS), then

$$f_{Vrt} = f_{aHVi}(1 - f_H)(1 - e^{-b_H t}) + f_{aGVi}(1 - f_G)(1 - e^{-b_G t}) \quad (4.23)$$

The concentration of the organic N released into the bulk liquid as ammonia and subsequently nitrified to nitrate is equal to the N content of the VSS concentration removed.

Accepting the N content of the OHO and PAOVSS to be f_n , the nitrate concentration in the batch aerobic digester at any time t will be

$$N_{nt} = f_n X_{Vi} f_{Vrt} \quad (\text{mgNO}_3\text{-N l}^{-1}) \quad (4.24)$$

where $f_n = 0.10 \text{ mgN mgVSS}^{-1}$

Substituting from Equation (4.22) into Equation (4.24) yields

$$N_{nt} = f_n X_{Vi} \frac{X_{Hi}(1 - f_H)(1 - e^{-b_H t}) + X_{Gi}(1 - f_G)(1 - e^{-b_G t})}{X_{Vi}} \quad (\text{mgNO}_3\text{-N l}^{-1}) \quad (4.25)$$

Simplifying and rearranging Equation (4.25) yields

$$N_{nt} = f_n \{X_{Hi}(1 - f_H)(1 - e^{-b_H t}) + X_{Gi}(1 - f_G)(1 - e^{-b_G t})\} \quad (\text{mgNO}_3\text{-N l}^{-1}) \quad (4.26)$$

The concentration of the P released into the bulk liquid appearing as OP is the sum of the P contents of the OHOs and PAOs removed.

The OHOVSS removed, f_{HVRT} at time t will be

$$f_{HVRT} = \frac{\Delta X_{Ht}}{X_{Vi}} = \frac{X_{Hi} - X_{Ht}}{X_{Vi}} \quad (4.27)$$

Substituting from Equation (4.9) into Equation (4.27) and simplifying yields

$$f_{HVRT} = \frac{\Delta X_{Ht}}{X_{Vi}} = \frac{X_{Hi} - (X_{Hi} e^{-b_H t})}{X_{Vi}} = f_{aHVi}(1 - e^{-b_H t}) \quad (4.28)$$

and the PAOVSS removed, f_{GVRT} at time t will be

$$f_{GVRT} = \frac{\Delta X_{Gt}}{X_{Vi}} \quad (4.29)$$

Substituting from Equation (4.12) into Equation (4.29) and simplifying yields

$$f_{GVt} = \frac{\Delta X_{Gt}}{X_{Vi}} = \frac{X_{Gi} - (X_{Gi} e^{-b_{Gi}t})}{X_{Vi}} = f_{aGVt} (1 - e^{-b_{Gi}t}) \quad (4.30)$$

Accepting the P content of the OHOs to be f_{pH} , the contribution of the OP concentration of the OHOs in the batch aerobic digester at any time t will be

$$P_{sHt} = f_{pH} X_{Vi} f_{HVT} \quad (\text{mgOP l}^{-1}) \quad (4.31)$$

Substituting from Equation (4.28) into Equation (4.31) yields

$$P_{sHt} = f_{pH} f_{aHVi} X_{Vi} (1 - e^{-b_{Ht}t}) \quad (\text{mgOP l}^{-1}) \quad (4.32)$$

where $f_{pH} = 0.03 \text{ mgP mgOHVSS}^{-1}$ (Wentzel *et al.*, 1990)

Accepting the P content of the PAOs to be f_{pG} , the contribution of the OP concentration of the PAOs in the batch aerobic digester at any time t will be

$$P_{sGt} = f_{pG} X_{Vi} f_{GVt} \quad (\text{mgOP l}^{-1}) \quad (4.33)$$

Substituting from Equation (4.30) to Equation (4.33) yields

$$P_{sGt} = f_{pG} f_{aGVt} X_{Vi} (1 - e^{-b_{Gt}t}) \quad (\text{mgOP l}^{-1}) \quad (4.34)$$

where $f_{pG} = 0.38 \text{ mgP mgPAOVSS}^{-1}$ (Wentzel *et al.*, 1990)

Therefore, the total OP concentration in the batch aerobic digester at any time t will be

$$\begin{aligned} P_{sTt} &= P_{sHt} + P_{sGt} \\ &= f_{pH} f_{aHVi} X_{Vi} (1 - e^{-b_{Ht}t}) + f_{pG} f_{aGVt} X_{Vi} (1 - e^{-b_{Gt}t}) \quad (\text{mgOP l}^{-1}) \end{aligned} \quad (4.35)$$

The OUR at any time t associated with the OHOs, O_{Ht} in the batch aerobic digester is

$$O_{Ht} = \frac{1}{24} (1 - f_H) f_{cvH} b_H (X_{Ht}) \quad (\text{mgO l}^{-1} \text{ h}^{-1}) \quad (4.36)$$

Substituting from Equation (4.9) into Equation (4.36) yields

$$O_{Ht} = \frac{1}{24} (1 - f_H) f_{cvH} b_H X_{Ht} e^{-b_H t} \quad (\text{mgO l}^{-1} \text{ h}^{-1}) \quad (4.37)$$

The OUR at any time t associated with the PAOs, O_{Gt} in the batch aerobic digester is

$$O_{Gt} = \frac{1}{24} (1 - f_G) f_{cvG} b_G X_{Gt} \quad (\text{mgO l}^{-1} \text{ h}^{-1}) \quad (4.38)$$

Substituting from Equation (4.12) into Equation (4.38) yields

$$O_{Gt} = \frac{1}{24} (1 - f_G) f_{cvG} b_G X_{Gt} e^{-b_G t} \quad (\text{mgO l}^{-1} \text{ h}^{-1}) \quad (4.39)$$

The carbonaceous (endogenous respiration) OUR at any time t , O_{ct} in the batch aerobic digester is the sum of the OUR of the OHOs and the PAOs, i.e.

$$O_{ct} = O_{Ht} + O_{Gt} \quad (\text{mgO l}^{-1} \text{ h}^{-1}) \quad (4.40)$$

Hence,

$$O_{ct} = \frac{1}{24} [\{(1 - f_H) (f_{cvH} b_H X_{Ht} e^{-b_H t})\} + \{(1 - f_G) (f_{cvG} b_G X_{Gt} e^{-b_G t})\}] \quad (\text{mgO l}^{-1} \text{ h}^{-1}) \quad (4.41)$$

With the occurrence of complete nitrification, the nitrification OUR in the batch aerobic digester at any time t , O_m is

$$O_m = \frac{4.57}{24} f_n \{(1 - f_H) (b_H X_{Ht} e^{-b_H t}) + (1 - f_G) (b_G X_{Gt} e^{-b_G t})\} \quad (\text{mgO l}^{-1} \text{ h}^{-1}) \quad (4.42)$$

where 4.57 = mgO required per mgNH₄-N nitrified to NO₃-N

$$\int \frac{dX}{dt} = -bX$$

The total OUR, with complete nitrification, in the batch aerobic digester at any time t , O_T will, then, be the sum of the carbonaceous and nitrification OUR, i.e.

$$O_T = O_{cl} + O_{nt} \quad (\text{mgO l}^{-1} \text{ h}^{-1}) \quad (4.43)$$

Substituting from Equation (4.41) and (4.42) into Equation (4.43) yields

$$O_T = \frac{1}{24} [\{(1-f_H)(f_{cvH} b_H X_{Hi} e^{-b_H t})\} + \{(1-f_G)(f_{cvG} b_G X_{Gi} e^{-b_G t})\}] + \frac{4.57}{24} f_n \{(1-f_H)(b_H X_{Hi} e^{-b_H t}) + (1-f_G)(b_G X_{Gi} e^{-b_G t})\} \quad (\text{mgO l}^{-1} \text{ h}^{-1}) \quad (4.44)$$

Simplifying and rearranging Equation (4.44) yields

$$O_T = \frac{1}{24} \{(f_{cvH} + 4.57 f_n)(1-f_H)(X_{Hi} b_H e^{-b_H t}) + (f_{cvG} + 4.57 f_n)(1-f_G)(X_{Gi} b_G e^{-b_G t})\} \quad (\text{mgO l}^{-1} \text{ h}^{-1}) \quad (4.45)$$

If $\frac{X_{Hi}}{X_{Vi}} = f_{aHV_i}$ (initial active fraction of the OHOVSS) and $\frac{X_{Gi}}{X_{Vi}} = f_{aGV_i}$ (initial active fraction of the PAOVSS), then

$$\frac{O_T}{X_{Vi}} = \frac{1}{24} \{(f_{cvH} + 4.57 f_n)(1-f_H)(f_{aHV_i} b_H e^{-b_H t}) + (f_{cvG} + 4.57 f_n)(1-f_G)(f_{aGV_i} b_G e^{-b_G t})\} \quad (\text{mgO [mgVSS.l.h]}^{-1}) \quad (4.46)$$

where O_T/X_{Vi} is the total OUR per influent VSS into the aerobic digester.

Similarly, multiplying both sides of Equation (4.45) by the volume of the digester and 24 hrs

per day and noting that $\frac{MX_{Hi}}{MX_{Vi}} = f_{aHV_i}$ and $\frac{MX_{Gi}}{MX_{Vi}} = f_{aGV_i}$ results in

$$\frac{MO_{T_i}}{MX_{V_i}} = (f_{cvH} + 4.57f_n)(1 - f_H)(f_{aH}b_H e^{-b_H t}) + (f_{cvG} + 4.57f_n)(1 - f_G)(f_{aG}b_G e^{-b_G t}) \quad (4.47)$$

(kgO kgVSS⁻¹ day⁻¹)

where MO_{T_i}/MX_{V_i} is the mass of oxygen required per day per kgVSS sludge load per day.

Steady State BEPR model of Wentzel *et al.* (1990)

Wentzel *et al.* (1990) developed a steady state BEPR model as a simplification of their kinetic model. Though the models apply strictly for enhanced cultures of polyP and non polyP organisms, with modification application is made for mixed cultures. For model development see Wentzel *et al.* (1990). The diagrammatic representation is given in Figure 4.1.

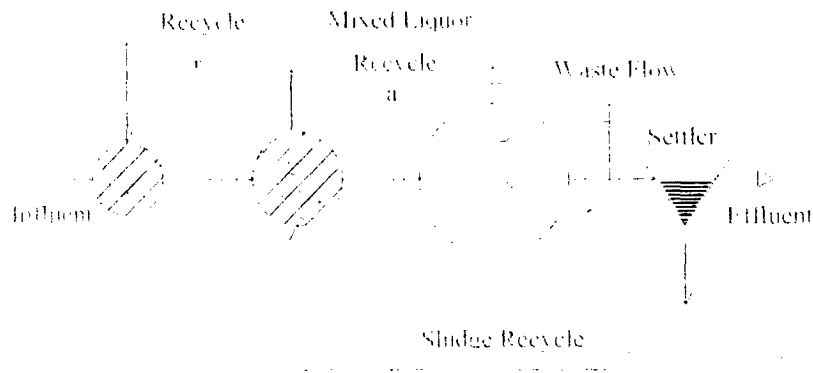


Figure 4.1. The UCT system

Hence, from the equations developed by Wentzel *et al.* (1990) for biological excess phosphorus removal – steady state process design, the biological active mass of the PAOs

generated in the BEPR AS system, the WAS of which becomes the influent active PAO mass to the aerobic digester, is given by

$$MX_G = \frac{Y_G MS_{seq} R_s}{(1 + b_G R_s)} \quad \text{mgPAOVSS} \quad (4.48)$$

And

$$MS_{seq} = MS_{CON} + Q_i S_{bsai} \quad \text{mgPAOVSS} \quad (4.49)$$

$$MS_{CON} = Q_i [S'_{bsfi} - (1 + r) S_{bsfN}] \quad (4.50)$$

$$S'_{bsfi} = S_{bsfi} - 8.6(rNO_{3r} + NO_{3i}) - 3.0(rO_r + O_i) \quad (4.51)$$

$$S_{bsfN} = \frac{S'_{bsfi} / (1 + r)}{[1 + K_{CT} \frac{f_{xa}}{N_r} \{MX_H / Q_i / (1 + r)\}]^n} \quad (4.52)$$

$$\frac{MX_H}{Q_i} = \frac{[S_{bi} - \{S'_{bsfi} - (1 + r) S_{bsfN} + S_{bsai}\}] Y_H R_s}{(1 + b_H R_s)} \quad (4.53)$$

where

- MX_G = Biological active mass of the PAOs generated in the BEPR AS system (mgAPAOVSS)
- Y_G = PAOs yield (mgAPAOVSS mgCOD⁻¹)
- MS_{seq} = Mass of substrate sequestered by the PAOs in the anaerobic reactor (mgCOD d⁻¹)
- R_s = Sludge age of the BEPR AS system
- MS_{CON} = Fermentable RBCOD (F-RBCOD) converted to SCFA
- Q_i = Influent average dry weather flow to BEPR system (l day⁻¹)
- S_{bsai} = SCFA in the influent (mgCOD l⁻¹)
- S'_{bsfi} = F-RBCOD available for conversion per litre of influent (mgCOD l⁻¹)
- S_{bsfN} = RBCOD concentration leaving the nth anaerobic reactor in the series of N anaerobic reactors (mgCOD l⁻¹)
- S_{bsfi} = Influent F-RBCOD concentration (mgCOD l⁻¹)
- r = Recycle ratio to the anaerobic reactor with respect to the influent flow of the

BEPR AS system

- NO_{3r} = Nitrate recycled to the anaerobic reactor of the BEPR AS system
 NO_{3i} = Nitrate in the influent to the anaerobic reactor of the BEPR AS system
 O_r = Oxygen recycled to the anaerobic reactor of the BEPR AS system
 O_i = Oxygen in the influent to the anaerobic reactor of the BEPR AS system
0.86 = Mass of COD removed per unit nitrate denitrified in synthesis ($\text{mgCOD mgNO}_3\text{-N}^{-1}$)
3.0 = Mass of COD removed per unit oxygen utilized (mgCOD mgO^{-1})
 K_{CT} = First order rate constant for conversion of F-RBCOD to SCFA RBCOD at temperature T (0.06 day^{-1} at 20°C)
 f_{xa} = Anaerobic mass fraction
 N_r = Total number of anaerobic reactors of equal volume in series $n = 1, 2, \dots N$
 MX_H = Active mass of the OHOs generated in the BEPR AS system, forming the influent mass of active OHOs to the aerobic digester (mgOHO)
 Y_H = OHOs yield ($\text{mgAOHOVSS mgCOD}^{-1}$)

Equations (4.52 and 4.53) are solved simultaneously to calculate the concentration of F-RBCOD, leaving the last anaerobic reactor (N_r) with the following iterative steps (Wentzel *et al.*, 1990):

- Assume $S_{bsfN} = 0 \text{ mgCOD l}^{-1}$
- Calculate MX_H/Q using Equation (4.53)
- Using the calculated value of MX_H/Q , calculate S_{bsfN} using Equation (4.52)
- Recalculate MX_H/Q using the calculated value of S_{bsfN}
- Repeat the last two steps until S_{bsfN} and MX_H/Q remain constant.

The endogenous mass of the PAOs generated in the AS system, the WAS of which forms part of the influent organic inert material to the aerobic digester is given by

$$\text{MX}_{eG} = f_{eG} b_G \text{MX}_G R_s \quad \text{mgVSS} \quad (4.54)$$

Determining the biological active mass of the OHOs generated in the AS system, the WAS of which becomes the influent active OHO mass to the aerobic digester, from the equation developed by Marais and Ekama (1976) for steady state AS process design:

$$MX_H = \frac{Y_H MS_H R_s}{(1 + b_H R_s)} \quad \text{mgPAOVSS} \quad (4.55)$$

And

$$MS_H = MS_{bi} - MS_{seq} \quad \text{mgPAOVSS} \quad (4.56)$$

$$MS_{bi} = MS_{ii} (1 - f_{S'us} - f_{S'up}) \quad (4.57)$$

where

MS_H = Mass of biodegradable substrate available to OHOs (mgCOD day⁻¹)

MS_{bi} = Mass of biodegradable substrate in the influent (mgCOD day⁻¹)

From the equation developed by Marais and Ekama (1976), the endogenous mass of the OHOs generated in the AS system, the WAS of which forms part of the influent organic inert material to the aerobic digester, MX_{eH} :

$$MX_{eH} = f_{eH} b_H MX_H R_s \quad \text{mgVSS} \quad (4.58)$$

The WAS of the inert mass, which exits the BEPR AS system unaltered (Marais and Ekama, 1976), forms part of the influent organic inert material to the aerobic digester:

$$MX_I = f_{S'up} Q_i S_{ii} R_s / f_{cvH} \quad \text{mgVSS} \quad (4.59)$$

where

S_{ii} = Influent COD to the BEPR AS system

f_{cvH} = COD/VSS ratio of the OHOs

Therefore, the influent active OHO mass into the aerobic digester is given by the sum of the influent OHOs and PAOs:

$$MX_{Hi} = \frac{MX_H}{R_s} \quad \text{mgVSS} \quad (4.60)$$

And the influent active PAO mass into the aerobic digester is given by

$$MX_{Gi} = \frac{MX_G}{R_s} \quad \text{mgVSS} \quad (4.61)$$

Hence, the influent active VSS mass into the aerobic digester is given by the sum of the influent OHOs and PAOs:

$$MX_{Vi} = MX_{Hi} + MX_{Gi} \quad \text{mgVSS} \quad (4.62)$$

And the influent organic inert mass into the aerobic digester is given by the sum of the endogenous masses of the OHOs and PAOs generated in the BEPR AS system and the inert mass:

$$MX_{Ii} = \frac{1}{R_s} (MX_{eH} + MX_{eG} + MX_I) \quad \text{mgVSS} \quad (4.63)$$

From the MBR UCT system (Figure 3.1) using Equations (4.48 to 4.63) and the constants listed in Table 4.1, the active OHO and PAO concentrations in the MBR UCT system were determined. From these computed OHOVSS, PAOVSS, OHO and PAO endogenous and organic inert material concentrations in the parent system (with 20 days of sludge age), the influent active fractions of the VSS (f_{aVi}), PAOVSS (f_{aGVi}) and OHOVSS (f_{aHVi}) into the aerobic batch digester were 37.6, 25.7 and 11.9% respectively. These active fractions were comparable to the simulated values computed with ASM-2 (see Chapter 5). Based on these influent active VSS, OHOVSS and PAOVSS fractions into the aerobic batch digester, the concentrations of the active VSS, OHOVSS and PAOVSS and the corresponding endogenous residue concentrations, the effluent active VSS, OHOVSS and PAOVSS fractions, the fraction of VSS, OHOVSS and PAOVSS removed, the effluent nitrate and total OP concentrations along with P release from the OHOs and PAOs, and the carbonaceous, nitrification and total oxygen demands of the aerobic batch digester were computed using the developed Equations (4.9 – 4.45) for hydraulic retention times ranging from 0 – 30 days (Figures 4.1a and b to 4.3a and b).

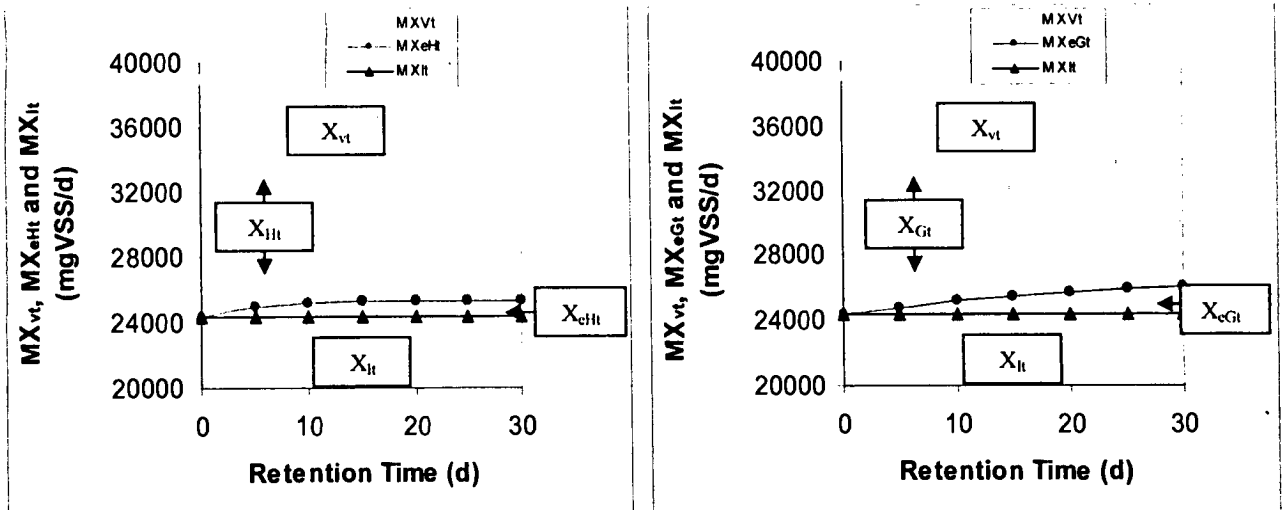


Figure 4.1a and b. Active OHOVSS, endogenous residue of the OHOs and inert material concentration, and active PAOVSS, endogenous residue of the PAOs and inert material concentration during aerobic digestion.

Table 4.1. Constants used in the determination of the influent active fractions of the OHOVSS, PAOVSS and VSS from the MBR UCT system for aerobic batch digestion.

Constant	Value	Unit	Constant	Value	Unit	Constant	Value	Unit
f_{cvH}	1.48	mgCOD mgVSS ⁻¹	f_{bs}	0.46	mgCOD l ⁻¹	NO_{3r}	1.00	mgN l ⁻¹
f_{cvG}	1.48	mgCOD mgVSS ⁻¹	$f_{S'up}$	0.20	mgCOD l ⁻¹	NO_{3i}	0.00	mgN l ⁻¹
b_H	0.24	day ⁻¹	$f_{S'us}$	0.04	mgCOD l ⁻¹	O_r	0.00	mgO l ⁻¹
b_G	0.04	day ⁻¹	Y_H	0.45	day ⁻¹	O_i	0.00	mgO l ⁻¹
f_n	0.10	mgN mgVSS ⁻¹	Y_G	0.45	day ⁻¹	f_{xa}	0.13	
f_{eH}	0.20		Q_i	140	l day ⁻¹	K_{CT}	0.06	day ⁻¹
f_{eG}	0.25		S_{ti}	944	mgCOD l ⁻¹	N_r	1.00	
f_{pH}	0.03	mgP mgOHOVSS ⁻¹	R_s	20.00	day	n	1.00	
f_{pG}	0.38	mgP mgPAOVSS ⁻¹	r	1.00				

The concentrations of oxygen and nitrate in the influent to the MBR UCT system were assumed to be zero. Moreover, the nitrate concentration in the recycle flow to the anaerobic reactor and the fraction of the WAS with respect to the total VSS in the MBR UCT system were taken as 1.0 mg l⁻¹ and 0.20 respectively. An average value of influent COD concentration of 944 mgCOD l⁻¹ was used.

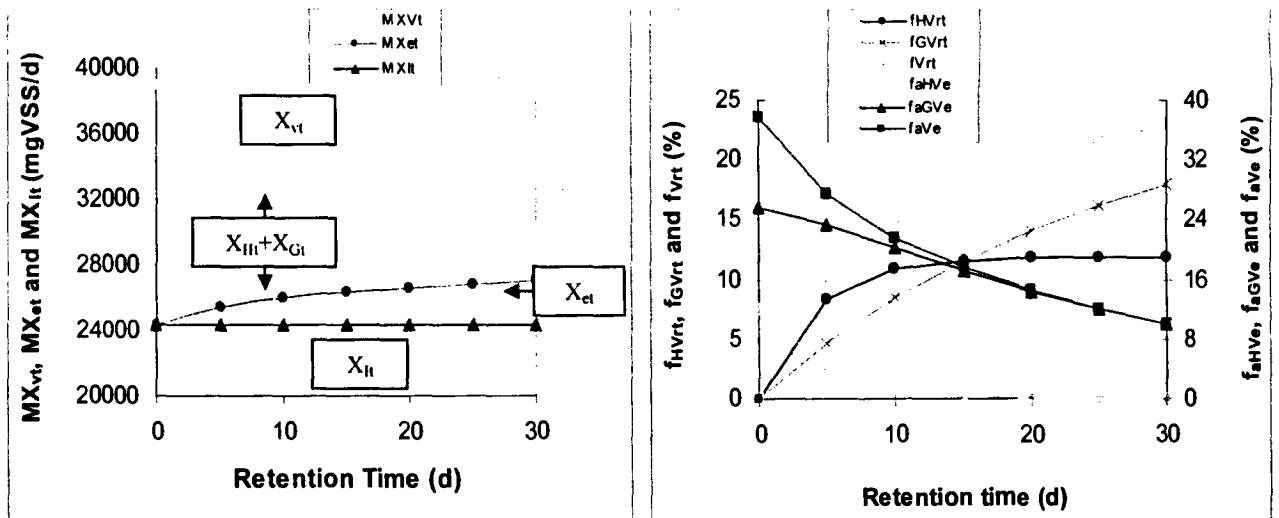


Figure 4.2a and b. Active VSS, total endogenous residue and inert material concentrations, and active effluent fractions of the OHOVSS, PAOVSS and total VSS (%) and fractions of OHOVSS, PAOVSS and total VSS removed(%) during aerobic digestion.

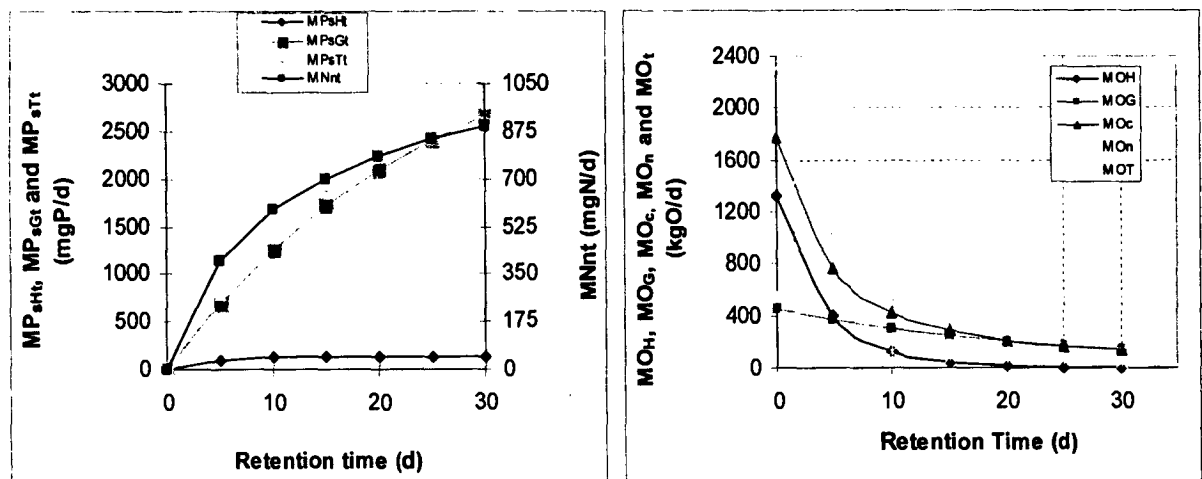


Figure 4.3a and b. Mass of effluent nitrate and phosphorus release from the OHOs and PAOs, and mass of carbonaceous, nitrification and total oxygen demand during aerobic batch digestion.

4.1.2 Adding the ISS and TSS to the aerobic batch reactor model (BRM)

Based on the models of Marais and Ekama (1976) and Ekama *et al.* (2006), a TSS (VSS + ISS) batch reactor model (BRM) with predicted ISS for the aerobic batch digestion of WAS from BEPR AS systems was developed.

In the development of adding the ISS concentration to the BRM, the following assumptions from the ISS model of Ekama and Wentzel (2004) were added:

- (a) Precipitation of minerals in the biological reactor (unless stimulated by chemical precipitant dosing) and dissolution of influent ISS, are considered negligible
- (b) The OHOs and the PAOs contain inorganic dissolved solids (IDS) as part of their cell contents which, when sludge samples are dried and incinerated in the TSS-VSS test procedure, precipitate as inorganic solids. Additionally, the PAOs take up IDS and store it as counter ions associated with polyphosphates (PP, see Chapter 5, Section 5.2.6.2). Because of their negligible contribution (< 2%) the IDS content of the ANOs is neglected
- (c) Slowly biodegradable particulate substrate and endogenous residue do not contain an inorganic component
- (d) The P content of the remaining live PAOs remains constant during digestion (an aspect that was investigated in this research – see Chapter 5, Section 5.2.6)

The TSS (TSS = VSS + ISS) in the aerobic batch reactor, X_{Ti} at time t is

$$X_{Ti} = X_{Vi} + X_{Hi} f_{iOHO} + X_{Gi} f_{iPAO} + X_{Ioi} \quad (4.64)$$

where

- X_{Hi} = Concentration of active OHOs at time t (mgOHOVSS l^{-1})
- X_{Gi} = Concentration of active PAOs at time t (mgPAOVSS l^{-1})
- X_{eHi} = Concentration of endogenous residue of the OHOs at time t (mgVSS l^{-1})
- X_{eGi} = Concentration of endogenous residue of the PAOs at time t (mgVSS l^{-1})
- X_{Ii} = Concentration of inert organic material in the WAS (originating from the unbiodegradable organics from the influent plus the endogenous residue concentrations of the OHOs and PAOs from the AS system) at time t (mgVSS l^{-1})
- X_{Ioi} = Concentration of inert inorganic material originating from the influent at time t (mgTSS l^{-1})
- f_{iOHO} = Inorganic suspended solids content of OHO cell mass (0.15 mgISS mgOHOVSS $^{-1}$)
- f_{iPAO} = Inorganic suspended solids content of PAOs (mgISS mgPAOVSS $^{-1}$)

And

$$f_{iPAO} = f_{iPAOBM} + 3.286(f_{XBGP} - f_{XBGPBM}) \quad (2.64)$$

$\overset{ISS}{0.15}$ $\overset{4.18}{P_{content}}$
 $\checkmark$ $\underset{0.03}{C_{03}}$

$$f_{XBGP} = f_{XBGPBM} + f_{XBGP} \quad (2.65)$$

where

f_{iPAOBM} = ISS content of PAO cell mass (0.15 mgISS mgPAOVSS⁻¹)

f_{XBGP} = Total P content of PAOs (mgP mgPAOVSS⁻¹)

f_{XBGP} ^{BM} = P content of PAOs (0.03 mgP mgPAOVSS⁻¹)

3.286 = ISS mass of the PAO intracellular PP (mgISS mgPP-P⁻¹)

$f_{XBGP} = P_{content} \text{ of PAOs.}$

The inert organic material (X_i), which is the unbiodegradable particulate organics from the influent and the endogenous residue of the OHOs and PAOs from the AS system, and the inorganic material (X_{io}) originating from the influent, remain constant and equal to the digester influent inert material, X_{ii} and X_{loi} respectively, whereas X_H , X_G , X_{eH} and X_{eG} are altered during the digestion process.

$$X_{ii} = X_{ie} \quad (4.65)$$

$$X_{loi} = X_{loe} \quad (4.66)$$

where

X_i = concentration of inert organic material, subscripts 'i' and 'e' refer to influent and effluent (mgISS l⁻¹)

X_{io} = concentration of inert inorganic material, subscripts 'i' and 'e' refer to influent and effluent (mgISS l⁻¹)

The degradation of the active OHOVSS, X_H is given by Equation (4.1) which has the solution

$$X_{Hi} = X_{Hi} e^{-b_H t} \quad (4.9)$$

where X_{Hi} = Initial concentration of active OHOs (mg l⁻¹)

From every unit of X_H that disappears, f_H units of X_{eH} are generated, i.e.

$$X_{eH} = f_H X_{Hi} (1 - e^{-b_H t}) \quad (4.11)$$

The degradation of the active PAOVSS, X_G is given by Equation (4.3) which has the solution

$$X_{Gi} = X_{Gi} e^{-b_G t} \quad (4.12)$$

where X_{Gi} = Initial concentration of active PAOs (mg l^{-1})

From every unit of X_G that disappears, f_G units of X_{eG} are generated, i.e.

$$X_{eGi} = f_G X_{Gi} (1 - e^{-b_G t}) \quad (4.14)$$

The total endogenous residue concentration at time t , X_{eI} in the batch aerobic digester is given by Equation (4.15). Hence the VSS concentration at time t , X_{Vt} is given by Equation (4.16) and after substitution and simplification by Equation (4.17). From the above, it is clear that the decrease in VSS with time is identical to that developed above in Section 4.1.1. The calculation of the ISS and, therefore, TSS simply adds these two parameters to the VSS model.

The TSS concentration at any time t , X_{Tt} in the batch aerobic digester is given by Equation (4.64). Substituting from Equation (4.9), (4.11), (4.12), and (4.14) into Equation (4.64) yields

$$\begin{aligned} X_{Tt} = & X_{Hi} e^{-b_H t} + X_{Gi} e^{-b_G t} + f_H X_{Hi} (1 - e^{-b_H t}) + f_G X_{Gi} (1 - e^{-b_G t}) + X_{It} + \\ & f_{iOHO} (X_{Hi} e^{-b_H t}) + f_{iPAO} (X_{Gi} e^{-b_G t}) + X_{lot} \end{aligned} \quad (4.67)$$

Simplifying and rearranging Equation (4.67) yields

$$X_{Tt} = X_{Hi} \{f_H + (1 - f_H + f_{iOHO})e^{-b_H t}\} + X_{Gi} \{f_G + (1 - f_G + f_{iPAO})e^{-b_G t}\} + X_{It} + X_{lot} \quad (4.68)$$

The change (reduction) in TSS concentration at any time t , ΔX_{Tt} , is given by

$$\Delta X_{Tt} = X_{Ti} - X_{Tt} \quad (4.69)$$

where X_{Ti} = Initial concentration of the TSS (mg l^{-1})

Substituting from Equation (4.68) into Equation (4.69) yields

$$\Delta X_{Ti} = (X_{Hi} + X_{Gi} + X_{Li} + X_{Hi}f_{iOHO} + X_{Gi}f_{iPAO} + X_{Loi}) - [X_{Hi}\{f_H + (1 - f_H + f_{iOHO})e^{-b_H t}\} + X_{Gi}\{f_G + (1 - f_G + f_{iPAO})e^{-b_G t}\} + X_{Li} + X_{Loi}] \quad (4.70)$$

Simplifying and rearranging Equation (4.70) yields

$$\Delta X_{Ti} = X_{Hi}(1 - f_H + f_{iOHO})(1 - e^{-b_H t}) + X_{Gi}(1 - f_G + f_{iPAO})(1 - e^{-b_G t}) \quad (4.71)$$

The fraction of total solids removed (TSS decrease) at any time t , f_{Tr} is given by

$$f_{Tr} = \frac{\Delta X_{Ti}}{X_{Ti}} \quad (4.72)$$

Substituting from Equation (4.71) into Equation (4.72) yields

$$f_{Tr} = \frac{X_{Hi}(1 - f_H + f_{iOHO})(1 - e^{-b_H t}) + X_{Gi}(1 - f_G + f_{iPAO})(1 - e^{-b_G t})}{X_{Ti}} \quad (4.73)$$

If $\frac{X_{Hi}}{X_{Ti}} = f_{aHTi}$ (initial active fraction of the OHO with respect to TSS) and $\frac{X_{Gi}}{X_{Ti}} = f_{aGTi}$

(initial active fraction of the PAO with respect to TSS), then

$$f_{Tr} = f_{aHTi}(1 - f_H + f_{iOHO})(1 - e^{-b_H t}) + f_{aGTi}(1 - f_G + f_{iPAO})(1 - e^{-b_G t}) \quad (4.74)$$

Recalling that $X_{Ti} = X_{Vi} + X_{Hi}f_{iOHO} + X_{Gi}f_{iPAO} + X_{Loi}$, the TSS concentration at time t , X_{Tt} is, then, given by

$$X_{Tt} = (1 - f_{Tr})X_{Ti} \quad (4.75)$$

The computation of the VSS components of the parent system (MBR UCT system) generating influent WAS to the aerobic batch digester is outlined in Section 4.1.1. The influent ISS concentration fed to the aerobic batch digester is equal to the ISS concentration in the WAS from the MBR UCT system. This ISS concentration is calculated from the ISS model of Ekama and Wentzel (2004) for BEPR AS systems viz.

$$MX_{lo} = Q_i X_{loi} R_s + f_{iOHO} MX_{Hi} + f_{iPAO} MX_{Gi} \quad (\text{mgISS}) \quad (4.76)$$

where

- MX_{lo} = Mass of ISS in the BEPR AS system (mgISS)
- Q_i = Influent average dry weather flow to BEPR AS system (l day^{-1})
- X_{loi} = Influent ISS concentration (mgISS l^{-1})
- R_s = Sludge age of BEPR AS system (d)
- MX_H = Mass of OHOs in the BEPR AS system (mgOHOVSS)
- MX_G = Mass of PAOs in the BEPR AS system (mgPAOVSS)
- f_{iOHO} = ISS content of the OHOs ($0.15 \text{ mgISS mgOHOVSS}^{-1}$)
- f_{iPAO} = $f_{iPAOBM} + 3.286(f_{XBGP} - f_{XBGPMB})$ (see Equation 2.64 and 2.65 above)

Hence, the mass of ISS into the aerobic digester, MX_{loi} is

$$MX_{loi} = \frac{MX_{lo}}{R_s} \quad (\text{mgISS}) \quad (4.77)$$

Based on the average simulated values of the influent ISS (X_{loi}) to the MBR UCT system, concentration of influent ISS of 3.5 mgISS l^{-1} and a polyphosphate (PP) content of the PAOs of $0.30 \text{ mgPP mgPAOVSS}^{-1}$ was applied in the ISS model of Ekama and Wentzel (2004) for BEPR AS systems. Therefore, employing Equations (2.64 and 2.65) an ISS content of PAOs, f_{iPAO} of $1.14 \text{ mgISS mgPAOVSS}^{-1}$ was obtained. These ISS components and the VSS components computed in Section 4.1.1 were added into the BEPR model of Wentzel *et al.* (1990) to give the ISS and TSS concentrations in the WAS of the MBR UCT system, from which were obtained the total (OHO + PAO) (f_{aTi}), OHO (f_{aHTi}) and PAO (f_{aGTi}) active fractions with respect to TSS in the aerobic digester feed. The total (f_{aTi}), PAO (f_{aGTi}) and OHO (f_{aHTi}) active fractions with respect to TSS were 28.4, 19.4 and 9.0% respectively. From

these influent active fractions the effluent active fractions of TSS, OHOs and PAOs with respect to TSS, and the fractions of TSS, OHOs and PAOs removed with respect to TSS were computed using the developed Equations (4.64 to 4.75) for hydraulic retention times ranging from 0 – 30 days (Figures 4.4 and 4.5).

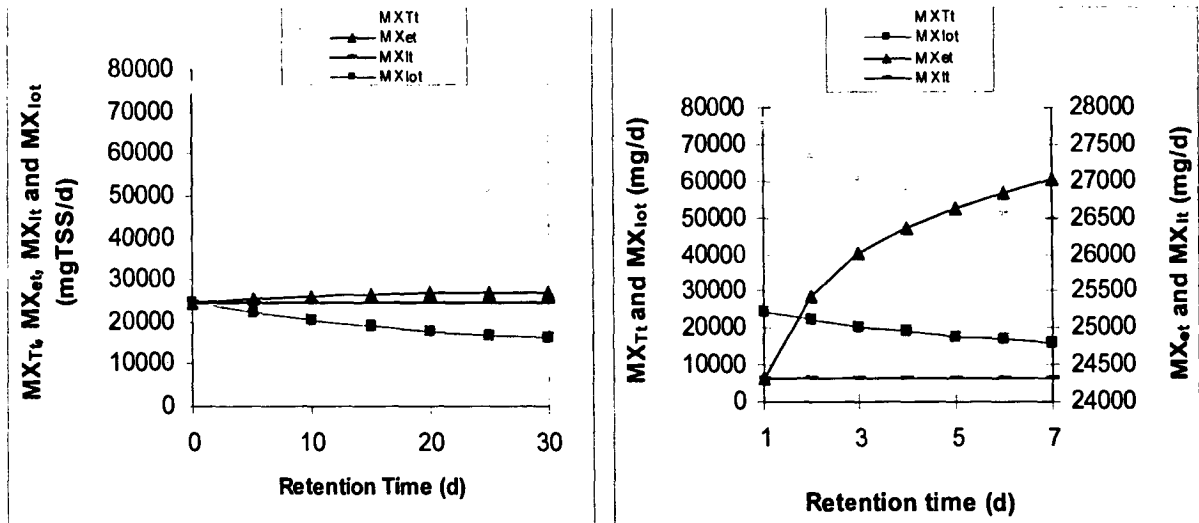


Figure 4.4a and b. TSS, endogenous residue, organic and inorganic inert material concentrations during aerobic digestion (endogenous residue and organic inert material concentrations magnified in Figure 4.4b).

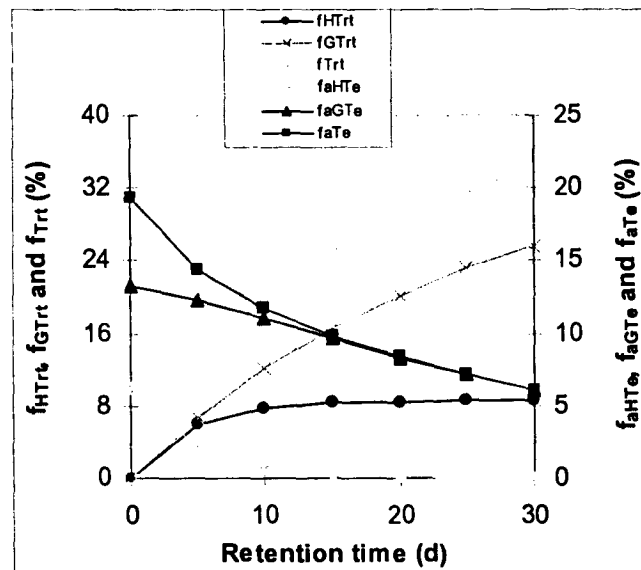


Figure 4.5. Fractions of TSS, OHOS and PAOs removed with respect to TSS (%), and active effluent fractions of TSS, OHOs and PAOs with respect to TSS (%) and during aerobic digestion.

The comparison of the predicted values with the steady state model and ASM-2 with those measured is done in Chapter 5.

4.2 Completely Mixed Aerobic Digester (Steady State Model)

Now the steady state model (SSM) for the single completely mixed aerobic digester (CMAD) will be developed because in practice, aerobic digesters are usually of the flow through type consisting of one or more digesters in series.

4.2.1 VSS based model

A diagrammatic representation of a flow through CMAD with the VSS-based components of the influent and effluent flows is given in Figure 4.6.

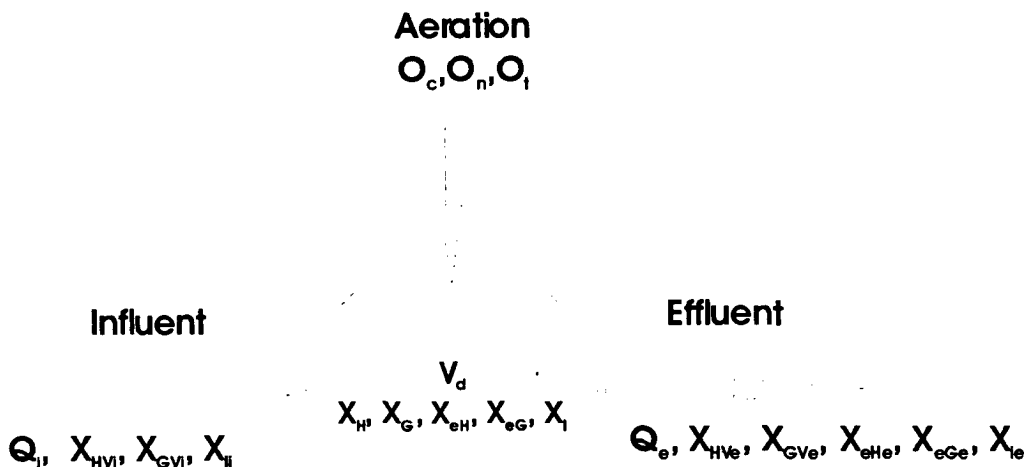


Figure 4.6. Diagrammatic representation of the single completely mixed aerobic digester

From the mass balance of the active organisms over the flow through completely mixed system and accepting as discussed earlier that the OHOs and PAOs act independently (see Equation 4.81 below),

$$V_d d(X_H + X_G) = (X_{Hi} + X_{Gi})Q_i dt - (X_{He} + X_{Ge})Q_e dt - (b_H X_H + b_G X_G)dt V_d \quad (4.78)$$

where

V_d = Volume of the aerobic digester

Q_i = Influent WAS into the aerobic digester

Q_e = Effluent WAS from the aerobic digester

X_H = Concentration of the active OHOs, subscripts 'i' and 'e' refer to influent and effluent

X_G = Concentration of the active PAOs, subscripts 'i' and 'e' refer to influent and effluent

b_H = OHOs endogenous respiration rate (day^{-1})

b_G = PAOs endogenous respiration rate (day^{-1})

Dividing both sides of Equation (4.78) by $V_d dt$ and noting that $Q_i = Q_e$ and $Q_i/V_d = R_h$ yields

$$\frac{d(X_H + X_G)}{dt} = \frac{1}{R_h}(X_{Hi} + X_{Gi}) - \frac{1}{R_h}(X_{He} + X_{Ge}) - (b_H X_H + b_G X_G) \quad (4.79)$$

where R_h = hydraulic retention time (for CMAD the hydraulic retention time and the sludge age, R_s are equal) (days)

Setting the transient $d(X_H + X_G)/dt = 0$ results in

$$0 = \frac{1}{R_h}(X_{Hi} + X_{Gi}) - \frac{1}{R_h}(X_{He} + X_{Ge}) - (b_H X_H + b_G X_G) \quad (4.80)$$

From the definition of completely mixed conditions, X_H (in the digester) = X_{He} (in the effluent) and $X_G = X_{Ge}$ and simplifying Equation (4.80) yields

$$X_{Hi} + X_{Gi} = X_{He}(1 + b_H R_h) + X_{Ge}(1 + b_G R_h) \quad (4.81)$$

From Equation (4.81) the following relationships can be developed because X_{Hi} and X_{Gi} degrade independently^c, each according to its own endogenous respiration rate,

^c Independent digestion of the OHOs and PAOs is assumed in this steady state model. This assumption also applies to the simulation models like ASM-2, because in these models mass loss of PAOs is dealt with an endogenous respiration (i.e. net effect) not death generation as for OHOs. In the

$$X_{Hi} = X_{He} (1 + b_H R_h) \quad (4.82)$$

$$X_{Gi} = X_{Ge} (1 + b_G R_h) \quad (4.83)$$

From the mass balance of the endogenous residue over the flow through completely mixed system, noting that there is no X_e in the influent but it is included in X_i of the influent,

$$X_{ete} = X_{eHe} + X_{eGe} = f_{eH} (X_{Hi} - X_{He}) + f_{eG} (X_{Gi} - X_{Ge}) \quad (4.84)$$

where

X_{eHe} = Concentration of the endogenous residue of the OHOs in the effluent (mg l^{-1})

X_{eGe} = Concentration of the endogenous residue of the PAOs in the effluent (mg l^{-1})

f_{eH} = Fraction of endogenous residue of the OHOs

f_{eG} = Fraction of endogenous residue of the PAOs

Substituting from Equations (4.82) and (4.83) into Equation (4.84) and simplifying yields

$$X_{ete} = X_{eHe} + X_{eGe} = f_{eH} X_{He} b_H R_h + f_{eG} X_{Ge} b_G R_h \quad (4.85)$$

Similarly, from Equation (4.85) the following relationships can be developed

$$\frac{X_{eHe}}{X_{He}} = f_{eH} b_H R_h \quad (4.86)$$

$$\frac{X_{eGe}}{X_{Ge}} = f_{eG} b_G R_h \quad (4.87)$$

The inert material (unbiodegradable VSS) is not affected by digestion, therefore,

$$X_{Hi} = X_{He} \quad (4.88)$$

endogenous respiration model, the PAOs do not release biodegradable organics to the bulk liquid – all PAO biodegradable organics are utilized catabolically by the PAOs themselves with the electron (COD) all passed to oxygen. The PAOs, therefore, do not release biodegradable organics to the bulk liquid for the OHOs to use; with the result they are modelled to operate independently. In reality this may not be the case where biodegradable PAO organics are utilized to grow new OHOs.

where X_i = concentration of inert material, subscripts 'i' and 'e' refer to influent and effluent (mg l^{-1})

The influent VSS concentration is given by

$$X_{Vi} = X_{Hi} + X_{Gi} + X_{Li} \quad (4.89)$$

The effluent VSS concentration is given by

$$X_{Ve} = X_{He} + X_{Ge} + X_{eHe} + X_{eGe} + X_{Le} \quad (4.90)$$

The digester influent active fraction of the sludge, f_{aVi} is given by

$$f_{aVi} = \frac{X_{Hi} + X_{Gi}}{X_{Hi} + X_{Gi} + X_{Li}} = \frac{X_{Hi}}{X_{Hi} + X_{Gi} + X_{Li}} + \frac{X_{Gi}}{X_{Hi} + X_{Gi} + X_{Li}} \quad (4.91)$$

where

$$\frac{X_{Hi}}{X_{Hi} + X_{Gi} + X_{Li}} = f_{aHVi}, \text{ influent active fraction of the OHOVSS} \quad (4.92)$$

$$\frac{X_{Gi}}{X_{Hi} + X_{Gi} + X_{Li}} = f_{aGVi}, \text{ influent active fraction of the PAOVSS} \quad (4.93)$$

Hence, the digester influent active fraction (with respect to VSS) is the sum of the OHO and PAO active influent fractions,

$$f_{aVi} = f_{aHVi} + f_{aGVi} \quad (4.94)$$

Simplifying and rearranging Equation (4.92) yields

$$\frac{1}{f_{aHVi}} - 1 = \frac{X_{Gi}}{X_{Hi}} + \frac{X_{li}}{X_{Hi}} \quad (4.95)$$

Substituting from Equations (4.82), (4.83) and (4.88) into Equation (4.95) yields

$$\frac{1}{f_{aHVi}} - 1 = \frac{X_{Ge}(1 + b_G R_h)}{X_{He}(1 + b_H R_h)} + \frac{X_{le}}{X_{He}(1 + b_H R_h)} \quad (4.96)$$

Simplifying and rearranging Equation (4.96) yields

$$\frac{X_{le}}{X_{He}} = \left(\frac{1}{f_{aHVi}} - 1 \right) (1 + b_H R_h) - \frac{X_{Ge}}{X_{He}} (1 + b_G R_h) \quad (4.97)$$

Simplifying and rearranging Equation (4.93) yields

$$\frac{1}{f_{aGV_i}} - 1 = \frac{X_{Hi}}{X_{Gi}} + \frac{X_{li}}{X_{Gi}} \quad (4.98)$$

Substituting from Equations (4.82), (4.83) and (4.88) into Equation (4.98) yields

$$\frac{1}{f_{aGV_i}} - 1 = \frac{X_{He}(1 + b_H R_h)}{X_{Ge}(1 + b_G R_h)} + \frac{X_{le}}{X_{Ge}(1 + b_G R_h)} \quad (4.99)$$

Simplifying and rearranging Equation (4.99) yields

$$\frac{X_{le}}{X_{Ge}} = \left(\frac{1}{f_{aGV_i}} - 1 \right) (1 + b_G R_h) - \frac{X_{He}}{X_{Ge}} (1 + b_H R_h) \quad (4.100)$$

The digester effluent active fraction of the sludge, f_{ave} is given by

$$\begin{aligned} f_{ave} &= \frac{X_{He} + X_{Ge}}{X_{He} + X_{Ge} + X_{eHe} + X_{eGe} + X_{le}} \\ &= \frac{X_{He}}{X_{He} + X_{Ge} + X_{eHe} + X_{eGe} + X_{le}} + \frac{X_{Gi}}{X_{He} + X_{Ge} + X_{eHe} + X_{eGe} + X_{le}} \end{aligned} \quad (4.101)$$

where

$$\frac{X_{He}}{X_{He} + X_{Ge} + X_{eHe} + X_{eGe} + X_{le}} = f_{aHVe}, \text{ active fraction of the effluent} \quad (4.102)$$

OHOVSS

$$\frac{X_{Gi}}{X_{He} + X_{Ge} + X_{eHe} + X_{eGe} + X_{le}} = f_{aGVe}, \text{ active fraction of the effluent} \quad (4.103)$$

PAOVSS

Hence, the digester effluent active fraction (with respect to VSS) is the sum of the OHO and PAO active effluent fractions,

$$f_{aVe} = f_{aHVe} + f_{aGVe} \quad (4.104)$$

Simplifying and rearranging Equation (4.102) yields

$$\frac{1}{f_{aHVe}} - 1 = \frac{X_{Ge}}{X_{He}} + \frac{X_{eHe}}{X_{He}} + \frac{X_{eGe}}{X_{He}} + \frac{X_{le}}{X_{He}} \quad (4.105)$$

Substituting from Equations (4.85), (4.86) and (4.97) into Equation (4.105) yields

$$\frac{1}{f_{aHVe}} - 1 = \frac{X_{Ge}}{X_{He}} + f_{eH} b_H R_h + \frac{X_{Ge}}{X_{He}} f_{eG} b_G R_h + \left\{ \left(\frac{1}{f_{aHVi}} - 1 \right) (1 + b_H R_h) - \frac{X_{Ge}}{X_{He}} (1 + b_G R_h) \right\} \quad (4.106)$$

Simplifying and rearranging Equation (4.106) yields

$$\frac{1}{f_{aHVe}} - 1 = \frac{X_{Ge}}{X_{He}} \{ (f_{eG} - 1) b_G R_h \} + f_{eH} b_H R_h + \left\{ \left(\frac{1}{f_{aHVi}} - 1 \right) (1 + b_H R_h) - \frac{X_{Ge}}{X_{He}} (1 + b_G R_h) \right\} \quad (4.107)$$

Assigning

$$\alpha_H = \frac{1}{f_{allVi}} - (1 - f_{cH}) \quad (4.108)$$

$$\beta_H = \frac{1}{f_{allVe}} - (1 - f_{cH}) \quad (4.109)$$

Equation (4.107) can be simplified and rearranged as

$$\frac{X_{Ge}}{X_{He}} = \frac{\beta_H - \alpha_H(1 + b_H R_h)}{(f_{cG} - 1)b_G R_h} \quad (4.110)$$

Simplifying and rearranging Equation (4.103) yields

$$\frac{1}{f_{aGVe}} - 1 = \frac{X_{He}}{X_{Ge}} + \frac{X_{eHe}}{X_{Ge}} + \frac{X_{eGe}}{X_{Ge}} + \frac{X_{Je}}{X_{Ge}} \quad (4.111)$$

Substituting from Equations (4.85), (4.87) and (4.100) into Equation (4.111) yields

$$\frac{1}{f_{aGVe}} - 1 = \frac{X_{He}}{X_{Ge}} + \frac{X_{He}}{X_{Ge}} f_{cH} b_H R_h + f_{cG} b_G R_h + \left\{ \left(\frac{1}{f_{aGVi}} - 1 \right) (1 + b_G R_h) - \frac{X_{He}}{X_{Ge}} (1 + b_H R_h) \right\} \quad (4.112)$$

Simplifying and rearranging Equation (4.112) yields

$$\frac{1}{f_{aGVe}} - 1 = \frac{X_{He}}{X_{Ge}} (f_{cH} - 1) b_H R_h + f_{cG} b_G R_h + \left(\frac{1}{f_{aGVi}} - 1 \right) (1 + b_G R_h) \quad (4.113)$$

Substituting from Equations (4.110) into Equation (4.113) yields

$$\frac{1}{f_{aGVe}} - 1 = \frac{(f_{cG} - 1) b_G R_h}{\beta_H - \alpha_H (1 + b_H R_h)} (f_{cH} - 1) b_H R_h + f_{cG} b_G R_h + \left(\frac{1}{f_{aGVi}} - 1 \right) (1 + b_G R_h) \quad (4.114)$$

Assigning

$$\alpha_G = \frac{1}{f_{aGV_i}} - (1 - f_{eG}) \quad (4.115)$$

$$\beta_G = \frac{1}{f_{aGV_e}} - (1 - f_{eG}) \quad (4.116)$$

Equation (4.114) can be simplified and rearranged as

$$R_h^2 \{(1 - f_{eH} - f_{eG} + f_{eH}f_{eG})b_H b_G\} + R_h(\alpha_H \beta_G b_H + \alpha_G b_G) + \{\beta_G(\alpha_H - \beta_H) + \alpha_G\} = 0 \quad (4.117)$$

This is a quadratic equation of the form

$$aR_h^2 + bR_h + c = 0$$

where

$$a = (1 - f_{eH} - f_{eG} + f_{eH}f_{eG})b_H b_G$$

$$b = \alpha_H \beta_G b_H + \alpha_G b_G$$

$$c = \beta_G(\alpha_H - \beta_H) + \alpha_G$$

By employing the solution for the quadratic equation

$$R_h = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

and substituting the values, the required hydraulic retention time, R_h is determined.

The fraction of VSS removed, f_{vr} is defined as the ratio of VSS mass degraded, $Q_i(X_{Vi} - X_{Ve})$ to the influent VSS mass, i.e.,

$$f_{vr} = \frac{Q_i X_{Vi} - Q_e X_{Ve}}{Q_i X_{Vi}} \quad (4.118)$$

Noting that $Q_i = Q_e$, Equation (4.118) can be reduced to

$$f_{vr} = \frac{X_{vi} - X_{ve}}{X_{vi}} \quad (4.119)$$

Substituting from Equations (4.89) and (4.90) into Equation (4.119)

$$f_{vr} = \frac{(X_{Hi} + X_{Gi} + X_{li}) - (X_{He} + X_{Ge} + X_{eHe} + X_{eGe} + X_{le})}{X_{vi}} \quad (4.120)$$

Noting that $X_{li} = X_{le}$ and rearranging Equation (4.120) yields

$$f_{vr} = \frac{(X_{Hi} - X_{He} - X_{eHe}) + (X_{Gi} - X_{Ge} - X_{eGe})}{X_{vi}} = \frac{(X_{Hi} - X_{He} - X_{eHe})}{X_{vi}} + \frac{(X_{Gi} - X_{Ge} - X_{eGe})}{X_{vi}} \quad (4.121)$$

Substituting from Equations (4.82), (4.83) and (4.85) into Equation (4.121) yields

$$f_{vr} = \frac{(X_{Hi} - (X_{Hi}/(1 + R_h b_H)) - f_{eH} R_h b_H (X_{Hi}/(1 + R_h b_H)))}{X_{vi}} + \frac{(X_{Gi} - (X_{Gi}/(1 + R_h b_G)) - f_{eH} R_h b_G (X_{Gi}/(1 + R_h b_G)))}{X_{vi}} \quad (4.122)$$

Simplifying and rearranging Equation (4.122) yields

$$f_{vr} = f_{aHvi} \frac{(1 - f_{eH}) b_H R_h}{(1 + b_H R_h)} + f_{aGvi} \frac{(1 - f_{eG}) b_G R_h}{(1 + b_G R_h)} \quad (4.123)$$

The concentration of the organic N released into the bulk liquid as ammonia and subsequently nitrified to nitrate, like that of the aerobic batch digestion, will be proportional to the N content of the VSS concentration removed. (It is accepted that the OHOs and PAOs have the same N content, f_n .)

Accepting the N content of the VSS to be f_n , the nitrate concentration generated in the aerobic digester will be

$$N_{ne} = f_n X_{Vi} f_{Vr} \quad (4.124)$$

where $f_n = 0.10 \text{ mgN mgVSS}^{-1}$

Noting that $f_{aHVi} = \frac{X_{Hi}}{X_{Vi}}$ and $f_{aGVi} = \frac{X_{Gi}}{X_{Vi}}$, and substituting from Equation (4.123) into Equation (4.124) yields

$$N_{ne} = f_n \left\{ X_{Hi} \frac{(1 - f_{eH}) b_H R_h}{(1 + b_H R_h)} + X_{Gi} \frac{(1 - f_{eG}) b_G R_h}{(1 + b_G R_h)} \right\} \quad (4.125)$$

Similarly, the OP concentration in the bulk liquid of the aerobic digester will be equivalent to the P contents of the OHOs and PAOs removed. Accepting the P content of the OHOs and the PAOs to be f_{pH} and f_{pG} respectively, the OP concentration in the aerobic digester will be

$$P_{se} = f_{pH} X_{Vi} f_{HVr} + f_{pG} X_{Vi} f_{GVr} \quad (4.126)$$

Noting that $f_{aHVi} = \frac{X_{Hi}}{X_{Vi}}$ and $f_{aGVi} = \frac{X_{Gi}}{X_{Vi}}$, and substituting from Equation (4.123) into Equation (4.126) yields

$$P_{se} = f_{pH} X_{Hi} \frac{(1 - f_{eH}) b_H R_h}{(1 + b_H R_h)} + f_{pG} X_{Gi} \frac{(1 - f_{eG}) b_G R_h}{(1 + b_G R_h)} \quad (4.127)$$

The carbonaceous (endogenous respiration) OUR in the aerobic digester is given by

$$O_c = \frac{1}{24} \left\{ f_{cvH} \frac{(1 - f_{eH}) X_{Hi} b_H}{(1 + b_H R_h)} + f_{cvG} \frac{(1 - f_{eG}) X_{Gi} b_G}{(1 + b_G R_h)} \right\} \quad (\text{mgO l}^{-1} \text{ h}^{-1}) \quad (4.128)$$

where

f_{cvH} = COD/VSS ratio of the OHOs (mgCOD mgOHOVSS⁻¹)

f_{cvG} = COD/VSS ratio of the PAOs (mgCOD mgPAOVSS⁻¹)

Multiplying both sides of Equation (4.128) by 24 hour per day and by the volume of the digester, V_d and noting that $V_d O_c = MO_c$, i.e. the mass carbonaceous oxygen demand per day (kgO day⁻¹), and $V_d X_{Hi} = Q_i X_{Hi} R_h = MX_{Hi}$ and $V_d X_{Gi} = Q_i X_{Gi} R_h = MX_{Gi}$ where MX_{Hi} and MX_{Gi} is the mass of active OHOVSS and PAOVSS load on the digester per day, yields

$$MO_c = f_{cvH} \frac{(1 - f_{eH}) MX_{Hi} b_H R_h}{(1 + b_H R_h)} + f_{cvG} \frac{(1 - f_{eG}) MX_{Gi} b_G R_h}{(1 + b_G R_h)} \quad (\text{kgO day}^{-1}) \quad (4.129)$$

Noting that $MX_{Hi} = f_{aHV_i} MX_{Vi}$ and $MX_{Gi} = f_{aGV_i} MX_{Vi}$ and dividing Equation (4.129) by MX_{Vi} yields the mass oxygen required per day per kgVSS sludge load on the digester per day,

$$\frac{MO_c}{MX_{Vi}} = f_{cvH} f_{aHV_i} \frac{(1 - f_{eH}) b_H R_h}{(1 + b_H R_h)} + f_{cvG} f_{aGV_i} \frac{(1 - f_{eG}) b_G R_h}{(1 + b_G R_h)} \quad (\text{kgO kgVSS}^{-1}) \quad (4.130)$$

Comparing Equation (4.123) with Equation (4.130) shows that MO_c/MX_{Vi} is equal to the fractions of the OHOVSS and PAOVSS removed multiplied by their respective COD/VSS ratios showing, from a COD mass balance point of view, that the COD of the VSS degraded is equal to the carbonaceous oxygen demand.

With the occurrence of complete nitrification, the nitrification OUR, O_n in the aerobic digester will be

$$O_n = \frac{4.57}{24} f_n \left\{ \frac{(1 - f_{eH}) X_{Hi} b_H}{(1 + b_H R_h)} + \frac{(1 - f_{eG}) X_{Gi} b_G}{(1 + b_G R_h)} \right\} \quad (\text{mgO l}^{-1} \text{ h}^{-1}) \quad (4.131)$$

where 4.57 = mgO required per mgNH₄-N nitrified to NO₃-N.

Similarly, the mass nitrification oxygen demand per day,

$$MO_n = 4.57 f_n \left(\frac{(1 - f_{cH})MX_{Hi}b_H R_h}{(1 + b_H R_h)} + \frac{(1 - f_{cG})MX_{Gi}b_G R_h}{(1 + b_G R_h)} \right) \quad (\text{kgO day}^{-1}) \quad (4.132)$$

The total OUR, with complete nitrification, in the aerobic digester, O_T will be the sum of the carbonaceous and nitrification OUR, i.e.

$$O_T = O_c + O_n \quad (\text{mgO l}^{-1} \text{ h}^{-1}) \quad (4.133)$$

Substituting from Equation (4.128) and (4.131) into Equation (4.133) yields

$$O_T = \frac{1}{24} \left[\left\{ f_{cvH} \frac{(1 - f_{cH})X_{Hi}b_H}{(1 + b_H R_h)} + f_{cvG} \frac{(1 - f_{cG})X_{Gi}b_G}{(1 + b_G R_h)} \right\} + 4.57 f_n \left\{ \frac{(1 - f_{cH})X_{Hi}b_H}{(1 + b_H R_h)} + \frac{(1 - f_{cG})X_{Gi}b_G}{(1 + b_G R_h)} \right\} \right] \quad (\text{mgO l}^{-1} \text{ h}^{-1}) \quad (4.134)$$

Simplifying and rearranging Equation (4.134) yields

$$O_T = \frac{1}{24} \left[\left\{ (f_{cvH} + 4.57 f_n) \frac{(1 - f_{cH})X_{Hi}b_H}{(1 + b_H R_h)} \right\} + \left\{ (f_{cvG} + 4.57 f_n) \frac{(1 - f_{cG})X_{Gi}b_G}{(1 + b_G R_h)} \right\} \right] \quad (\text{mgO l}^{-1} \text{ h}^{-1}) \quad (4.135)$$

And the total oxygen demand per day:

$$MO_T = \left\{ (f_{cvH} + 4.57 f_n) \frac{(1 - f_{cH})MX_{Hi}b_H}{(1 + b_H R_h)} \right\} + \left\{ (f_{cvG} + 4.57 f_n) \frac{(1 - f_{cG})MX_{Gi}b_G}{(1 + b_G R_h)} \right\} \quad (\text{kgO day}^{-1}) \quad (4.136)$$

The determination of the active VSS, OHOVSS, PAOVSS and inert organic material concentrations in the parent system is done in Section 4.1.1. From these concentrations the influent active VSS, OHOVSS and PAOVSS fractions and concentrations and the concentration of the inert organic material into the CMAD were computed using Equations

(4.48 to 63). The influent active fractions of the VSS (f_{aVi}), PAOVSS (f_{aGVi}) and OHOVSS (f_{aHVi}) into the aerobic batch digester were 37.6, 25.7 and 11.9% respectively. Based on these influent active VSS, OHOVSS and PAOVSS fractions the effluent active VSS, OHOVSS and PAOVSS fractions and concentrations, the fractions of VSS removed, the effluent nitrate and OP concentrations, and the carbonaceous, nitrification and total oxygen demands in the CMAD were computed using the developed Equations (4.81 – 4.136) for hydraulic retention times ranging from 0 – 30 days (Figures 4.7a and b, and 4.8a and b).

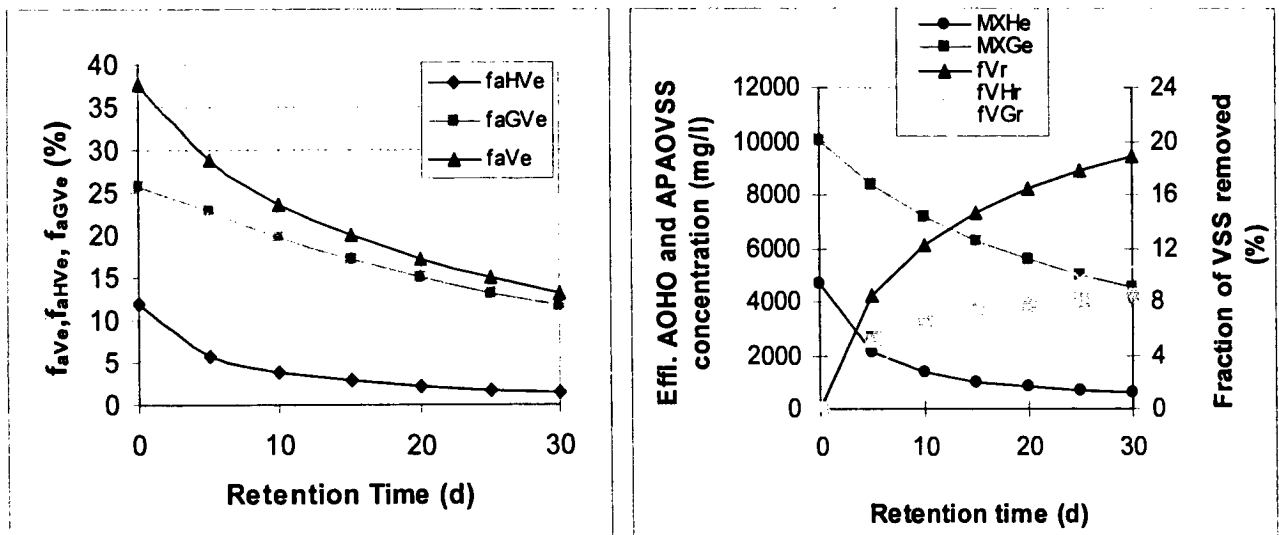


Figure 4.7a and b. Effluent active fractions of the OHOVSS, PAOVSS and VSS (in percentage), and effluent AHOVSS and APAOVSS concentrations and fractions of VSS removed for single CMAD

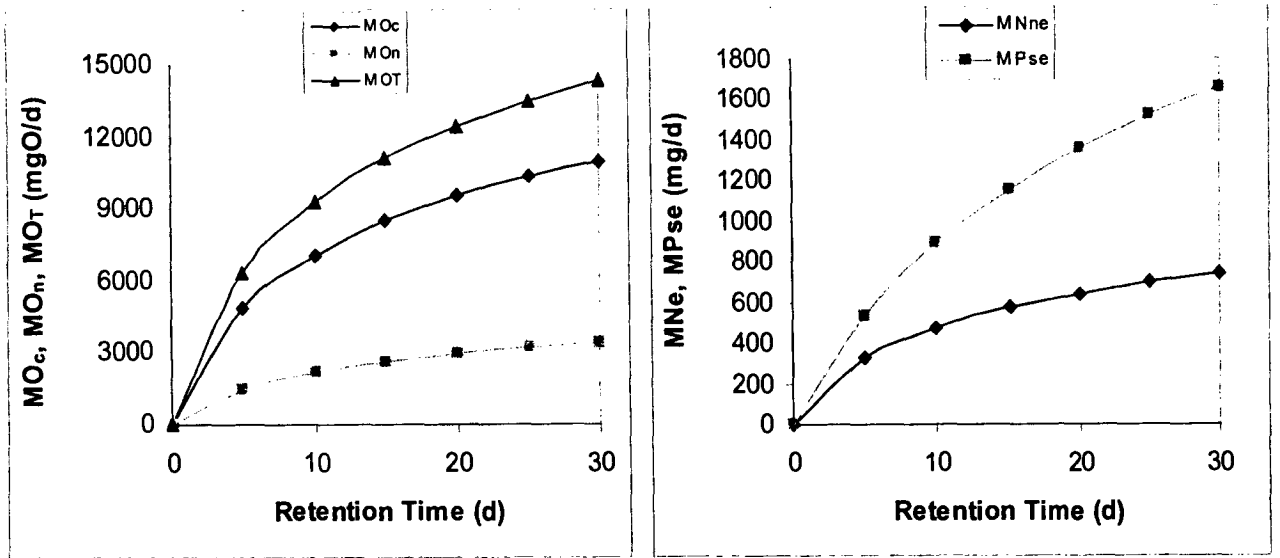


Figure 4.8a and b. Mass of carbonaceous, nitrification and total oxygen demand, and mass of effluent nitrate and phosphorus for single CMAD

4.2.2 Adding ISS and TSS to the VSS model

Adding the ISS and, therefore, the TSS concentration to the VSS-based SSM (i.e. TSS = VSS + ISS) follows a similar pattern to that given in Section 4.1.2.

The influent TSS concentration to the single CMAD, X_{Ti} is given by

$$X_{Ti} = X_{Vi} + X_{Hi}f_{iOHO} + X_{Gi}f_{iPAO} + X_{Ioi} \quad (4.137)$$

And the effluent TSS concentration is given by

$$X_{Te} = X_{Ve} + X_{He}f_{iOHO} + X_{Ge}f_{iPAO} + X_{Ioe} \quad (4.138)$$

The inert organic material (X_I), which is the unbiodegradable particulate organics from the influent and the endogenous residue of the OHOs and PAOs from the AS system, and the inorganic material (X_{Io}) originating from the influent, remain constant and equal to the digester influent inert material, X_{Ii} and X_{Ioi} , therefore,

$$X_{li} = X_{le} \quad (4.88)$$

$$X_{loi} = X_{loe} \quad (4.139)$$

where

X_{li} = concentration of inert organic material, subscripts 'i' and 'e' refer to influent and effluent (mgISS l⁻¹)

X_{loi} = concentration of inert inorganic material, subscripts 'i' and 'e' refer to influent and effluent (mgISS l⁻¹)

The digester influent active fraction of the sludge (with respect to TSS), f_{aTi} is given by

$$\begin{aligned} f_{aTi} &= \frac{X_{Hi} + X_{Gi}}{X_{Hi} + X_{Gi} + X_{li} + X_{Hi}f_{iOHO} + X_{Gi}f_{iPAO} + X_{loi}} \\ &= \frac{X_{Hi}}{X_{Hi} + X_{Gi} + X_{li} + X_{Hi}f_{iOHO} + X_{Gi}f_{iPAO} + X_{loi}} + \\ &\quad \frac{X_{Gi}}{X_{Hi} + X_{Gi} + X_{li} + X_{Hi}f_{iOHO} + X_{Gi}f_{iPAO} + X_{loi}} \end{aligned} \quad (4.140)$$

where

$$\frac{X_{Hi}}{X_{Hi} + X_{Gi} + X_{li} + X_{Hi}f_{iOHO} + X_{Gi}f_{iPAO} + X_{loi}} = f_{aHTi}, \text{ active fraction of the influent OHO} \quad (4.141)$$

with respect to TSS

$$\frac{X_{Gi}}{X_{Hi} + X_{Gi} + X_{li} + X_{Hi}f_{iOHO} + X_{Gi}f_{iPAO} + X_{loi}} = f_{aGTi}, \text{ active fraction of the influent PAO} \quad (4.142)$$

with respect to TSS

Hence, the influent active fraction (with respect to TSS), f_{aTi} is given by the sum of the OHO and PAO active fractions (with respect to TSS),

$$f_{aTi} = f_{aHTi} + f_{aGTi} \quad (4.143)$$

Simplifying and rearranging Equation (4.141) results in

$$\frac{1}{f_{uHTi}} - 1 - f_{iOHO} = \frac{X_{Gi}(1 + f_{iPAO})}{X_{Hi}} + \frac{X_{li} + X_{loi}}{X_{Hi}} \quad (4.144)$$

Substituting from Equations (4.82), (4.83), (4.88) and (4.140) into Equation (4.144) yields

$$\frac{1}{f_{aHTi}} - 1 - f_{iOHO} = \frac{X_{Ge}}{X_{He}} \frac{(1 + f_{iPAO})(1 + b_G R_h)}{(1 + b_H R_h)} + \frac{X_{le} + X_{loe}}{X_{He}(1 + b_H R_h)} \quad (4.145)$$

Simplifying and rearranging Equation (4.145) yields

$$\frac{X_{le} + X_{loe}}{X_{He}} = \left(\frac{1}{f_{aHTi}} - 1 - f_{iOHO} \right) (1 + b_H R_h) - \frac{X_{Ge}}{X_{He}} (1 + f_{iPAO})(1 + b_G R_h) \quad (4.146)$$

Simplifying and rearranging Equation (4.142) yields

$$\frac{1}{f_{aGTi}} - 1 - f_{iPAO} = \frac{X_{Hi}}{X_{Gi}} (1 + f_{iOHO}) + \frac{X_{li} + X_{loi}}{X_{Gi}} \quad (4.147)$$

Substituting from Equations (4.82), (4.83), (4.88) and (4.140) into Equation (4.147) yields

$$\frac{1}{f_{aGTi}} - 1 - f_{iPAO} = \frac{X_{He}}{X_{Ge}} \frac{(1 + f_{iOHO})(1 + b_H R_h)}{(1 + b_G R_h)} + \frac{X_{le} + X_{loe}}{X_{Ge}(1 + b_G R_h)} \quad (4.148)$$

Simplifying and rearranging Equation (4.148) yields

$$\frac{X_{le} + X_{loe}}{X_{Ge}} = \left(\frac{1}{f_{aGTi}} - 1 - f_{iPAO} \right) (1 + b_G R_h) - \frac{X_{He}}{X_{Ge}} (1 + f_{iOHO})(1 + b_H R_h) \quad (4.149)$$

The digester effluent active fraction of the sludge (with respect to TSS), f_{aTe} is given by

$$f_{aTe} = \frac{X_{He} + X_{Ge}}{X_{He} + X_{Ge} + X_{eHe} + X_{eGe} + X_{le} + X_{He}f_{iOHO} + X_{Ge}f_{iPAO} + X_{loi}} =$$

$$\frac{X_{He}}{X_{He} + X_{Ge} + X_{eHe} + X_{eGe} + X_{le} + X_{He}f_{iOHO} + X_{Ge}f_{iPAO} + X_{loi}} +$$

$$\frac{X_{Ge}}{X_{He} + X_{Ge} + X_{eHe} + X_{eGe} + X_{le} + X_{He}f_{iOHO} + X_{Ge}f_{iPAO} + X_{loi}} \quad (4.150)$$

where

$$\frac{X_{He}}{X_{He} + X_{Ge} + X_{eHe} + X_{eGe} + X_{le} + X_{He}f_{iOHO} + X_{Ge}f_{iPAO} + X_{loe}} = f_{aHTe}, \text{ active} \quad (4.151)$$

fraction of the effluent OHO with respect to TSS

$$\frac{X_{Ge}}{X_{He} + X_{Ge} + X_{eHe} + X_{eGe} + X_{le} + X_{He}f_{iOHO} + X_{Ge}f_{iPAO} + X_{loe}} = f_{aGTe}, \text{ active} \quad (4.152)$$

fraction of the effluent PAO with respect to TSS

Hence, the effluent active fraction of the sludge (with respect to TSS), f_{aTe} is given by the sum of the OHO and PAO effluent active fractions (with respect to TSS),

$$f_{aTe} = f_{aHTe} + f_{aGTe} \quad (4.153)$$

Simplifying and rearranging Equation (4.151) yields

$$\frac{1}{f_{aHTe}} - 1 - f_{iOHO} = \frac{X_{Ge}(1 + f_{iPAO})}{X_{He}} + \frac{X_{eHe}}{X_{He}} + \frac{X_{eGe}}{X_{He}} + \frac{X_{le} + X_{loe}}{X_{He}} \quad (4.154)$$

Substituting from Equations (4.86), (4.87) and (4.146) into Equation (4.154) yields

$$\frac{1}{f_{aHTe}} - 1 - f_{iOHO} = \frac{X_{Ge}(1 + f_{iPAO})}{X_{He}} + f_{cH}b_H R_h + \frac{X_{Ge}f_{cG}b_G R_h}{X_{He}} +$$

$$\left\{ \left(\frac{1}{f_{aHTi}} - 1 - f_{iOHO} \right) (1 + b_H R_h) - \frac{X_{Ge}}{X_{He}} (1 + f_{iPAO}) (1 + b_G R_h) \right\} \quad (4.155)$$

Simplifying and rearranging Equation (4.155) yields

$$\frac{1}{f_{aHTe}} - 1 - f_{iOHO} = f_{eH} b_H R_h + \frac{X_{Ge}}{X_{He}} (f_{eG} - 1 - f_{iPAO}) b_G R_h + \left(\frac{1}{f_{aHTi}} - 1 - f_{iOHO} \right) (1 + b_H R_h) \quad (4.156)$$

Assigning

$$\delta_H = \frac{1}{f_{aHTi}} - 1 - f_{iOHO} \quad (4.157)$$

$$\gamma_H = \frac{1}{f_{aHTe}} - 1 - f_{iOHO} \quad (4.158)$$

Equation (4.156) can be simplified as

$$\frac{X_{Ge}}{X_{He}} = \frac{\gamma_H - \delta_H (1 + b_H R_h) - f_{eH} b_H R_h}{(f_{eG} - 1 - f_{iPAO}) b_G R_h} \quad (4.159)$$

Simplifying and rearranging Equation (4.152) yields

$$\frac{1}{f_{aGTe}} - 1 - f_{iPAO} = \frac{X_{He} (1 + f_{iOHO})}{X_{Ge}} + \frac{X_{eGe}}{X_{Ge}} + \frac{X_{eHe}}{X_{Ge}} + \frac{X_{Ie} + X_{Ioe}}{X_{Ge}} \quad (4.160)$$

Substituting from Equations (4.86), (4.87) and (4.149) into Equation (4.160) yields

$$\begin{aligned} \frac{1}{f_{aGTe}} - 1 - f_{iPAO} &= \frac{X_{He} (1 + f_{iOHO})}{X_{Ge}} + f_{eG} b_G R_h + \frac{X_{He}}{X_{Ge}} f_{eH} b_H R_h + \\ &\left\{ \left(\frac{1}{f_{aGTi}} - 1 - f_{iPAO} \right) (1 + b_G R_h) - \frac{X_{He}}{X_{Ge}} (1 + f_{iOHO}) (1 + b_H R_h) \right\} \end{aligned} \quad (4.161)$$

Simplifying and rearranging Equation (4.161) yields

$$\frac{1}{f_{aGTe}} - 1 - f_{iPAO} = f_{eG} b_G R_h + \frac{X_{He}}{X_{Ge}} (f_{eH} - 1 - f_{iOHO}) b_H R_h + \left(\frac{1}{f_{aGTi}} - 1 - f_{iPAO} \right) (1 + b_G R_h) \quad (4.162)$$

Substituting from Equations (4.159) into Equation (4.162) yields

$$\begin{aligned} \frac{1}{f_{aGTe}} - 1 - f_{iPAO} &= f_{eG} b_G R_h + \left(\frac{(f_{eG} - 1 - f_{iPAO}) b_G R_h}{\gamma_H - \delta_H (1 + b_H R_h) - f_{eH} b_H R_h} \right) (f_{eH} - 1 - f_{iOHO}) b_H R_h + \\ &\left(\frac{1}{f_{aGTi}} - 1 - f_{iPAO} \right) (1 + b_G R_h) \end{aligned} \quad (4.163)$$

Assigning

$$\delta_G = \frac{1}{f_{aGTi}} - 1 - f_{iPAO} \quad (4.164)$$

$$\gamma_G = \frac{1}{f_{aGTe}} - 1 - f_{iPAO} \quad (4.165)$$

Equation (4.163) can be simplified as

$$\gamma_G = f_{eG} b_G R_h + \left\{ \frac{(f_{eG} - 1 - f_{iPAO}) b_G R_h}{\gamma_H - \delta_H (1 + b_H R_h) - f_{eH} b_H R_h} \right\} (f_{eH} - 1 - f_{iOHO}) b_H R_h + \delta_G (1 + b_G R_h) \quad (4.165)$$

Simplifying and rearranging Equation (4.165) yields a quadratic equation of the form of

$$aR_h^2 + bR_h + c = 0 \quad (4.166)$$

where

$$\begin{aligned} a &= b_H b_G \{ \delta_H f_{eG} + f_{eH} (\delta_G + f_{eG}) - (f_{eH} - 1 - f_{iOHO}) (f_{eG} - 1 - f_{iPAO}) \} \\ b &= b_H (\delta_G - \gamma_G) (f_{eH} + \delta_H) + b_G \{ \gamma_H \delta_G + f_{eG} (\delta_H - \gamma_H) \} \\ c &= (\gamma_H - \delta_H) (\gamma_G - \delta_G) \end{aligned}$$

By employing the solution for the quadratic equation

$$R_h = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

and substituting the values, the required hydraulic retention, R_h time is determined.

The fraction of TSS removed, f_{Tr} is defined as the ratio of TSS mass degraded, $Q_i(X_{Ti} - X_{Te})$ to the influent TSS mass, i.e.,

$$f_{Tr} = \frac{Q_i X_{Ti} - Q_e X_{Te}}{Q_i X_{Ti}} \quad (4.167)$$

where, X_T = TSS concentration, subscripts 'i' and 'e' refer to influent and effluent (mg l^{-1})

Noting that $Q_i = Q_e$, Equation (4.167) can be reduced to

$$f_{Tr} = \frac{X_{Ti} - X_{Te}}{X_{Ti}} \quad (4.168)$$

Noting that $X_{li} = X_{le}$ and $X_{loi} = X_{loe}$ and substituting from Equations (4.137) and (4.138) into Equation (4.168) yields

$$f_{Tr} = \frac{(X_{Hi} + X_{Gi} + X_{Hi}f_{iOHO} + X_{Gi}f_{iPAO}) - (X_{He} + X_{Ge} + X_{cHe} + X_{eGe} + X_{He}f_{iOHO} + X_{Ge}f_{iPAO})}{X_{Ti}} \quad (4.169)$$

Simplifying and rearranging Equation (4.169) yields

$$f_{Tr} = \frac{X_{Hi}(1 + f_{iOHO}) - X_{He}(1 + f_{iOHO}) - X_{cHe}}{X_{Ti}} + \frac{X_{Gi}(1 + f_{iPAO}) - X_{Ge}(1 + f_{iPAO}) - X_{eGe}}{X_{Ti}} \quad (4.170)$$

Substituting from Equations (4.82), (4.83), (4.86) and (4.87) into Equation (4.170) yields

$$f_{Tr} = \frac{X_{Hi}(1 + f_{iOHO}) - \frac{X_{Hi}(1 + f_{iOHO})}{(1 + b_H R_h)} - X_{He} f_{eH} b_H R_h}{X_{Ti}} + \frac{X_{Gi}(1 + f_{iPAO}) - \frac{X_{Gi}(1 + f_{iPAO})}{(1 + b_G R_h)} - X_{Ge} f_{eG} b_G R_h}{X_{Ti}} \quad (4.171)$$

Substituting from Equation (4.82) and (4.83) into Equation (4.171) yields

$$f_{Tr} = \frac{X_{Hi}(1 + f_{iOHO}) - \frac{X_{Hi}(1 + f_{iOHO})}{(1 + b_H R_h)} - \frac{X_{Hi}}{(1 + b_H R_h)} f_{eH} b_H R_h}{X_{Ti}} + \frac{X_{Gi}(1 + f_{iPAO}) - \frac{X_{Gi}(1 + f_{iPAO})}{(1 + b_G R_h)} - \frac{X_{Gi}}{(1 + b_G R_h)} f_{eG} b_G R_h}{X_{Ti}} \quad (4.172)$$

Simplifying and rearranging Equation (4.172) yields

$$f_{Tr} = f_{aHTi} \left\{ (1 + f_{iOHO}) \left(1 - \frac{1}{(1 + b_H R_h)} \right) - \frac{f_{eH} b_H R_h}{(1 + b_H R_h)} \right\} + f_{aGTi} \left\{ (1 + f_{iPAO}) \left(1 - \frac{1}{(1 + b_G R_h)} \right) - \frac{f_{eG} b_G R_h}{(1 + b_G R_h)} \right\} \quad (4.173)$$

where

$$\frac{X_{Hi}}{X_{Ti}} = f_{aHTi}, \text{ active fraction of the influent OHOTSS (with respect to TSS)}$$

$$\frac{X_{Gi}}{X_{Ti}} = f_{aGTi}, \text{ active fraction of the influent PAOTSS (with respect to TSS)}$$

The determination of the influent VSS, AOHVSS, APAOVSS and inert organic material concentrations is done in Section 4.1.1. And the computation of the components of the ISS

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Introduction

In this chapter the experimental batch test results are evaluated. First, the trends measured in the batch tests are qualitatively discussed. This is followed by quantitative modelling of the batch test results with batch reactor, steady state and ASM-2 simulation models.

5.2 The Experimental Data – Observed Trends

5.2.1 Batch test initial conditions

Batch Test No.1 (BT-1), BT-3, BT-4 and BT-6 were run until the digestion processes were complete, i.e., until the OUR in the reactor was almost zero and no further decrease in VSS was observed. BT-2 and BT-5 were interrupted due to failure of the motor for mixing the sludge. BT-7 and BT-8 were run simultaneously until the digestion processes of BT-8, which was fed with diluted WAS, was complete.

The experimental conditions of the aerobic digestion of WAS along with the measured initial concentrations of VSS, TSS, TKN and COD in the batch reactor are given in Table 5.1.

Table 5.1. Experimental conditions for the aerobic batch digestion of WAS

Date	Batch Test No.	Batch of Source Sludge	Operation Time of Parent System	Detention Time of Batch Test (days)	Initial Conditions of the Batch Reactor (@ 20°C and pH controlled @ ~7.20)			
					VSS (mg l ⁻¹)	TSS (mg l ⁻¹)	TKN (mg l ⁻¹)	COD (mg l ⁻¹)
Mar 14-25, 2005	BT-1	SB-1	Mar 05-18, 2005	12	12983	16819		17194
Mar 26-31, 2005	BT-2	SB-2	Mar 19-Apr 04, 2005	6	12947	15957		17874
Apr 01-25, 2005	BT-3	SB-2	Mar 19-Apr 04, 2005	25	14300	17421	1451	19832
May 19-June 09, 2005	BT-4	SB-5	May 16-31, 2005	21	13401	16992	1309	19662
Mar 25-Apr 04, 2006	BT-5	SB-26	Mar 24-Apr 07, 2006	11	14647	18381	1043	16683
May 06-20, 2006	BT-6	SB-28	Apr 24- May 06, 2006	15	13189	17544	1320	17193
June 05-13, 2006	BT-7	SB-30	June 04-17, 2006	9	15558	19657	1479	19662
June 05-13, 2006	BT-8	SB-30	June 04-17, 2006	9	2985	3770	291	4019

During the aerobic batch digestion process, an average of 38 ml per day evaporation loss was observed, which was made up with distilled water.

5.2.2 pH and Alkalinity

At the beginning of the batch test the pH values for all the tests were above 7.35. However, within four days of the commencement of digestion the pH started to decrease below 7.2, thereby necessitating the addition of sodium bicarbonate. The decrease in pH necessitating the addition of increased amounts of sodium bicarbonate indicated increased nitrification activity of the sludge biomass which produces hydrogen ions resulting in the consumption of alkalinity. After the addition of increasing amounts of sodium bicarbonate during the early period of the digestion, the amount of sodium bicarbonate added was reduced as the decrease in pH declined.

In keeping the pH at ~7.20, the addition of measured amounts of sodium bicarbonate along with the resulting change in alkalinity is shown in Figure 5.1a and b. The cumulative

consumption of alkalinity increased sharply after the fourth day of digestion for all the batch tests. Following a logarithmic trend, this change in alkalinity consumption became very low at the end of the digestion period.

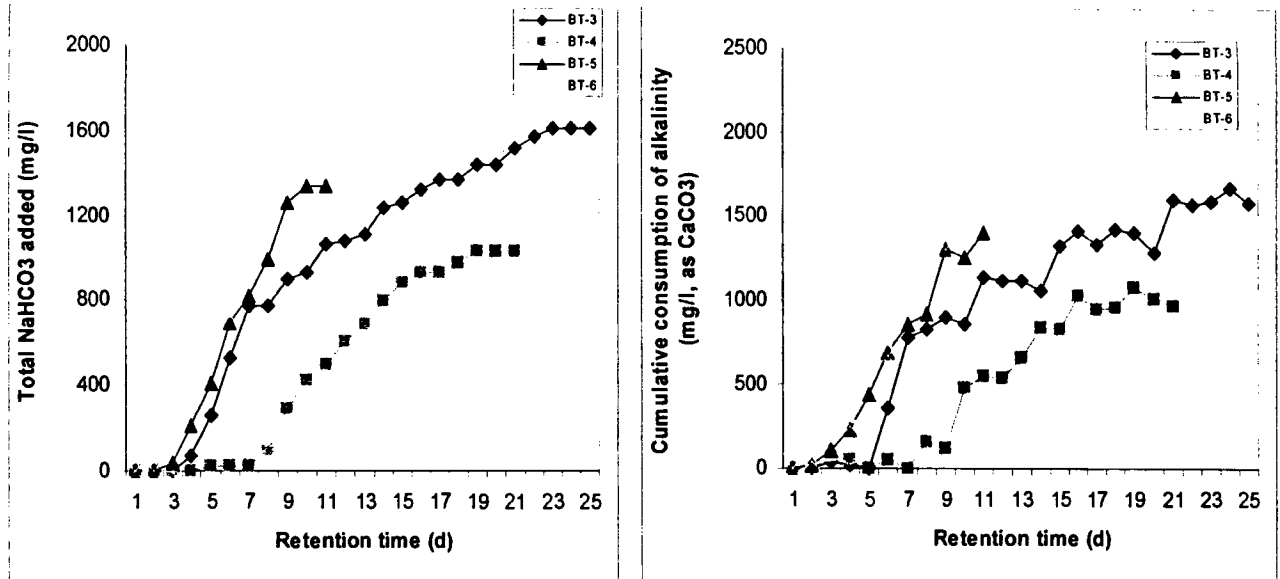


Figure 5.1a and b. Total sodium bicarbonate added and cumulative consumption of alkalinity while regulating the pH @ 7.20

The trends of increase of both of the total addition of NaHCO_3 and the cumulative consumption of alkalinity were similar, except that the cumulative consumption of alkalinity was of a higher scale. This was expected as the addition of NaHCO_3 is making up for the alkalinity consumed due to the production of hydrogen ions as a result of nitrification. The higher scale of the cumulative consumption of alkalinity over the total addition of NaHCO_3 is a consequence of the initial alkalinity present in the WAS prior to the drop of pH to just below 7.20.

5.2.3 VSS, ISS and TSS

The initial VSS concentration for all the batch tests ranged from 12500 to 14300 mg l^{-1} . As shown in Figure 5.2a, apart for some fluctuation, the VSS decreased almost linearly. For BT-3 and BT-4, the VSS concentration decreased from initial values of 14300 and 13400 mg l^{-1} to 7125 and 8772 mg l^{-1} , with 50.2 and 34.5% VSS reductions in 25 and 21 days of aeration time respectively. Similarly, 39.3 and 25.5% VSS reductions were obtained for BT-5 and BT-

6 with aeration times of 11 and 14 days respectively. The highest percentage VSS destruction was obtained with the longest aeration time (BT-3), as expected from theory, followed by that of the shortest aeration time (BT-5), which is not expected from theory.

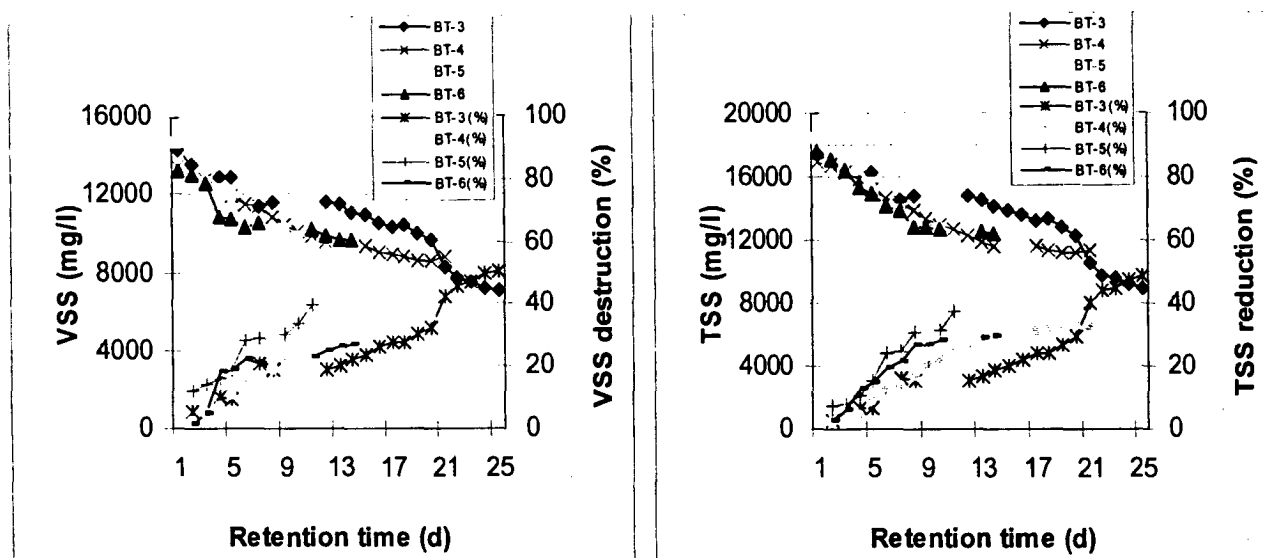


Figure 5.2a and b. Reduction of VSS and TSS versus percentage VSS destruction and TSS reduction obtained during the aerobic digestion of WAS

For BT-3 and BT-4, the TSS concentration decreased from initial values of 17420 and 16630 mg l^{-1} to 8970 and 11280 mg l^{-1} , with 48.5 and 32.2% TSS reductions respectively. Similarly, TSS reductions of 37.3 and 29.6% were obtained for BT-5 and BT-6 when the TSS concentration dropped from initial values of 18380 and 17540 mg l^{-1} to 11520 and 12350 mg l^{-1} respectively (Figure 5.2b).

Both VSS and TSS decreased approximately linearly during the aerobic digestion process. Except for the magnitudes of the initial concentrations of the VSS and TSS, the trend and rate of decrease of both the VSS and TSS were similar. Generally, the percentages of VSS destruction were slightly higher than the percentages of TSS reduction, except for BT-6 where the percentage of VSS destruction was slightly lower than the percentages of TSS reduction (Figure 5.2a and b). In their aerobic digestion of non-BEPR WAS Khalili *et al.* (2000) reported a slightly higher VSS removal efficiency than that for the TSS. Moreover, Al-Ghusain *et al.* (2002) observed VSS and TSS removal efficiencies of 42.7 and 37.4% respectively.

For all the batch tests the ISS decreased with some undulations, especially at the beginning of the digestion period (Figure 5.3a). For BT-4, the ISS decreased linearly from an initial concentration of 3591 mgISS l⁻¹ to a final value of 2509 mgISS l⁻¹ with 43.1% ISS reduction in 21 days of aeration time. After an initial increase, the ISS concentration of BT-2 decreased to a final value equivalent to the initial ISS concentration. For the rest of the batch tests, after an initial increase, the ISS concentration decreased almost linearly during the digestion process. The highest decrease in ISS concentration was for BT-3 where the ISS decreased from an initial concentration of 3122 mgISS l⁻¹ to a final value of 1845 mgISS l⁻¹ with 69.2% ISS reduction in 25 days of aeration time. With 33.8% ISS reduction BT-1 exhibited the lowest ISS reduction from an initial concentration of 3836 mgISS l⁻¹ to a final value of 2867 mgISS l⁻¹ in 8 days of aeration time. This observed decrease of ISS concentration during digestion is in keeping with the ISS model of Ekama and Wentzel (2004) that for a decrease in biomass VSS, a commensurate decrease in biomass ISS also takes place. Although in their aerobic batch digestion of BNR WAS Matsuda *et al.* (1988) reported that the values of the fixed suspended solids (FSS, i.e. ISS) were roughly constant throughout their aerobic digestion tests, in their aerobic digestion of non-BEPR WAS Randall *et al.* (1975) and Reece *et al.* (1979) reported that the FSS decreased during aerobic batch digestion.

As shown in Figure 5.3b, apart from some fluctuations especially for BT-5 and BT-6 the VSS/TSS ratio remained almost constant during the aerobic digestion tests. The average VSS/TSS ratio for BT-1 to BT-6 was 0.78 mgVSS mgTSS⁻¹ with a standard deviation of 0.016. For SBs of the parent system where the WAS was harvested for these six batch tests, the average VSS/TSS ratio in the anaerobic, anoxic and aerobic reactors were 0.83, 0.81 and 0.80 mgVSS mgTSS⁻¹ respectively, with standard deviations of 0.01. The average VSS/TSS ratio of the MBR UCT system for all the SBs from March 2005 to May 2006 in the anaerobic, anoxic and aerobic reactors were 0.82, 0.80 and 0.79 mgVSS mgTSS⁻¹ with standard deviations of 0.01, 0.01 and 0.02 respectively. Because of P release, the VSS/TSS ratio is higher in the anaerobic reactor and lower in the aerobic reactor due to P uptake. The average VSS/TSS ratio for the batch tests, however, was slightly lower than that of the parent system.

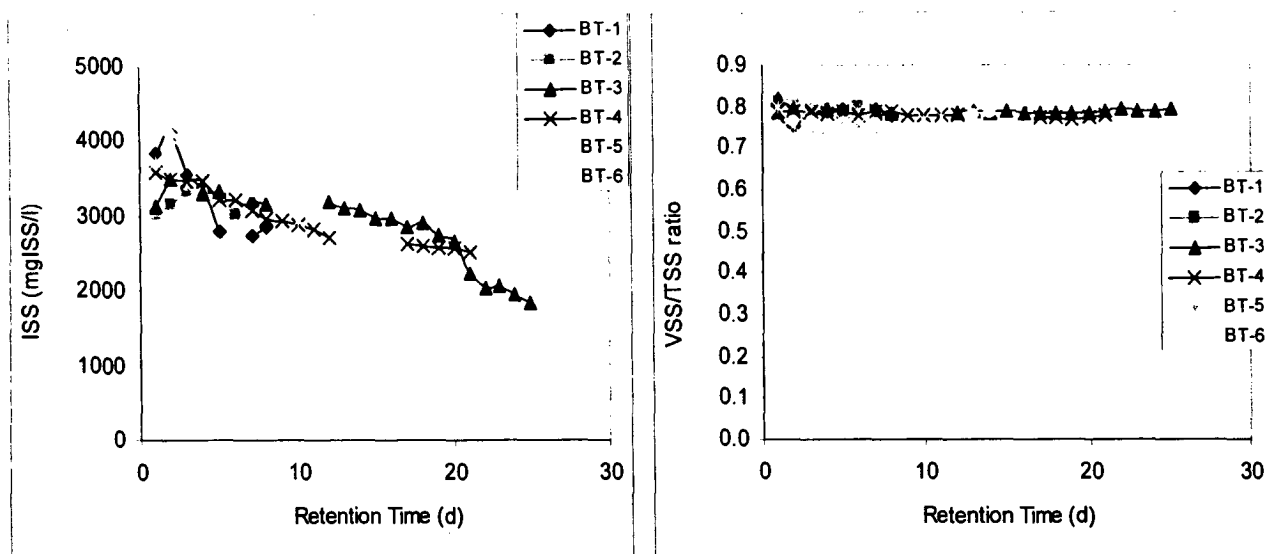


Figure 5.3a and b. ISS concentration and the VSS/TSS ratio of the WAS during the aerobic digestion process

For BT-7 and BT-8, operated simultaneously with undiluted and diluted WAS, the percentage VSS destructions were similar. With 23.4% VSS destruction, the VSS of the diluted WAS decreased uniformly from an initial VSS concentration of 2985 mg l^{-1} to a final value of 2287 mg l^{-1} . During the same period of aeration time, the VSS of the undiluted WAS decreased from an initial concentration of 15560 mg l^{-1} to 11510 mg l^{-1} which is a 26.0% VSS destruction (Figure 5.4).

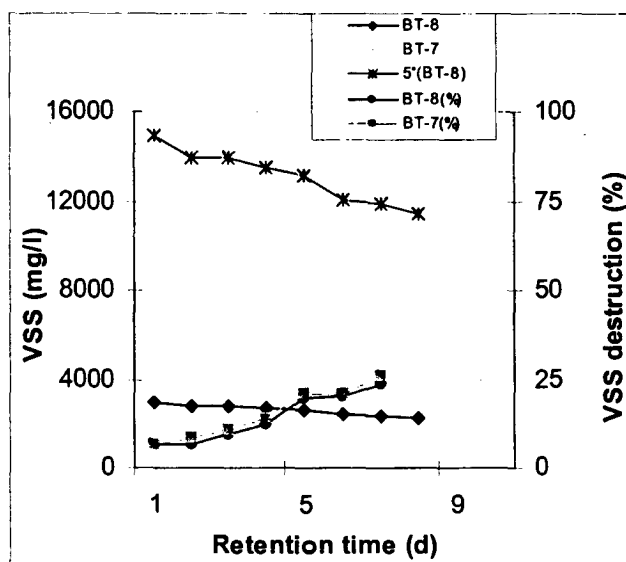


Figure 5.4. Comparison of the concentration of VSS and percentage VSS destruction for BT-7 (undiluted WAS) and BT-8 (diluted WAS)

Theoretically, multiplying the diluted WAS by the factor of dilution, i.e. bringing it back to its undiluted state, would make it equivalent to the undiluted WAS. In doing so, as shown in Figure 5.4, apart from a small discrepancy, the reduction in VSS of the 5 times multiplied diluted WAS was close to that of the undiluted WAS.

5.2.4 COD

Like the VSS, the total (unfiltered) COD concentration decreased almost linearly for all the batch tests (Figure 5.5a). The total COD decreased from initial values of 19350 and 19180 mgCOD l⁻¹ to 9840 and 11880 mgCOD l⁻¹ for BT-3 and BT-4 respectively. The highest and the lowest COD reduction obtained, with detention times of 23 and 10 days, were 49.1 and 34.7% for BT-3 and BT-5 respectively. Within 20 and 14 days of digestion period BT-4 and BT-6 had COD reductions of 38.1 and 36.1% respectively.

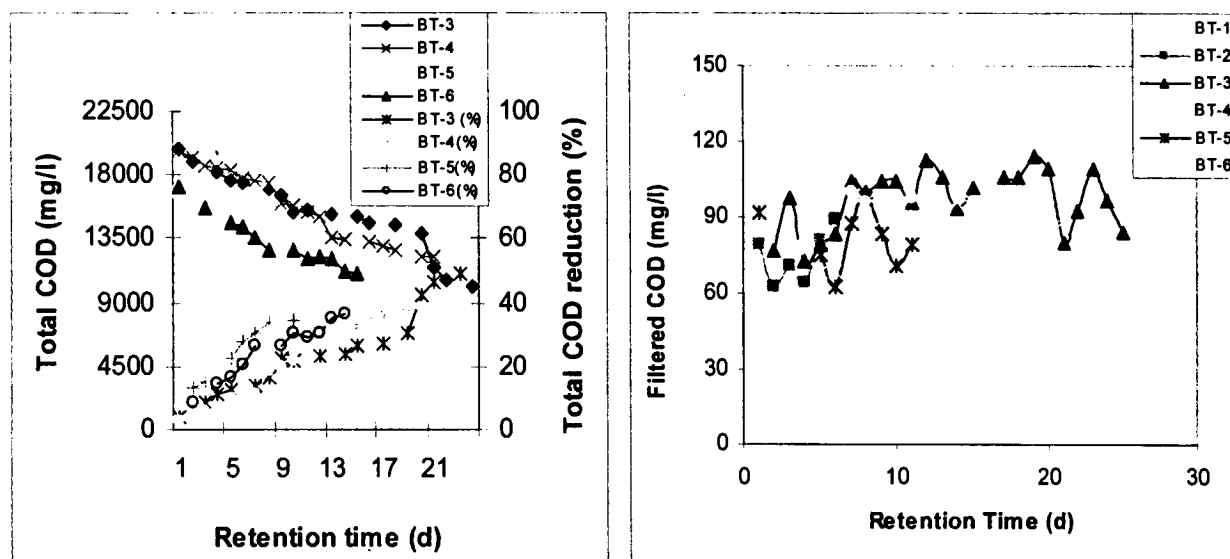


Figure 5.5a and b. Decrease in total COD along with the percentage total-COD reduction achieved and concentration of soluble (filtered) COD during the aerobic digestion process

On average, for all the batch tests, similar or slightly higher percentage of total COD reduction was achieved to that of the percentage VSS destruction. The total COD reductions obtained were 36.1, 38.1 and 49.1% for BT-6, BT-4, and BT-3 respectively. Moreover, the aeration times for BT-6, BT-4 and BT-3 were 11, 24 and 25 days respectively. Like the VSS, the highest percentage COD reduction was obtained with the longest detention time (BT-3)

but, unlike the VSS, the lowest percentage total COD reduction was obtained with the shortest detention time (BT-5), as expected from theory.

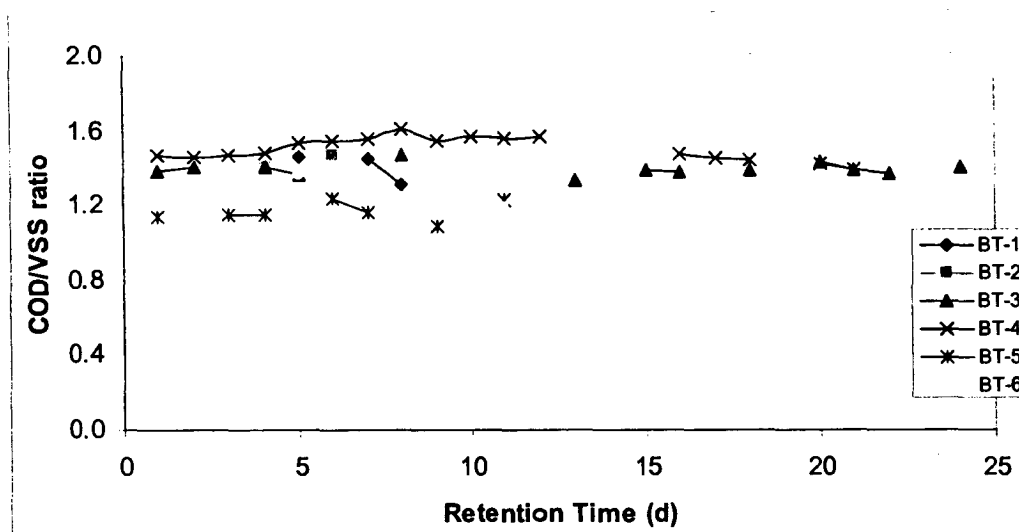


Figure 5.6. COD/VSS ratio of the WAS during the aerobic digestion process

Higgins *et al.* (1982) indicated that the order of removal efficiency would be higher for COD than for VSS, which indicated that the COD/VSS ratio decreases with digestion retention time. The results of this study, however, showed this conclusion not to be true. In fact, the removal efficiency of VSS was slightly higher than that of the COD, indicating a slight increase in COD/VSS ratio of the remaining solids.

The soluble (filtered) COD is unaffected by the digestion process and its value was expected to remain constant and low throughout the digestion process. However, as shown in Figure 5.5b, the filtered COD was observed to increase very slightly (relative to total COD) with variation between minimum and maximum values of 52 and 125 mg l⁻¹. A similar generation of a soluble endogenous 'residue', ascribed to a high specificity of the micro-organism population, was observed by Wentzel *et al.* (1988) in their enhanced PAO BEPR cultures. The PAO release of unbiodegradable soluble organics was not included in the UCTPHO and ASM-2 OHO and PAO mixed culture models because it was assumed that the OHOs would be able to utilize these soluble organics released by the PAOs, i.e. these organics are only unbiodegradable to themselves. These batch tests validate this assumption considering an average increase of only ~30 mgCOD l⁻¹ of soluble unbiodegradable organics from a total COD reduction of ~10000 mgCOD l⁻¹ which is only ~0.3% and can be considered negligible.

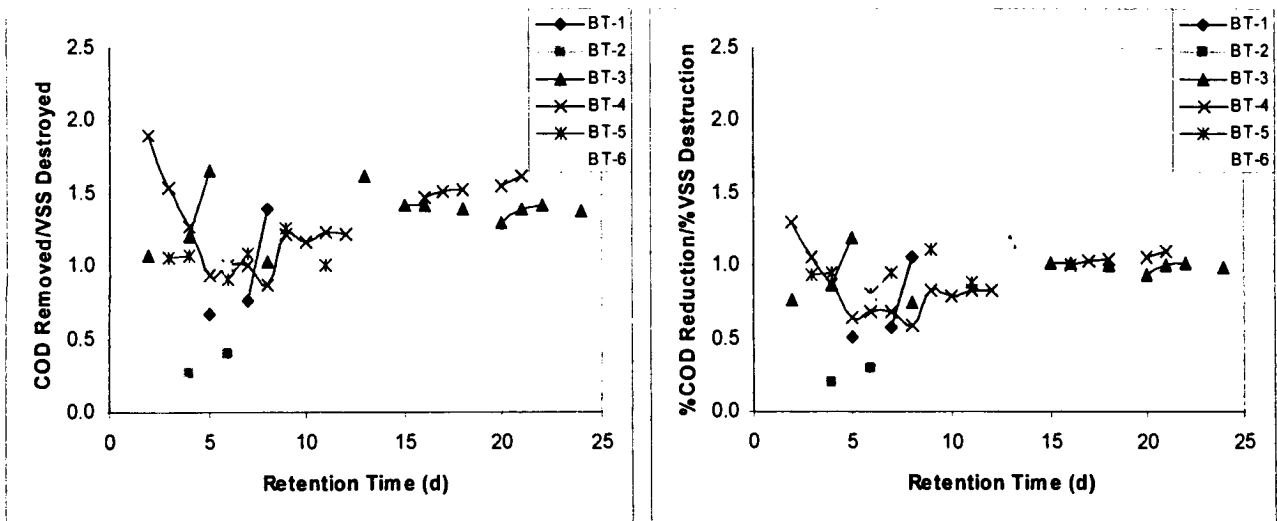


Figure 5.7a and b. Ratios of COD reduction/VSS reduction and %COD reduction/%VSS reduction of the WAS during the aerobic digestion process

Generally, during the digestion process the COD/VSS ratio of the remaining sludge mass fluctuated between minimum and maximum values of 1.33 and 1.47 mgCOD mgVSS⁻¹ (Figure 5.6). For BT-3, while the initial and final values of the COD/VSS were the same, i.e. 1.39 mgCOD mgVSS⁻¹, the intermittent values oscillated between minimum and maximum values of 1.33 and 1.47 mgCOD mgVSS⁻¹ respectively. For BT-4, the COD/VSS ratio decreased from an initial value of 1.47 to a final value of 1.39 mgCOD mgVSS⁻¹. Besides, the COD/VSS ratio fluctuated between 1.09 and 1.23 mgCOD mgVSS⁻¹, and 1.15 and 1.39 mgCOD mgVSS⁻¹, for BT-5 and BT-6 respectively.

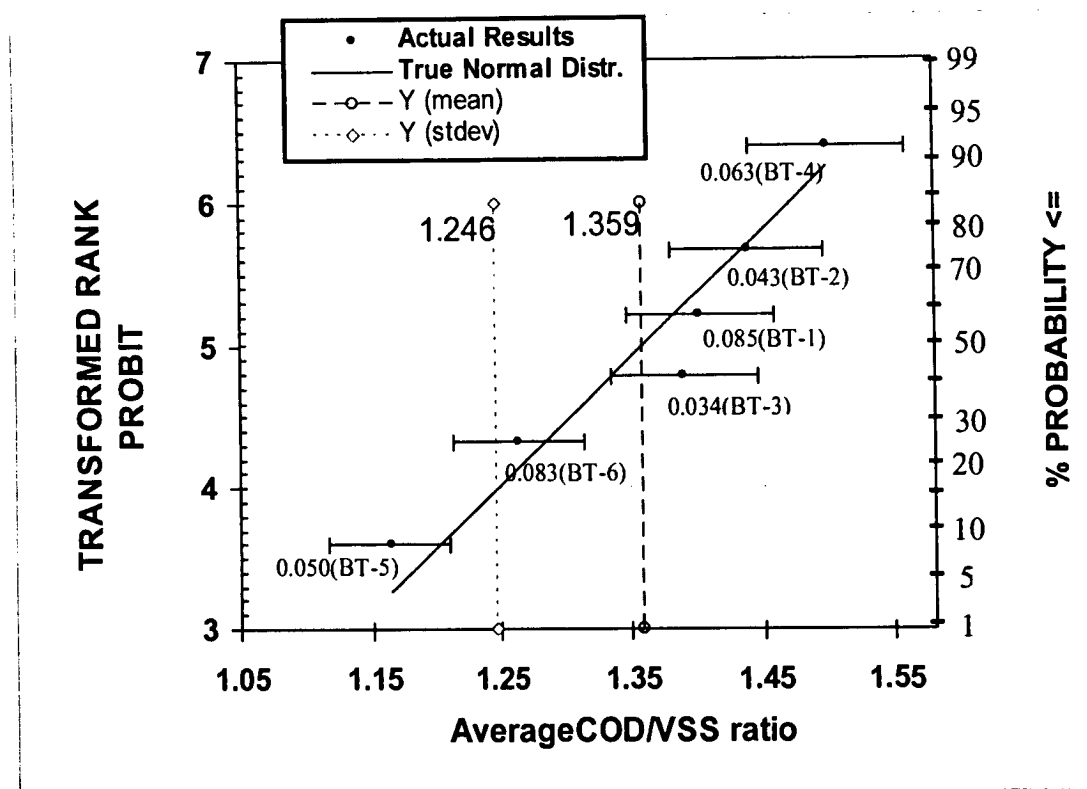


Figure 5.8. Statistical plot for the measured average COD/VSS ratio for BT-1 to BT-6

The lowest average COD/VSS ratio was obtained for BT-5 (1.16 mgCOD mgVSS⁻¹ with standard deviation of 0.050), while BT-4 exhibited the highest average COD/VSS ratio of 1.50 mgCOD mgVSS⁻¹ with standard deviation of 0.063 (Figure 5.8). The COD/VSS ratio for BT-3 and BT-6 were 1.26 and 1.39 mgCOD mgVSS⁻¹ with standard deviations of 0.034 and 0.083 respectively. An average COD/VSS ratio of 1.36 mgCOD mgVSS⁻¹ with a standard deviation of 0.113 was obtained for all the six batch tests. This average value is lower than the accepted value of 1.48 mgCOD mgVSS⁻¹. Besides, for the parent system for all the SBs from March 2005 to May 2006 and for SBs where the WAS was harvested for these six batch tests, the average COD/VSS ratios in the aerobic reactor were 1.40 and 1.35 mgCOD mgVSS⁻¹ with standard deviations of 0.12 and 0.15 respectively (du Toit *et al.*, 2006), which are equivalent to the average value for the batch tests. Though no adequate explanation could be given, the very high concentrations of the waste activated sludges considered might have contributed to the deviation of the average COD/VSS ratio obtained in this study (1.36 mgCOD mgVSS⁻¹) from the conventionally accepted or standard value of 1.48 mgCOD mgVSS⁻¹.

Table 5.2. Comparison of the measured average remaining, removed and percentage reductions of COD to VSS ratios

Type	Batch Test Number								
	BT-1	BT-2	BT-3	BT-4	BT-5	BT-6	BT-7	BT-8	Average
COD/VSS	1.40	1.44	1.39	1.50	1.16	1.26	1.20	1.27	1.33
COD Removed /VSS Removed	0.94	0.33	1.36	1.31	1.06	1.53	1.52	1.98	1.25
%COD Reduction / %VSS Destruction	0.71	0.24	0.98	0.90	0.93	1.17	1.20	1.47	0.95
Percentage increase of COD Removed /VSS Removed over %COD Reduction /%VSS Destruction	32.43	38.06	38.69	46.72	13.90	30.36	26.38	34.66	

As shown in Figure 5.7a and b, the COD removed/VSS destroyed ratio fluctuated between minimum and maximum values of 0.27 (BT-2) and 2.4 (BT-6) while the %COD reduction/%VSS destruction ratio fluctuated between minimum and maximum values of 0.20 (BT-2) and 1.87 (BT-6). Except for the scale, the trends of fluctuation of the COD removed/VSS destroyed and %COD reduction/%VSS destruction ratios were exactly the same. Both COD removed/VSS destroyed and %COD reduction/%VSS destruction ratios showed, with undulations, an increasing trend with digestion aeration times except for BT-4 and BT-6 where the undulating increase was preceded with an initial decrease at the beginning of the digestion test.

The COD removed/VSS destroyed ratios were higher than those of the %COD reduction/%VSS destruction ratios by 32.4, 38.1, 38.7, 46.7, 13.9 and 30.4% for BT-1, BT-2, BT-3, BT-4, BT-5 and BT-6 respectively (Table 5.2). Interestingly, the percentage increase of the COD removed/VSS destroyed ratios over the %COD reduction/%VSS destruction ratios remained constant for each of the batch tests, i.e. the average percentage increase of the COD removed/VSS destroyed ratios over the %COD reduction/%VSS destruction ratios for a specific batch test was equal to each daily value of that batch test.

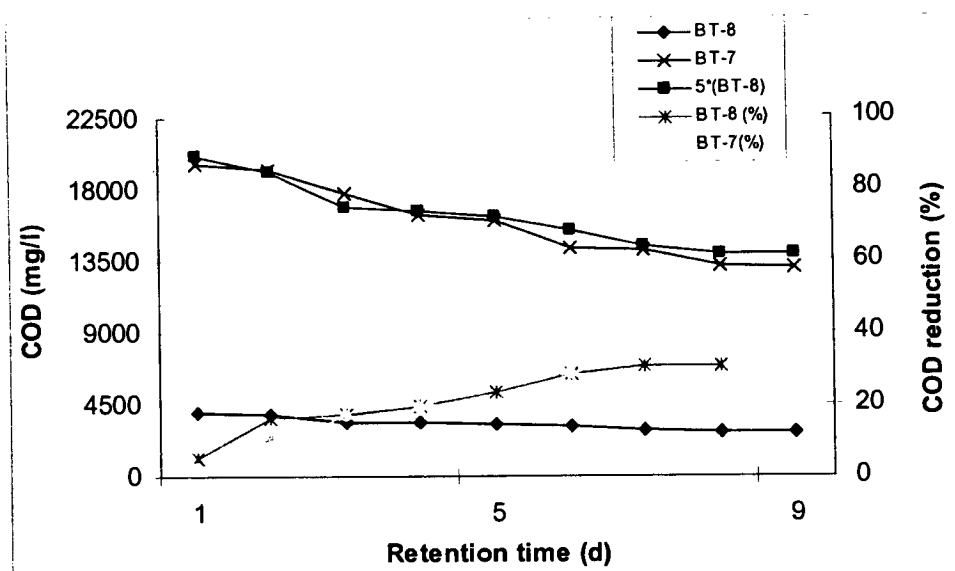


Figure 5.9. Comparison of the concentration of COD and percentage COD reduction for BT-7 (undiluted WAS) and BT-8 (diluted WAS)

As shown in Figure 5.9, the decrease in the concentration of COD and the percent COD reduction for BT-7 and BT-8, with undiluted and diluted waste activated sludges respectively, were very close. Moreover, when the diluted WAS was 'undiluted' by multiplying it with the dilution factor, the pattern of the decrease in COD concentration was equivalent to that of the undiluted WAS.

5.2.5 Nitrogen

The fractions of nitrogen present in the WAS bulk liquid are the FSA and the unbiodegradable soluble organic nitrogen ($N_{\text{ousi}} = N_{\text{ouse}}$) (both very low $< 3 \text{ mgN l}^{-1}$), and the organic nitrogen bound in the sludge mass. Of these fractions, the unbiodegradable soluble organic fraction remained unaffected by the digestion process. The organic nitrogen contained in the sludge mass was released by endogenous respiration as FSA by the OHOs and PAOs. The released FSA and the FSA that was originally present in the WAS are nitrified to nitrate by the autotrophic nitrifying organisms in the WAS. Nitrification was complete and no significant amount of ammonia and nitrite existed in the batch tests at any time of the digestion period ($< 2 \text{ mg NH}_4^+ - \text{N l}^{-1}$ and $< 1 \text{ mg NO}_2^- - \text{N l}^{-1}$).

As shown in Figure 5.10, the nitrate concentration increased rapidly within 7 days of the commencement of aerobic digestion. At the end of the digestion period the increase in nitrate concentration was small, especially for the BT-3 where it showed a slight increase following a decrease during the 13th and 14th day of the digestion period.

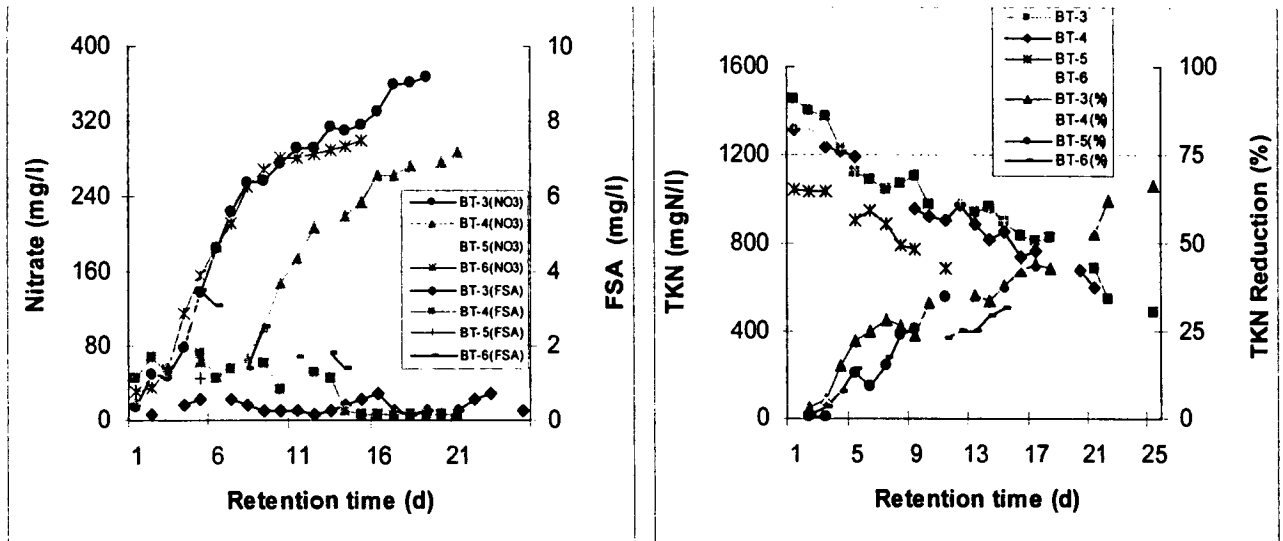


Figure 5.10a and b. Concentration of nitrate and FSA, and TKN and percentage of TKN reduction during the aerobic digestion process

The appearance of nitrate on the second day of digestion indicated the immediate commencement of nitrification, which is expected from the nitrifiers from the parent system. Except for BT-6, where FSA concentrations of 3.50 mg l⁻¹ and 3.08 mg l⁻¹ were obtained on the fifth and sixth days, the concentrations of the FSA for the rest of the digestion period were below 2 mg l⁻¹. Moreover, during the second half of the batch tests the measured concentrations of the FSA were below detectable limits of the FSA procedure, i.e. 0.5 mg l⁻¹.

The decrease in TKN concentration and the percent reduction in TKN are given in Figure 5.11a and b. After the initial high decrease in TKN, the magnitude of the decrease became smaller as the test progresses and was low at the end of the test. This trend is similar to the changes in COD and VSS. The organic nitrogen bound within the sludge cell decreased uniformly during the digestion process. The TKN reductions obtained ranged between 31.7 and 66.4%. Because there was no build up of FSA and nitrite, the decrease in TKN should mirror the increase in nitrate. This is shown in Figure 5.11a. Moreover, as the increase in the soluble unbiodegradable organics in relation to the decrease of total COD was negligible,

similarly the increase in organic unbiodegradable soluble nitrogen was negligible compared to the total reduction in TKN.

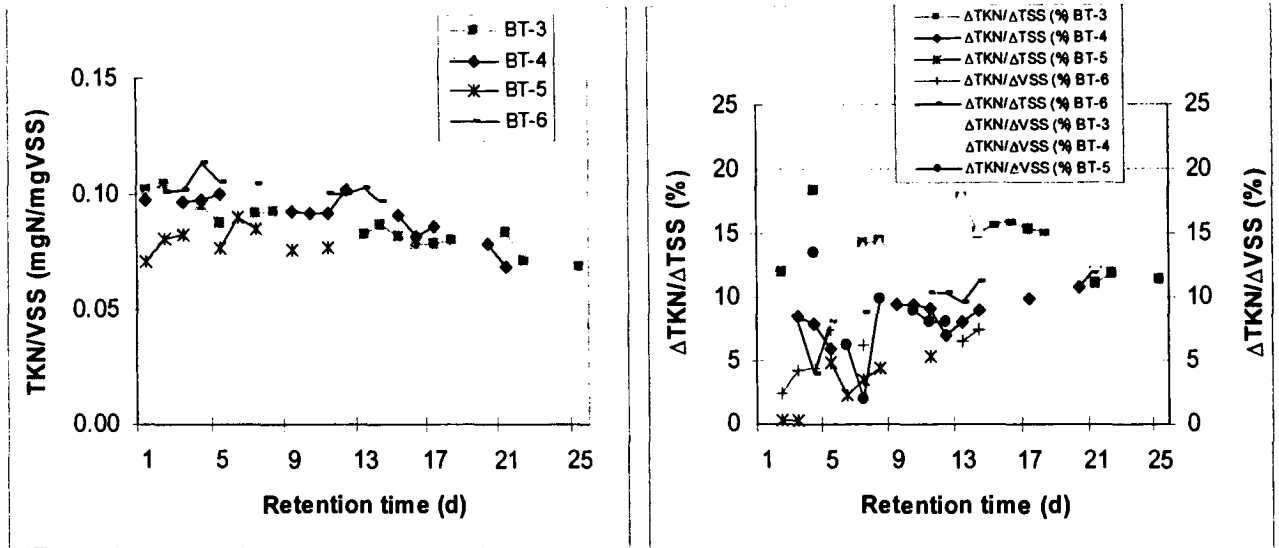


Figure 5.11 a and b. Ratios of TKN/VSS and percentage reduction of TKN/percentage TSS reduction and percentage reduction of TKN/ percentage the degradation of VSS during the aerobic digestion process

During the digestion process, the nitrogen content of the sludge (TKN/VSS ratio) slightly decreased while fluctuating between a minimum and maximum values of 0.071 (BT-5) and 0.113 mgN mgVSS⁻¹ (BT-6) respectively. The average TKN/VSS ratio obtained for BT-3 to BT-6 was 0.09 mgN mgVSS⁻¹ with a standard deviation of 0.009 (Figure 5.12). For the parent system for all the SBs from March 2005 to May 2006 and for SBs where the WAS was harvested for these six batch tests, the average TKN/VSS ratio in the aerobic reactor was 0.09 mgN mgVSS⁻¹ with standard deviation of 0.01 (du Toit *et al.*, 2006), which is identical to the average value for the batch tests. This value is very close to the conventionally accepted TKN/VSS ratio of 0.10 mgN mgVSS⁻¹.

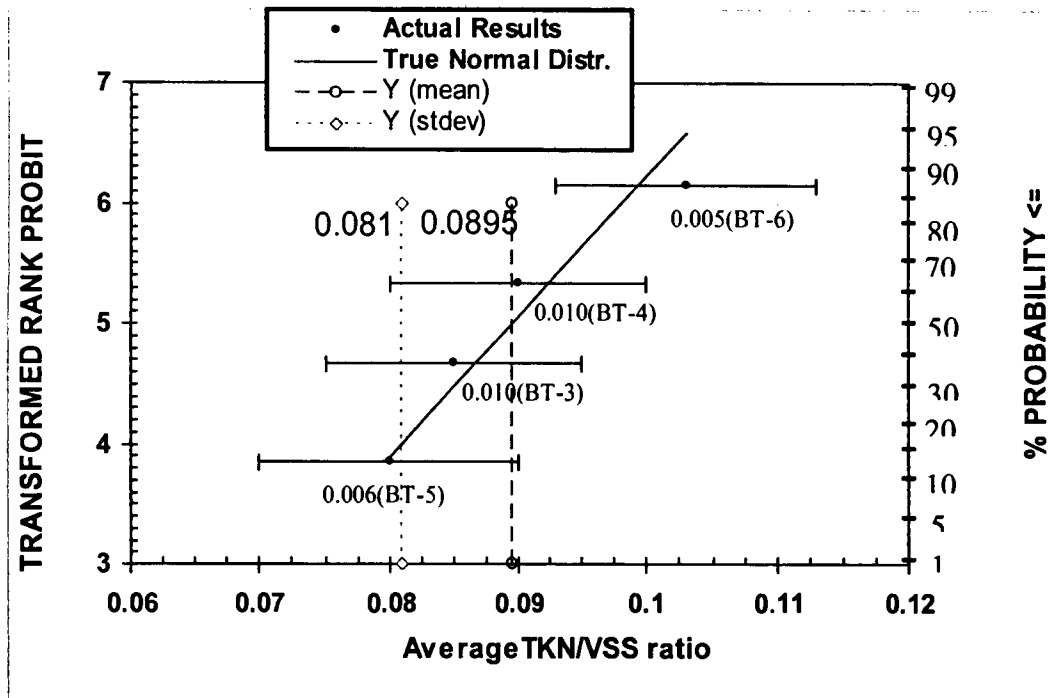


Figure 5.12. Statistical plot for average TKN/VSS ratios of BT-3 to BT-6

Moreover, the reduction of TKN with respect to VSS destruction ($\Delta\text{TKN}/\Delta\text{VSS}$) and TSS reduction ($\Delta\text{TKN}/\Delta\text{TSS}$) were similar (Figure 5.11b). This almost identical TKN reduction observed with respect to the VSS and TSS degradation renders the solubilization of the organic N in the sludge cell and subsequent conversion to FSA to be solely associated with the degradation of VSS.

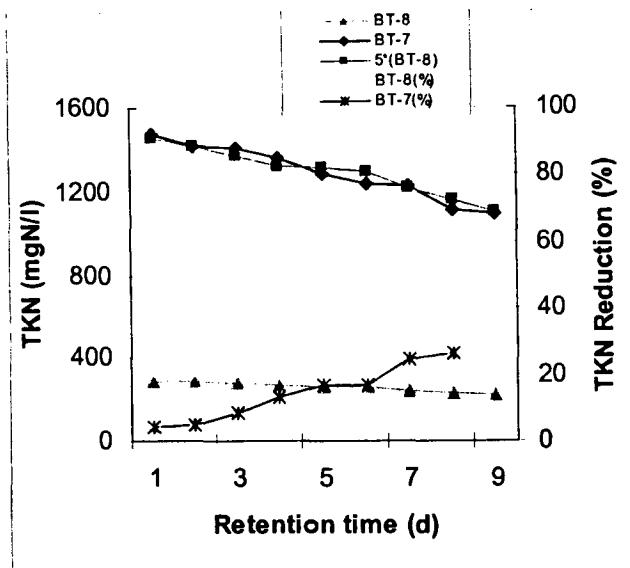


Figure 5.13. Comparison of the concentration of TKN and percentage TKN reduction for BT-7 (undiluted WAS) and BT-8 (diluted WAS)

In comparing BT-7 and BT-8, the simultaneous tests carried out with undiluted and diluted WAS respectively, apart for some small deviations, comparable percent TKN reductions were observed. When the diluted WAS was 'undiluted' by multiplying it with the dilution factor, its pattern matched almost identically that of the undiluted WAS (Figure 5.13). This indicated that dilution or concentration did not influence the aerobic digestion process.

5.2.6 Phosphorus

Phosphorus contained in the WAS either as organically bound P or internally stored P is released into the bulk liquid by aerobic digestion as OP. During this study of aerobic digestion of WAS an approximately linear increase of OP in the bulk liquid was observed. It is only near the end of the digestion period that the increase became smaller with time.

The main objective of doing the diluted WAS batch test (BT-8) was to ensure that no mineral precipitation would take place with which to compare the undiluted test (BT-7) in which mineral precipitation possibly could take place, even though the ammonia concentration was generally less than $1 \text{ mgNH}_4\text{-N l}^{-1}$ due to complete nitrification during the batch tests. Because the measured ortho P concentration at the end of the undiluted BT-7 (208.5 mgP l^{-1}) was only about 65% of the diluted BT-8 times the dilution factor (5), it was possible that precipitation of P took place in the undiluted batch test.

In the comparison of the VSS, TKN and COD between the undiluted BT-7 and diluted BT-8, when the measured values for the diluted test were multiplied back by the dilution factor they were comparable to the corresponding values of the undiluted WAS of BT-7. This 1:1 relationship, however, was not obtained for the phosphorus concentrations (Figure 5.14).

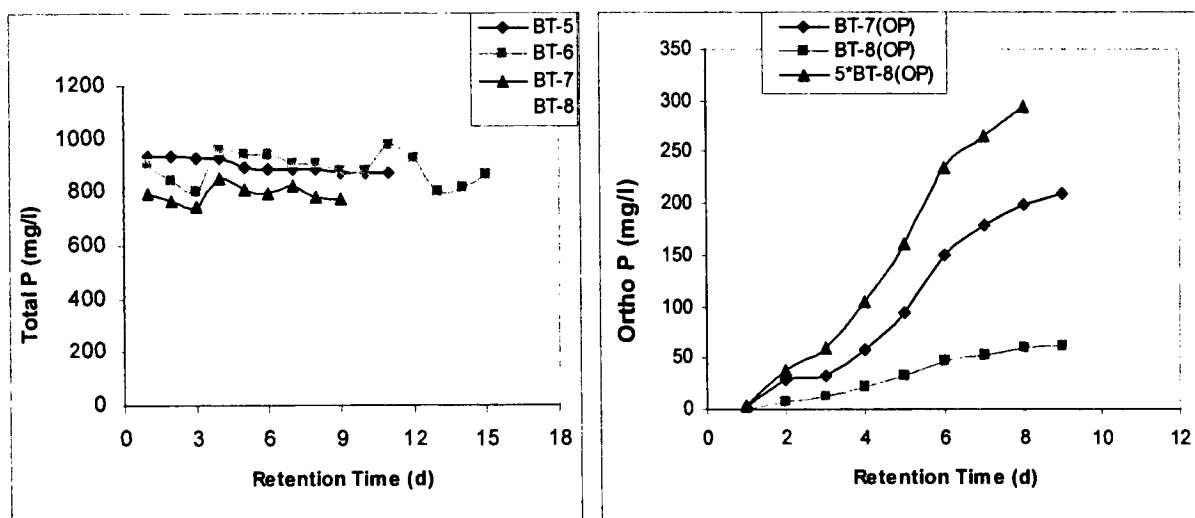


Figure 5.14a and b. Total P and ortho P concentrations for BT-5 to BT-8 and OP concentrations for undiluted BT-7, diluted BT-8 and diluted BT-8 multiplied by the dilution factor (5)

As shown in Figure 5.14a and b, there was significant difference between the TP of BT-7 (with undiluted WAS) and BT-8 (with diluted WAS). Moreover, when the measured TP concentration of BT-8 was multiplied by the dilution factor (5) it was much higher than that of BT-7. Similarly, when comparing the OP concentrations of BT-7 and BT-8, the difference between the measured OP concentrations was high. When the OP concentration of BT-8 was 'undiluted' by multiplying back by the dilution factor (5) it was higher than that of the undiluted WAS of BT-7. This difference could be (1) a dilution effect in the OP or TP test method, (2) mineral precipitation, or (3) no P release by the PAO biomass. This last reason was considered highly unlikely because the biomass nitrogen was released (as FSA which was nitrified to nitrate) at the expected concentrations. The remaining two possible sources of the difference are discussed below.

5.2.6.1. Dilution effect

As explained in the previous section, the OP and the TP analyses were done using a vanadomolybdate colour development using a UNICAM 8625 UV/VIS spectrometer. The standards used in the test were within a concentration range of 0 to 25 mgP l⁻¹. The concentrations of the measured OP and TP were much higher than the range of standards used in the analysis. Because the samples tested for OP and TP were not diluted to fall below the 25 mgP l⁻¹, a comparison was made between undiluted samples of BT-5 and diluting these samples so that the OP concentration would be within the range of the standards (0 to 25 mgP l⁻¹). Comparison of these dilution effect tests produced no difference in the OP concentration of the analyzed diluted and undiluted samples (Figure 5.15a). Additionally, to check the effect of dilution, standard concentrations of di-potassium hydrogen orthophosphate (K₂HPO₄) ranging from 0 to 400 mgP l⁻¹ were prepared and analysed using the same procedure. As shown in Figure 5.15b, apart for small deviation at concentrations of >350 mgP l⁻¹, the analyzed results were equivalent to the prepared standard concentration of K₂HPO₄, showing that a linear relationship was still valid for concentrations out of the 0 – 25 mgP l⁻¹ range of the standards up to 400 mgP l⁻¹ (Figure 5.15b). This eliminated 'out of range' as possible cause for the deviation between the diluted and undiluted batch tests OP concentrations (Figure 5.14b). The difference could be due to mineral precipitation because it is the undiluted test that has lower P concentrations than the diluted test – if precipitation occurs it is more likely in the undiluted test. This is considered in detail below.

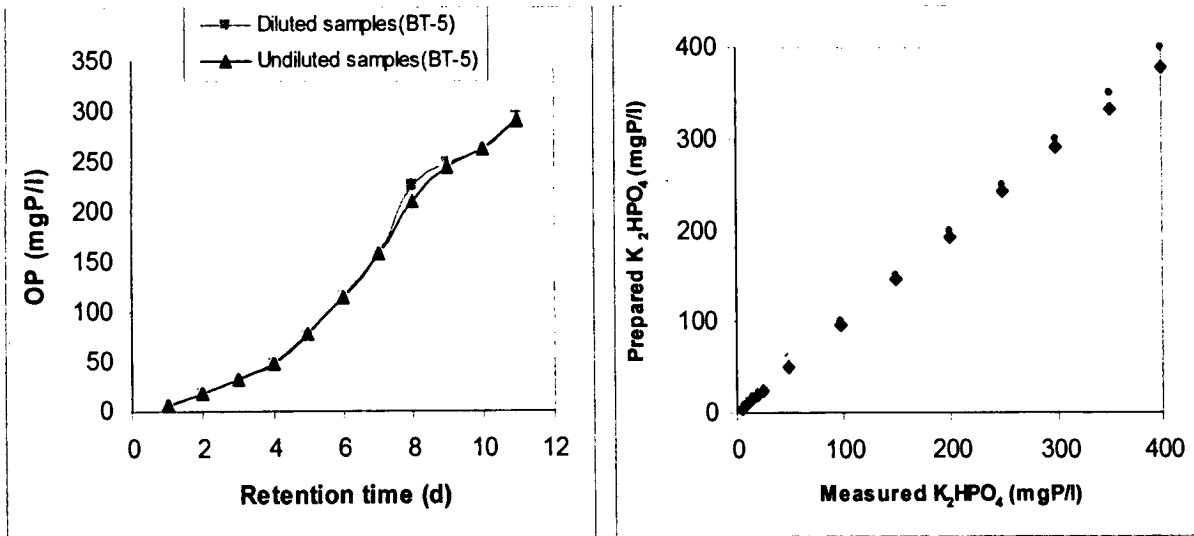


Figure 5.15a and b. Comparison of diluted and undiluted samples of BT-5, and prepared and analyzed concentrations of di-potassium hydrogen orthophosphate

5.2.6.2 Calcium, Magnesium and Mineral precipitation

In the endogenous respiration process when the micro-organisms die, they release the cations which were contained in the cells to stabilize the stored polyphosphate. The cations calcium and magnesium were measured in the batch tests. During the aerobic digestion of the WAS, the concentration of calcium remained almost constant while fluctuating between a minimum and maximum values of 19.4 and 41.0 mg l⁻¹ while the magnesium concentration increased linearly with time from 0 to 77 mg l⁻¹ (Figure 5.16a and b).

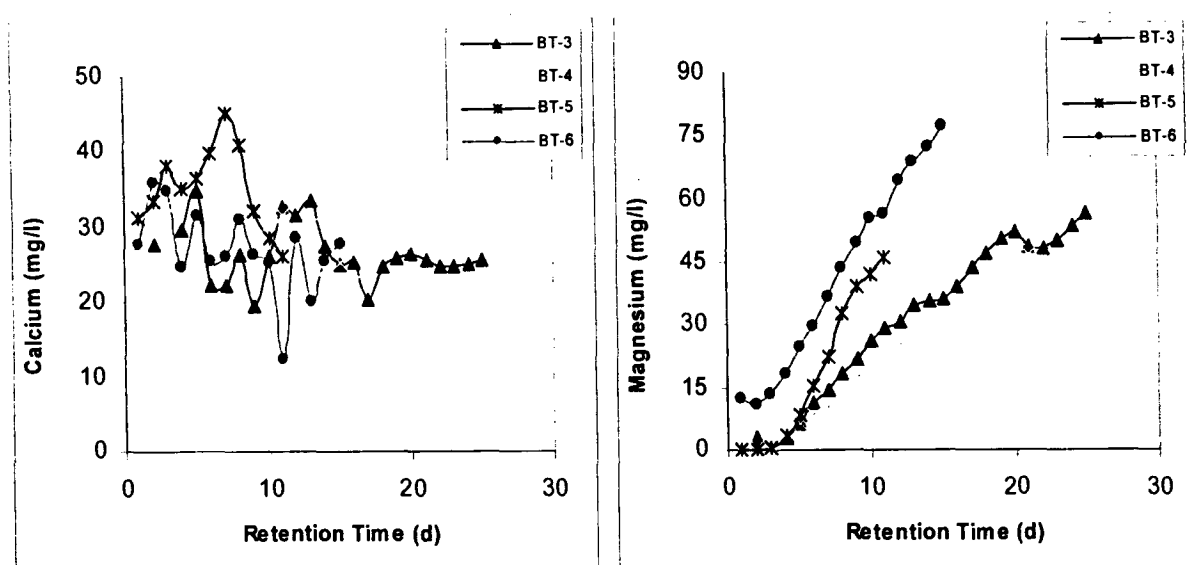


Figure 5.16a and b. Concentrations of calcium and magnesium during the digestion process

With the occurrence of a conducive environment, the magnesium (Mg), ammonium (NH_4) and phosphate (PO_4^{3-}) released into the bulk liquid may react to form magnesium ammonium phosphate (MgNH_4PO_4) precipitate, known as struvite, which forms a hard crystalline deposit blocking aerators, pipes and pumps of sludge treatment facilities.

Struvite precipitation is expected to occur if the molar concentration product of magnesium, orthophosphate and ammonium exceeds the solubility product, K_{sp} of struvite. The occurrence for this condition for the precipitation of struvite was examined by comparing of the product of the measured concentrations of magnesium, orthophosphate and ammonium with the solubility product of struvite as shown in Table 5.3.

Table 5.3. Comparison of the product of molar concentrations of magnesium, ammonium and phosphate with the solubility product of struvite ($\leq$ = less; $>$ = greater).

Detention Time (d)	Molar Product ($\text{Mg} \cdot \text{NH}_4 \cdot \text{PO}_4$)				Molar Product Compared to K_{sp} of Struvite ($2.512\text{E-}13$)			
	BT-3	BT-4	BT-5	BT-6	BT-3	BT-4	BT-5	BT-6
1		3.53E-17				>		
2		5.27E-16				>		
3		4.42E-15	1.15E-13			>	<	
4	1.04E-14				<			
5	5.65E-14	1.17E-13	1.76E-13	1.78E-12	>	<	<	<
6		1.33E-13		2.48E-12		<		<
7	2.24E-13	2.2E-13	3.44E-12		<	<	>	
8	2.48E-13	6.43E-13	1.13E-11	2.81E-12	<	>	<	>
9	2.53E-13	6.25E-13		6.59E-12	>	>		>
10	3.36E-13	4.64E-13	1.71E-11	1.29E-11	>	>	<	<
11	3.88E-13	1.65E-12	4.48E-13	6.31E-12	>	<	>	>
12	2.18E-13	9.68E-13			<	>		
13	5.74E-13	1.04E-12		9.92E-12	>	<		>
14	9.14E-13	2.83E-13		8.65E-12	>	>		>
15	1.25E-12	1.65E-13			<	<		
16	1.78E-12	1.79E-13			<	<		
17	8.63E-13	2.17E-13			>	<		
18		2.76E-13				>		
19	1.01E-12	2.87E-13			<	>		
20		3.19E-13				>		
21	9.43E-13	3.41E-13			>	>		
22	1.75E-12				<			
23	2.34E-12				<			
24								
25	1.13E-12				<			

Though without uniform trend, in a number of cases the molar product of concentrations of Mg^{2+} , NH_4^+ and PO_4^{3-} were observed to exceed (as indicated by '>') the solubility product of struvite. Because the Mg and OP concentrations were generally increasing during the batch tests, the fluctuation in ionic product was mainly caused by the fluctuating ammonia concentration between 0.5 and 2 mgN l^{-1} . The fact that the ionic product fluctuated around the solubility product during the course of the batch tests, indicated that mineral precipitation probably did take place. This conclusion is supported by

- (1) the much lower OP concentration in the undiluted BT-7 compared with the diluted BT-8 "corrected" for dilution (Figure 5.14b)
- (2) the only batch test which the OP concentration could be correctly predicted was diluted BT-8 – all the other undiluted batch tests had predicted OP concentrations

2 to 3 times higher than the measured OP concentrations (see below – Figure 5.41). Such a big difference is unlikely for a calibrated simulation model for which the starting TP concentrations are the same as those measured, unless the P remains in the solid phase either through P precipitation or through non-release of the stored P of the PAOs

- (3) the measured Mg concentration was only about $1/3^{\text{rd}}$ of that expected from the polyphosphate content and batch test simulation model predicted OP concentration. From $\text{Mg:K:Ca:P} = 0.275:0.295:0.05:1$ content of polyphosphate, the predicted bulk liquid cation concentrations from the predicted final OP concentration of around 700 mgP l^{-1} should be $192:206:35:700$. The observed final concentrations were significantly below these predicted concentrations from the P content of the PAOs at around $60: - :30:300$ (Mebrahtu *et al.*, 2007). In hindsight, K should have been measured also because it does not readily precipitate. High and increasing K concentrations with digestion time would have provided further evidence that P was being released by the PAOs but Mg and OP remained low in the bulk liquid due to struvite precipitation.

The initial liquid OP concentrations for BT-4, BT-5, BT-6 and BT-7 were 0.3, 6.2, 2.1 and 2.4 mgOP l^{-1} respectively. After aeration times of 21, 11, 15 and 9 days the liquid OP concentrations for BT-4, BT-5, BT-6 and BT-7 reached 218.7, 289.5, 378.1 and $208.5 \text{ mgOP l}^{-1}$ respectively. The initial TP content of the VSS, $(P/VSS)_i$ and TSS, $(P/TSS)_i$ for BT-5, BT-6 and BT-7 were 7.3, 6.6 and 5.1% and 5.8, 5.1 and 4.0%, respectively. The initial and final aeration had the effect of transferring P from the particulate to the dissolved phase. This also indicated that P did not go missing in the batch tests – the question was in relation to the simulated model, what caused it to stay in the sludge – mineral precipitation or incomplete release of PAO P content.

The lowest $(P/VSS)_i$ and $(P/TSS)_i$ ratios (BT-7) resulted in the lowest OP release into the bulk liquid, while the highest $(P/VSS)_i$ and $(P/TSS)_i$ ratios (BT-6) resulted in the highest OP release into the bulk liquid. This shows that the release of OP into the bulk liquid was directly related to the initial concentration of the suspended solids. The higher the initial phosphorus content of the sludge, the higher the OP released in to the bulk liquid. This is in agreement with the findings of Ju *et al.* (2005), where they observed a clear dependency of

the liquid phosphorus concentration on the initial phosphorus content of the solids; the higher the initial phosphorus content in the solids, the higher the supernatant phosphorus concentration. If the released P was precipitating one would not expect a consistent relationship between the bulk liquid OP concentration and the initial P content of the VSS. In comparison with the calibrated simulation model (see below), which shows also a consistent relationship between P released and initial P/VSS ratio, but with a P release 2 to 3 times higher than measured, this observation seems to indicate that the complete P content of the PAOs is not being released to the bulk liquid as aerobic digestion progresses.

As shown in Figure 5.17a, during the aerobic digestion of the WAS the OP concentration increased almost linearly until the end of the digestion period. On the other hand, as explained earlier, the decrease of VSS concentration during the digestion process was almost linear. This implies that the observed P release can be attributed to the degradation of the VSS. Similar conclusion was drawn by Ju *et al.* (2005) when they asserted that P release is not independent of the VSS destruction. From this it can be inferred, with caution that, with regulated pH, P release due to inorganic P dissolution did not occur during the aerobic digestion process. On the contrary, it is more likely that precipitation would occur.

Besides, the unfiltered TP concentration showed a slight decrease from the initial values of 934.4, 905.3 and 794.3 mgP l⁻¹ to 873.9, 864.1 and 771.3 mgP l⁻¹ for BT-5, BT-6 and BT-7 respectively. While for BT-8, the TP concentration showed a slight increase from the initial value of 598.5 to final value of 619.2 mgP l⁻¹ (Figure 5.19b). This shows that P balances in the batch tests were reasonable (94 – 103 %).

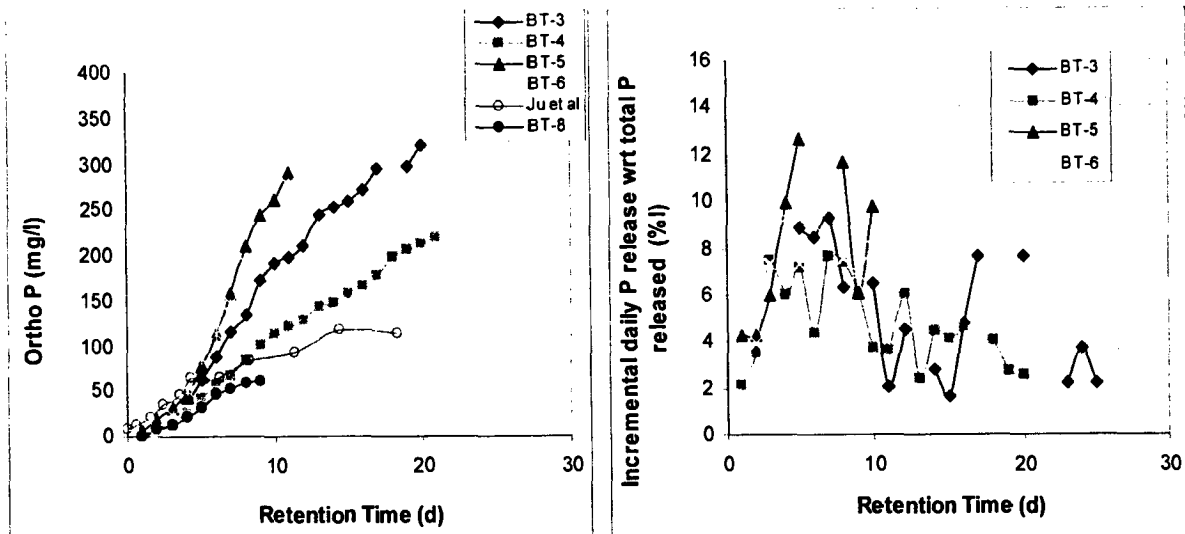


Figure 5.17a and b. Orthophosphate concentrations as compared to the data of Ju *et al.*(2005) and the daily incremental P release with respect to the total P release (in percentage) during the aerobic digestion process

The daily incremental P release with respect to the total P release fluctuated between initial and final values of 8.9, 2.2, 4.3, 1.7 and 11.1% and 2.2, 2.6, 9.4, 5.9 and 4.6% for BT-3, BT-4, BT-5, BT-6 and BT-8 respectively. For BT-3, BT-4, BT-5 and BT-6, the minimum and maximum daily incremental P release with respect to the total P release were 1.7, 2.2, 4.3 and 1.7% and 9.3, 7.6, 12.7 and 11.6% respectively (Figure 5.17b). Though the daily incremental P release with respect to the total P release for BT-3, BT-4, BT-5 and BT-6 follow no definite pattern, generally after an initial slight increase, a gradual decrease with digestion time was observed. Omitting the extreme values, the almost comparable daily incremental daily P release values seem to indicate the P release was due to the release of the organically bound P in the sludge mass of the OHOs and the PAOs as the endogenous process proceeded. The observed initial slight increase may be due to a delay of the onset of true 'endogenous respiration' behaviour of PAOs, and that of the gradual decrease with digestion time due to the high death rate of the OHOs and low death rate of the PAOs where the P release from the death of the OHOs diminishes faster leaving behind a gradual P release from the organically bound P of the sludge mass of the dying PAOs. Besides, the absence of a consistent high discrepancy between the percentage daily incremental P release values with respect to the total P release suggest that the poly phosphate (PP) content of the remaining live PAOs remains constant during the digestion process. An initial high release of P by all the live PAOs until their P content is the same low value as OHOs before the endogenous respiration

commences was not observed. It is, therefore, reasonable to accept that P is released by PAOs during aerobic digestion as they die at their endogenous rate, i.e. as their VSS mass decreases.

The liquid OP/ Δ VSS and OP/ Δ TSS ratios, in percentage, for BT-4, BT-5 and BT-6 increased from initial values of 1.9, 1.0 and 1.3 mgOP mgVSS⁻¹ and 1.1, 1.4 and 1.9 mgOP mgTSS⁻¹ to final values of 4.7, 5.0 and 2.8 mgOP mgVSS⁻¹ and 3.8, 4.2 and 2.2 mgOP mgTSS⁻¹ respectively. For BT-3 within 21 days of digestion, the OP/ Δ VSS and OP/ Δ TSS ratios (in percentage) increased from 2.6 mgOP mgVSS⁻¹ and 3.0 mgOP mgTSS⁻¹ to 4.1 mgOP mgVSS⁻¹ and 3.5 mgOP mgTSS⁻¹ respectively (Figure 5.18a). Generally, the OP/ Δ VSS ratios were higher than the OP/ Δ TSS ratios. The trends of the incremental P-release with respect to VSS degradation (Δ P/ Δ VSS) and TSS reduction (Δ P/ Δ TSS) were similar. Except for some initial values of BT-5 and BT-6 where Δ P/ Δ TSS were higher than Δ P/ Δ VSS, generally the incremental P release with respect to VSS destruction was higher than the corresponding TSS reduction (Figure 5.18b).

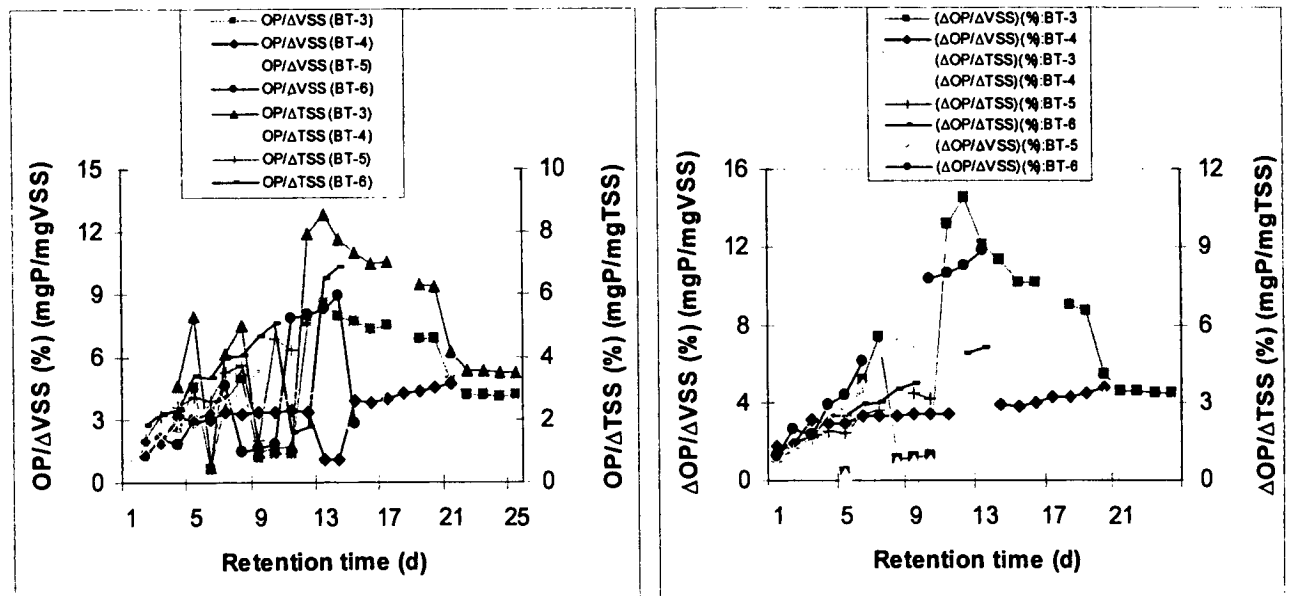


Figure 5.18a and b. Ratios of liquid OP/ Δ VSS and OP/ Δ TSS in percentages, and Δ OP/ Δ VSS and Δ OP/ Δ TSS in percentages during the aerobic digestion process

The average OP/ Δ VSS ratio (%) for the batch tests was 3.8 mgOP mgVSS⁻¹ with standard deviation of 0.83. The variation for the OP/ Δ VSS ratios among the batch tests ranged from 3.1 mgOP mgVSS⁻¹ (BT-5), with a standard deviation of 1.68 and detention time of 11 days,

to 4.9 mgOP mgVSS⁻¹ (BT-3) with standard deviation of 2.50 and detention time of 21 days (Figure 5.19). This high variation is also related to the variability of the initial P content of the solids before the aerobic digestion of the WAS.

For all the SBs of the parent system (from March 2005 to May 2006) the average P/VSS ratio was 8.3%. For the SBs where the WAS was harvested for batch tests, the average P/VSS ratio was 6.8%.

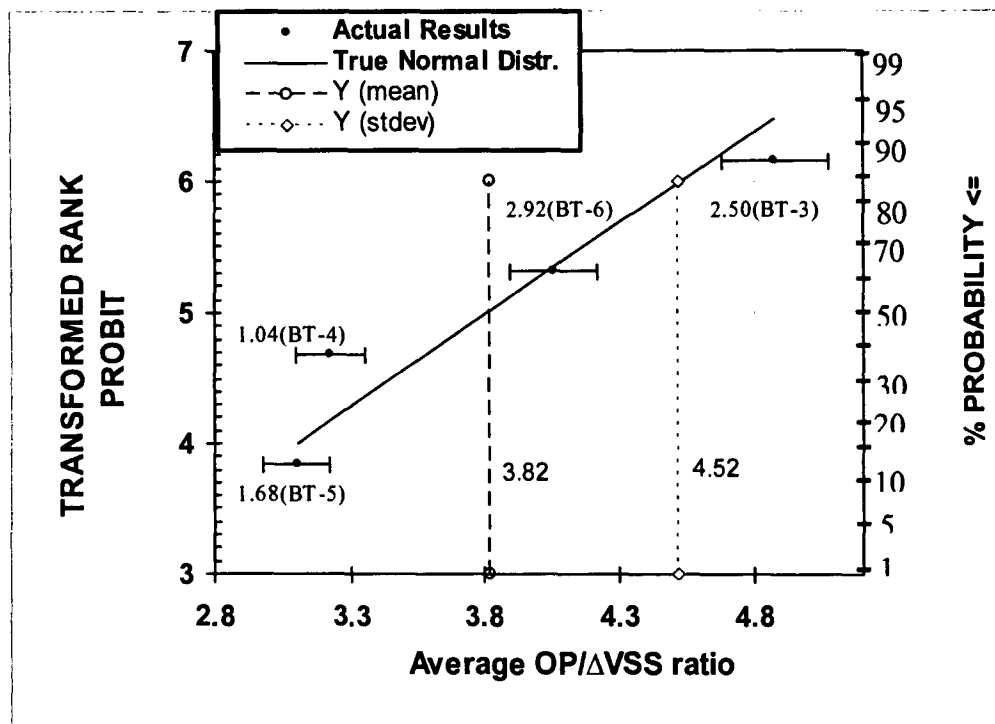


Figure 5.19. Statistical plot of measured average OP/ΔVSS (%) ratio during the aerobic digestion process

For comparison, the finding of Ju *et al.* (2005) on aerobic digestion of WAS, with regulated pH at 7.0, from a BNR WWTP is plotted in Figure 5.17a. Though the difference between the parent systems where the sludges were harvested and the acclimatization of the samples shipped from the WWTP to the laboratory where Ju *et al.* (2005) done the batch tests would create a hindrance for a comparative evaluation of the results of both studies, the data of Ju *et al.* (2005) when compared to the results of the undiluted WAS sludge of BT-3 to BT-6, for the first five days of digestion, the P release trends of both sludges coincided well. Thereafter, the rate of P release of Ju *et al.* (2005) flattened out till the end of the digestion period (Figure 5.17a). Moreover, when compared to the result of BT-8, with diluted WAS, the P release of

Ju *et al.* (2005) followed a similar trend, though at a slightly higher level. Though the sludge used in the study of Ju *et al.* (2005) had low TSS concentration ($\sim 1500 \text{ mg l}^{-1}$) as compared to the undiluted WAS of BT-7 (19660 mg l^{-1}) and diluted WAS of BT-8 (3770 mg l^{-1}), its initial $(P/TSS)_i$ content ($\sim 7.0\%$) was higher than that of BT-7 (4.0%) and lower than that of BT-8 (15.9%). However, a slightly higher P release was observed with Ju *et al.* (2005) than obtained for BT-8 (diluted WAS) and lower than BT-7 (undiluted WAS) of this study.

Comparing the undiluted BT-7 and diluted BT-8, their initial P/VSS and P/TSS ratios were not the same which is contrary to what was expected. The initial TP concentration of the diluted BT-8 (598.5 mgP l^{-1}) was only 75% of that of the undiluted BT-7 (794.3 mgP l^{-1}). Considering that the dilution factor was 5:1, it was expected that the initial P for BT-8 be 20% (i.e. $\sim 150 \text{ mgP l}^{-1}$) of that of BT-7. Moreover, in the diluted BT-8 the OP released was only 10% of the initial TP concentration, whereas for the undiluted BT-7 it was $\sim 26\%$ of its corresponding initial TP concentration, which seems to contradict the conclusion that mineral precipitation took place in BT-7 and not BT-8 – in the undiluted BT-7 the released OP concentration with respect to the initial TP concentration was higher than that of the diluted BT-8. This completely deepens when considering the simulation results (see below). The predicted P release matched that observed in BT-8 but was ~ 2 times higher for BT-7, speculated to be due to mineral precipitation in BT-7. No definite explanation can be given at this point.

5.2.8 Oxygen Utilization Rate and Specific Oxygen Utilization Rate

During the aerobic digestion process the sludge cells are oxidized to CO_2 and H_2O . The impracticality of measuring the by-product, i.e. the water, has urged the use of an indirect way of measuring it. The oxygen utilized represents the substrate (or cell material) oxidized to form the water. Hence, the OUR serves as an important indicator of biological activity in aerobic biological process, a reflection of the rate of mass reduction through endogenous respiration. The oxygen uptake rate of aerobically digesting sludge depends on the temperature, the type of sludge fed to the digester, the initial concentration of the sludge, and the sludge age of the digesting sludge. The oxygen uptake rate would normally decrease with increasing detention time and decreasing reactor temperature.

For BT-4 and BT-6 the OUR, as shown in Figure 5.20a, decreased from initial values of 43.8 and 34.0 $\text{mgO l}^{-1} \text{h}^{-1}$ to final values of 6.1 and 1.9 $\text{mgO l}^{-1} \text{h}^{-1}$ respectively. For BT-5 the OUR decreased from an initial value of 31.8 to 7.4 $\text{mgO l}^{-1} \text{h}^{-1}$ in 10 days of aerobic digestion. Except for BT-4 where the OUR dropped sharply from the beginning, the OUR for BT-3, BT-5 and BT-6 fluctuated unevenly for the first four days of the digestion period. For all the batch tests the sharp decline of the OUR occurred within 11 days of the digestion process. Thereafter, the decrease of OUR was much lower until the end of each digestion test. For BT-3 the 'initial' value of OUR considered is that of the 4th day, i.e. 31.6 $\text{mgO l}^{-1} \text{h}^{-1}$. This value is an average of 89 readings taken for that day, as all the daily OUR values shown as one data point are the computed daily average values. Taking the decrease of OUR in the fourth day alone, there was a sharp decrease from the first value of 46.3 to the last, 29.2 $\text{mgO l}^{-1} \text{h}^{-1}$ in an interval of 16 hours. However, considering the daily averages, after some fluctuations during the first 8 days, there was a steep decrease in OUR until the 14th day to an OUR value of 6.2 $\text{mgO l}^{-1} \text{h}^{-1}$. Thereafter, the OUR decreased gradually to a final value of 3.7 $\text{mgO l}^{-1} \text{h}^{-1}$.

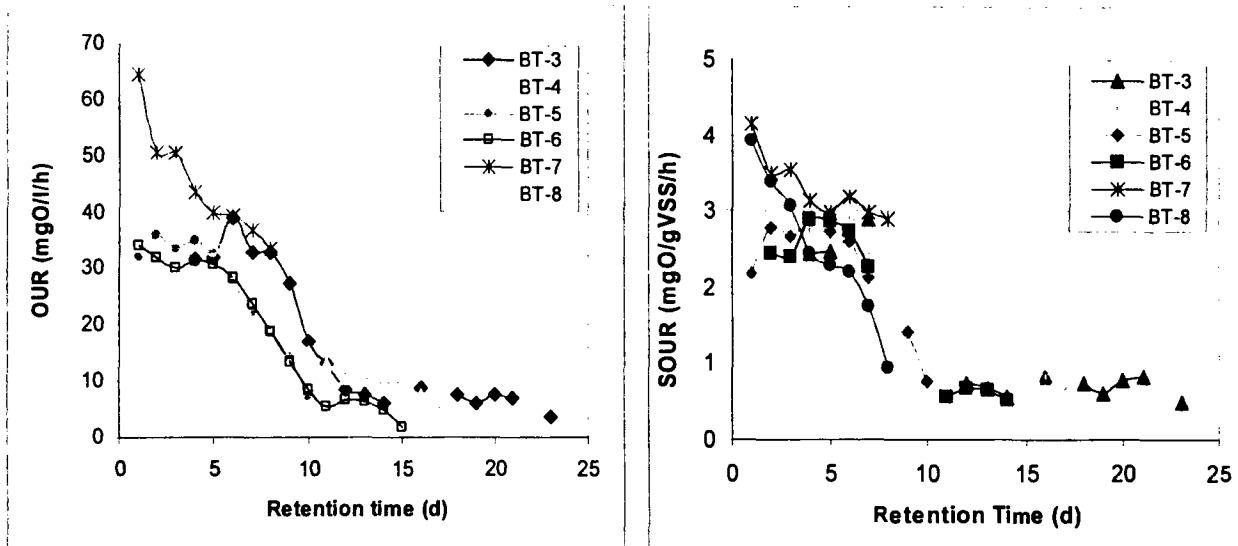


Figure 5.20a and b. OUR and SOUR during the aerobic digestion process

The ratio of the consecutive OUR values remained almost constant with slight fluctuations between a minimum and maximum value of 0.8 and 1.6 respectively. The ratio of consecutive daily average OURs of 1.2, 1.1, 1.1, 1.3, 1.1 and 1.2 were obtained for BT-3, BT-4, BT-5, BT-6, BT-7 and BT-8 respectively.

The area under the OUR-time plot, computed using the method of Riemann sum (Swokowski, 1984), gives the total oxygen utilized (OU) for the respective batch tests. As shown from the plot of the total OU against the measured nitrate and OP concentrations (Figure 5.21a and b), an almost linear increase of OP with increase in the total oxygen utilized was observed. Similarly, apart for some deviation for BT-4, the increase of nitrate was almost linear with the corresponding increase of the total oxygen utilized. Hence, it can be said that the total oxygen utilized has a stoichiometric relation to the OP and nitrate concentrations in the bulk solution. This, therefore, signifies that the solubilization of organic nitrogen to ammonia and the subsequent conversion to nitrate, and the P release were as a result of VSS destruction via the endogenous process.

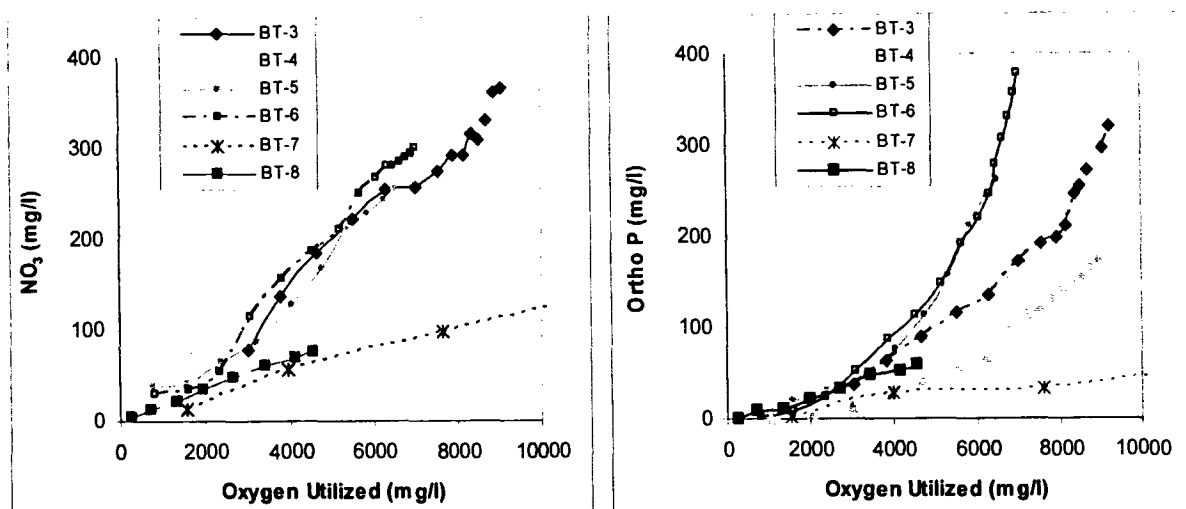


Figure 5.21a and b. Relationship of total oxygen utilized (OU) with the orthophosphate and nitrate concentration in the bulk solution during aerobic digestion

The rate of substrate removal and endogenous mass decrease are ultimately dependent on the active mass concentration of the mixed liquor. Therefore, when the OUR is expressed as specific values (i.e. per mass of VSS) it serves as an indicator of the specific activity of the mixed liquor only. The specific oxygen utilization rate (SOUR) changes with sludge age (Eikum *et al.*, 1974; Huag and Cheng, 1984) and organic load (Edwards and Sherrard, 1982). Ahlberg and Boyko (1972) and Samson and Ekama (2000) stated that the specific uptake rate is a more reliable indication of digested sludge stability because it is a measure of biological activity. Because the purpose of the aerobic digestion process is to oxidize organic compounds to stable organic and inorganic end products biologically, and because the biological activity decreases as the unstable organic fraction of material in the sludge decreases, this measure of biological activity (specific uptake rate) is an absolute basis of sludge stability that is not peculiar to an individual plant. On the other hand, Mavinic and Koers (1979) contend that OUR is not a suitable parameter as an indicator of stability of low-temperature, digested, waste activated sludges.

The SOUR divided the digestion period into three regions (Figure 5.20b). In the first region, i.e., the first one third of the digestion period, the SOUR, with some fluctuations decreased very gradually. In the second region, i.e., the second one third period of digestion, a sharp decrease in SOUR is exhibited. The sharp decent of the SOUR, therefore, shows the period where much of the microbial activity with a fast decline in the microbial population takes

place. During the last one third period of the digestion the SOUR declines gradually to the end of the digestion process.

The SOUR decreased from initial values of 3.3 and 2.2 mgO gVSS⁻¹ h⁻¹ to final values of 0.7 and 0.8 mgO gVSS⁻¹ h⁻¹ for BT-4 and BT-5 respectively. For BT-3 and BT-6, the SOUR decreased from 2.5 mgO gVSS⁻¹ h⁻¹ to 0.5 mgO gVSS⁻¹ h⁻¹ within 19 and 13 days of digestion process respectively. The final values of the SOUR, even for BT-5 where test was stopped due to motor failure just before the degradation process was completed, were all well below the accepted SOUR value for a 'stable' sludge, i.e., less than 1 mgO gVSS⁻¹ h⁻¹. Therefore, according to this measure of biodegradability, the WAS aerobically digested in the batch tests was well stabilized to an acceptable degree. For their batch fed aerobic digestion of non-BEPR WAS, Benedeck *et al.* (1972) obtained an average value of oxygen consumption per gram of organic matter decomposed of 1.7 mgO (gVSS)⁻¹ hr⁻¹.

For BT-3, BT-5 and BT-6, the fluctuation of the OUR and the corresponding increase of SOUR values for the first six days of the digestion period seem to indicate the occurrence of growth as opposed to endogenous respiration. It is paradoxical, though it may be possible, that growth, on a slowly degradable substrate, could occur on the aerobic digestion process of the waste activated sludge cultivated from a 20 days sludge age parent system. Though further verification may be needed, the apparent growth could also be associated with that of the PAOs using their stored PHA and growth of OHOs on biodegradable organics of dead PAOs.

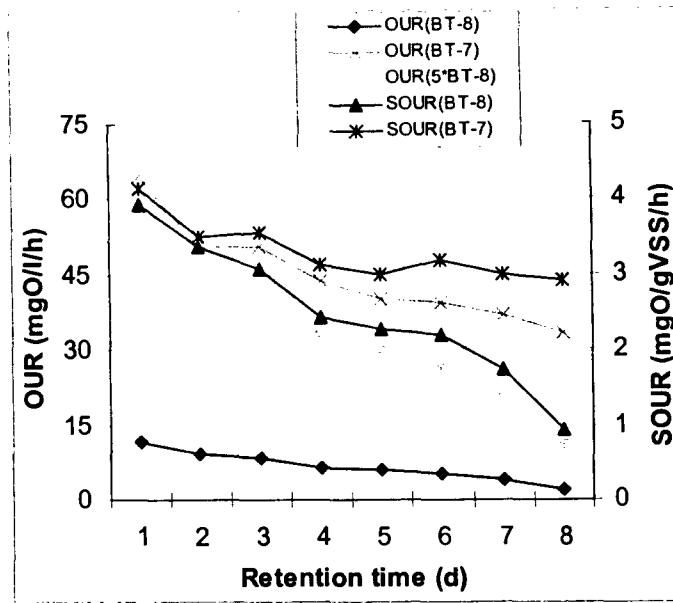


Figure 5.22. Comparison of OUR and SOUR for BT-7 (undiluted WAS) and BT-8 (diluted WAS).

The OUR of BT-8, with diluted WAS, decreased uniformly from an initial value of 11.7 to a final value of 2.5 mgO l⁻¹ h⁻¹ (Figure 5.22). During the corresponding detention time of 8 days, the OUR for BT-7, with undiluted WAS, decreased from an initial value of 64.7 to 33.4 mgO l⁻¹ h⁻¹. The decrease of OUR for BT-7, like the other batch tests with undiluted WAS, was not on a uniform scale. The sharp decrease of OUR at the beginning of the digestion was followed by a plateau, thereafter the OUR decreased gradually.

The irregular decrease of OUR during the very few days of digestion may have two causes: (1) The high concentrations of the WAS studied. The high concentration of the suspended solids may affect the rate of oxygen transfer to the micro-organisms, though this conclusion merits further investigation. Besides, Upadhyaya & Eckenfelder (1975) remarked that a variation in floc sizes with different VSS concentrations could have an effect on the oxygen penetration through the floc. (2) Residual enmeshed slowly biodegradable particulate organics in the WAS from the parent system. Since DO penetration in the floc at high MLSS did not appear to affect the kinetic rates in the parent MBR system (Parco *et al.*, 2006) as second cause is the most likely.

5.2.9 COD Balance of Batch Tests

A COD balance of the batch tests was done to check the equivalency of the change in total (unfiltered) COD to the cumulative carbonaceous OUR for a successive 1-day interval values and for the initial and values from measured COD, OUR and NO_3 concentrations. Since the measured OUR is the lumped total OUR, the carbonaceous OUR is obtained by deducting nitrification OUR from the measured total OUR for the respective batch test. The nitrification OUR was computed by multiplying the respective nitrate concentrations by the equivalency factor 4.57. The cumulative OUR was obtained from the OUR-digestion time plot using the best fit line. The values of the COD balance obtained for both the 1-day interval and initial and final values is given in Table 5.4.

Table 5.4. COD balance of the batch tests based on measured 1-day interval and initial and final values

BT	COD Balance (%)	
	1-Day Interval Values	Initial & Final Values
3	93.0	105.0
4	96.2	102.4
5	93.7	93.2
6	92.3	92.0
7	95.8	98.4
8	88.1	88.1

As shown in Table 5.4, the COD balance based on 1-day interval and initial and final values for BT-3 to BT-8 ranged from 88.1 to 96.2% and 88.1 to 105.0% respectively. Except for the diluted BT-8, where the COD balance based on 1-day interval and initial and final values was 88.1%, the rest of the COD balance values were within close proximity to 100%, that is 90 to 110%, showing that the experimental data was internally consistent. Hence the disappearance of COD was consistent with the consumption of oxygen in the experimental data.

5.2.10 Reaction Rate and Decay Constants

The rate constant, b is a net value of the OHO and PAO endogenous respiration rates. From the derived batch reactor models (Chapter 4, Section 4.1) it may be possible to determine the b rate of OHOs and PAOs from the batch digestion data. Hence, employing the Marais and

Ekama (1976) method and assuming a single lumped organism group the endogenous respiration (b) rates of OHOs and PAOs are determined from the measured OUR, VSS, OP, nitrate and COD concentrations. The summary of the rate constants computed with the different test parameters is given in Table 5.5.

Table 5.5. Net PAO and OHO endogenous respiration rate (b) determined using the VSS, OUR, OP, COD and nitrate analysis.

Batch Test	Rate Constant, b (d ⁻¹)										Average (std.dev.)
	VSS	R ²	OUR	R ²	P	R ²	Nitrate	R ²	COD	R ²	
BT-1					0.15	0.99					0.15
BT-2					0.37	0.93					0.37
BT-3	0.05	0.92	0.25	0.84	0.11	0.96	0.17	0.98	0.06	0.97	0.13 (0.073)
BT-4	0.15	0.98	0.12	0.97	0.09	0.98	0.10	0.94	0.08	0.97	0.11 (0.02)
BT-5	0.20	0.95	0.18	0.76	0.23	0.92	0.17	0.96	0.22	0.97	0.20 (0.02)
BT-6	0.64	0.93	0.17	0.89	0.14	0.97	0.31	0.98	0.18	0.95	0.29 (0.19)
Average (std.dev.)	0.48 (0.219)		0.18 (0.046)		0.18 (0.096)		0.187 (0.075)		0.14 (0.067)		
BT-8	0.22	0.95	0.17	0.99	0.23	0.96			0.26	0.94	0.26 (0.073)

The endogenous respiration (b) rates obtained from the measured VSS concentrations showed the highest variation for the different batch tests, ranging from 0.05 d⁻¹ (BT-3) to 0.64 d⁻¹ (BT-6), with correlation coefficients of 0.92 and 0.93 respectively. The b rates with the least variation among the different batch tests were obtained with OUR, with the lowest of 0.12 d⁻¹ (BT-4) and highest of 0.25 d⁻¹ (BT-3) and correlation coefficients of 0.97 and 0.84 respectively.

When considering the average values of b rates computed from the different measured parameters for each batch test, the lowest value was 0.13 d⁻¹ (BT-3) and the highest 0.29 d⁻¹ (BT-6) with standard deviations of 0.07 and 0.19 respectively. Comparable values of b rates were obtained for the diluted BT-8, where a minimum b rate of 0.17 d⁻¹ was obtained from the OUR and the highest value of 0.26 d⁻¹ from the COD. As shown in Figure 5.23a and b, the average b rate for BT-1 to BT-6 obtained using the OUR and nitrate were 0.18 and 0.19 d⁻¹ with a standard deviation of 0.046 and 0.075 respectively. For BT-8, with diluted WAS,

the average b rate obtained from the different measured parameters was 0.26 d^{-1} with standard deviation of 0.073 .

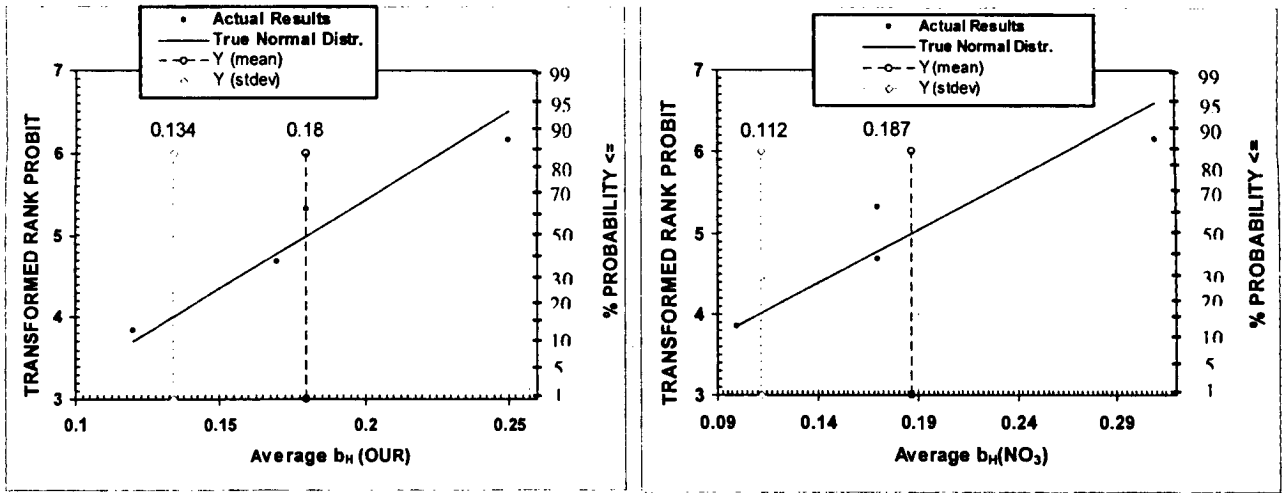


Figure 5.23a and b. Statistical plot for average b_H values determined using OUR and nitrate

As mentioned above, the b rate is a lumped value obtained as a result of endogenous mass loss of the OHOs, PAOs and ANOs. The ANOs are too few to make any significant difference, but the different b_H and b_G rates of the OHOs and PAOs should have a major impact on the net b rate. With $b_H = 0.24 \text{ day}^{-1}$ and $b_G = 0.04 \text{ day}^{-1}$ at 20°C in the steady BEPR model, a lumped net rate between these of $\sim 0.17 \text{ day}^{-1}$ is reasonable.

The simultaneous presence of the OHO and PAO in the aerobically digested sludge adds to the complexity and difficulty of determining the individual b rates of each group from the measured OUR and other parameters. The measured parameters are combined values for the OHOs and PAOs. That is,

$$O_{Ti} = \frac{1}{24} \{ [(f_{cvH} + 4.57f_n)(1 - f_H)(b_H X_{Hi} e^{-b_H t})] + [(f_{cvG} + 4.57f_n)(1 - f_G)(b_G X_{Gi} e^{-b_G t})] \} \quad (\text{mgO l}^{-1} \text{ h}^{-1}) \quad (4.75)$$

Determination of the initial concentration of the active OHOs and PAOs from the measured OUR would require knowing the relative proportion of these groups of micro-organisms as well as their individual b rates and COD/VSS ratios. This also adds to the complexity of the problem. Even if the initial concentrations of the OHOs and PAOs could be taken from the simulated OHO and PAO concentrations in the aerobic reactor of the parent (MBR UCT) system and/or from the measured initial concentration of the batch aerobic digestion test,

determining the b rates of both of the OHOs and the PAOs from the semi-log plot of OUR versus time is not feasible as demonstrated below.

From the steady state models of the OHOs and PAOs (Marais and Ekama, 1976 and Wentzel *et al.*, 1990), the b value of the OHOs and PAOs are very different viz. $b_H = 0.24 \text{ day}^{-1}$ and $b_G = 0.04 \text{ day}^{-1}$. With such a large difference the changes at the start of the batch test are dominated by the OHOs and those at the end of the batch test by the PAOs. So assuming the early stages of the digestion process the changes are dominated by the OHOs and the late stages of the digestion process by the PAOs, the decay rates of the OHOs and the PAOs were obtained from the head and tail ends of the $\ln(\text{OUR})$ versus retention time plot respectively. The OUR for the ANOs does not change the slope of the $\ln(\text{OUR})$ versus time plot, therefore, does not influence the determination of the b rates. The results are shown in Figure 5.24.

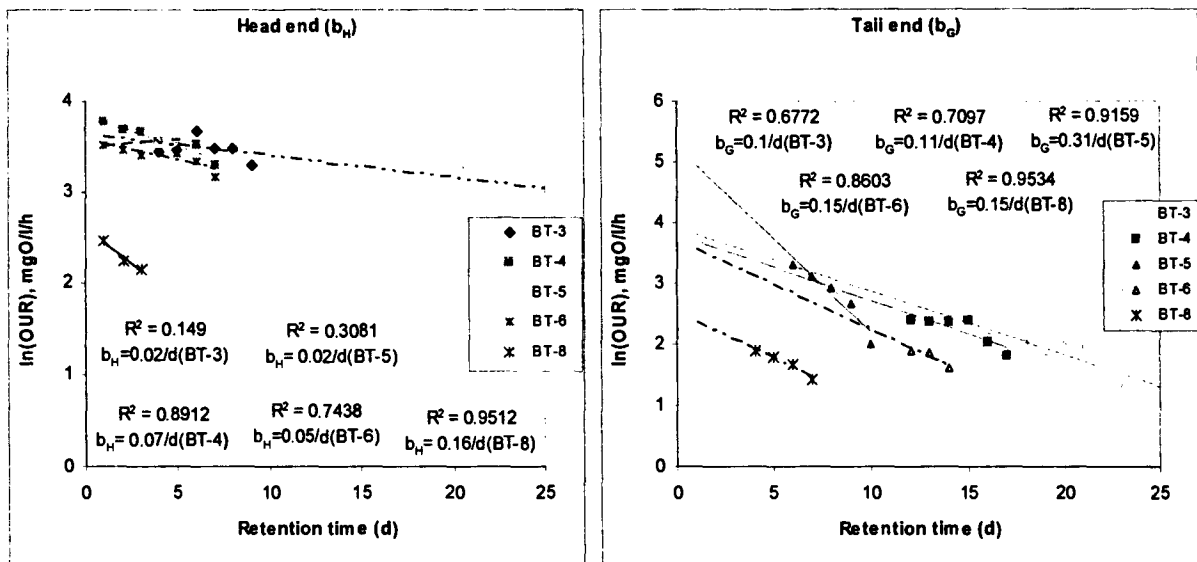


Figure 5.24a and b. Plot of $\ln(\text{OUR})$ versus retention time for computing b rates of the OHOs and PAOs from the measured OUR

From the head end (where the OHO activity is expected to be the highest) of the plot of $\ln(\text{OUR})$ versus retention time, the b rates of the OHOs for BT-3 to BT-6 and BT-8 ranged from 0.02 to 0.16 d^{-1} with correlation coefficients (R^2) of 0.15 and 0.95 respectively. For BT-6 and BT-4, the b rate of the OHOs obtained were 0.05 and 0.07 d^{-1} with correlation coefficients of 0.74 and 0.89 respectively. An OHOs b rate of 0.16 d^{-1} with correlation coefficient of 0.95 was obtained for BT-8, with diluted WAS (Figure 5.24a).

From the tail end of the OUR (where the OHO activity is expected to have ceased), the b rates of the PAOs obtained varied between 0.10 and 0.31 d^{-1} with correlation coefficients ranging from 0.68 to 0.92. For the diluted WAS of BT-8, a PAOs b rate of 0.15 d^{-1} with a correlation coefficient of 0.95 was obtained (Figure 5.24b).

Though the cause or nature of variation could not be explained, the obtained b rates of the OHOs and the PAOs are at variance with the accepted rates of 0.24 d^{-1} (Marais and Ekama, 1976) and 0.04 d^{-1} (Wentzel *et al.*, 1989) respectively. Besides, the correlation coefficients (R^2) for the obtained b rates of the OHOs and PAOs were mostly very low with only two greater than 0.90. This indicated that the individual b_H and b_G rates cannot be determined from batch test data. This conclusion was made also by Wentzel *et al.* (1988) when conducted the BEPR research to obtain the b_G and other kinetic constants of the PAOs from enhanced PAO cultures, in which the PAOs dominated the observed behaviour (OUR, VSS, etc) and negligible OHO contribution. The N and P release behaviour under aerobic digestion condition was, therefore, determined via modelling with ASM-2 as described in Chapter 3.

5.3 Simulation

5.3.1 Parent system

The simulation of the MBR UCT system was performed by adjusting the one of two kinetic constants (1) the maximum rate of fermentation of the OHOs (q_{Fe}) and (2) the rate constant for storage of PP (q_{pp}) and two wastewater characteristics (3) the fraction of unbiodegradable particulate ($f_{S'up}$) and (4) the influent ISS concentration into the biological reactor to match the measured and simulated OP, VSS and TSS concentrations in the aerobic reactor respectively. One of the two kinetic constants was adjusted to match the predicted P removal to that measured, the first (q_{Fe}) by reducing the mass of PAOs in the system or the second (q_{pp}) by reducing the P content of the PAOs. The wastewater characteristics, $f_{S'up}$ was adjusted to match the measured VSS and the influent ISS to match the measured TSS, which includes the OHO and PAO generated ISS. Details on how and why this was done are given in Section 3.3.3.

As shown in Figure 5.26b, in the two ways of simulation done, i.e., by adjusting the constants number (1), (3) and (4) or (2), (3) and (4) above the simulated OP concentrations closely matched the measured values for all the SB periods of the MBR UCT system where WAS was harvested for batch tests. The two ways of matching the measured and simulated effluent OP concentrations does alter the simulated VSS concentrations. In the two situations, the simulated VSS concentrations in the anaerobic, anoxic and aerobic reactors were almost equal (Figure 5.25). This is so because increasing q_{Fe} (1) increases the VSS values (more PAOs, fewer OHOs) and decreasing $f_{S'up}$ increases the effluent OP concentrations. That is, when matching up the measured and simulated effluent OP concentrations, increasing the magnitude of q_{Fe} to increase the simulated concentration of the PAOs resulted in higher simulated VSS concentrations. To reduce the simulated VSS concentration until a close match up to the measured VSS values was obtained, the magnitude of the $f_{S'up}$ was reduced. This means that higher q_{Fe} is accompanied by lower $f_{S'up}$ and vice versa. The increase or decrease of the simulated PAO concentration was, therefore, compensated by the decrease or increase in the inert material. As a result, under both ways of simulation the simulated VSS concentration remained the same in the anaerobic, anoxic and aerobic reactors of the MBR UCT system (Figure 5.25). As shown in Figure 5.25, in the aerobic reactor the measured VSS concentration and those two-way simulated coincided in a single line on the graph. In the two-way simulation the VSS concentrations in the anoxic and anaerobic reactors were similar lying on the same line on the graph. However, the measured VSS concentrations in the anoxic and anaerobic reactors were higher than those simulated.

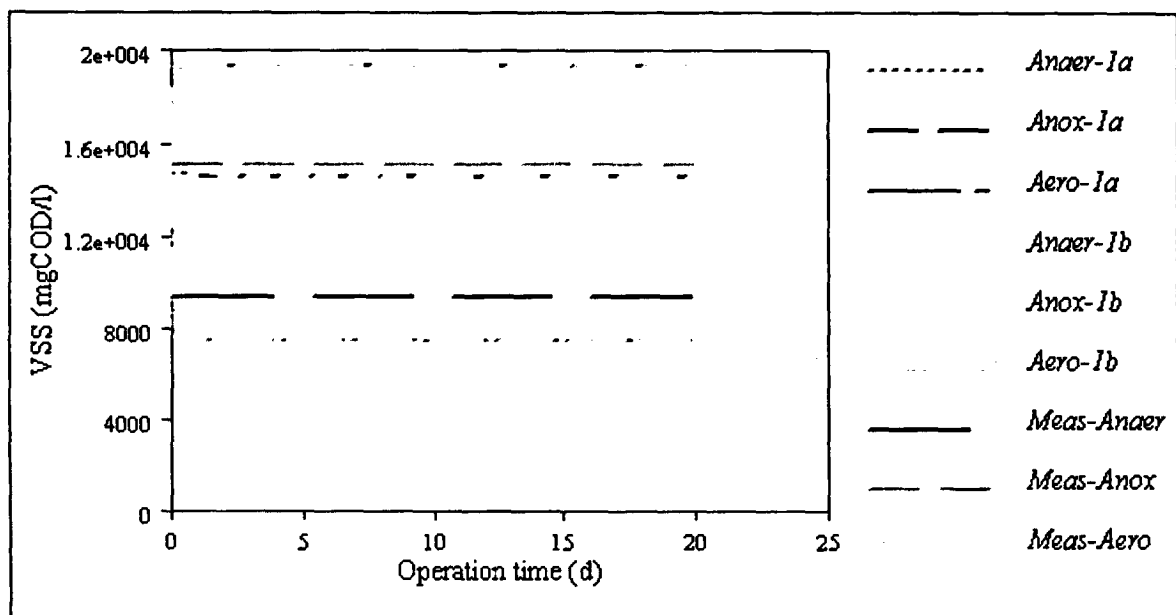


Figure 5.25. Comparison of measured and simulated VSS for SB-1 in the anaerobic, anoxic and aerobic reactors of the MBR UCT system.

The simulation results, along with the mass balances, of all the measured parameters of the parent system (MBR UCT system) are given in Appendix A. The summary of the comparison of the measured and simulated concentrations of VSS, TSS, FSA, nitrate and OP are given in Table 5.6. Also Tables 5.7 and 5.8 give the values of the influent wastewater characteristics and kinetic constants for these simulations.

Table 5.6. Comparison of some of the measured parameters of the MBR UCT system with simulated results

Batch No.	VSS (Aerobic)		TSS (Anoxic)		FSA (Effluent)		NO ₃ (Effluent)		OP (Effluent)	
	Measured	Simulated	Measured	Simulated	Measured	Simulated	Measured	Simulated	Measured	Simulated
	(mg l ⁻¹)	(mg l ⁻¹)	(mg l ⁻¹)	(mg l ⁻¹)	(mg l ⁻¹)	(mg l ⁻¹)	(mg l ⁻¹)	(mg l ⁻¹)	(mg l ⁻¹)	(mg l ⁻¹)
B-1	13006 ^d	13034	13068	12170	1.20	0.48	24.80	17.72	11.60	11.47
		13014		12100		0.48		22.54		11.66
B-2	12726	12689	13060	12430	2.35	0.49	23.81	27.45	15.41	15.21
		12682		12480		0.49		38.31		15.12
B-5	13856	13831	13358	13460	1.00	0.48	18.70	48.98	4.60	5.06
		13865		13530		0.48		47.39		4.42
B-26	13520	13561	13292	13380	0.40	0.48	19.20	18.00	9.00	9.09
		13561		13460		0.48		22.36		8.67
B-28	14640	14615	13198	14720	0.60	0.47	12.40	19.33	4.70	4.94
		14662		14780		0.47		21.36		4.74
B-30	13661	13662	13170	13070	1.11	0.48	19.77	28.77	8.44	8.47
		13682		13100		0.48		31.69		8.46

The graphical comparison of the measured and simulated VSS and effluent OP concentrations is depicted in Figure 5.26a and b.

^d For one measured value of a parameter two simulated values are given. This is, as explained in the experimental procedure, due to the two ways of simulation employed, i.e., by adjusting the kinetic constants related to the population of the PAOs (q_{Fe}) and the poly-P content of the PAOs (q_{PP}).

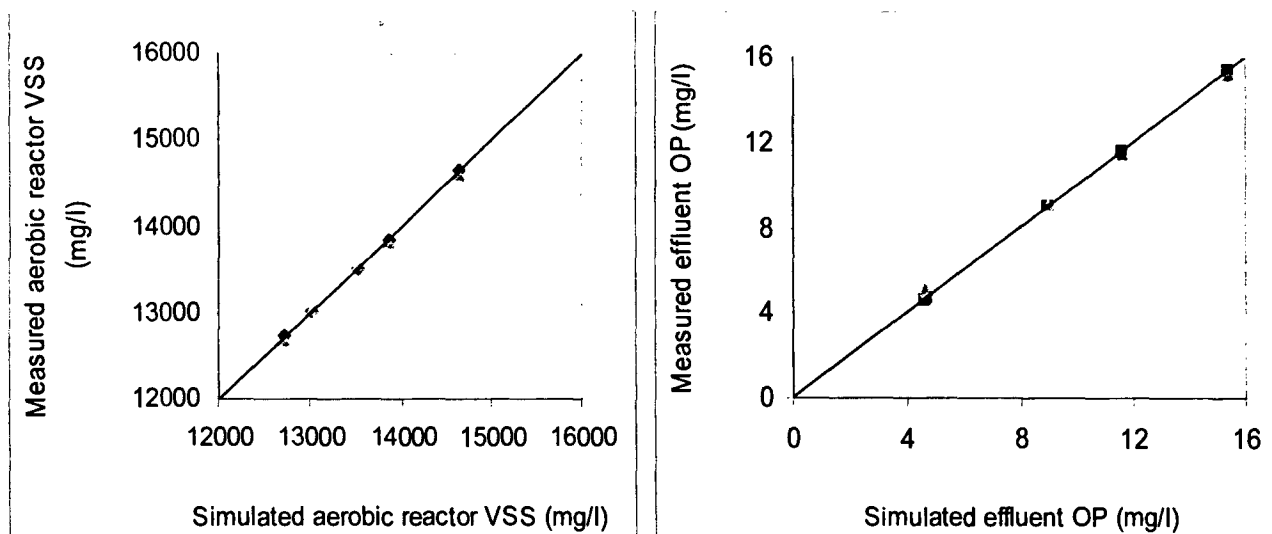


Figure 5.26a and b. Comparison of measured and simulated VSS and effluent OP for the MBR UCT system.

The measured and simulated values of effluent OP and aerobic reactor VSS concentrations MBR UCT system were almost the same (Figure 5.26a and b). In the aerobic reactor the simulated ISS concentration, and therefore, the simulated TSS were higher than the measured values, except for SB-1 where the simulated ISS and TSS were equivalent to those measured. This is despite the fact that the influent ISS concentration in ISS model of Ekama and Wentzel (2004) was adjusted to the minimum value near to zero. In the anoxic reactor, the simulated and measured ISS and TSS concentrations were equivalent while in the anaerobic reactor the simulated ISS and TSS were lower than those measured (Appendix A). The influent ISS concentration is very sensitive to the BEPR achieved due to the very large contribution to the reactor ISS by the P content of the PAOs. A small difference in PAO P content would significantly increase the influent ISS to realistic values of 10-20 mg ISS l⁻¹. The simulated effluent nitrate concentrations of SB-2, SB-5 and SB-28 were higher than the measured effluent nitrate concentrations. For SB-1, the simulated effluent nitrate concentration was lower than the measured effluent nitrate concentration, while comparable values of measured and simulated effluent nitrate concentrations were obtained for SB-26.

Table 5.7. Stoichiometric coefficients and kinetic constants, which are the same for all the SBs, used in simulating the MBR UCT system

Parameter	Description	Unit	Value
General			
η_{Fe}	Anaerobic hydrolysis reduction factor		0.10
η_{NO3}	Anoxic hydrolysis reduction factor		0.60
f_{cv}	COD/VSS ratio	mgCOD mgVSS ⁻¹	1.48
f_{SI}	Fraction of inert COD in particulate substrate	mgCOD mgCOD ⁻¹	0.00
i_{NBM}	N content of the OHO, PAO and ANO biomass	mgN mgCOD ⁻¹	0.07
i_{NSf}	N content of soluble substrate	mgN mgCOD ⁻¹	0.03
i_{NSi}	N content of inert soluble COD	mgN mgCOD ⁻¹	0.01
i_{NXi}	N content of inert particulate COD	mgN mgCOD ⁻¹	0.07
i_{NXs}	N content of particulate substrate	mgN mgCOD ⁻¹	0.04
i_{PBM}	P content of the OHO, PAO and ANO biomass	mgP mgCOD ⁻¹	0.02
i_{PSf}	P content of soluble substrate	mgP mgCOD ⁻¹	0.01
i_{PSi}	P content of inert soluble COD	mgP mgCOD ⁻¹	0.00
i_{PXi}	P content of inert particulate COD	mgP mgCOD ⁻¹	0.01
i_{PXs}	P content of particulate substrate	mgP mgCOD ⁻¹	0.01
K_h	Hydrolysis rate constant	day ⁻¹	2.00
K_{LA}	Oxygen mass transfer rate	day ⁻¹	700.00
K_{NO3}	Saturation/inhibition coefficient/factor for nitrate	mgN l ⁻¹	0.10
K_{O2}	Saturation/inhibition coefficient/factor for oxygen	mgO l ⁻¹	0.20
K_{X20}	Saturation coefficient for particulate COD (@ 20°C)	mgCOD mgcellCOD ⁻¹	0.03
Q_i	Influent flow rate	l day ⁻¹	140.00
R_h	Hydraulic retention time	day	0.536
R_s	Sludge age	day	20.00
OHOs			
b_{OHO}	OHOs decay rate	day ⁻¹	0.62
η_{NO3d}	Reduction factor for denitrification by the OHOs		1.00
f_{iOHO}	ISS content of the OHOs	mgISS mgOHO ⁻¹	0.15
f_{XiOHO}	Fraction of inert COD in OHO biomass	mgCOD mgCOD ⁻¹	0.08
K_{AOHO}	Saturation coefficient for acetate	mgCOD l ⁻¹	4.00
K_F	Saturation coefficient for growth on soluble substrate	mgCOD l ⁻¹	4.00
K_{fe}	Saturation coefficient for fermentation of soluble substrate	mgCOD l ⁻¹	150.00
K_{NH4OHO}	Saturation coefficient for ammonium	mgN l ⁻¹	0.01
Y_{OHO}	Yield of OHOs	day ⁻¹	0.67
μ_{OHO20}	Maximum specific growth rate (@ 20°C)	day ⁻¹	6.00
PAOs			
b_{PAO}	PAOs decay rate	day ⁻¹	0.04
b_{PHA}	Decay rate of PHA	day ⁻¹	0.04
b_{PP}	Decay rate of PP	day ⁻¹	0.04
f_{iPAOBM}	ISS content of the PAO cell mass	mgISS mgPAO ⁻¹	0.15
f_{XiPAO}	Fraction of inert COD in PAO biomass	mgCOD mgCOD ⁻¹	0.25
K_{APAO}	Saturation coefficient for acetate	mgCOD l ⁻¹	1.00
K_{IPP}	Inhibition coefficient for PP storage	mgPP mgPAO ⁻¹	0.02
K_{MAX}	Maximum ratio of PP/PAO	mgPP mgPAO ⁻¹	1.00
K_{NH4PAO}	Saturation coefficient for ammonium	mgN l ⁻¹	0.001
K_P	Saturation coefficient for P in PP	mgP l ⁻¹	0.01
K_{PHA}	Saturation coefficient for PHA	mgPHA mgPAO ⁻¹	0.18
K_{PP}	Saturation coefficient for PP	mgPP mgPAO ⁻¹	0.001

Continued			
Parameter	Description	Unit	Value
K_{PS}	Saturation coefficient for P in PP storage	mgP l ⁻¹	0.10
q_{PHA20}	Rate constant for storage of PHA	mgCOD mgPAO ⁻¹ d ⁻¹	6.00
Y_{PAO}	Yield of PAOs	day ⁻¹	0.67
Y_{PHA}	PHA requirement for PP storage	day ⁻¹	0.03
Y_{PO4}	Yield of P release/PHA storage	day ⁻¹	0.52
μ_{PAO20}	Maximum specific growth rate (@ 20°C)	day ⁻¹	1.20
ANOs			
b_{AUT}	ANOs decay rate	day ⁻¹	0.04
f_{XiAUT}	Fraction of inert COD in ANO biomass	mgCOD mgCOD ⁻¹	0.08
K_{NH4AUT}	Saturation coefficient for ammonium	mgN l ⁻¹	1.00
Y_{AUT}	Yield coefficient (biomass/nitrate)	mgCOD mgN ⁻¹	0.15
μ_{AUT20}	Maximum specific growth rate (@ 20°C)	day ⁻¹	0.45

For all the SBs of the MBR UCT system the simulated FSA concentrations were lower than 1 mg l⁻¹. The measured effluent FSA concentration of the MBR UCT system were all close to or less than 1 mg l⁻¹ except for SB-2 where the measured effluent FSA concentration was 2.4 mg l⁻¹. Hence, while the simulated effluent FSA values were lower than the measured concentrations for SB-1, SB-2 and SB-5, for SB-26 and SB-28 the simulated and measured effluent FSA concentrations were comparable (Table 5.6). Moreover, the measured and simulated volumes of sludge wasted were equivalent. The mass balances for simulated COD, phosphorus nitrogen and of the MBR UCT system were checked and found to be in the range of 99.8 to 100.5, 99.8 to 100.0 and 99.9 to 100.2%, respectively (Appendix A1 to A6).

Table 5.8. Wastewater characteristics and kinetic constants used in simulating the MBR UCT system

Parameter	Name	Unit	Sewage Batch Number					
			SB-1	SB-2	SB-5	SB-26	SB-28	SB-30
f_{ac}	Fraction of acetate	mgCOD mgCOD ⁻¹	0.301	0.3100	0.480	0.420	0.608	0.430
f_{bs}	Fraction of biodegradable soluble COD	mgCOD mgCOD ⁻¹	0.441	0.431	0.459	0.450	0.499	0.457
$f_{S'us}$	Fraction of unbiodegradable soluble COD	mgCOD mgCOD ⁻¹	0.031	0.037	0.036	0.043	0.041	0.043
$f_{S'up}$	Fraction of unbiodegradable particulate COD	mgCOD mgCOD ⁻¹	0.205 ^e	0.092	0.215	0.168	0.211	0.206
			0.142 ^f	0.052	0.239	0.145	0.206	0.195
q_{Fe}	anaerobic fermentation rate	mgCOD mgCOD ⁻¹	0.001	0.586	158.00	1.300	2.129	1.650
			5.00	5.00	5.00	5.00	5.00	5.00
q_{pp}	rate constant for storage of PP	mgPP mgPAO ⁻¹ d ⁻¹	1.35	1.35	1.35	1.35	1.35	1.35
			1.108	1.199	1.500	1.268	1.326	1.129
X_{loin}	Influent ISS	mgISS l ⁻¹	22.0000	0.0010	0.0010	0.0010	0.0001	0.0001
			20.1200	0.0010	0.0010	0.0001	0.0001	0.0001
S_{ti}	Influent COD	mgCOD l ⁻¹	958.41 ^g	1112.17	912.44	993.50	956.3	943.98
N_{ti}	Influent nitrogen	mgN l ⁻¹	101.42	134.84	133.60	101.20	95.00	112.14
P_i	Influent P	mgP l ⁻¹	18.25	30.94	25.19	29.30	31.00	26.10
NH_{4i}^h	Influent FSA	mgN l ⁻¹	64.23	96.58	99.86	65.71	61.95	77.18
			66.54	98.28	98.95	66.62	62.19	77.60

5.3.2 Aerobic batch digestion

5.3.2.1 Comparison of observed data with ASM-2

The two way simulation^{g, h} of the MBR UCT system for the adjustment of the simulated effluent OP to the measured concentrations for all the SBs where WAS was harvested for

^e Simulation with the adjustment of the anaerobic fermentation rate, q_{Fe} .

^f Simulation with the adjustment of the PP content of the PAOs, q_{pp} .

^g The influent COD (S_{ti}), TKN (N_{ti}) and OP (P_i) remain the same under both simulations, i.e. with the adjustment of q_{Fe} and q_{pp} . These influent parameters are average values of the measured concentrations.

^h When characterizing the influent TKN to its various components a discrepancy was observed on the measured TKN and FSA concentrations. These discrepancies were reconciled by adjusting the measured FSA in which the sum of the various components of the TKN would equal to the measured TKN concentration. The variation of the fraction of the unbiodegradable particulate COD during the two-way simulation, therefore results in variation of the influent ammonia (NH_{4i}) concentration.

batch tests resulted in two sets of initial concentrations of the ANOs, OHOs, PAOs, PP, PHAs and inert material. Among the initial concentrations of these two sets of parameters the highest variation was observed for the PAOs, PP and the inert material. However, as explained earlier, the total VSS concentration of the MBR UCT system under both simulation conditions remained the same. As a result, though the simulation of the batch aerobic digestion was carried out with two sets of initial conditions, both sets of initial conditions rendered no variation in the aerobic batch test simulation results. The behaviour of a low PAO population with a high P content was the same as that of a higher PAO population with a low P content. Therefore, the results and discussion of the simulation of one set of initial conditions also equally apply to the other set of initial conditions. A comparison of the simulated and measured batch test results are given in Figures 5.27 to 5.44.

As shown in Figure 5.27 and 5.28, for BT-3 and BT-4, for the first one third of the digestion period the measured and simulated total COD concentrations were equivalent. Thereafter, the simulated total COD concentrations were observed to lie above those measured. For BT-1, BT-5 and BT-6, the simulated concentrations were higher than those measured. For BT-2, except for the initial COD concentrations, the measured COD concentrations were higher than those simulated. Generally, the measured total COD concentrations dropped faster than those simulated.

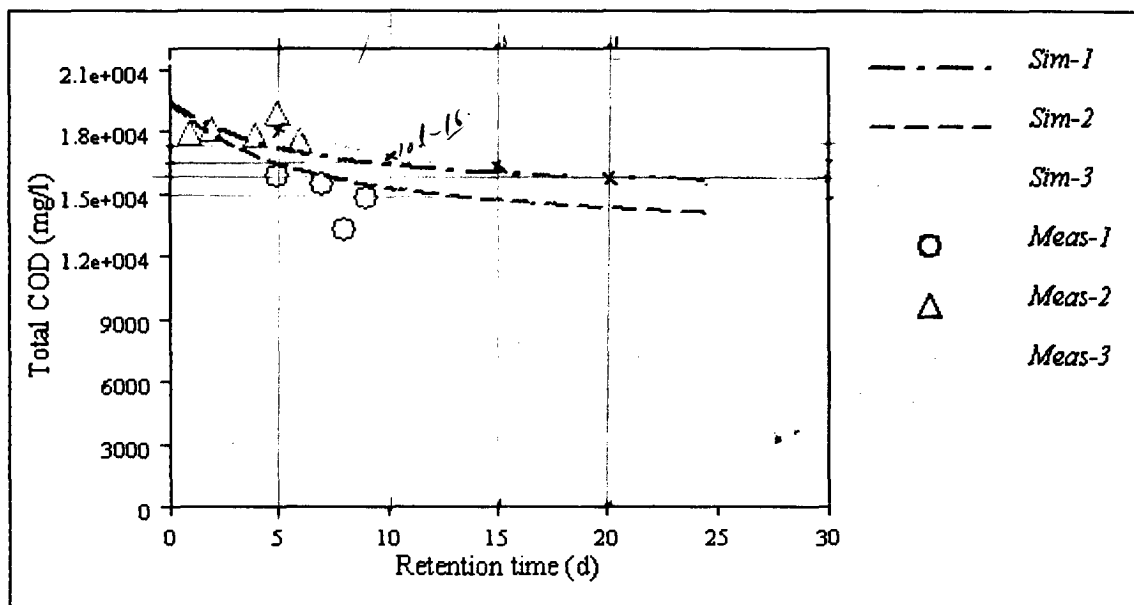


Figure 5.27. Measured and simulated total COD for BT-1, BT-2 and BT-3

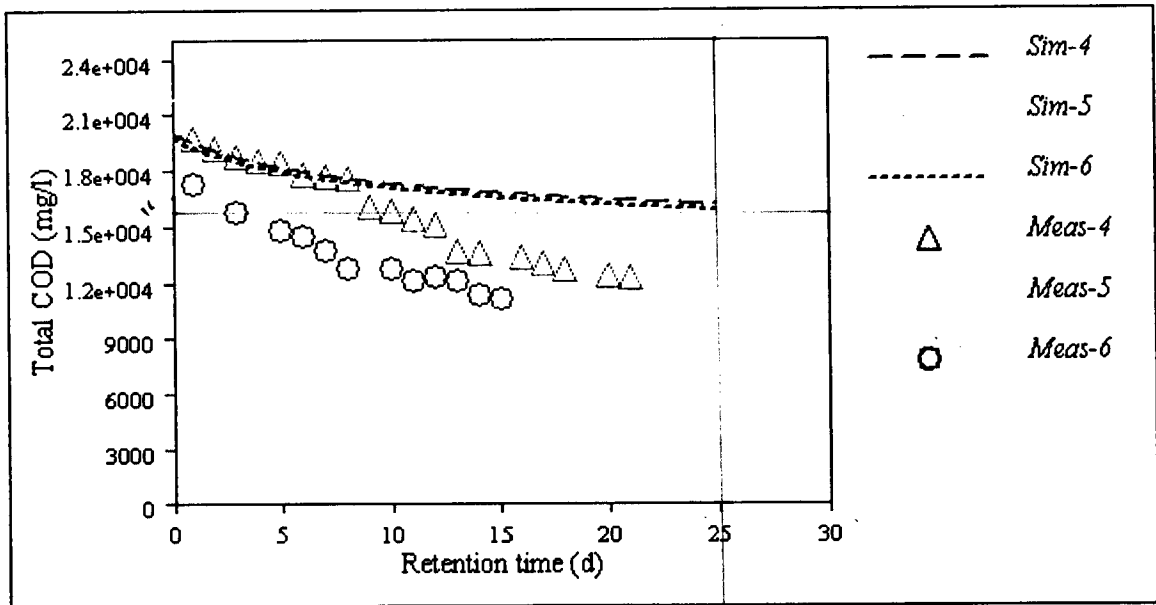


Figure 5.28. Measured and simulated total COD for BT-4, BT-5 and BT-6

A close match of the simulated and measured VSS concentrations was obtained for BT-1 and BT-2. Apart for the end of the digestion period where the drop in the measured VSS concentration was higher than the simulated values, for BT-3 the simulated and measured VSS concentration coincided very well (Figure 5.29). Except for the early periods of digestion, the drop in the measured VSS was higher than that of the simulated values for BT-4, BT-5 and BT-6 (Figure 5.30).

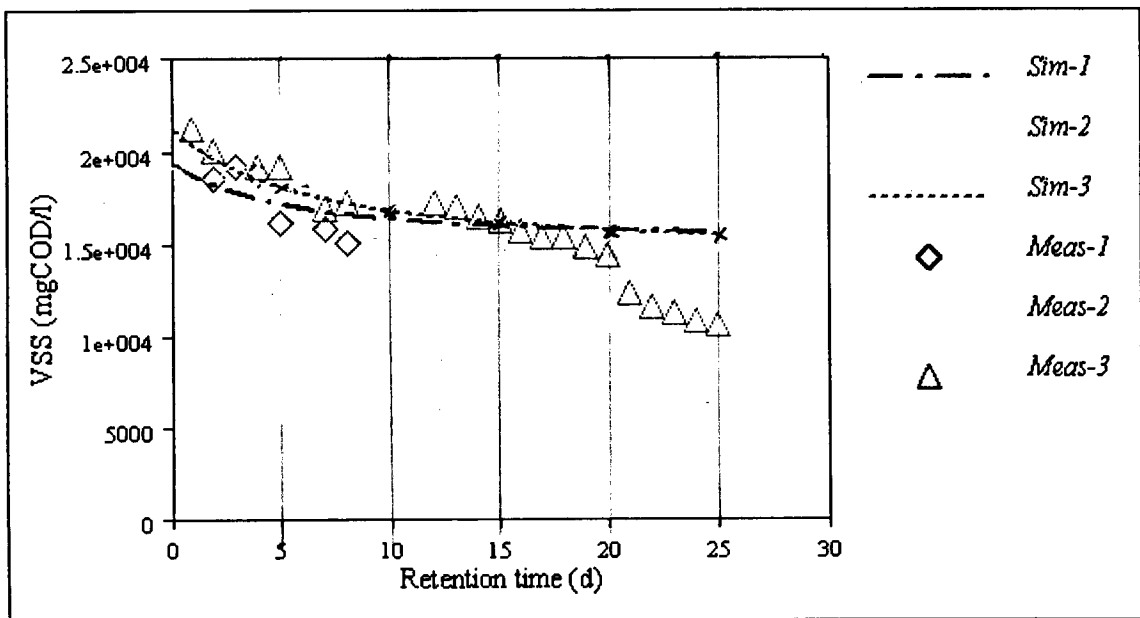


Figure 5.29. Measured and simulated VSS for BT-1, BT-2 and BT-3

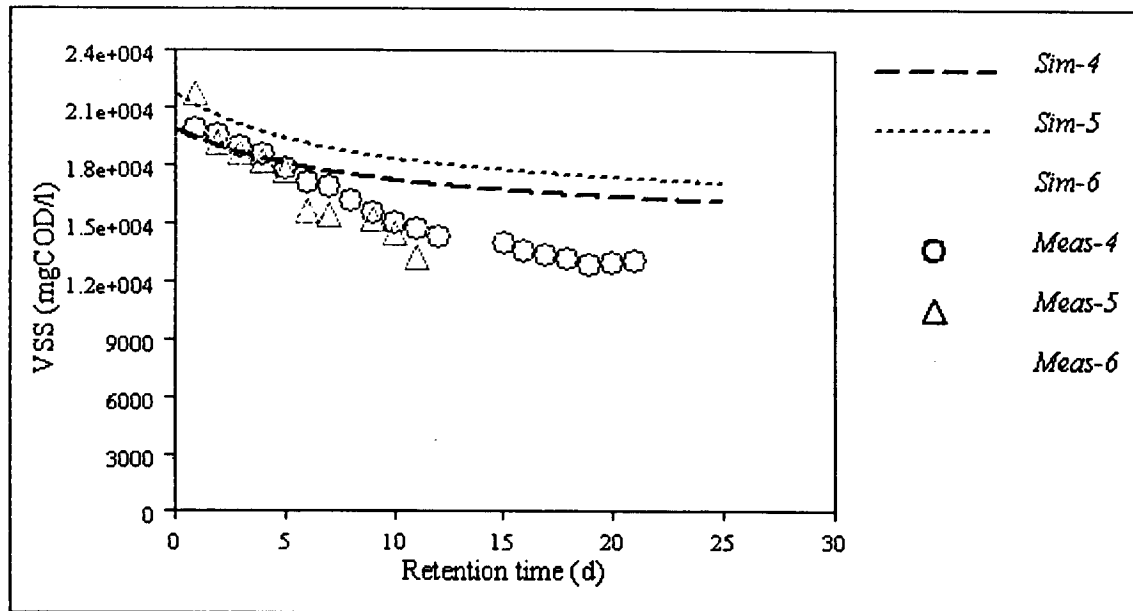


Figure 5.30. Measured and simulated VSS for BT-4, BT-5 and BT-6

The lowest average measured COD/VSS ratio was $1.16 \text{ mgCOD mgVSS}^{-1}$ (BT-5) and the highest $1.50 \text{ mgCOD mgVSS}^{-1}$ (BT-4), the average value for the first six batch tests being $1.36 \text{ mgCOD mgVSS}^{-1}$ with standard deviation of 0.113. The simulated COD/VSS ratios for all the first six batch aerobic digestion tests remained constant at $\sim 1.48 \text{ mgCOD mgVSS}^{-1}$, which is equal to the accepted COD/VSS ratio (Figure 5.31). Hence, the simulated COD/VSS ratios were higher than the measured COD/VSS ratios, except for BT-4 where the mid values were slightly higher than $1.48 \text{ mgCOD mgVSS}^{-1}$.

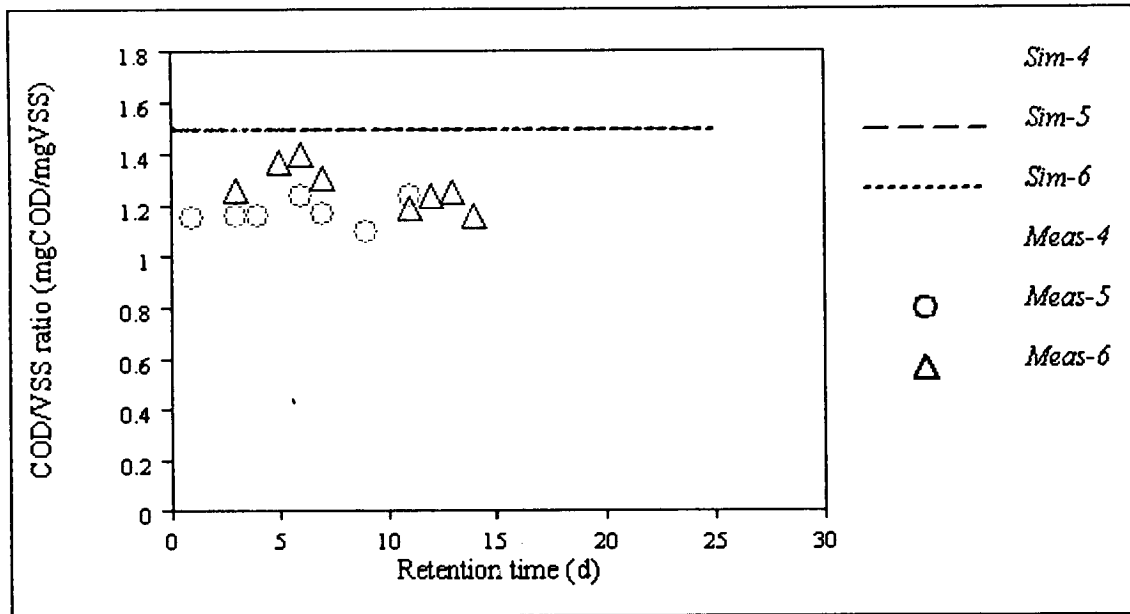


Figure 5.31. Measured and simulated COD/VSS ratios for BT-4, BT-5 and BT-6

For BT-6, except for the fluctuating measured concentrations at the beginning of the digestion period, the simulated ISS concentrations matched those measured. For BT-4, the simulated and measured ISS values were equivalent for the first quarter of the digestion period. Thereafter, the drop in simulated ISS concentrations was higher than that of the measured. For BT-5, the simulated ISS concentrations were equivalent to those measured, save for the undulations of measured ISS concentrations at the beginning of the digestion period and the higher drop of the measured ISS concentrations at the end of the digestion period (Figure 5.32).

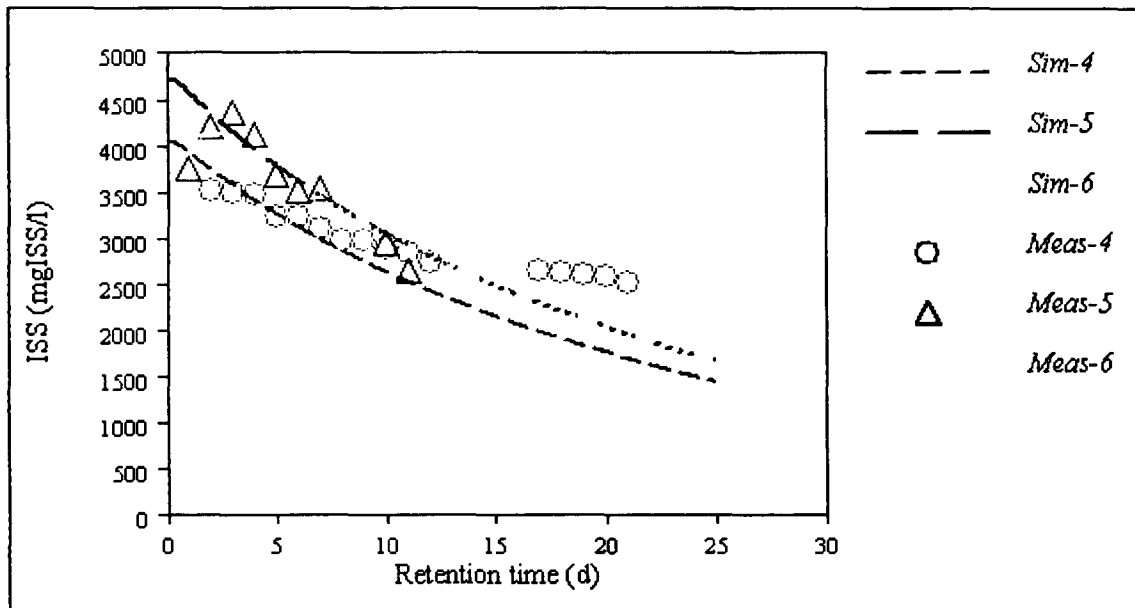


Figure 5.32. Measured and simulated ISS ratios for BT-4, BT-5 and BT-6

The measured TSS concentrations were higher than those simulated for BT-1 and for BT-2, except at the beginning of the digestion period where the measured TSS concentration matched the simulated for BT-2. For BT-3, the measured and simulated TSS concentrations were comparable except at the end of the digestion period where the measured TSS concentration dropped more sharply than those simulated (Figure 5.33) due to sharp decrease in VSS (Figure 5.29). For BT-5, the simulated TSS concentrations were higher than those measured. For BT-4 and BT-6, during the first six days of digestion the simulated TSS concentrations coincided with those measured. Thereafter the drop in the measured TSS concentration was higher than that of the simulated values (Figure 5.34).

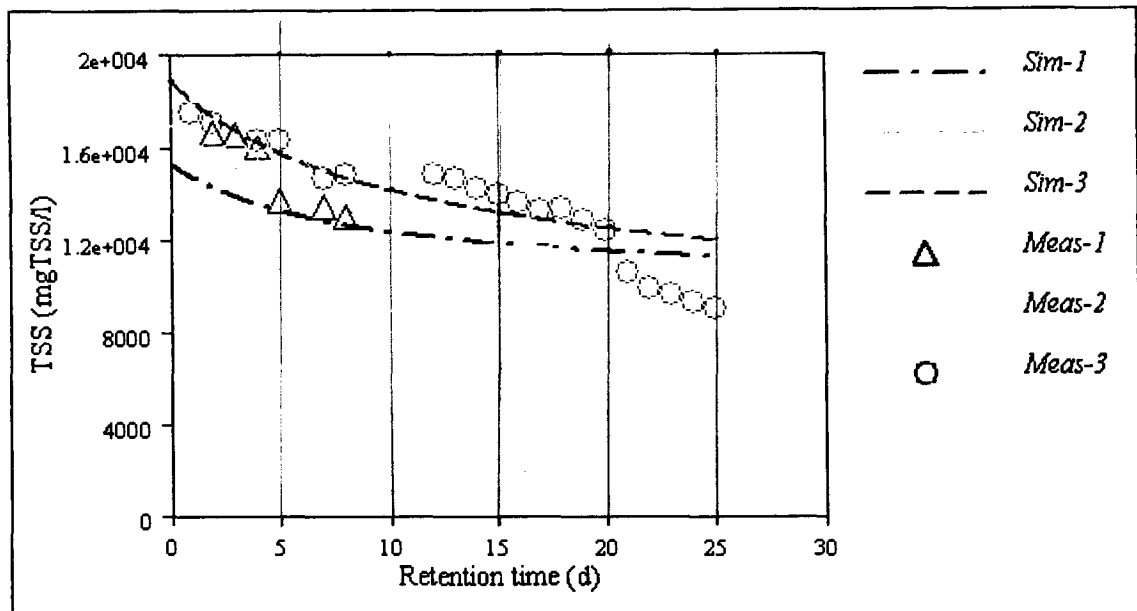


Figure 5.33. Measured and simulated TSS for BT-1, BT-2 and BT-3

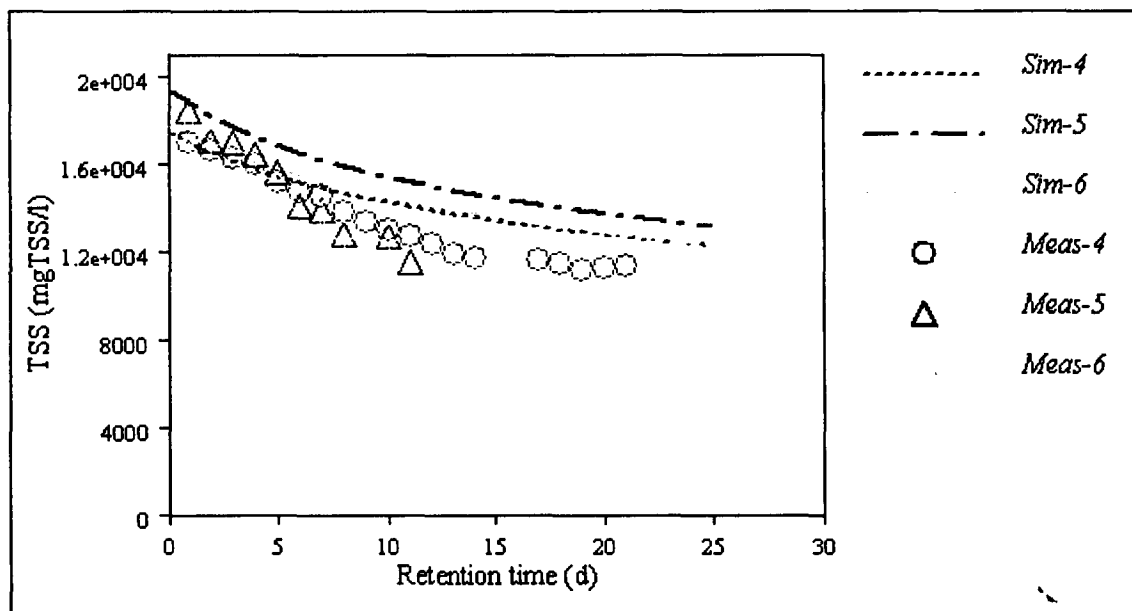


Figure 5.34. Measured and simulated TSS for BT-4, BT-5 and BT-6

The measured VSS/TSS ratio for BT-1 to BT-6 remained almost constant, with an average value of 0.78 and a standard deviation of 0.016. The simulated VSS/TSS ratios for all the batch tests, however, were observed to slightly increase with retention time (Figure 5.35). For BT-2 and BT-3 the simulated VSS/TSS ratios linearly increased from an initial value of $0.76 \text{ mgVSS mgTSS}^{-1}$ to final values of 0.78 and $0.88 \text{ mgVSS mgTSS}^{-1}$ with retention times of 6 and 25 days respectively. For BT-4, BT-5 and BT-6, the simulated VSS/TSS ratios

linearly increased from initial values of 0.77, 0.75 and 0.73 mgVSS mgTSS⁻¹ to final values of 0.87, 0.80 and 0.80 mgVSS mgTSS⁻¹ with detention times of 21, 11 and 14 respectively.

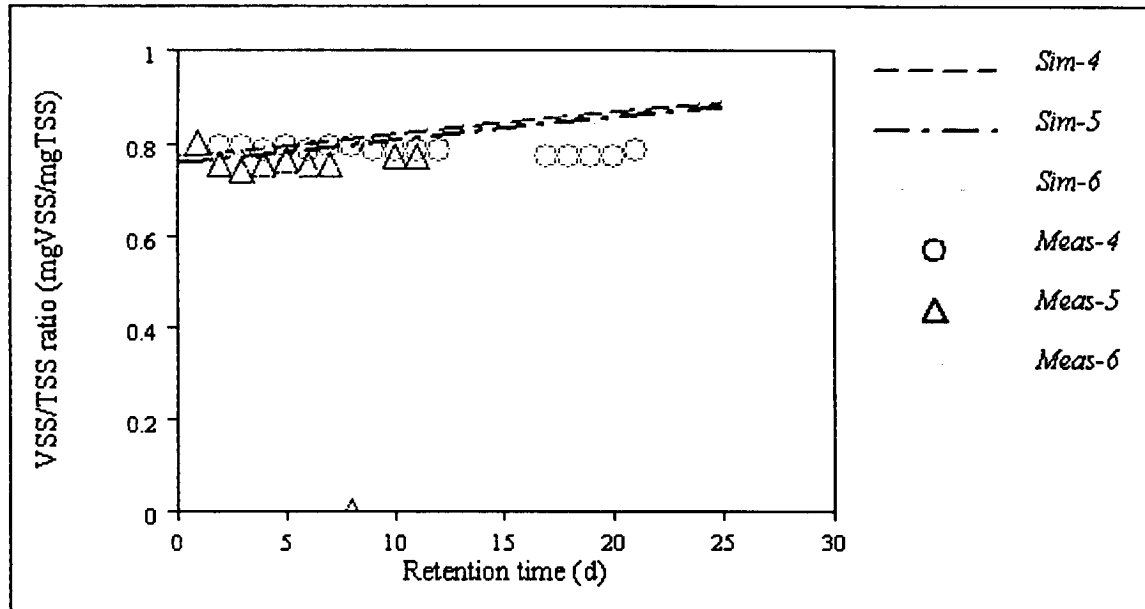


Figure 5.35. Measured and simulated VSS/TSS ratios for BT-4, BT-5 and BT-6

Though during the second half period of the digestion process the FSA concentrations for the entire batch tests were lower than 1 mg l⁻¹, during the beginning of the digestion FSA concentrations as high as 1.5 mg l⁻¹ were obtained. On the other hand, the simulated FSA concentrations were lower than 0.5 mg l⁻¹ (Figure 5.36). As a result the measured concentrations were higher than the simulated values, but the difference is of no concern.

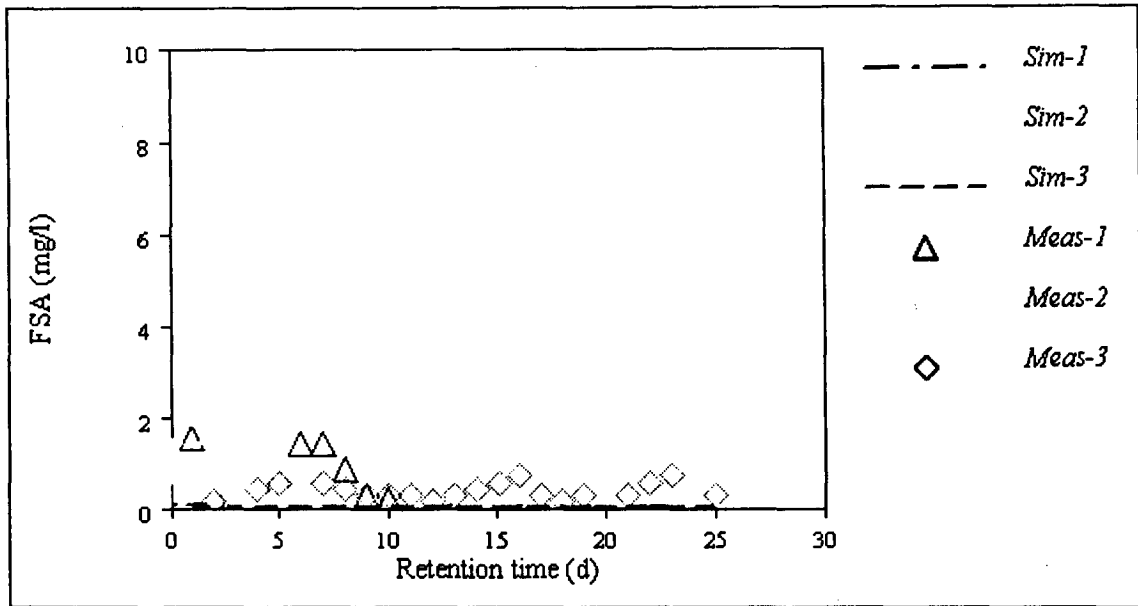


Figure 5.36. Measured and simulated FSA for BT-1, BT-2 and BT-3

Except for the first half of the digestion period where the simulated nitrate concentrations were slightly higher than those measured, as shown in Figure 5.37, for BT-3 and BT-5 the measured nitrate concentrations closely matched those simulated. For BT-4, the simulated nitrate concentrations were higher for the first three quarters of the digestion period while for the last quarter of the digestion period the measured nitrate concentrations were slightly higher than those simulated. For BT-6, except for the first quarter of the digestion period, the measured nitrate concentrations were higher than those simulated. The measured and simulated initial nitrate concentrations, however, were exactly the same for all the batch tests.

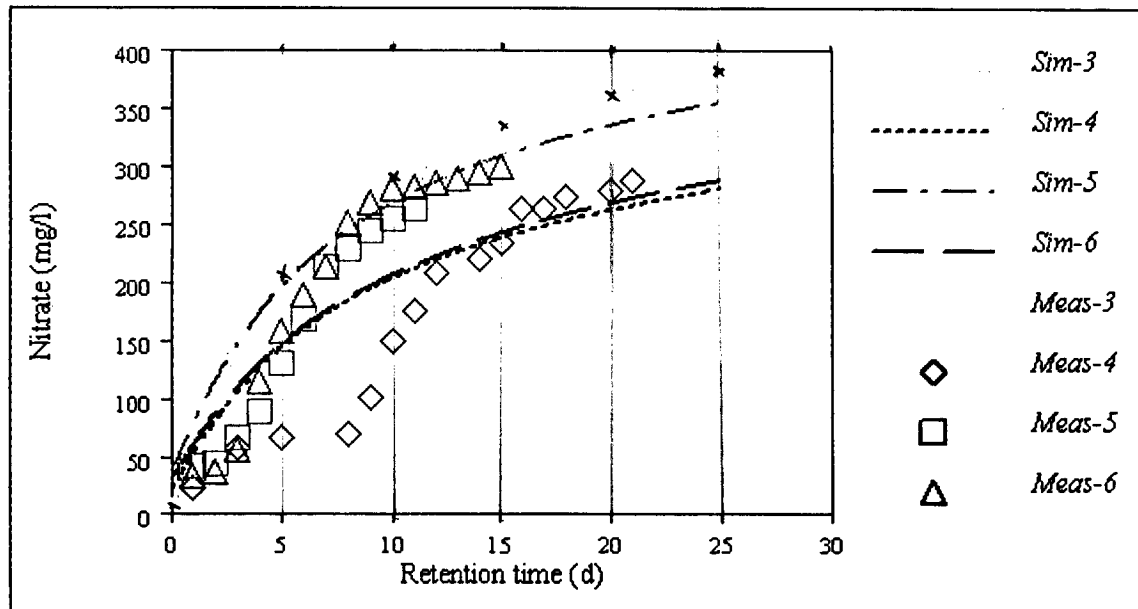


Figure 5.37. Measured and simulated nitrate for BT-3, BT-4, BT-5 and BT-6

The simulated TKN concentrations were higher than those measured for BT-5. For BT-3, BT-4 and BT-6, except for the first few days of digestion period where the measured and simulated TKN concentrations matched up, for the rest of the digestion period the simulated concentrations were higher than those measured (Figure 5.38). Generally, the rate of TKN reduction was higher for the measured concentrations than those simulated.

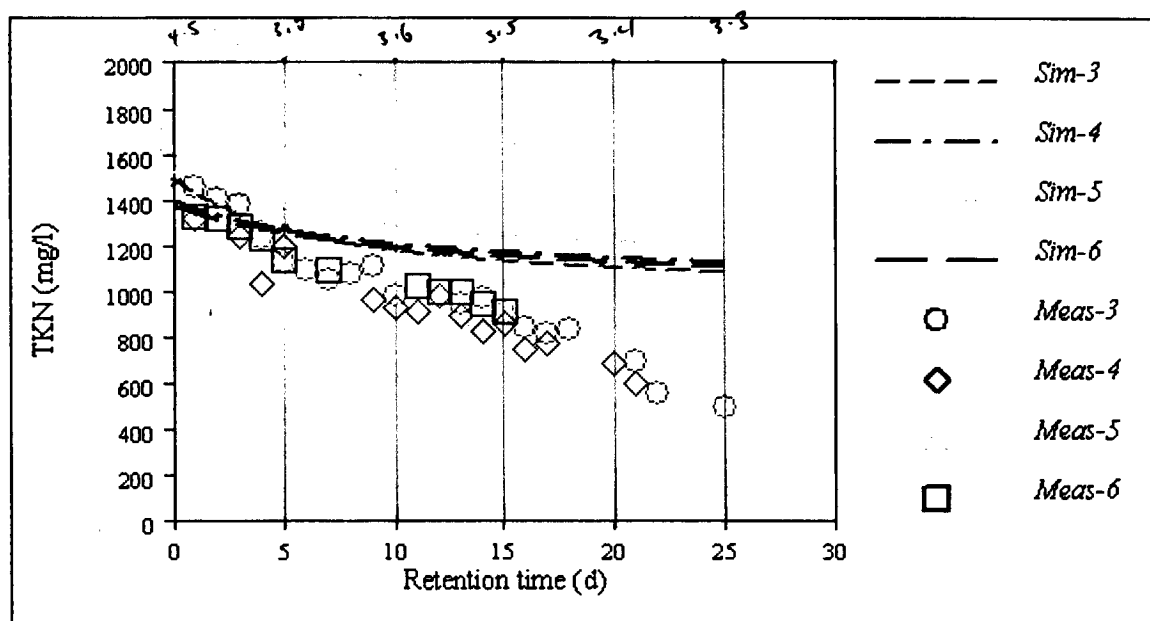


Figure 5.38. Measured and simulated TKN for BT-3, BT-4, BT-5 and BT-6

As shown in Figure 5.39, for BT-1 the measured OP concentrations matched those simulated for the first half of the digestion period and thereafter the measured OP concentrations were much higher than those simulated. For BT-2, BT-3, BT-4, BT-5 and BT-6, the simulated OP concentrations were higher than those measured (Figure 5.40). For BT-8 (with diluted WAS) the simulated OP concentrations were comparable to those measured, while the simulated OP concentration for BT-7 (with undiluted WAS) was higher than those measured (Figure 5.41).

The above observation is probably the strongest evidence for mineral precipitation for the released P. The fact that in the diluted BT-8 the predicted and measured OP concentrations were closely the same, indicated that in this batch test, experimentally all the PAO P content was released to the bulk liquid. It would seem unlikely that concentration alone would change the PAO endogenous behaviour and cause them to release only one third to one half of their P content. In the batch tests the quantity of mineral precipitation is too small to detect a change in VSS/TSS ratio within the natural variation in the VSS and TSS data. In fact, as mentioned above, the ISS concentration decreases during digestion – but this is expected from the ISS model of Ekama and Wentzel (2004), the decrease being much larger than the increase due to precipitation.

As explained in section 5.3.2.1, the two different ways of calibrating the P removal made negligible difference to the predicted P concentrations in the batch tests. From these simulations, the P content of the PAOs was known because it accounted for the observed P removal in the parent UCT NDBEPR system. Also from Fukase *et al.* (1982), Arvin and Christensen (1985), Comeau *et al.* (1985) and Wentzel *et al.* (1989), the cation and P content of polyphosphate is $\text{Mg}:\text{K}:\text{Ca}:\text{P} = 0.0275:0.295:0.05:1$, which gives an ISS/P ratio of $31.9 \text{ mgISS mgP}^{-1}$, which closely matched the ISS/P ratio found by Ekama and Wentzel in the ISS model (2004). This indicated that the Mg, K and Ca concentrations expected in the bulk liquid can be calculated from the simulated P release. The measured Mg concentration was only about $1/3^{\text{rd}}$ of that expected from the polyphosphate content and batch test simulation model predicted OP concentration. From $\text{Mg}:\text{K}:\text{Ca}:\text{P} = 0.275:0.295:0.05:1$ content of polyphosphate, the predicted bulk liquid cation concentrations from the predicted final OP concentration of around 700 mgPI^{-1} should be $192:206:35:700$. The observed final concentrations were significantly below these predicted concentrations from the P content of the PAOs at around $60:-:30:300$. In hindsight, K should have been measured also because it does not readily precipitate. High and increasing K concentrations with digestion time would

have provided further evidence that P was being released by the PAOs but Mg and OP remained low in the bulk liquid due to struvite precipitation.

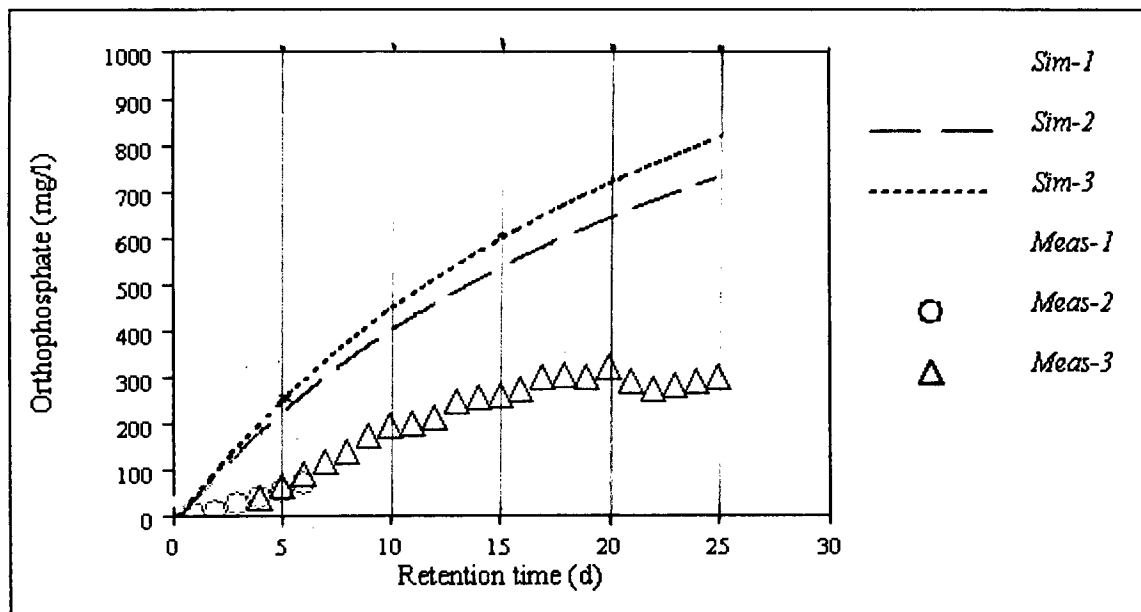


Figure 5.39. Measured and simulated orthophosphate for BT-1, BT-2 and BT-3

Like that of nitrate, for all the batch tests the measured and simulated initial ortho P concentrations were exactly the same.

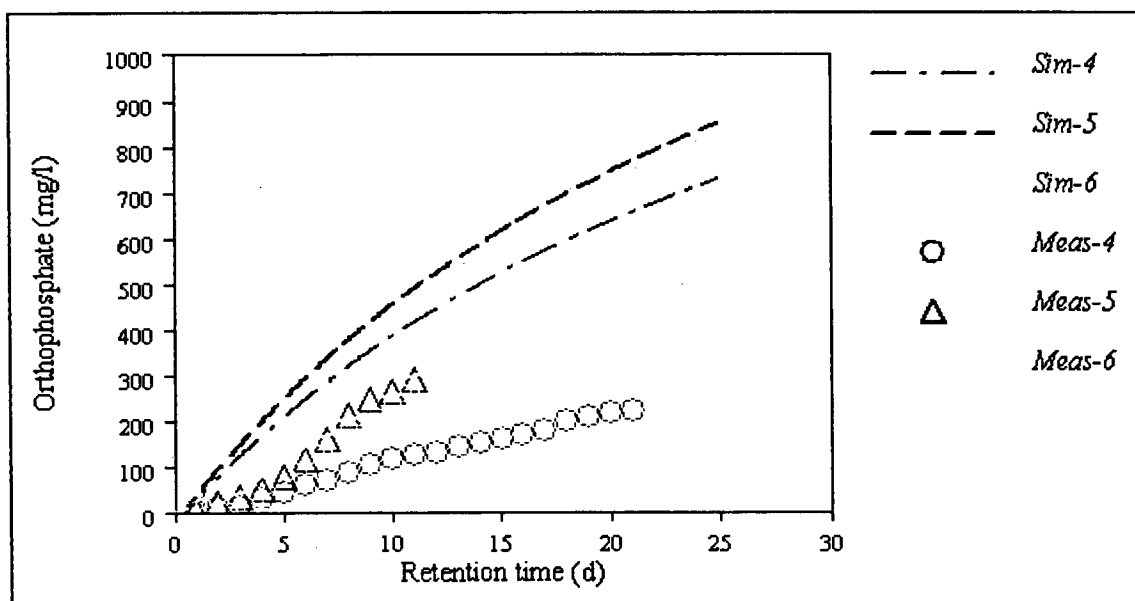


Figure 5.40. Measured and simulated orthophosphate for BT-4, BT-5 and BT-6

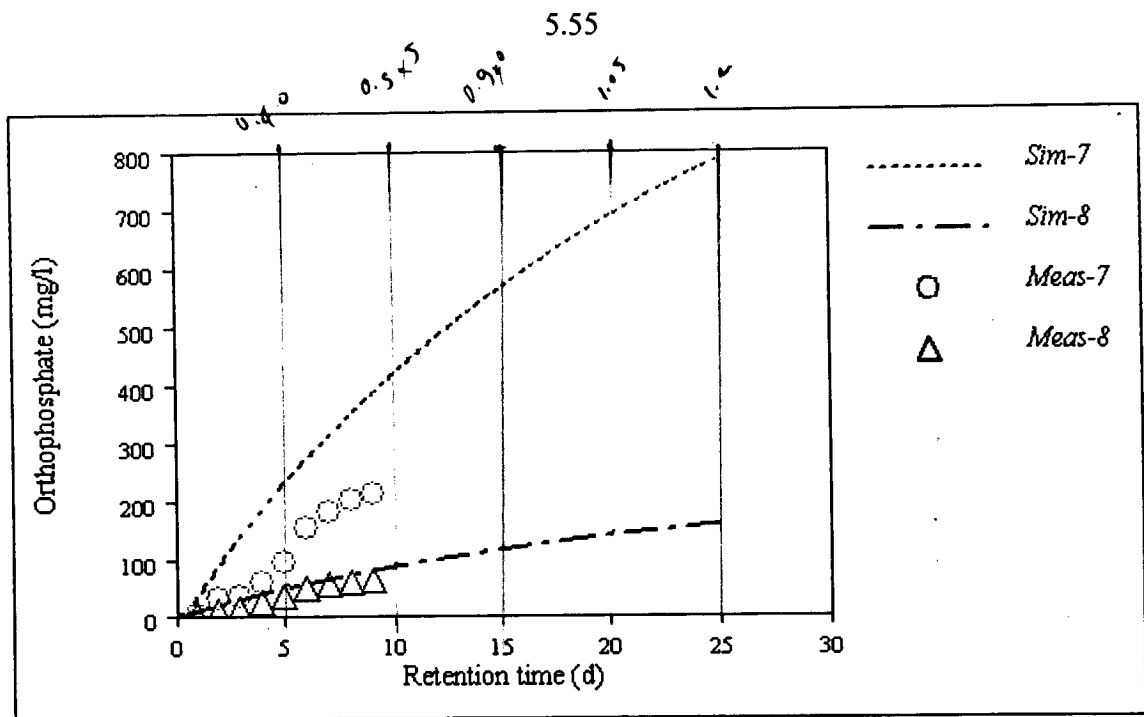


Figure 5.41. Measured and simulated orthophosphate for BT-7 (undiluted WAS) and BT-8 (diluted WAS)

Except for BT-2 (Figure 5.42) where the simulated OUR values coincided with the measured values, for the rest of the batch tests the simulated OUR values were lower than those measured (Figure 5.43). Besides, the fluctuation of the observed OUR during the beginning of the digestion process could not be reflected in the simulation even if a lag of up to four days was introduced in the simulation. With regard to the OUR, therefore, there is marked deviation of the predicted from the measured values. As has been mentioned earlier this could be due to the high concentration of the WAS under consideration influencing the oxygen mass transfer rate. Due to this or some unknown reason(s), however, the simulated OUR results could not match the measured values. For BT-8, except for the last measured value of OUR which coincided with that simulated, the measured OUR values were higher than those simulated (Figure 5.44).

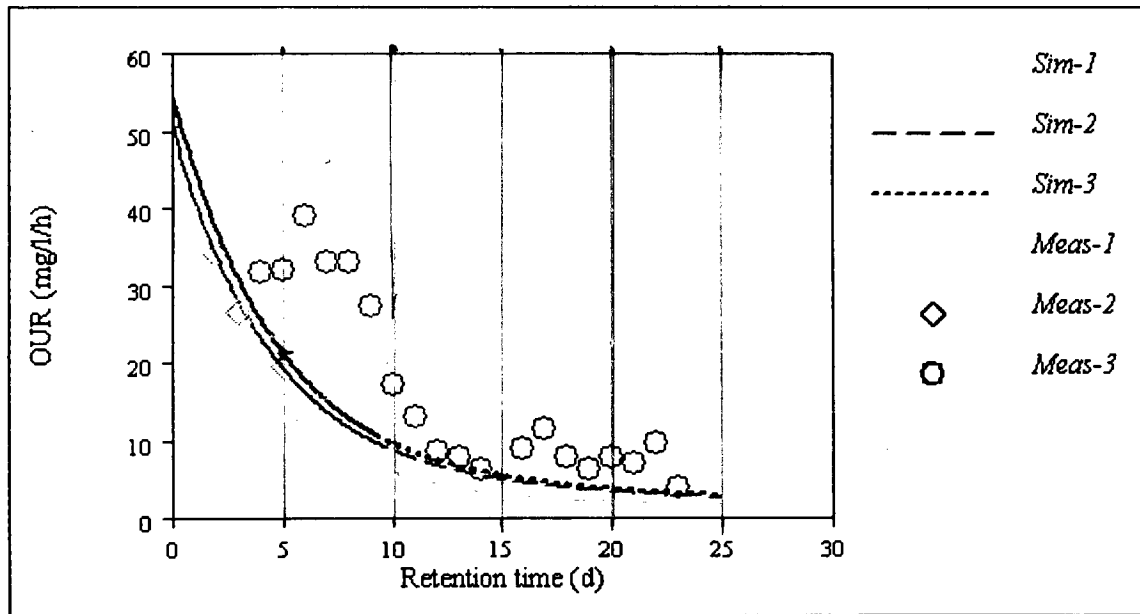


Figure 5.42. Measured and simulated OUR for BT-1, BT-2 and BT-3

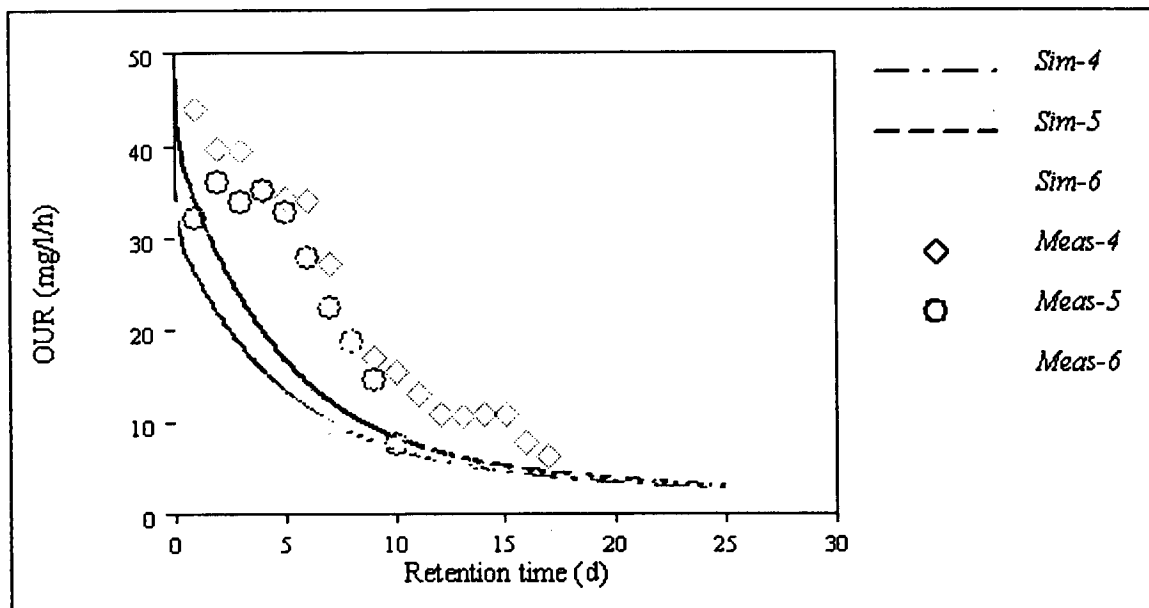


Figure 5.43. Measured and simulated OUR for BT-4, BT-5 and BT-6

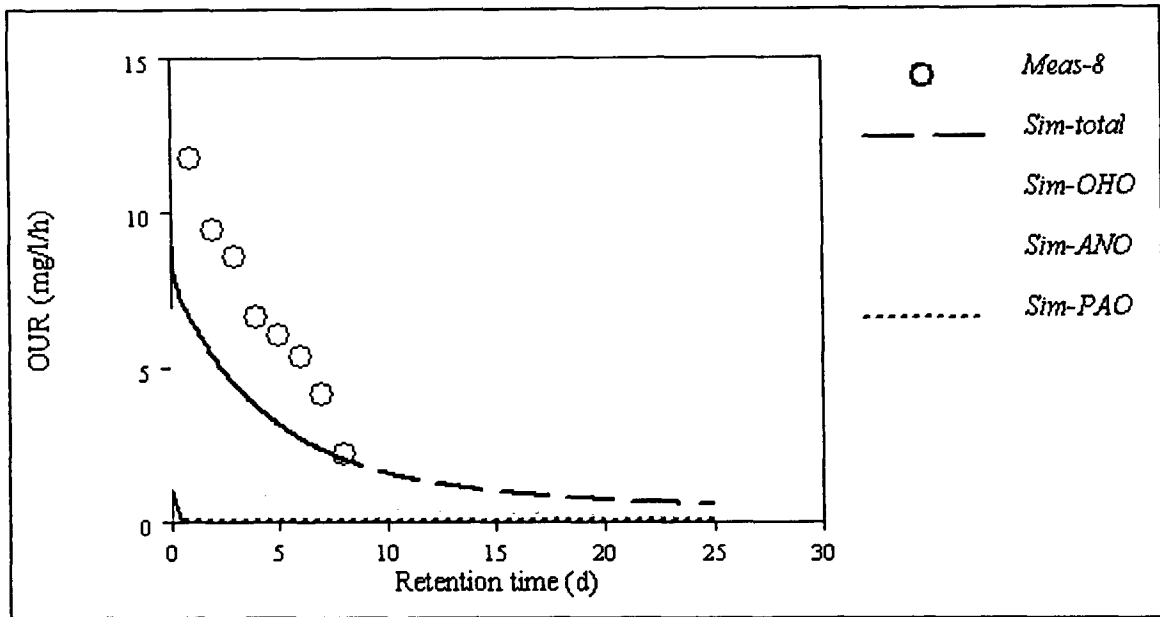


Figure 5.44. Measured and simulated total OUR and OUR for OHOs, ANOs and PAOs for BT-8 (with diluted WAS)

Similar to the graphical comparison of the observed released OP and nitrate concentrations to the total oxygen utilized (OU) given in Section 5.2.8, graphs of simulated total OU against the simulated released OP and nitrate concentration is given in Figure 5.45a and b. The total OU was determined using the method of Riemann sum (Swokowski, 1984) from the OUR-time plot for the respective batch tests. For BT-4, BT-5 and BT-6, the increase in simulated total OU was accompanied by a corresponding linear increase of simulated released OP and nitrate concentrations. For BT-7 and BT-8, though the increase in simulated released OP and nitrate concentration was linear, it was at a scale lower than the increase in simulated total OU. In contrast to the almost linear increase in simulated OU, a subdued increase in simulated released OP and nitrate concentrations was observed for the diluted BT-8. Generally speaking, however, the observed and simulated patterns of increase of the released OP and nitrate concentrations with the corresponding increase of the total OU were similar.

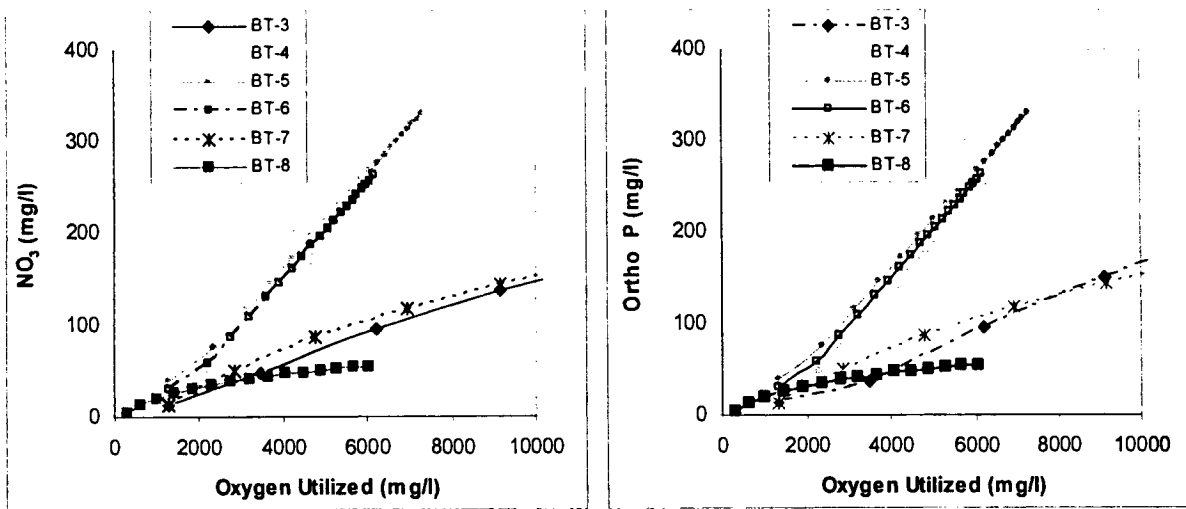


Figure 5.45a and b. Relationship of total oxygen utilized (OU) with simulated OP and nitrate concentrations in the bulk solution

In determining the specific b rates of the OHOs from the simulated OUR for OHOs, the average b rate of the OHOs was 0.13 d^{-1} (Figure 5.46). As the simulated OUR for the PAOs was essentially a horizontal line just above the x-axis for all the batch tests (e.g. Figure 5.44), the death rate of the PAO could not be determined from the simulated OUR for the PAOs, i.e. the b rate of the PAOs as computed from the simulated OUR for PAOs was very close to zero.

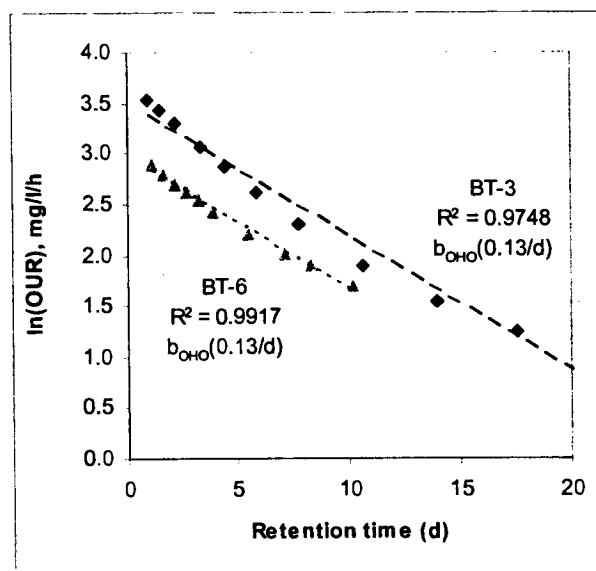


Figure 5.46. Plot of $\ln(\text{OUR})$ versus retention time for computing b rates of the OHOs from the simulated OUR for OHOs for BT-3 and BT-6

As shown in Figure 5.47a and b, for BT-3 and BT-4 the b rates of the OHOs and the PAOs computed from the head and tail ends of the simulated total OUR were 0.18 and 0.04 d^{-1} respectively. The average b rate of the OHOs computed from the simulated OUR for OHOs (0.13 d^{-1}) was lower than that computed from the head end of the simulated total OUR (0.18 d^{-1}). Similarly, the b rate of the PAOs computed from the simulated OUR for PAOs (0 d^{-1}) was lower than that computed from the tail end of the simulated total OUR (0.04 d^{-1}) (Table 5.8). Although computed from the head end of the simulated OUR, because the active fraction of PAOs is high (due to the acetate supplement to the parent system feed), the b value of the OHOs (b_H) is low due to significant effect of the PAOs with the lower b value ($b_G = 0.04 \text{ day}^{-1}$).

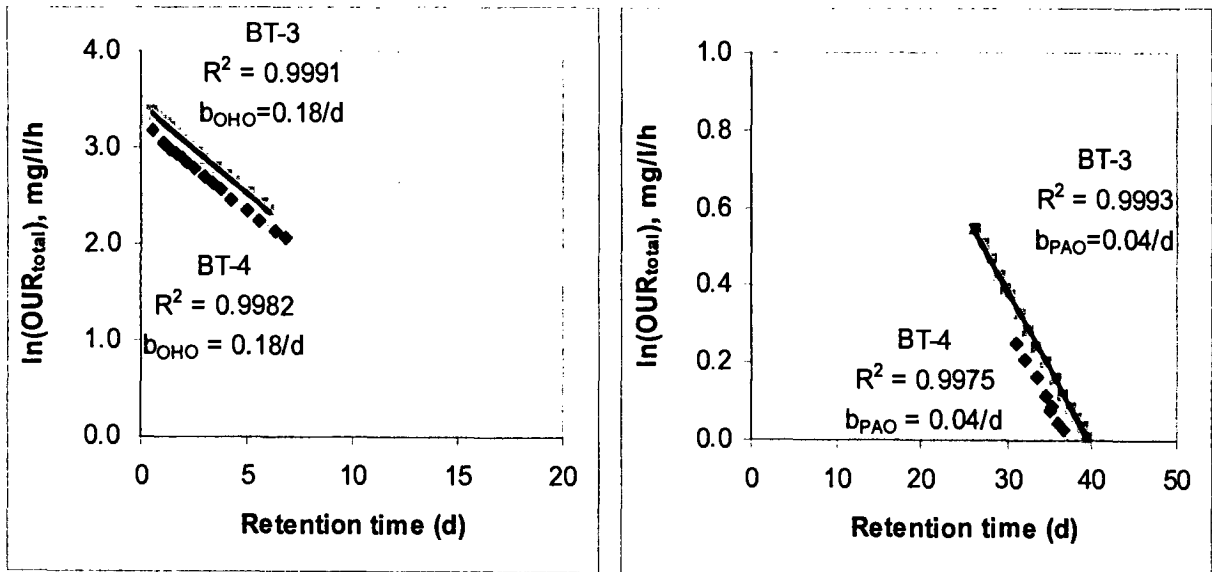


Figure 5.47a and b. Plot of $\ln(\text{OUR})$ versus retention time for computing b rates of the OHOs and PAOs from the head and tail ends of the simulated total OUR for BT-3 and BT-4

Moreover, the variation between the measured and simulated total OUR values resulted in the observed discrepancy between the b rates of OHOs and PAOs from the measured and simulated total OUR. The summary of the b rates of OHOs and PAOs computed from simulated OUR is given in Table 5.9.

Table 5.9. Summary of the b rates of OHOs and PAOs computed from simulated OUR using ASM-2

b rate (d ⁻¹)	Batch Test No.				Average
	BT-3	BT-4	BT-5	BT-6	
<i>Computed from simulated OUR for OHOs and PAOs</i>					
OHO	0.13	0.12	0.13	0.13	0.13
PAO	0.00	0.00	0.00	0.00	0.00
<i>Computed from the head and tail ends of simulated total OUR</i>					
OHO	0.19	0.18	0.19	0.16	0.18
PAO	0.04	0.04	0.04	0.05	0.04

5.3.2.2 COD Balance of simulation values

The values of the COD balance obtained for both the simulated 1-day interval and initial and final values is given in Table 5.10.

Table 5.10. COD balance of the batch tests based on simulated 1-day interval and initial and final values

BT	COD Balance (%)	
	1-Day Interval Values	Initial & Final Values
3	100.0	100.2
4	100.0	100.9
5	100.0	100.2
6	100.1	101.1
7	100.1	100.9
8	100.2	101.1

As expected, the COD balance for the simulated 1-day interval values was close to 100%. The COD balance for the simulated initial and final values, however, ranged from 100.2 to 101.1% (Table 5.10).

5.3.2.3 Comparison of batch reactor with simulation model

The comparison of the results simulated with ASM-2 and those computed with the batch reactor model (BRM) is done graphicallyⁱ.

As shown in Figure 5.48 and 5.49, similar trends of decrease of VSS concentration with retention time was observed with ASM-2 and the BRM, though at a slightly higher level for ASM-2 simulation results than those computed with BRM.

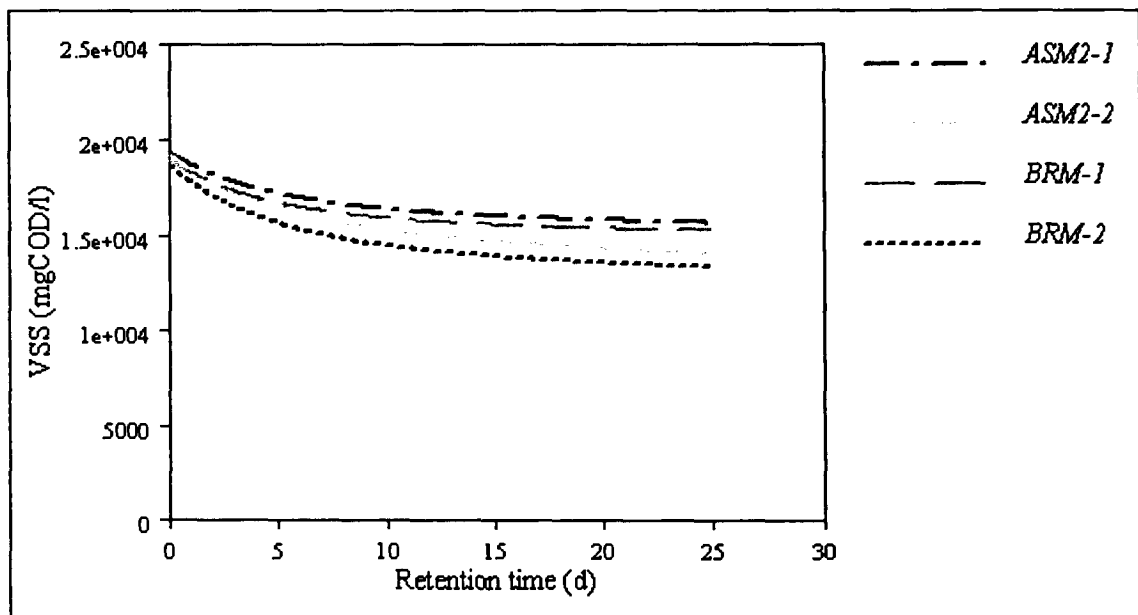


Figure 5.48. Comparison of VSS concentrations simulated with ASM-2 and computed with BRM for BT-1 and BT-2

ⁱ For the comparison of ASM-2 and BRM, in order to get similar initial concentrations for both models a slight adjustment of the initial set of conditions was made.

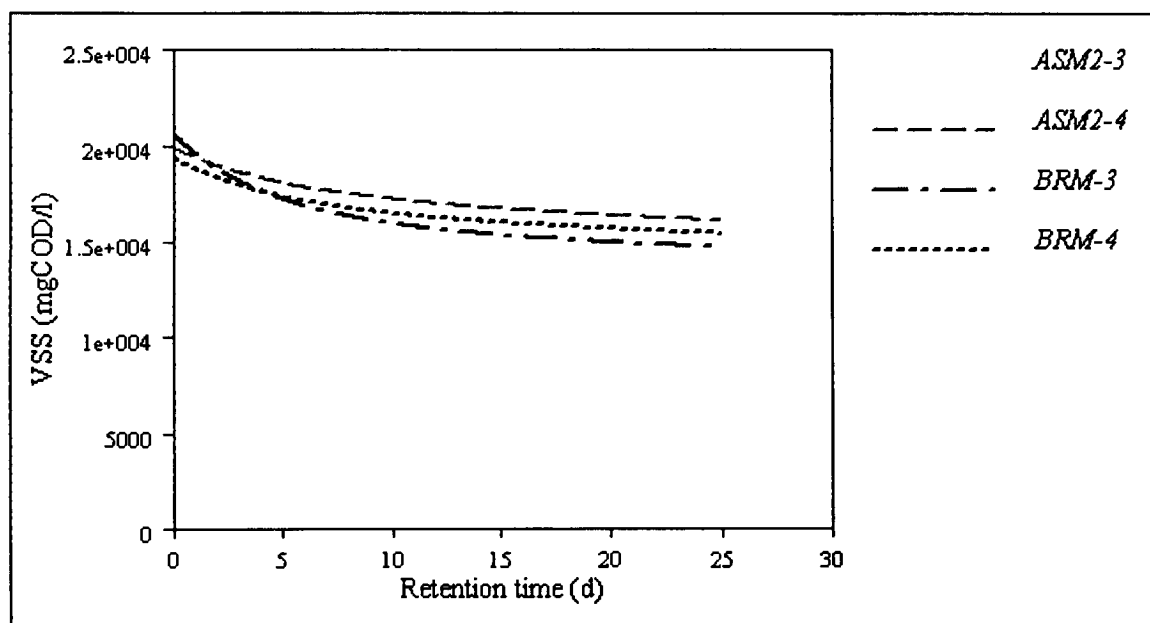


Figure 5.49. Comparison of VSS concentrations simulated with ASM-2 and computed with BRM for BT-3 and BT-4

For BT-2, the VSS concentrations simulated with ASM-2 and computed with the BRM decreased from initial values of 12900 and 12600 mgVSS l⁻¹ to final values of 9430 and 8950 mgVSS l⁻¹ respectively (Figure 5.48). Similarly, for BT-4 and BT-5 the VSS concentrations decreased from initial values of 13350 and 14600, and 13080 and 14390 mgVSS l⁻¹ to final values of 10820 and 11490, and 10370 and 11010 mgVSS l⁻¹ when simulated with ASM-2 and computed with BRM respectively (Figure 5.49 and 4.50).

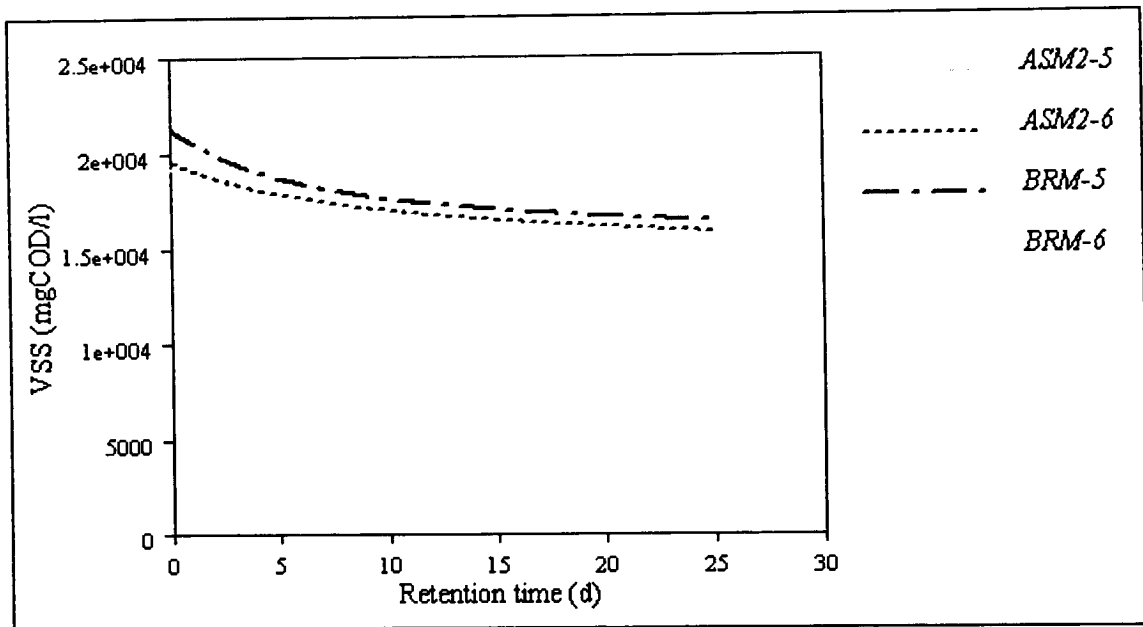


Figure 5.50. Comparison of VSS concentrations simulated with ASM-2 and computed with BRM for BT-5 and BT-6

Like that of the VSS, a similar pattern of decrease of TSS concentrations was observed with ASM-2 and BRM. However, unlike that of VSS, the magnitude of the TSS concentrations computed with BRM was slightly higher than those simulated with ASM-2. For BT-2 the TSS concentrations decreased from initial values of 17570 and 16900 mgTSS l⁻¹ to final values of 11160 and 10770 mgTSS l⁻¹ when computed with BRM and simulated with ASM-2 respectively (Figure 5.51). As shown in Figure 5.52, for BT-4 the TSS concentration decreased from initial values of 18190 and 17380 mgTSS l⁻¹ to final values of 12830 and 12240 mgTSS l⁻¹ when computed with BRM and simulated with ASM-2 respectively.

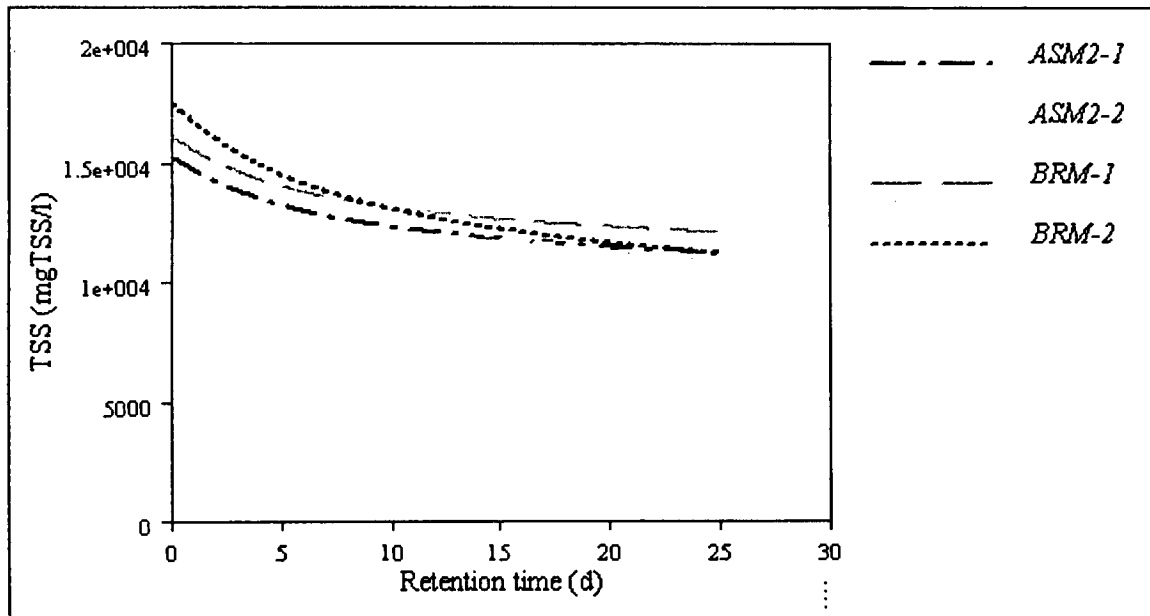


Figure 5.51. Comparison of TSS concentrations simulated with ASM-2 and computed with BRM for BT-1 and BT-2

Likewise, for BT-5, when computed with BRM and simulated with ASM-2 the TSS concentration decreased from initial values of 20230 and 19320 mgTSS l⁻¹ to final values of 13740 and 13130 mgTSS l⁻¹ respectively (Figure 5.53).

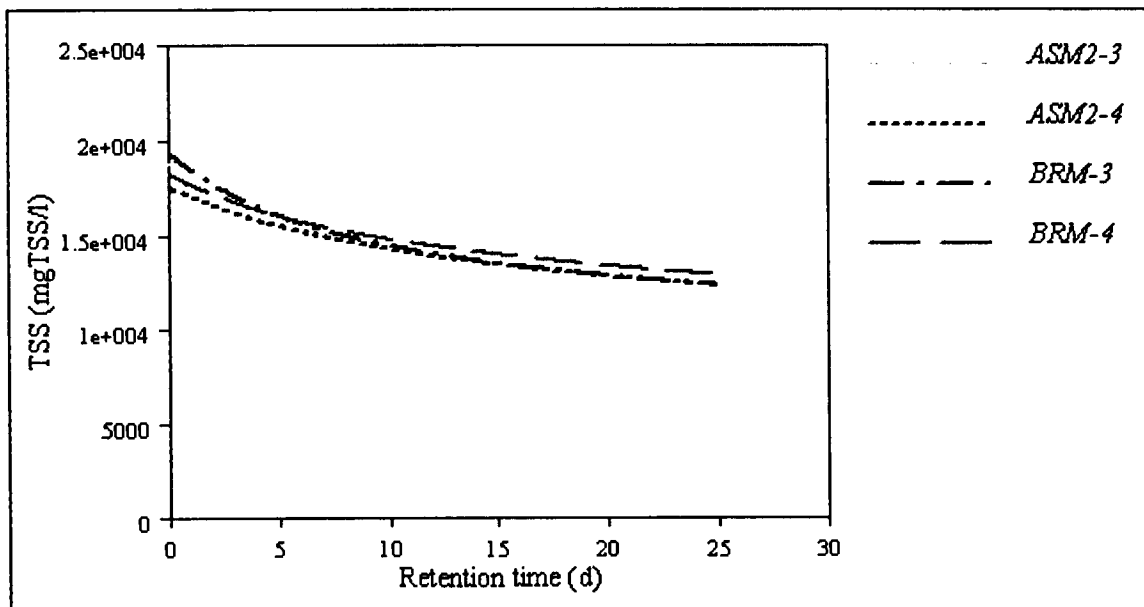


Figure 5.52. Comparison of TSS concentrations simulated with ASM-2 and computed with BRM for BT-3 and BT-4

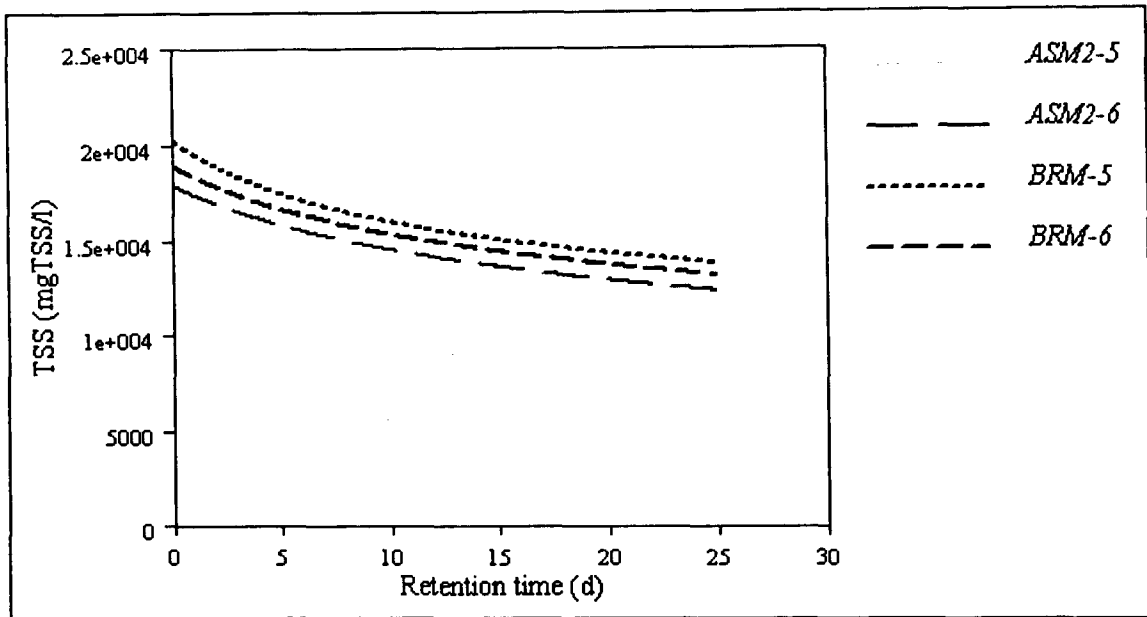


Figure 5.53. Comparison of TSS concentrations simulated with ASM-2 and computed with BRM for BT-5 and BT-6

During the aerobic digestion process, the increase in nitrate concentrations as simulated with ASM-2 and computed with BRM was almost the same apart from a slightly higher magnitudes of nitrate computed with the BRM. For BT-3 the nitrate concentration computed with the BRM and simulated with ASM-2 increased from initial value of 0.5 and 5.7 mgN l⁻¹ to final values of 403.1 and 380.8 mgN l⁻¹ respectively (Figure 5.54). For BT-6 the nitrate concentration increased from initial values of 0.6 and 31.8 mgN l⁻¹ to final values of 277.2 and 286.9 mgN l⁻¹ when computed with the BRM and simulated with ASM-2 respectively (Figure 5.55).

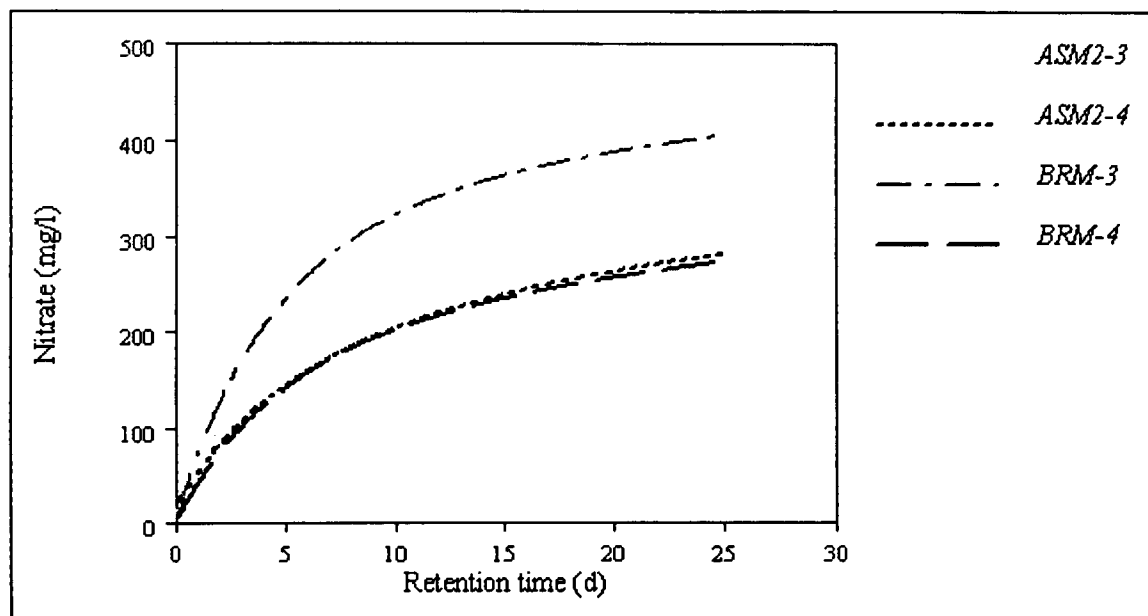


Figure 5.54. Comparison of nitrate concentrations simulated with ASM-2 and computed with BRM for BT-3 and BT-4

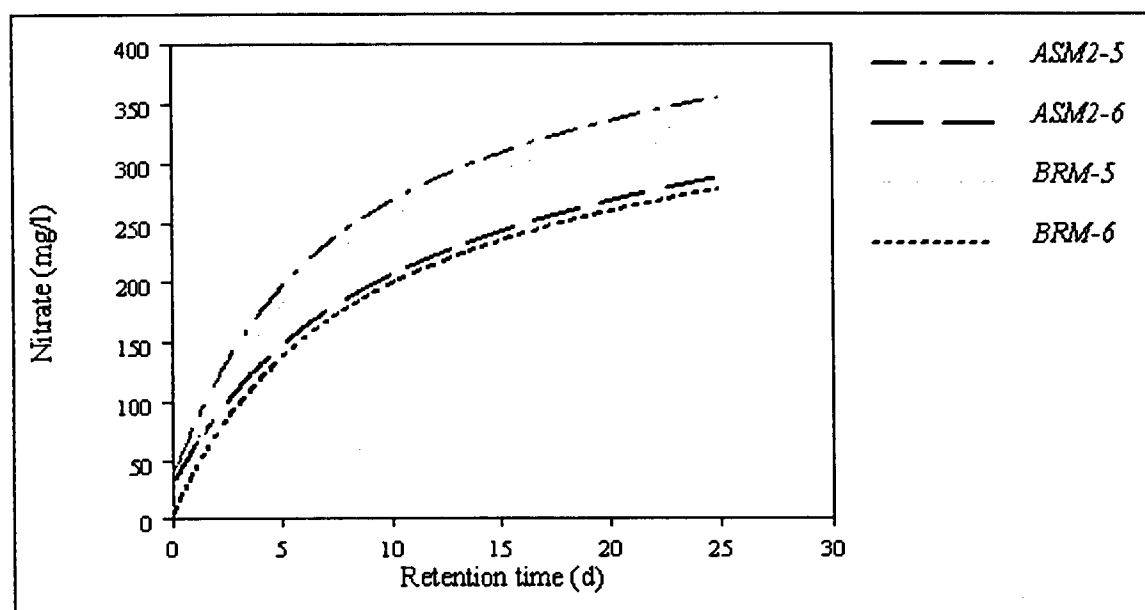


Figure 5.55. Comparison of nitrate concentrations simulated with ASM-2 and computed with BRM for BT-3 and BT-4

The increase of liquid OP concentrations with aeration time as simulated with ASM-2 was slightly higher than that computed with BRM. For BT-2 the liquid OP concentration simulated with ASM-2 and computed with the BRM increased from an initial value of 0.4 mgOP l⁻¹ to final values of 726.0 and 649.9 mgOP l⁻¹ respectively (Figure 5.56).

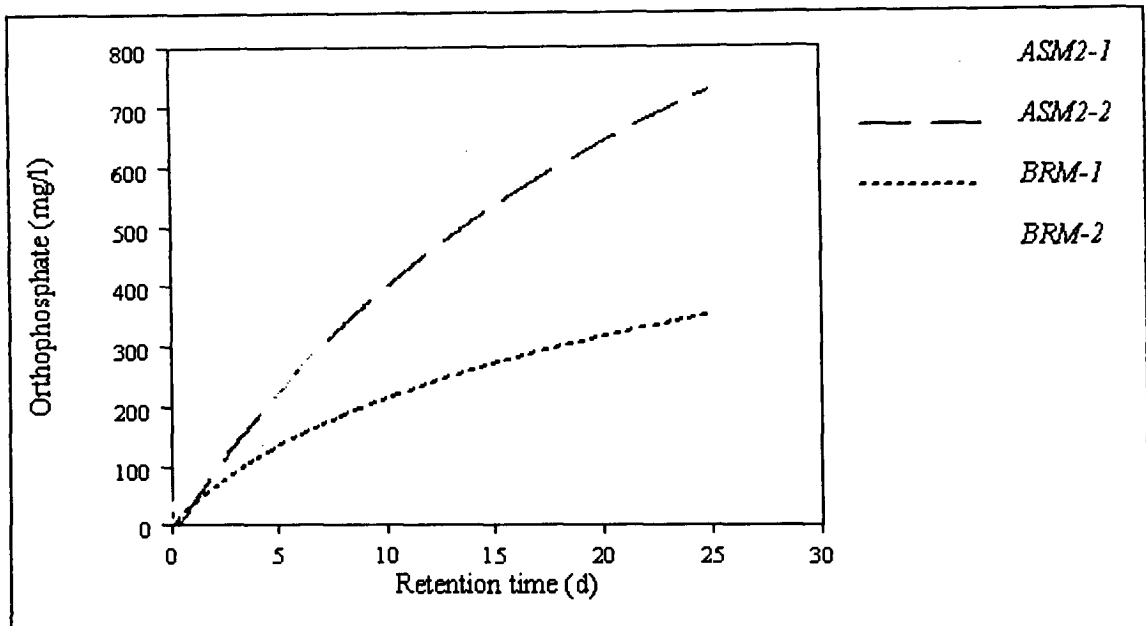


Figure 5.56. Comparison of OP concentrations simulated with ASM-2 and computed with BRM for BT-1 and BT-2

For BT-3, when simulated with ASM-2 and computed with BRM, the liquid OP concentrations increased from an initial value of 3.1 mgOP l⁻¹ to final values of 810.9 and 717.9 mgOP l⁻¹ respectively (Figure 5.57).

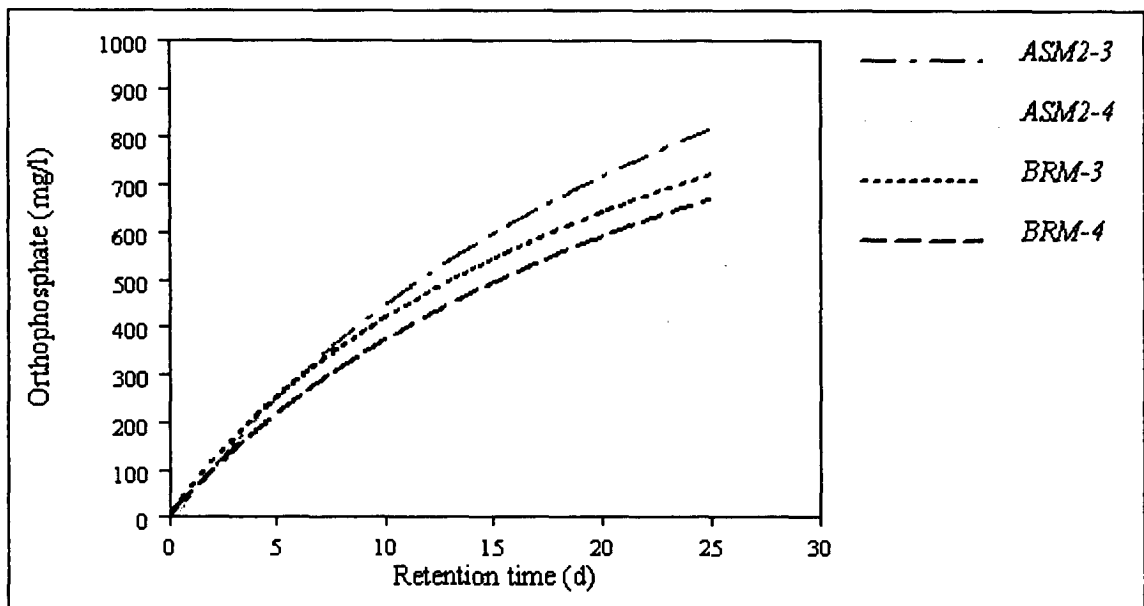


Figure 5.57. Comparison of OP concentrations simulated with ASM-2 and computed with BRM for BT-3 and BT-4

Similarly, for BT-5 the liquid OP concentration increased from an initial value of 1.1 mgOP l⁻¹ to final values of 850.6 and 760.3 mgOP l⁻¹ when simulated with ASM-2 and computed with the BRM respectively (Figure 5.58).

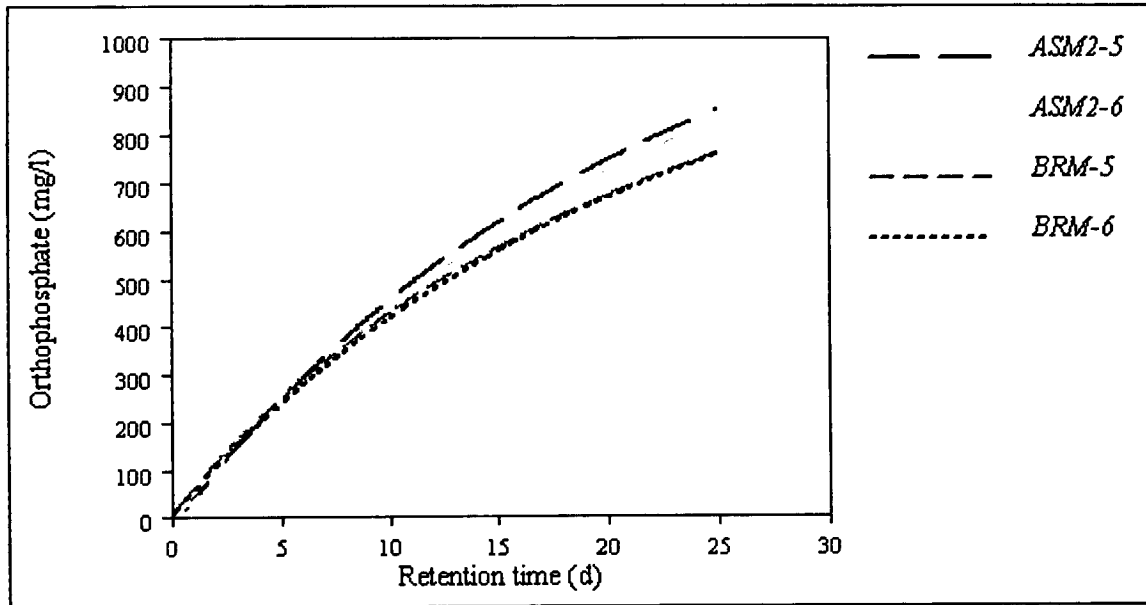


Figure 5.58. Comparison of OP concentrations simulated with ASM-2 and computed with BRM for BT-5 and BT-6

As shown in Figures 5.59, 5.60 and 5.61, the OUR values computed with BRM were higher than those simulated with ASM-2, especially at the beginning of the aerobic digestion. At the end of the aeration time, however, the OUR values simulated with ASM-2 and computed with BRM reached similar final lowest levels.

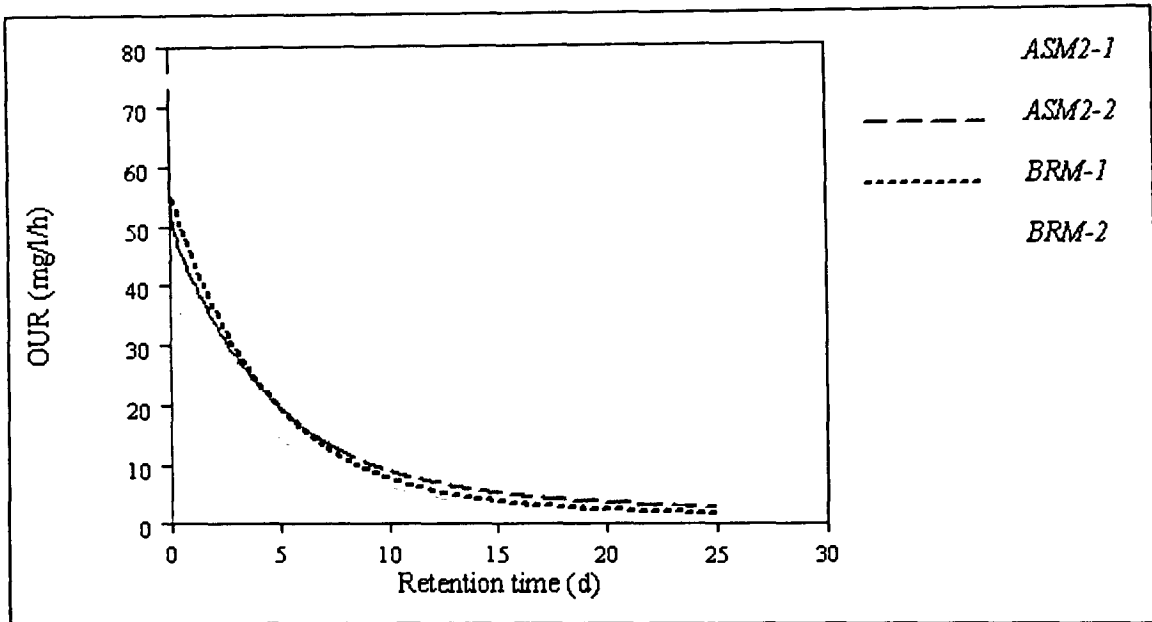


Figure 5.59. Comparison of OUR values simulated with ASM-2 and computed with BRM for BT-1 and BT-2

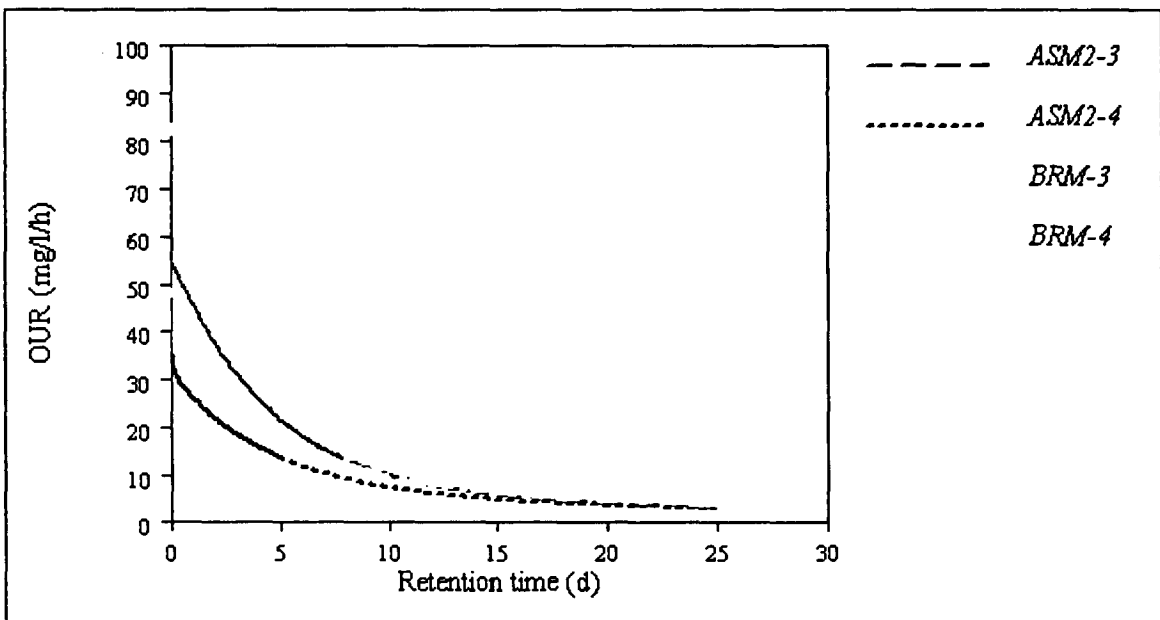


Figure 5.60. Comparison of OUR values simulated with ASM-2 and computed with BRM for BT-3 and BT-4

For BT-2 the OUR values computed with the BRM and simulated with ASM-2 decreased from initial values of 75.5 and 53.7 mgO (l.h)^{-1} to final values of 3.0 and 2.6 mgO (l.h)^{-1} respectively (Figure 5.59). Likewise, for BT-5 the OUR values decreased from initial values

of 62.7 and 47.3 mgO (l.h)⁻¹ to final values of 3.7 and 3.0 mgO (l.h)⁻¹ when computed with the BRM and simulated with ASM-2 respectively (Figure 5.61).

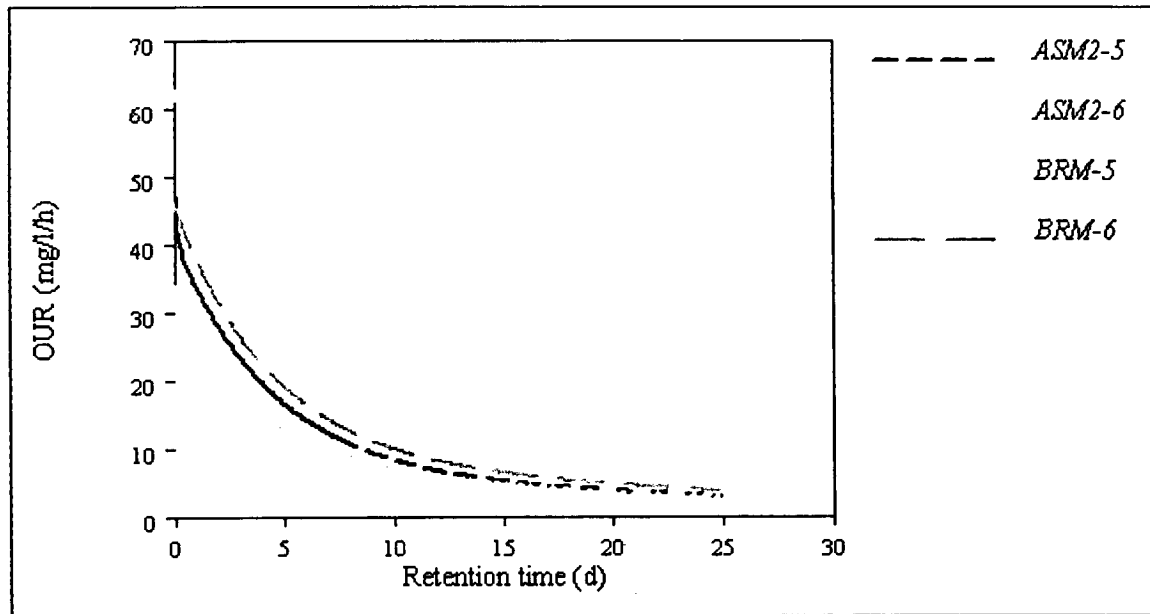


Figure 5.61. Comparison of OUR values simulated with ASM-2 and computed with BRM for BT-5 and BT-6

5.3.2.4 Comparison of observed data with the batch reactor model (BRM)

The variable inputs into the BRM are the initial concentrations of the OHOs and PAOs and the organic and inorganic inert materials (or equivalently the OHO and PAO active fractions). The occurrence of two sets of initial conditions as a result of the two way simulation of the MBR UCT system to match the simulated effluent OP concentration to the corresponding measured concentrations would, therefore, result in variation of the results computed with the BRM. However, as explained earlier, since the increase or decrease of the PAOs was accompanied by a corresponding decrease or increase of inert organic material and PAO P content, both sets of initial conditions resulted in no substantial changes in the results of the BRM except for small differences in the OP concentrations. Consideration of one set of initial conditions in the BRM would, therefore, represent the other set of initial conditions.

For BT-1, for the first half of the digestion period the measured VSS concentrations were higher than those computed with BRM and vice versa for the second half of the digestion

period. For BT-2, the measured VSS concentrations were higher than those computed with BRM. For BT-3, except for the end of the digestion periods where the measured VSS concentrations were lower than those computed with the BRM, the measured VSS concentrations were slightly higher than those computed with BRM (Figure 5.62).

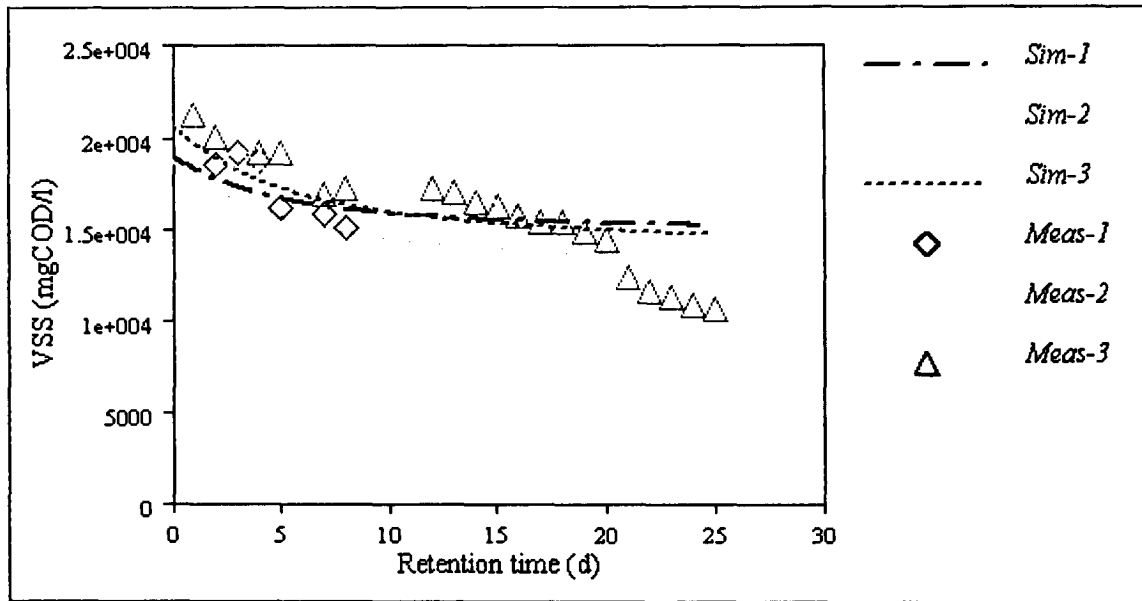


Figure 5.62. Measured and computed (with BRM) VSS concentrations for BT-1, BT-2 and BT-3

For BT-4, BT-5 and BT-6, for the first one third of the digestion period the measured VSS concentrations were equivalent to those computed with BRM. For the last two third of the digestion period, however, the measured VSS concentrations decreased at higher rate than those computed with BRM (Figure 5.63).

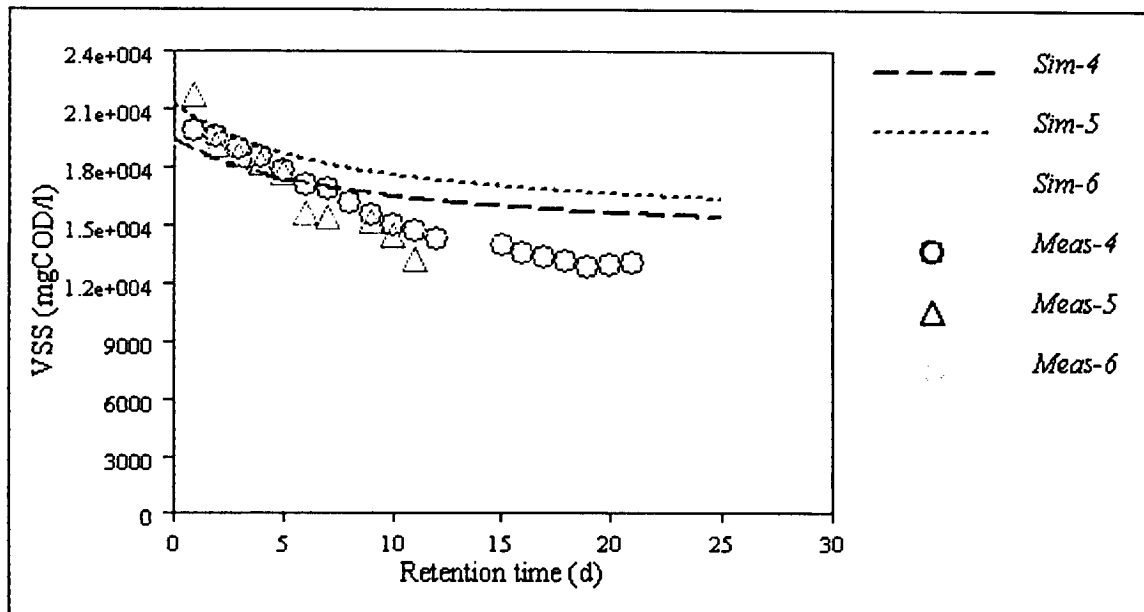


Figure 5.63. Measured and computed (with BRM) VSS concentrations for BT-4, BT-5 and BT-6

Generally, the VSS concentrations computed with SSM were similar to those simulated with the ASM-2. During the early periods of the digestion process the measured VSS concentrations were almost equivalent to those computed, while during the end of the digestion period the measured VSS concentrations were lower than those computed with BRM.

For BT-1 and BT-3, for the first half of the digestion period the measured VSS reductions were lower than those calculated with BRM while during the second half of the digestion period the calculated VSS reductions were higher than those measured. For BT-2, the measured VSS reductions were lower than those simulated (Figure 5.64). For BT-4 and BT-6, except for the early periods of digestion, the measured VSS reductions were higher than those calculated while for BT-5 the measured VSS reductions were higher than those calculated with BRM (Figure 5.65). Generally, as shown in Figures 5.64 and 5.65, except for the first quarter of the digestion period where the measured and calculated VSS reductions were equivalent, for the entire batch tests the measured VSS reductions were higher than those computed with BRM.

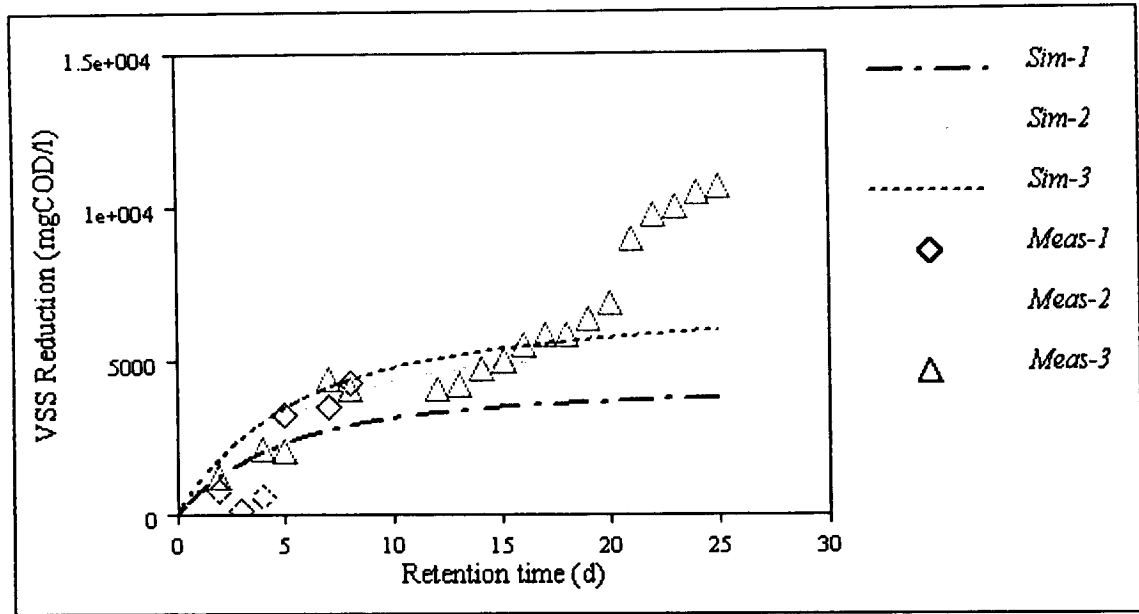


Figure 5.64. Measured and computed VSS reductions for BT-1, BT-2 and BT-3

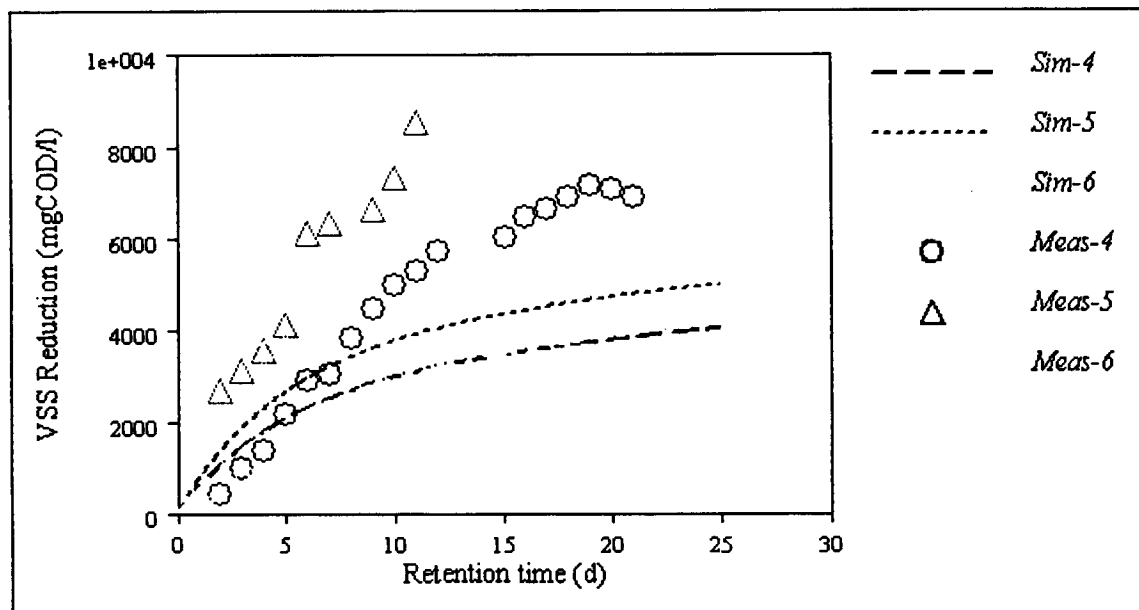


Figure 5.65. Measured and calculated VSS reductions for BT-4, BT-5 and BT-6

For BT-1 and BT-2, the measured fractions of VSS removed, f_{Vr} , were lower than those computed with BRM. For BT-3, the measured fractions of VSS removed were lower than those computed with BRM, except for the last quarter of the digestion period where the measured fraction of VSS removed were higher than those computed with BRM. Hence, for BT-3 the measured and computed fractions of VSS removed increased from initial values of 5.5 and 10.4% to final values of 50.1 and 36.1% respectively (Figure 5.66).

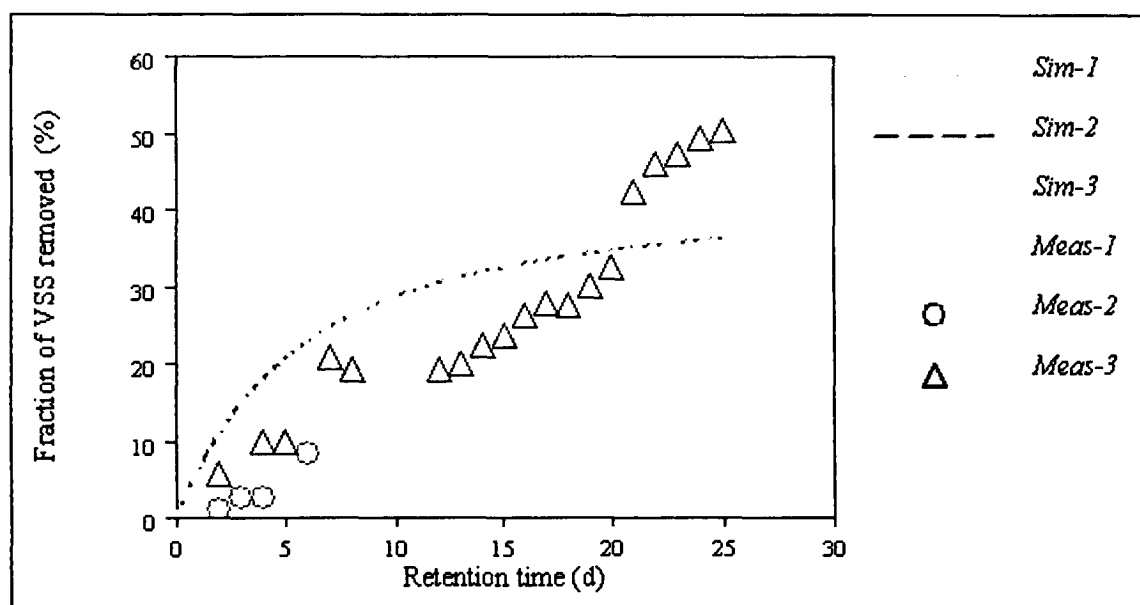


Figure 5.66. Measured and calculated fractions of VSS removed (percentage of VSS destruction) for BT-1, BT-2 and BT-3

For BT-5, like that of VSS reductions, the measured fractions of VSS removed were higher than those computed with BRM. For BT-4 and BT-6, except for the first quarter of the digestion period, the measured fractions of VSS removed were higher than those computed with BRM. Hence, for BT-4 and BT-6 the measured and computed fractions of VSS removed increased from initial values of 2.6 and 7.1%, and 1.1 and 6.5% to final values of 34.9 and 25.1%, and 26.4 and 22.5% respectively (Figure 5.67).

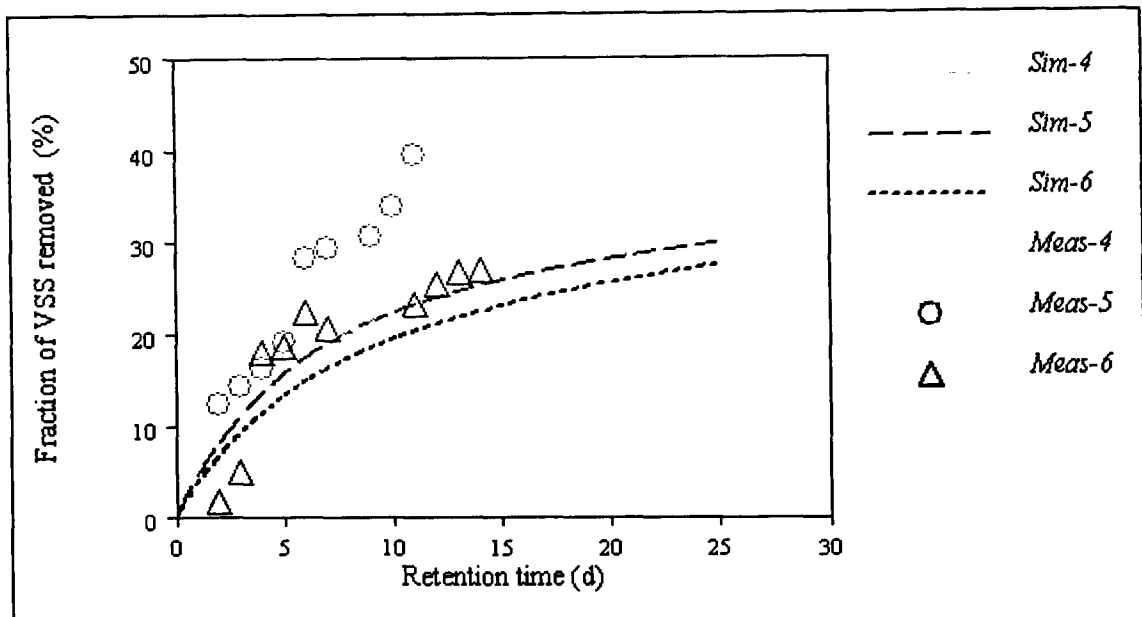


Figure 5.67. Measured and computed fractions of VSS removed (percentage of VSS destruction) for BT-4, BT-5 and BT-6

For BT-1, though the measured TSS concentrations were higher than those computed with BRM for the first half of the digestion period, for the second half of the digestion period the measured TSS concentrations were comparable to those computed with BRM. For BT-2 and BT-3, the measured TSS concentrations were equivalent to those computed with BRM, except at the end of the digestion period where the measured TSS concentrations of BT-3 decreased faster than those computed with BRM. Generally, as the comparable measured TSS concentrations for BT-1, BT-2 and BT-3 decreased in similar pattern, the TSS concentrations computed with BRM also decreased similarly except for BT-1 where the decrease in TSS concentration computed with BRM was gradual (Figure 5.68).

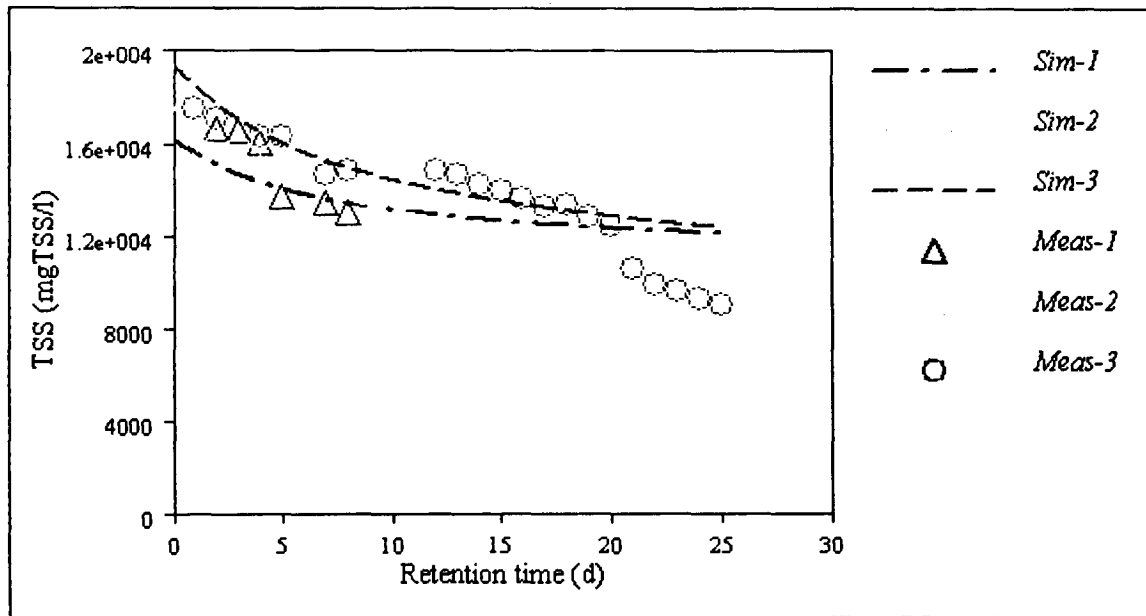


Figure 5.68. Measured and calculated TSS concentrations for BT-1, BT-2 and BT-3

As shown in Figure 5.69, for BT-4, BT-5 and BT-6 the measured TSS concentrations were lower than those computed with BRM.

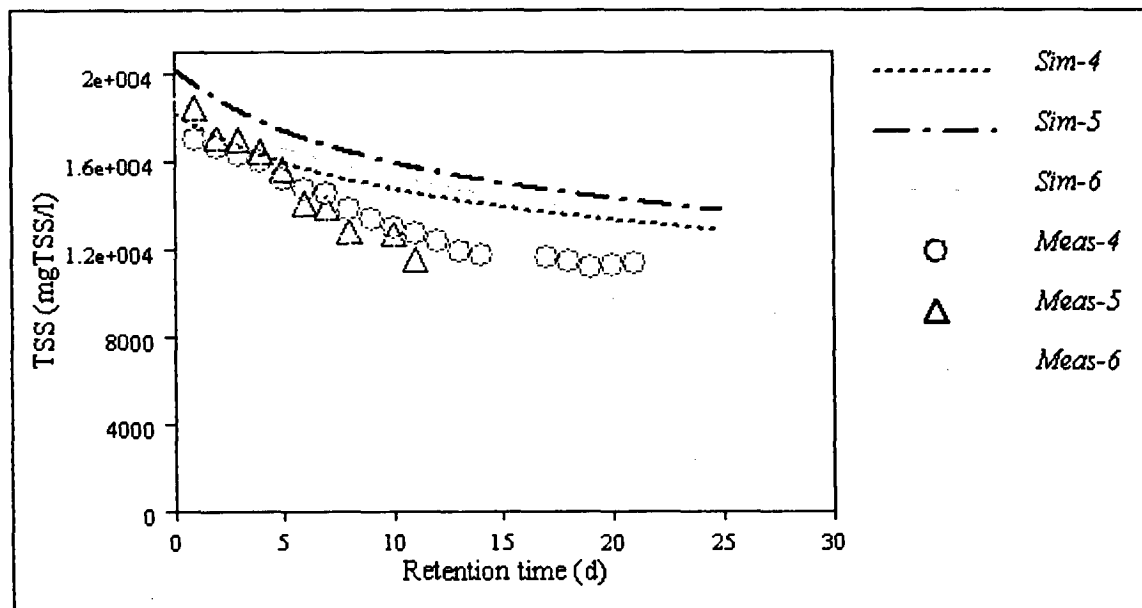


Figure 5.69. Measured and calculated TSS concentrations for BT-4, BT-5 and BT-6

For BT-2, the measured TSS reductions were lower than those computed with BRM. For BT-1 and BT-3, the measured TSS reductions were lower than those computed with BRM for the first half and two third of the aerobic digestion period, respectively. However, for the second

half and last one third of the digestion period the measured TSS reductions were higher than those calculated with BRM (Figure 5.70).

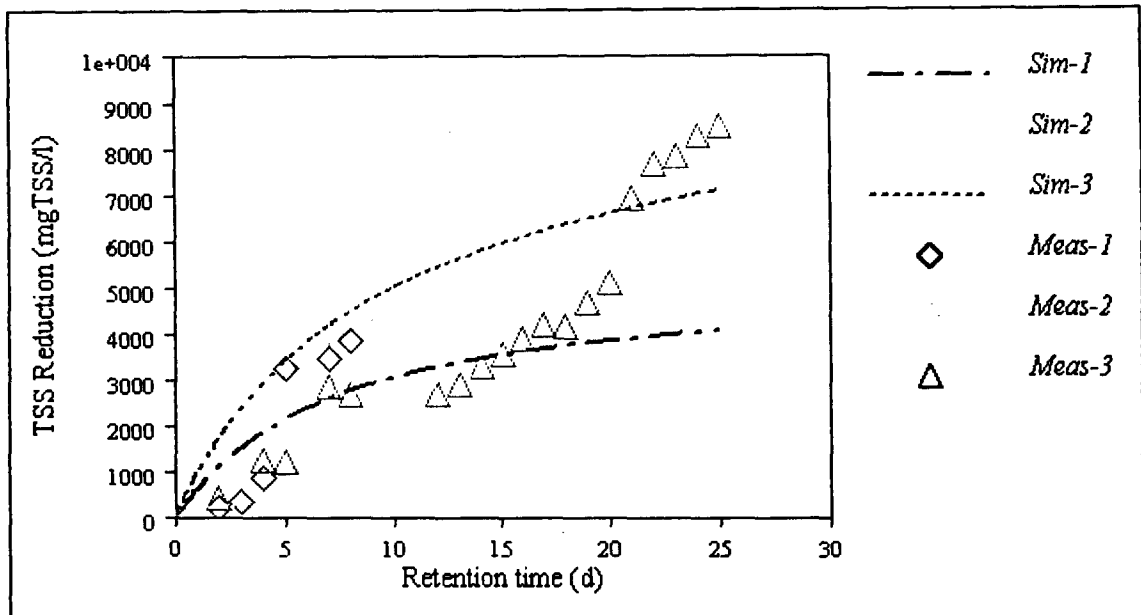


Figure 5.70. Measured and calculated TSS reductions for BT-1, BT-2 and BT-3

For BT-4 and BT-6, close match of the measured and calculated TSS reductions were observed. For BT-5, for the first half of the aerobic digestion period measured TSS reductions were equivalent to those computed with BRM. For the second half of the digestion period, however, the measured TSS reductions were higher than those computed with BRM (Figure 5.71).

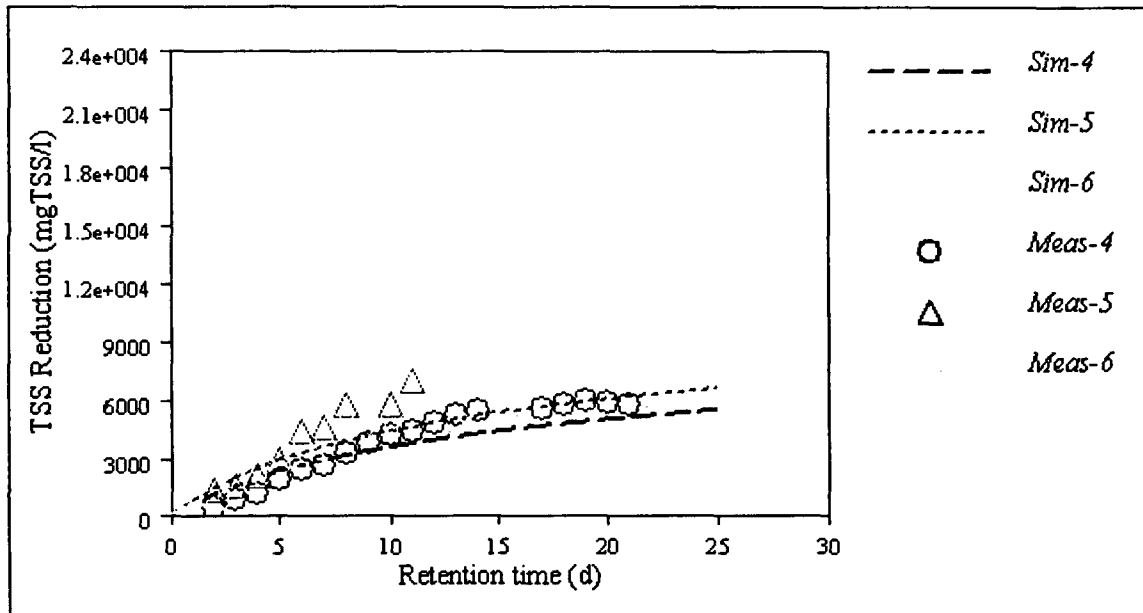


Figure 5.71. Measured and calculated TSS reductions for BT-4, BT-5 and BT-6

As shown in Figure 5.72, for BT-2 the measured fractions of TSS removed, f_{Tr} (%) were lower than those computed with BRM. For BT-1, the measured f_{Tr} were lower than those computed with BRM for the first half of the digestion period; thereafter, the measured f_{Tr} were higher than those computed with BRM. For BT-3, for the first two third of the aerobic digestion period the measured f_{Tr} were lower than those computed with BRM and vice versa for the last one third period of the digestion period. The measured and computed fractions of TSS removed for BT-3 increased from initial values of 2.2 and 7.3% to final values of 48.3 and 30.0% respectively.

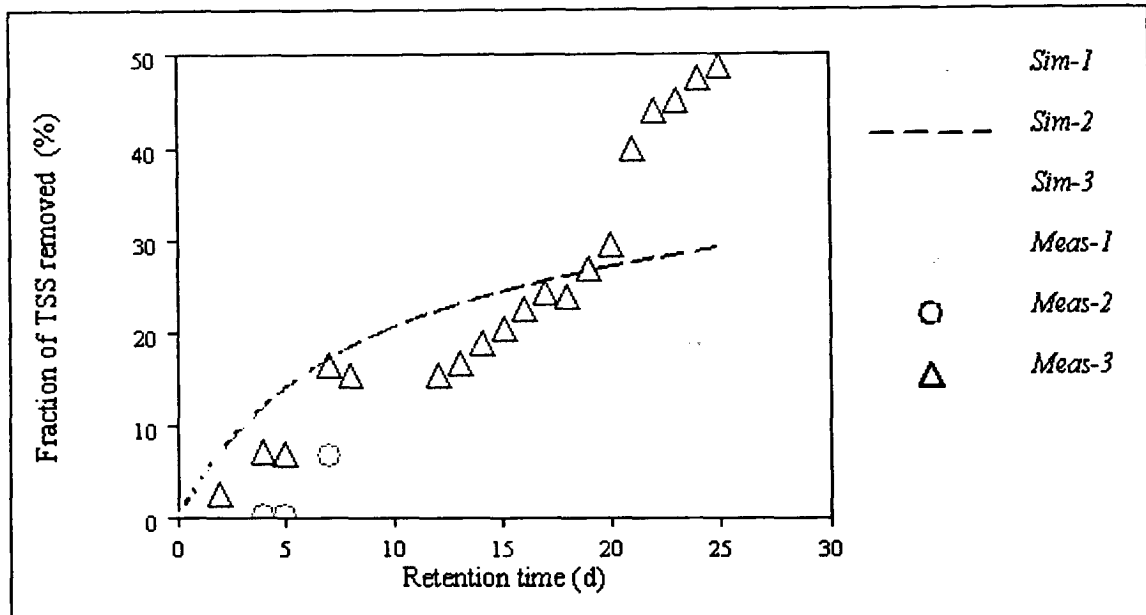


Figure 5.72. Measured and calculated fractions of TSS removed (percentage of TSS destruction) for BT-1, BT-2 and BT-3

For BT-4 and BT-6, for the first quarter of the aerobic digestion period, the measured f_{Tr} were comparable to those computed with BRM. For the last three quarters of the digestion period, however, the measured f_{Tr} were higher than those computed with BRM. The measured and computed fractions of TSS removed, for BT-6, increased from initial values of 2.3 and 4.3% to final values of 29.3 and 17.7% respectively. For BT-5, the measured f_{Tr} were higher than those calculated with BRM (Figure 5.73).

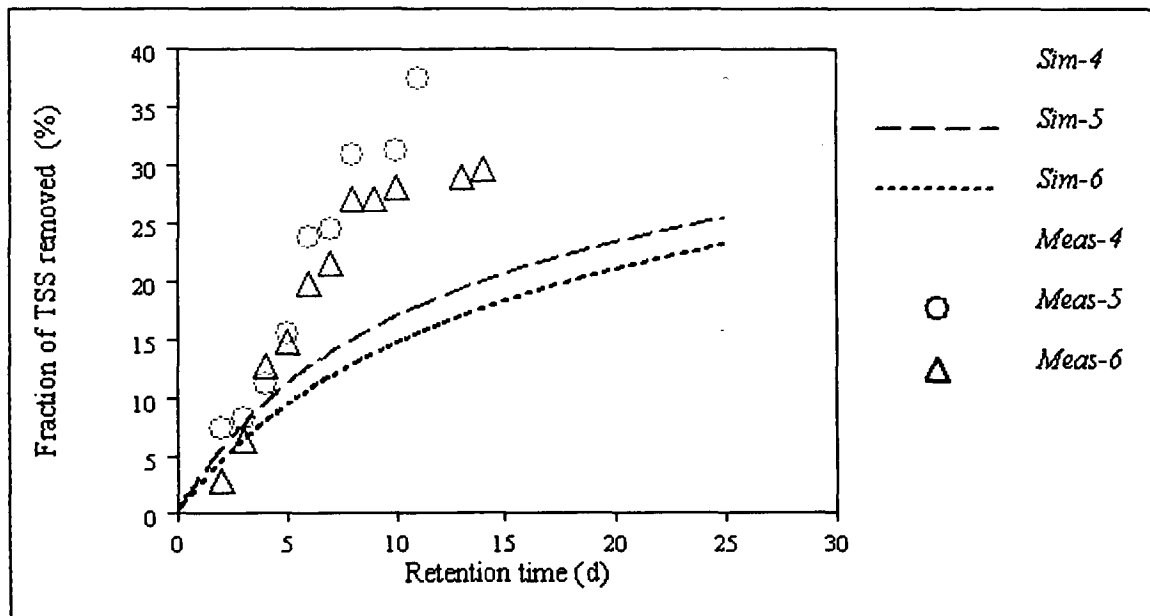


Figure 5.73. Measured and calculated fractions of TSS removed (percentage of TSS destruction) for BT-4, BT-5 and BT-6

For BT-3, the measured nitrate concentrations were lower than those computed with BRM. For the first two third of the digestion period, for BT-4, the measured nitrate concentrations were lower than those computed with BRM, and vice versa for the last one third of the digestion period. For BT-5, the measured nitrate concentrations were almost equivalent to those computed with BRM. For BT-6, while the measured nitrate concentrations were close to those computed with BRM for the first one third of the digestion period, for the last two third of the digestion period the measured nitrate concentrations were higher than those computed with BRM. Generally, the trend of increase of the calculated and measured nitrate concentrations was the same for BT-3, BT-4, BT-5 and BT-6 (Figure 5.74).

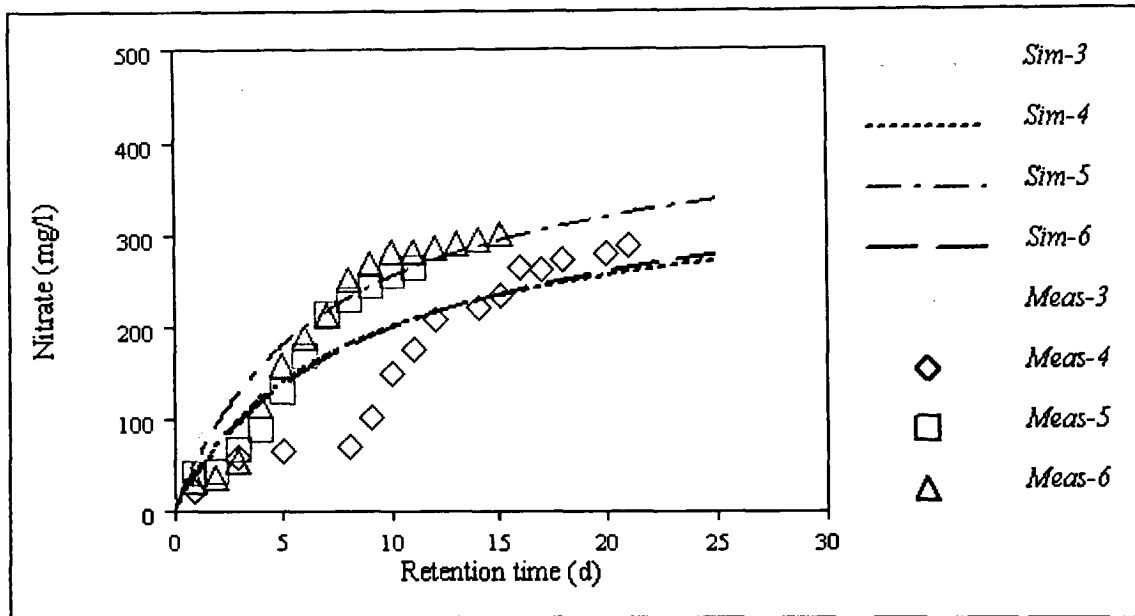


Figure 5.74. Measured and calculated nitrate concentrations for BT-3, BT-4, BT-5 and BT-6

The two sets of initial conditions for the aerobic batch digestion as a result of the two way simulation of the parent (MBR UCT) system, i.e. with the adjustment of (1) the maximum rate of fermentation of the OHOs (q_{Fe}) and (2) the rate constant for storage of PP (q_{pp}), rendered the OP concentrations computed with BRM to be higher for the set of initial conditions related to q_{Fe} than that of q_{pp} . The comparison of the measured OP concentrations with those computed with BRM for the two sets of initial conditions is shown in Figures 5.75 and 5.76.

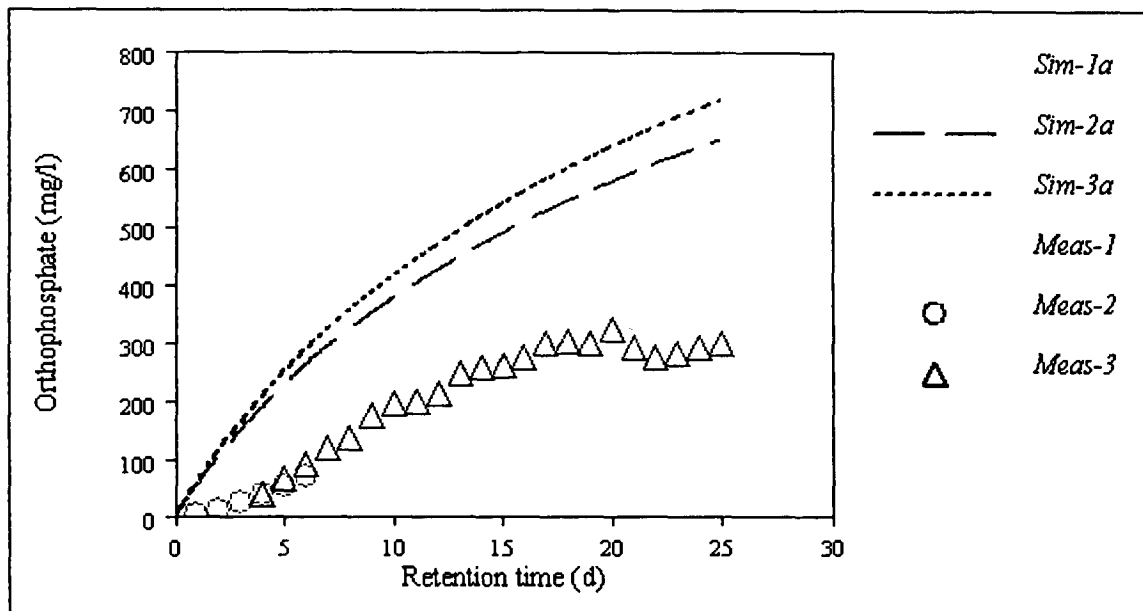


Figure 5.75. Measured and calculated orthophosphate concentrations (using the set of initial conditions with the adjustment of q_{Fe}) for BT-1, BT-2 and BT-3

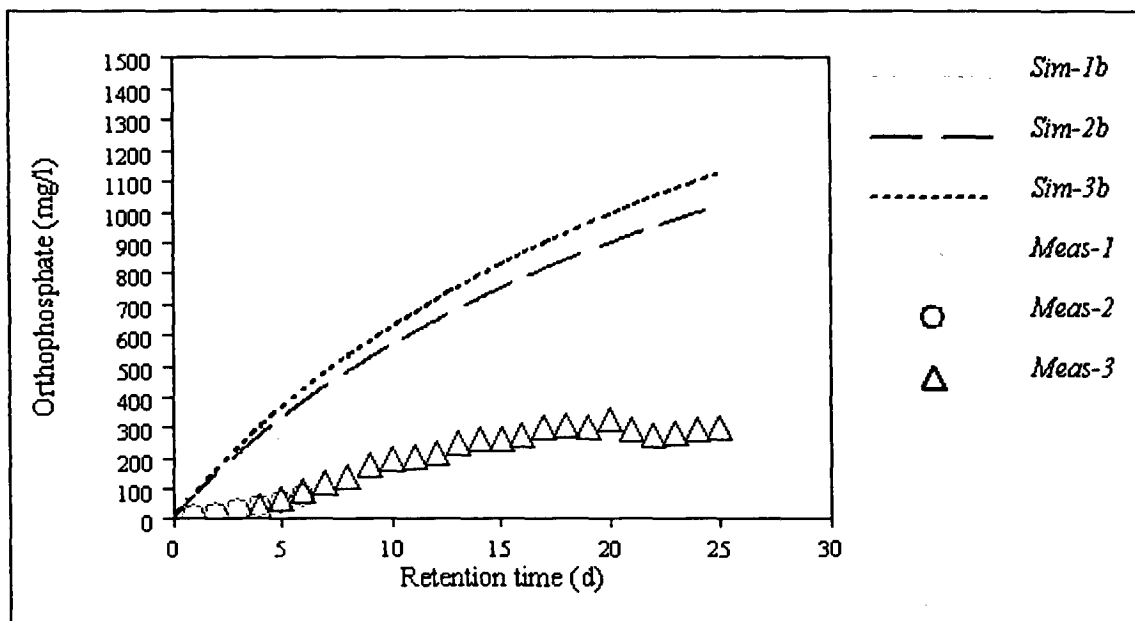


Figure 5.76. Measured and calculated orthophosphate concentrations (using the set of initial conditions with the adjustment of q_{pp}) for BT-1, BT-2 and BT-3

As shown in Figures 5.75, 5.76 and 5.77, however, except for BT-1 where the measured OP concentrations were higher than those computed with BRM for the set of initial conditions with the adjustment of q_{Fe} , the measured OP concentrations were, generally, lower than those computed with BRM for both sets of initial conditions.

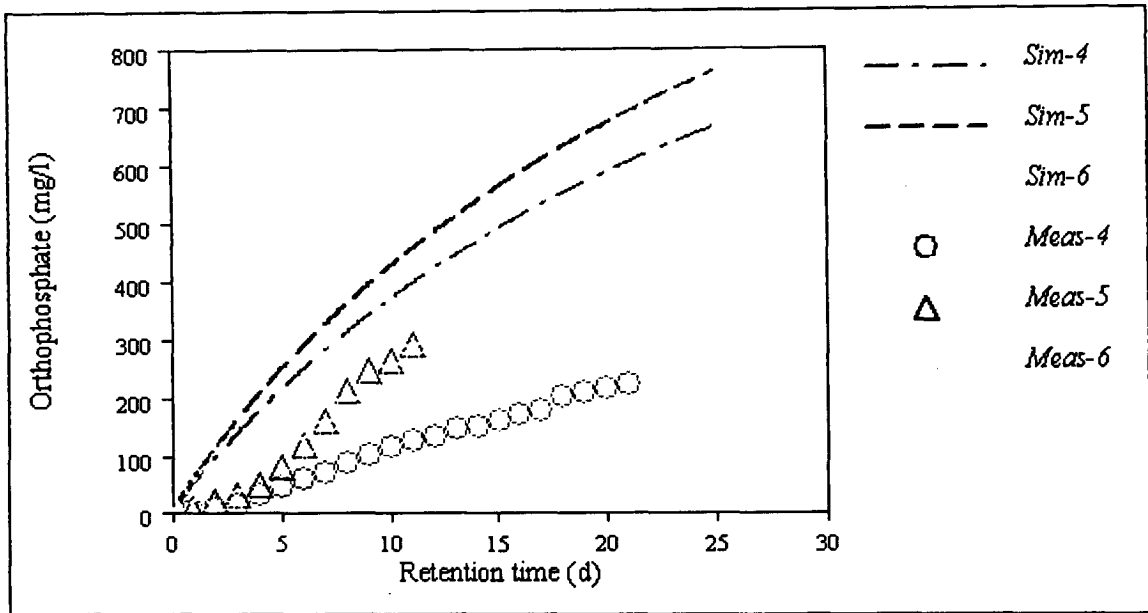


Figure 5.77. Measured and calculated orthophosphate concentrations for BT-4, BT-5 and BT-6

As shown in Figures 5.78 and 5.79, although the OUR values computed with the BRM were higher than those simulated with the ASM-2, they were still lower than the measured OUR values for BT-1 to BT-6. For BT-8, with diluted WAS, the measured and computed OUR values were almost equivalent with similar trends of decrease.

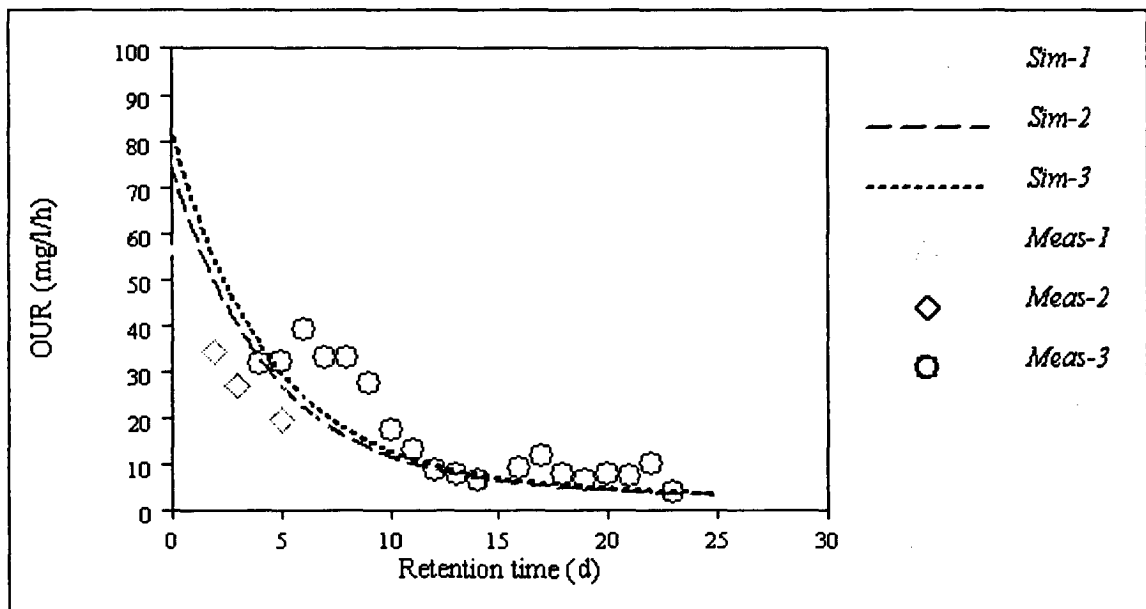


Figure 5.78. Measured and computed OUR values for BT-1, BT-2 and BT-3

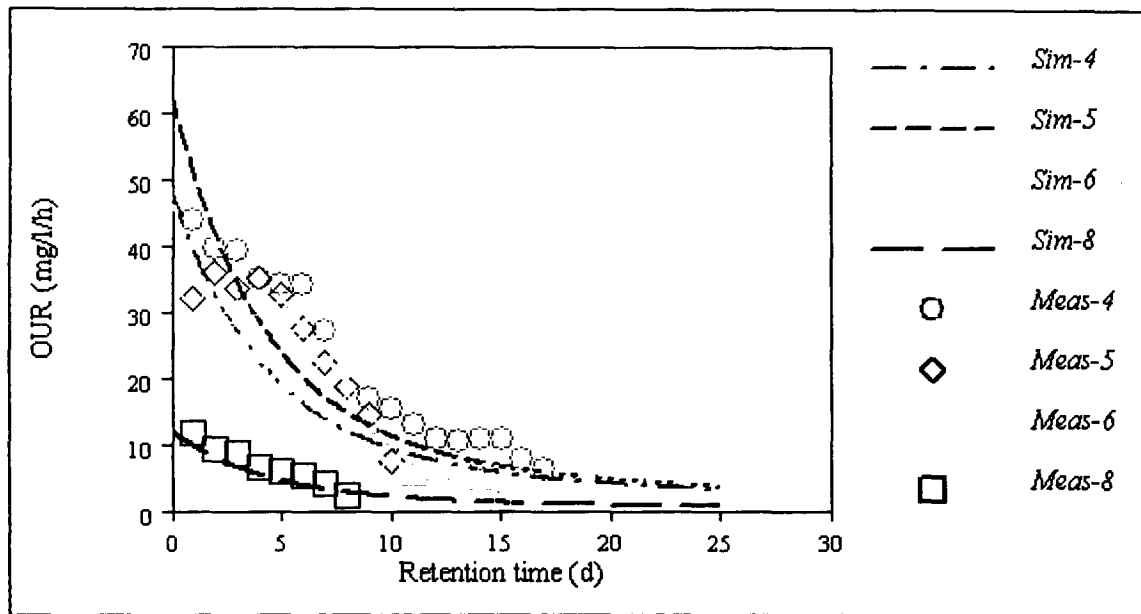


Figure 5.79. Measured and computed OUR values for BT-4, BT-5, BT-6 and BT-8 (diluted WAS)

The endogenous respiration (b) rates of the OHOs and PAOs determined from the computed OUR using the BRM were 0.23 and 0.04 d^{-1} respectively. The summary of the b rates of OHOs and PAOs determined from OUR computed with BRM is given in Table 5.11.

Table 5.9. Summary of the endogenous respiration (b) rates of OHOs and PAOs determined from OUR computed with the BRM

b rate (d ⁻¹)	Batch Test No.				Average
	BT-3	BT-4	BT-5	BT-6	
<i>Determined from computed OUR for OHOs and PAOs</i>					
OHO	0.23	0.24	0.24	0.23	0.24
PAO	0.04	0.04	0.04	0.04	0.04
<i>Determined from the head and tail ends of computed total OUR</i>					
OHO	0.20	0.18	0.18	0.17	0.18
PAO	0.07	0.05	0.06	0.06	0.06

Besides, from the OUR values computed with BRM, the sensitivity of the endogenous respiration (b) rate of the OHOs to the change in b of the PAOs and vice versa were evaluated. By varying the b of the PAOs from 0.01 to 0.12 the b rate of the OHOs were computed from $\ln(\text{OUR})$ vs. retention time plot. The variation in the b rate of the PAOs did

not alter the slope of the $\ln(\text{OUR})$ vs. time plot, therefore did not affect the b of the OHOs which remained constant at 0.23 d^{-1} (Figure 5.80a and b).

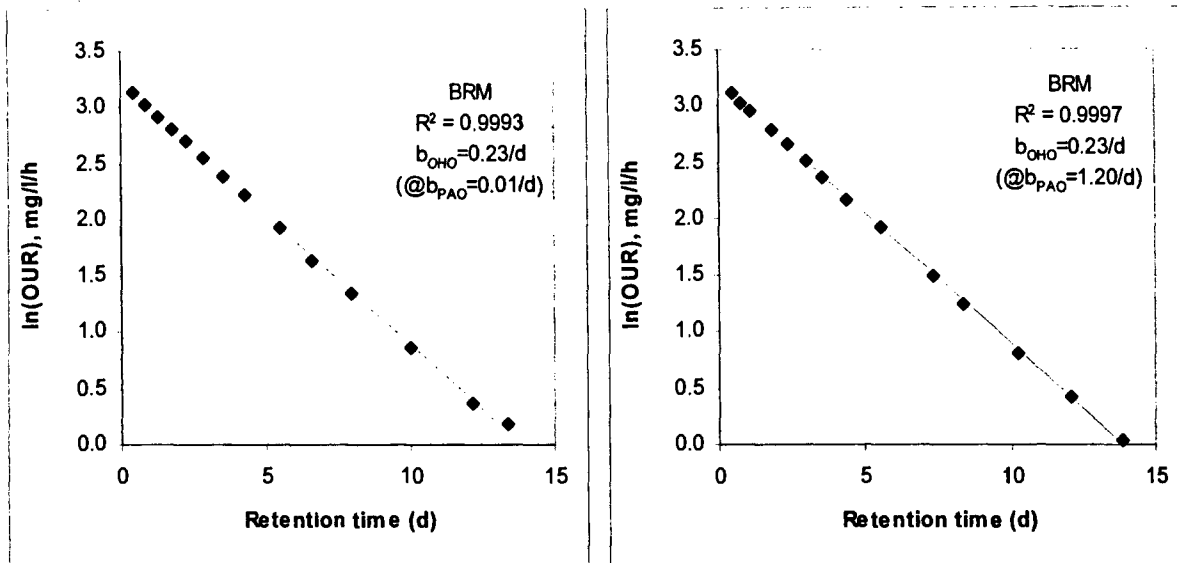


Figure 5.80a and b. Sensitivity of the endogenous respiration (b) rate of OHOs to the change of b rate of the PAOs

On the other hand, when the b rate of the OHOs was varied from 0.05 to 0.28 d^{-1} , the corresponding b rate of the PAOs remained almost constant at 0.04 d^{-1} (Figure 5.81a and b). This confirms that the OHOs and the PAOs operated independently during the aerobic digestion process.

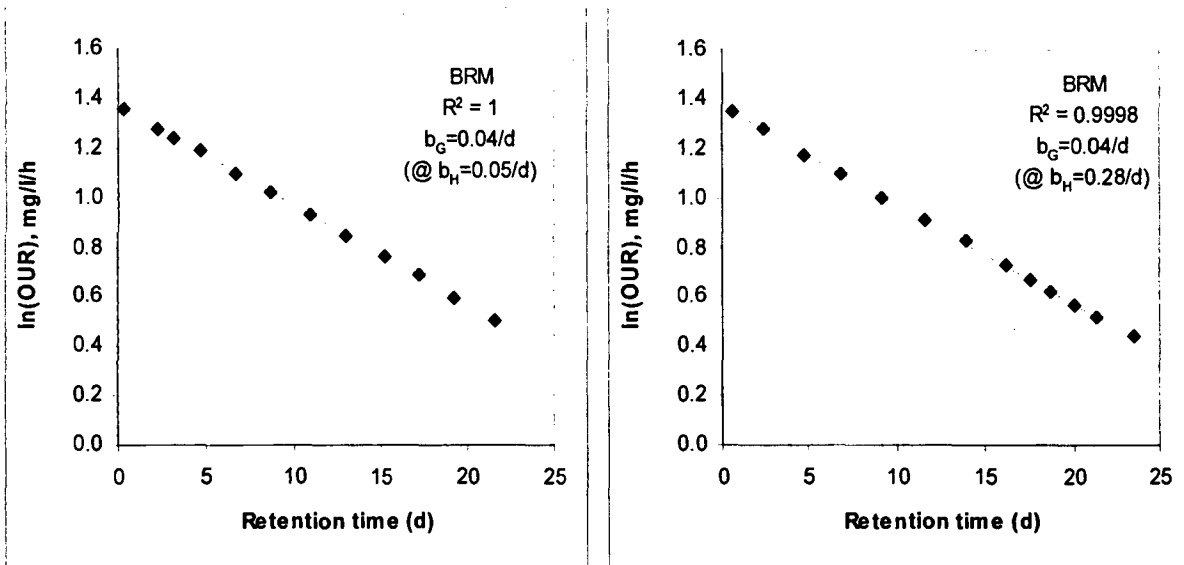


Figure 5.81a and b. Sensitivity of the endogenous respiration (b) rate of PAOs to the change of b rate of the OHOs

5.4 Closure

In this chapter the general experimental conditions of the parent system and the aerobic batch digestion of the WAS were described. The results of all the measured parameters of the aerobic batch tests were presented numerically and graphically. Explanation of the trends of variation with detention times as related to other relevant and interlinked parameters were given. The average measured values of parameters under aerobic digestion process were seen in comparison with the corresponding average values of the parent system. Comparative check up for the effect of dilution with diluted and undiluted tests and samples analysis were made. Moreover, a comparative evaluation of other researchers' published data in relation to results of this study was performed. Along with the procedural explanation, the two way simulation (with the adjustment of (1) the maximum rate of fermentation of the OHOs, q_{Fe} and (2) the rate constant for storage of PP, q_{pp}) of the parent system and comparison of the measured and simulated concentrations of parameters both for the parent system and aerobic batch digestion tests were presented. The conclusion drawn from this section will be presented in Chapter 6.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Aerobic batch digestion of waste activated sludge (WAS) from a laboratory scale nitrification denitrification biological excess P removal (NDBEPR) system was carried out with regulated pH (7.20) and in the temperature regulated (20°C) water research laboratory of the University of Cape Town. The parent NDBEPR system operated at 20 days sludge age and high mixed liquor suspended solids (MLSS) concentration in the aerobic reactor (16 to 20 g l⁻¹) because submerged panel membranes effected the solid-liquid separation step. The influent COD concentration was 1000 mgCOD l⁻¹, of which 200 mgCOD l⁻¹ was added acetate to increase the BEPR in the system. Eight batch aerobic digestion tests were conducted on aerobic reactor with sludge harvested from this system; seven at high MLSS concentration (~16 to 20 g l⁻¹) and one at low MLSS concentration (~4 g l⁻¹). Both the NDBEPR parent system and the eight batch digestion tests on sludge harvested from it were simulated with the Activated Sludge Model No. 2 (ASM-2) modified to include the ISS model of Ekama and Wentzel (2004). The model was calibrated against the parent NDBEPR system data as follows: From the measured influent COD characteristics, i.e. RBCOD and unbiodegradable soluble COD fraction ($f_{S_{us}}$), the unbiodegradable particulate COD fraction ($f_{S_{up}}$) was selected such that the predicted VSS concentrations in the system matched those measured – an average value of $f_{S_{up}}$ of 0.183 was obtained, which is in the range of values obtained in the past. Next the influent RBCOD split between the OHOs and POAs was determined to match the predicted P removal to that measured. This was done in two ways, by changing the (1) influent RBCOD anaerobic fermentation rate to VFA or (2) the PAO polyphosphate uptake rate. These have the effect of (1) changing PAO mass at a fixed PAO P content (~0.38 mgP mgPAOVSS⁻¹) or (2) changing the PAO content for a fixed PAO mass. Finally, the influent ISS concentration is selected such that the predicted ISS mass in the system matched that measured. This was an iterative process because of the interaction between the predicted variables such as the P removal and system ISS concentration. Once calibrated against the measured NDBEPR system performance, the predicted results were used as initial conditions for the simulation of the batch test data and the calibration

established for the parent system was used unchanged for the batch tests. The two different ways of calibrating the P removal made negligible difference to the predicted P concentrations in the batch tests:

- 1) A lag of two to four days was observed experimentally for the onset of a true endogenous behaviour during the aerobic digestion process. This possibly was caused by an apparent growth during the early period of the digestion, for the phosphorus accumulating organisms (PAOs), on the stored polyhydroxyalkanoates (PHA) and for the ordinary heterotrophic organisms (HOs) on slowly biodegradable substrate enmeshed in the sludge harvested from the NDBEPR system. This behaviour was not observed theoretically – the concentration of stored PHA in the PAOs and enmeshed SBCOD were low.
- 2) Similar trends and rates of volatile suspended solids (VSS) destruction and total suspended solids (TSS) reduction were observed in the aerobic digestion tests and the VSS/TSS ratio remained almost constant with digestion time. The parallel reduction in VSS and TSS implies that there is also a reduction in inorganic suspended solids (ISS). This reduction is both qualitatively and quantitatively described by the ISS model of Ekama and Wentzel (2004). The calibrated ASM-2 model predicted closely the observed decrease in VSS and TSS with time in the batch digestion tests.
- 3) Although subject to some variation, the filtered COD was observed to increase, on average, about 30 mg l^{-1} indicating a very low generation of residual filtered unbiodegradable COD during the aerobic digestion process. Considering the very high total COD concentration at which seven batch tests were done (17,000 to 20,000 mgCOD l^{-1}) this increase is negligible. The total COD reductions obtained were comparable to the VSS destructions. The COD/VSS ratio remained approximately constant during aerobic digestion. While no unbiodegradable soluble COD is generated in the model, the simulated COD and COD/VSS ratio for the batch test matched closely those observed.
- 4) The highest percentage of VSS destruction and total COD reduction were obtained with the longest batch detention times. However, experimentally there was some variation in that the percentage VSS reduction did not consistently follow the aerobic digestion time for all eight batch tests. For the percentage COD reduction consistency was observed. The removal efficiency of VSS was slightly higher than that of the COD, indicating a slight increase in COD/VSS ratio ($0.03 \text{ mgCOD mgVSS}^{-1}$) of the

remaining solids. Because this increase was small, the correlation between the predicted and measured COD/VSS ratio was good.

- 5) With complete mixing and adequate aeration ($2 - 5 \text{ mgO l}^{-1}$) complete nitrification was observed. The FSA concentrations in the bulk solution at the end of the digestion period were all well below 1 mgN l^{-1} . This was also predicted by the model.
- 6) Similar TKN reductions with respect to VSS destruction and TSS reduction were observed. The almost identical TKN reductions with respect to VSS destruction and TSS reduction and linear increase in nitrate concentration with cumulative total oxygen utilized during the digestion period indicates, as expected from the model, that the source of the released N was the solubilization of the organic N in the sludge mass. And this N release is solely associated with the degradation of OHO and PAO biodegradable organics. Moreover, the nitrogen content of the WAS was almost constant throughout the digestion period, i.e., at an average of $0.087 \text{ mgN mgVSS}^{-1}$ for the eight batch tests. The calibrated ASM-2 model predicted reasonably well the measured ammonia and nitrate concentrations with time, indicating that the observed OHO death and PAO endogenous respiration rates matched those of the ASM-2 model. The observed increase in soluble (unbiodegradable) organic N was extremely low in relation to the total TKN reduction in unfiltered TKN and validates the ASM-2 model (zero generation) in this respect.
- 7) A direct relationship was observed between the supernatant ortho phosphate (OP) concentration in the batch tests and the initial phosphorus content in the solids; the higher the initial P content, the higher the supernatant OP concentration with time. The P release was significantly more than from biomass P content only, indicating that PAO poly phosphate was released during aerobic digestion. The calibrated ASM-2 in which all the stored poly phosphate of the PAOs that have “died” in the endogenous respiration as well as the biomass P content of the PAOs and OHOs that have “died”, was used to assess the magnitude of the P release observed in the batch tests.
- 8) The absence of a consistent high discrepancy between the observed percentage daily incremental P release with respect to the total P release in the batch tests suggest that the poly phosphate (PP) content of the remaining live PAOs remains approximately constant during the digestion process. An initial very high release of P by all the live PAOs until their P content is the same low value as OHOs before the endogenous respiration commences was not observed. It seems, therefore, reasonable to accept, as

is the case in the ASM-2 model, that P is released by PAOs during aerobic digestion as they die at their endogenous rate, i.e. as their VSS mass decreases, though validation of this may entail further investigation due to the confounding issue of mineral precipitation in the batch tests.

- 9) Compared with the ASM-2 predicted OP concentration with time, the observed OP concentration was much lower, by 2 to 3 times, for the seven concentrated TSS batch tests ($16 - 20 \text{ g l}^{-1}$). The only batch test for which the predicted OP concentration with time matched that observed was the diluted one (BT-8, 4 g l^{-1}). Although complete nitrification kept the FSA concentration low ($< 1 \text{ mg l}^{-1}$), the ionic product of Mg, OP and FSA was close to the solubility product for struvite during digestion time indicating that, for the concentrated batch tests mineral precipitation was possible in these tests. Although the measured Mg and OP concentrations increased progressively with digestion time in the concentrated batch tests, it was concluded that struvite precipitation took place in these tests, which would account for the much lower observed OP release than predicted by the ASM-2 model. This was confirmed with the simulation model predicted OP concentration and known polyphosphate Mg, K, Ca and P composition - only about $1/3^{\text{rd}}$ of the simulation model expected Mg and P concentrations were measured in the bulk liquid. For all other parameters, the correlation between predicted and observed results was reasonable considering the complexity of the system being modelled.
- 10) The predicted OUR declined much more rapidly over the first 2 to 3 days than observed. The theoretical (predicted) nitrate and OP concentrations versus cumulative oxygen utilized (OU) was linear. Due to the high initial observed OUR, the observed nitrate versus cumulative OU has an initial lag but thereafter becomes linear at the same slope as that predicted. This confirms that the nitrate generated is due to the OHO and PAO death/endogenous processes. There was also a lag for the observed OP concentration versus cumulative OU. However, the observed slope did not become linear but continued to increase with digestion time. This suggests that PAOs die/release P faster as digestion progresses but this observation cannot be validated due to the high likelihood of P precipitation in the concentrated batch tests.
- 11) Except for the initial OUR where a marked deviation of the predicted from the measured values was observed over the first 2 to 4 days of the batch test, the calibrated ASM-2 model acceptably predicted the COD, TKN, FSA, VSS and nitrate concentrations. With regard to the OP concentration, it would appear that ASM-2 can

predict the potential supernatant OP concentration correctly for low concentration ($\sim 4 \text{ gTSS l}^{-1}$) aerobic digestion, but whether the high predicted OP concentration will be actually observed in high concentration ($16 - 20 \text{ gTSS l}^{-1}$) aerobic digestion seems unlikely due to struvite precipitation. Therefore, once calibrated the ASM-2 model can be used to simulate aerobic digestion systems to estimate the nitrate and maximum OP concentrations in digester liquor. From simulation runs with anoxic-aerobic digestion (50% aerobic time with 2 or 3 hour air on), near complete denitrification can be obtained ($\text{nitrate} < 2$) in the aerobic digester. This also helps keep digester alkalinity and pH up without chemical dosing.

- 12) A steady state aerobic digestion model for NDBEPR WAS was developed based on the OHO and PAO active fractions of the VSS. With the widely accepted endogenous respiration rates of OHOs (0.24 d^{-1}) and PAOs (0.04 d^{-1}) this steady state model including nitrification and extended to include the ISS and TSS concentration, yielded closely similar VSS, TSS, ortho P and nitrate concentrations with time in batch aerobic digestion as ASM-2. The developed VSS-based and TSS (with the addition of ISS to the VSS-based model) aerobic batch reactor and steady state models, therefore, acceptably describes the aerobic digestion of WAS from BEPR AS systems.
- 13) The average values of the endogenous respiration (b) rate for OHOs obtained from the initial part (6 – 8 days) of the batch tests (where the OHO activity is expected to be the highest) with the different measured test parameters, such as COD, OUR, VSS and nitrate was very variable and differed widely from the commonly accepted values of $b_{\text{H}_2\text{O}} = 0.24 \text{ d}^{-1}$ due to variability in measured data. The b rate of the OHOs determined from the ASM-2 batch test simulated OUR was 0.13 d^{-1} . This was between the commonly accepted $b_{\text{H}_2\text{O}}$ (0.24 d^{-1}) and $b_{\text{G}_2\text{O}}$ (0.04 d^{-1}) rates, which was reasonable considering that the PAO active fraction was higher due to the acetate dosing to the parent system resulting in a high PAO OUR also at the start of the batch test. The b rate obtained for the PAOs from the simulated results of the last part of the batch tests (where the OHO activity is expected to have ceased) was quite consistent and close to the commonly accepted value $b_{\text{G}_2\text{O}} = 0.04 \text{ d}^{-1}$. It was concluded from this that the b_{H} and b_{G} rates cannot be determined experimentally from aerobic batch tests or sludge harvested from NDBEPR systems. Besides, from the OUR values computed with batch reactor models (BRMs), the sensitivity of the endogenous respiration (b) rate of the OHOs to the variation of the b rate of the PAOs from 0.01 to 0.12 d^{-1} did not affect the b of the OHOs but remained constant at 0.23 d^{-1} . Likewise, when the b

rate of the OHOs was varied from 0.05 to 0.28 d⁻¹, the corresponding b rate of the PAOs remained almost constant at 0.04 d⁻¹. This confirms that the OHOs and the PAOs operated independently during the aerobic digestion process.

- 14) Generally, VSS reduction is accepted as a measure of residual biodegradability in treated sludge in which sludges with > 38% reduction VSS and 20 – 30% TSS are considered stable. However, specific oxygen uptake rate (SOUR) of sludges has recently gained in popularity as a method of measuring aerobic digester effectiveness. For land disposal, the biosolids must achieve a SOUR criteria of less than 1.5 mgO gTSS⁻¹ h⁻¹ for biosolids treated by an aerobic process (Tonkovic, 1999) and generally, SOUR < 1 mgO (gVSS)⁻¹ h⁻¹ are considered well-stabilized sludges. The SOUR observed at the end of the batch tests were all below the SOUR < 1 mgO gVSS⁻¹ h⁻¹ threshold value signifying that the aerobically digested waste activated sludge was well stabilized.
- 15) Aerobic digestion, modified to include intermittent aeration to promote nitrate removal and lime addition to enhance mineral precipitation, is a simple stabilization system for NDBEPR WAS producing a low N and P dewatering liquor for recycle to the biological reactor.

6.2 Recommendation

In this research mineral precipitation in aerobic digestion of concentrated BDBEPR sludge was not expected and resulted in significantly (by 2 to 3 times) lower OP concentration in the bulk liquid. While this is a major advantage practically because it leads to much lower OP concentration in digester dewatering liquors it is an aspect that requires further investigation. Perhaps it is possible to integrate the biological processes of ASM-2 into a 3 phase mixed weak acid base chemistry model so that mineral precipitation can be modelled also. ASM-1 and Anaerobic Digestion Model No. 1 (ADM1) have been integrated into a two phase (aqueous gas) mixed weak acid base model (Sötemann *et al.*, 2005a and b) but not into three phase weak acid base chemistry models yet.

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APPENDIX

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APPENDIX A

Mass Balance of the Simulated Values for the MBR UCT System with the Adjustment of the Anaerobic RBCOD Fermentation Rate (q_{Fe}) and the Rate Constant for Storage of PP (q_{pp})

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APPENDIX A.1

Parameter		Unit	Sewage Batch Number					
			SB-1	SB-2	SB-5	SB-26	SB-28	SB-30
q_{Fe}		gCOD gCOD ⁻¹	0.001	0.586	158.000	1.300	2.129	1.650
$f_{S'up}$		mgCOD mgCOD ⁻¹	0.205	0.092	0.215	0.168	0.211	0.206
Influent	Sti (Meas)	mg/l	958.41	1112.17	912.44	993.50	956.30	943.98
	Xs (Sim)	mg/l	409.31	551.19	369.73	431.13	358.37	384.95
	Xi (Sim)	mg/l	196.47	102.32	196.17	166.91	201.78	194.46
	S A (Sim)	mg/l	97.20	129.43	150.57	148.15	217.02	139.31
	S F (Sim)	mg/l	225.72	288.08	163.12	204.59	139.92	184.67
	S I (Sim)	mg/l	29.71	41.15	32.85	42.72	39.21	40.59
	Sti (Sim)	mg/l	958.41	1112.17	912.44	993.50	956.30	943.98
	TKN (Meas)	mg/l	101.42	134.84	133.60	101.20	95.00	112.14
	TKN (Sim)	mg/l	101.42	134.84	133.60	101.20	95.00	112.14
	FSA (Meas)	mg/l	81.06	107.33	104.06	79.70	71.70	86.65
	FSA (Sim)	mg/l	64.23	96.58	99.86	65.71	61.95	77.18
	ISS (Sim)	mg/l	22.00	0.0010	0.0010	0.0001	0.0001	0.0001
Nitrogen content of Influent	Xs (Sim)	mg/l	16.37	22.05	14.79	17.25	14.33	15.40
	Xi (Sim)	mg/l	13.75	7.16	13.73	11.68	14.12	13.61
	S A (Sim)	mg/l	0.00	0.00	0.00	0.00	0.00	0.00
	S F (Sim)	mg/l	6.77	8.64	4.89	6.14	4.20	5.54
	S I (Sim)	mg/l	0.30	0.41	0.33	0.43	0.39	0.41
	N _{Biom} (Sim)	mg/l	0.00	0.00	0.00	0.00	0.00	0.00
	NO ₃ (Sim)	mg/l	0.00	0.00	0.00	0.00	0.00	0.00
Anox	N ₂ (Sim)	mg/l	0.00	0.00	0.00	0.00	0.00	0.00
	N ₂ (Sim)	mg/l	54.82	79.17	54.21	53.26	43.63	53.17
Aero	ISS (Sim)	mg/l	3177.00	3927.00	4149.00	4335.00	5074.00	3798.00
	ISS (Meas)	mg/l	3769.00	2812.00	3344.67	3796.40	3179.30	3284.00
	VSS (Sim)	mg/l	13034.00	12689.00	13831.00	13561.00	14615.00	13662.00
	VSS (Meas)	mg/l	13006.00	12726.44	13856.33	13519.60	14640.30	13661.43
	S A (Sim)	mg/l	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
	S F (Sim)	mg/l	0.59	0.55	0.52	0.58	0.58	0.55
	S I (Sim)	mg/l	29.71	41.15	32.85	42.72	39.21	40.59
	NH ₄ (Sim)	mg/l	0.48	0.49	0.48	0.48	0.47	0.48
	NH ₄ (Meas)	mg/l	1.20	2.35	1.00	0.40	0.60	1.11
	NO ₃ (Sim)	mg/l	17.72	27.45	48.98	18.00	19.33	28.77
	NO ₃ (Meas)	mg/l	24.80	23.81	18.70	19.20	12.40	19.77
	Xs (Sim)	mg/l	141.40	156.10	87.98	127.40	104.80	106.50
	Xi (Sim)	mg/l	13540.00	10270.00	13200.00	12320.00	13600.00	13240.00
	PAO (Sim)	mg/l	1700.00	3342.00	3872.00	3903.00	4815.00	3411.00
	OHO (Sim)	mg/l	3719.00	4650.00	2887.00	3456.00	2835.00	3152.00
	ANO (Sim)	mg/l	293.00	432.00	416.90	288.30	254.80	331.10
	PHA (Sim)	mg/l	43.00	85.05	98.15	98.32	120.80	86.12
	PP (Sim)	mg/l	479.40	948.60	1054.00	1092.00	1308.00	953.30
Waste	Q _w (Sim)	mg/l	2.894	2.884	2.89	2.885	2.885	2.889
	Q _w (Meas)	mg/l		2.46	3.00	2.80	2.90	3.00
MN _{ti}		mgN d ⁻¹	14198.80	18877.60	18704.00	14168.00	13300.00	15699.04
MN _e		mgN d ⁻¹	10054.71	14744.78	14261.72	9897.19	8753.57	11358.33
MN _w		mgN d ⁻¹	4128.67	4102.08	4432.82	4255.34	4539.17	4323.35
N Mass Balance		%	99.89	99.84	99.95	99.89	99.95	99.89

APPENDIX A.2

Parameter		Unit	Sewage Batch Number					
			SB-1	SB-2	SB-5	SB-26	SB-28	SB-30
q_{PP}		$\frac{gPP}{gPAO^{-1} d^{-1}}$	1.108	1.199	1.500	1.268	1.326	1.298
$f_{S,up}$		$\frac{mgCOD}{mgCOD^{-1}}$	0.142	0.052	0.239	0.145	0.206	0.195
Influent	Sti (Meas)	mg/l	958.41	1112.17	912.44	993.50	956.30	943.98
	Xs (Sim)	mg/l	443.07	576.50	357.88	443.70	360.77	390.59
	Xi (Sim)	mg/l	136.09	57.83	218.07	144.06	197.00	184.08
	S _A (Sim)	mg/l	105.21	135.37	145.75	152.47	218.47	141.35
	S _F (Sim)	mg/l	244.33	301.31	157.89	210.55	140.86	187.37
	S _I (Sim)	mg/l	29.71	41.15	32.85	42.72	39.21	40.59
	Sti (Sim)	mg/l	958.41	1112.17	912.44	993.50	956.30	943.98
	TKN (Meas)	mg/l	101.42	134.84	133.60	101.20	95.00	112.14
	TKN (Sim)	mg/l	101.42	134.84	133.60	101.20	95.00	112.14
	FSA (Meas)	mg/l	81.06	107.33	104.06	85.17	71.70	86.65
	FSA (Sim)	mg/l	66.54	98.28	98.95	66.62	62.16	77.60
	ISS (Sim)	mg/l	20.12	0.0010	0.0010	0.0001	0.0001	0.0001
Nitrogen content of Influent	Xs (Sim)	mg/l	17.72	23.06	14.32	17.75	14.43	15.62
	Xi (Sim)	mg/l	9.53	4.05	15.27	10.08	13.79	12.89
	S _A (Sim)	mg/l	0.00	0.00	0.00	0.00	0.00	0.00
	S _F (Sim)	mg/l	7.33	9.04	4.74	6.32	4.23	5.62
	S _I (Sim)	mg/l	0.30	0.41	0.33	0.43	0.39	0.41
	N _{Biom} (Sim)	mg/l	0.00	0.00	0.00	0.00	0.00	0.00
	NO ₃ (Sim)	mg/l	0.00	0.00	0.00	0.00	0.00	0.00
Anox	N ₂ (Sim)	mg/l	0.00	0.00	0.00	0.00	0.00	0.00
	N ₂ (Sim)	mg/l	50.29	68.46	55.62	48.94	41.47	50.26
Aero	ISS (Sim)	mg/l	3191.00	4074.00	4189.00	4471.00	5313.00	3827.00
	ISS (Meas)	mg/l	3769	2812	3344.67	3796.4	3179.3	3284
	VSS (Sim)	mg/l	13014.00	12682.00	13865.00	13561	14662.00	13682.00
	VSS (Meas)	mg/l	13006	12726.44	13856.33	13519.6	14640.3	13661.43
	S _A (Sim)	mg/l	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
	S _F (Sim)	mg/l	0.58	0.57	0.53	0.59	0.59	0.56
	S _I (Sim)	mg/l	29.71	41.15	32.85	42.72	39.21	40.59
	NH ₄ (Sim)	mg/l	0.48	0.49	0.48	0.48	0.47	0.48
	NH ₄ (Meas)	mg/l	1.20	2.35	1.00	0.40	0.60	1.11
	NO ₃ (Sim)	mg/l	22.54	38.31	47.39	22.36	21.36	31.69
	NO ₃ (Meas)	mg/l	24.80	23.81	18.70	19.20	12.40	19.77
	Xs (Sim)	mg/l	125.40	160.60	93.75	126.80	105.60	108.20
	Xi (Sim)	mg/l	10860.00	8282.00	14150.00	11280.00	13370.00	12780.00
	PAO (Sim)	mg/l	4667.00	5575.00	2864.00	5085.00	5186.00	3958.00
	OHO (Sim)	mg/l	3316.00	4339.00	3016.00	3288.00	2766.00	3073.00
	ANO (Sim)	mg/l	294.50	433.50	416.30	288.90	254.10	331.30
	PHA (Sim)	mg/l	117.60	141.90	72.65	128.00	130.20	99.81
	PP (Sim)	mg/l	444.20	934.10	1093.00	1102.00	1311.00	947.70
Waste	Q _w (Sim)	mg/l	2.883	2.876	2.893	2.882	2.884	2.887
	Q _w (Meas)	mg/l		2.46	3.00	2.80	2.90	3.00
MN _{ii}		mgN d ⁻¹	14198.80	18877.60	18704.00	14168.00	13300.00	15699.04
MN _e		mgN d ⁻¹	10094.74	14764.34	14236.67	9902.72	8735.87	11359.86
MN _w		mgN d ⁻¹	4088.85	4078.99	4451.83	4245.84	4551.71	4322.24
N Mass Balance		%	99.89	99.83	99.92	99.86	99.91	99.89

COMPUTATION OF N MASS BALANCE

Formula for computing the N mass balance

$MN_{te} = (Q_i - Q_w) * (S_{NH_4(ef)} + S_{NO_3(ef)} + S_{N_2} + (i_{NSf} * S_{F_{eff}}) + (i_{NSi} * S_I))$
$MN_w = Q_w * (i_{NBM} * (PAO_w + OHO_w + ANO_w) + (i_{NXs} * X_{S_w}) + (i_{NXi} * X_{I_w}))$
$MN_{w(s)} = Q_w * (S_{NH_4(ef)} + S_{NO_3(ef)} + S_{N_2} + (i_{NSf} * S_{F_{eff}}) + (i_{NSi} * S_I))$
$MN_{ti} = Q_i * N_{ti}$
$N\text{-MB} (\%) = 100 * (MN_{te} + MN_w + MN_{w(s)}) / MN_{ti}$

where

ANO_w	= Concentration of autotrophic nitrifying organisms in the waste sludge
i_{NBM}	= Nitrogen content of biomass
i_{NSf}	= Nitrogen content of F-RBCOD
i_{NSi}	= Nitrogen content of inert soluble COD
i_{NXi}	= Nitrogen content of inert particulate COD
i_{NXs}	= Nitrogen content of particulate COD
MN_{te}	= Mass of effluent nitrogen in the effluent
MN_{ti}	= Mass of influent nitrogen in the influent
MN_w	= Mass of organic nitrogen in the waste sludge
$MN_{w(s)}$	= Mass of soluble nitrogen in the waste sludge
N_{ti}	= Influent total nitrogen
OHO_w	= Concentration of ordinary heterotrophic organisms in the waste sludge
PAO_w	= Concentration of phosphorus accumulating organisms in the waste sludge
Q_i	= Influent flow
Q_w	= Waste flow
$S_{F_{eff}}$	= Fermentable RBCOD
S_I	= Unbiodegradable soluble COD
S_{N_2}	= Denitrogen
$S_{NH_4(ef)}$	= FSA concentration in the effluent
$S_{NO_3(ef)}$	= Nitrate concentration in the effluent
X_{I_w}	= Concentration of unbiodegradable particulate COD in the waste sludge
X_{S_w}	= Concentration of slowly biodegradable particulate COD in the waste sludge
$N\text{-MB} (\%)$	= Nitrogen mass balance (in percentage)

APPENDIX A.3

Parameter		Unit	Sewage Batch Number					
			SB-1	SB-2	SB-5	SB-26	SB-28	SB-30
q_{Fe}		gCOD gCOD ⁻¹	0.830	1.430	650.000	3.600	75.000	6.400
$f_{S,up}$		mgCOD mgCOD ⁻¹	0.207	0.092	0.218	0.162	0.208	0.200
Influent	Sti (Meas)	mg l ⁻¹	958.41	1112.17	912.44	993.50	956.30	943.98
	Xs (Sim)	mg l ⁻¹	409.31	551.19	369.73	431.13	358.37	384.95
	Xi (Sim)	mg l ⁻¹	196.47	102.32	196.17	166.91	201.78	194.46
	S _A (Sim)	mg l ⁻¹	97.20	129.43	150.57	148.15	217.02	139.31
	S _F (Sim)	mg l ⁻¹	225.72	288.08	163.12	204.59	139.92	184.67
	S _I (Sim)	mg l ⁻¹	29.71	41.15	32.85	42.72	39.21	40.59
	Sti (Sim)	mg l ⁻¹	958.41	1112.17	912.44	993.50	956.30	943.98
	ISS (Sim)	mg l ⁻¹	22.00	0.0010	0.0010	0.0001	0.0001	0.0001
Anaer	VSS (Sim)	mg l ⁻¹	4974.32	4839.19	5379.05	5213.51	5658.11	5273.65
	VSS (Meas)	mg l ⁻¹	6309.78	7012.50	6174.50	6063.25	6069.14	6296.00
	TSS (Sim)	mg l ⁻¹	6067.00	6095.00	6697.00	6590.00	7255.00	6481.00
	TSS (Meas)	mg l ⁻¹	7953.20	8251.11	7523.09	7494.25	7195.11	7646.56
Anox	VSS (Sim)	mg l ⁻¹	9824.32	9567.57	10445.95	10229.73	11033.78	10310.81
	VSS (Meas)	mg l ⁻¹	10123.11	10670.22	10735.17	10443.33	10888.00	10646.10
	TSS (Sim)	mg l ⁻¹	12170.00	12430.00	13460.00	13380.00	14720.00	13070.00
	TSS (Meas)	mg l ⁻¹	13068.40	13059.78	13357.50	13292.22	13197.62	13170.30
Aero	ISS (Sim)	mg l ⁻¹	3177.00	3927.00	4149.00	4335.00	5074.00	3798.00
	ISS (Meas)	mg l ⁻¹	3197.33	2812.00	3344.67	3796.40	3179.30	3156.04
	VSS (Sim)	mg l ⁻¹	13034.00	12689.00	13831.00	13561.00	14615.00	13662.00
	VSS (Meas)	mg l ⁻¹	13006.00	12726.44	13856.33	13519.60	14640.30	13661.43
	TSS (Sim)	mg l ⁻¹	16210.00	16610.00	17980.00	17890.00	19690.00	17460.00
	TSS (Meas)	mg l ⁻¹	16203.33	15538.44	17201.00	17316.00	17819.60	16817.47
	OUR _c (Sim)	mgO l ⁻¹ h ⁻¹	62.42	77.74	52.14	64.58	103	115.4
	OUR _i (Sim)	mgO l ⁻¹ h ⁻¹	114.7	155.4	126.6	115.7	58.11	56.57
	OUR _i (Meas)	mgO l ⁻¹ h ⁻¹				81.00	140.00	
	S _A (Sim)	mg l ⁻¹	0.00	0.00	0.00	0.00	0.00	0.00
	S _F (Sim)	mg l ⁻¹	0.59	0.55	0.52	0.58	0.58	0.55
	S _I (Sim)	mg l ⁻¹	29.71	41.15	32.85	42.72	39.21	40.59
	Xs (Sim)	mg l ⁻¹	141.40	156.10	87.98	127.40	104.80	106.50
	Xi (Sim)	mg l ⁻¹	13540.00	10270.00	13200.00	12320.00	13600.00	13240.00
	PAO (Sim)	mg l ⁻¹	1700.00	3342.00	3872.00	3903.00	4815.00	3411.00
	OHO (Sim)	mg l ⁻¹	3719.00	4650.00	2887.00	3456.00	2835.00	3152.00
	ANO (Sim)	mg l ⁻¹	293.00	432.00	416.90	288.30	254.80	331.10
	PHA (Sim)	mg l ⁻¹	43.00	85.05	98.15	98.32	120.80	86.12
	PP (Sim)	mg l ⁻¹	479.40	948.60	1054.00	1092.00	1308.00	953.30
Waste	Q _w (Sim)	mg/l	2.894	2.884	2.89	2.885	2.885	2.889
	Q _w (Meas)	mg/l		2.46	3.00	2.80	2.90	3.00
MS _{ii}		mgCOD d ⁻¹	134177	155704	127742	139090	133882	132158
MS _{te}		mgCOD d ⁻¹	4074	5642	4504	5858	5376	5566
MS _w		mgCOD d ⁻¹	55401	53363	58219	57425	61957	57767
MS _{w(s)}		mgCOD d ⁻¹	88	120	96	125	115	119
MN _d		mgO d ⁻¹	21950	31700	21706	21325	17469	21289
MO _i		mgO d ⁻¹	96348	130536	106344	97188	86520	96936
MO _c		mgO d ⁻¹	52433	65302	43798	54247	48812	47519
MO _n		mgO d ⁻¹	43915	65234	62546	42941	37708	49417
COD Mass Balance		%	99.83	100.27	100.46	99.92	99.89	100.08

APPENDIX A.4

Parameter		Unit	Sewage Batch Number					
			SB-1	SB-2	SB-5	SB-26	SB-28	SB-30
q_{pp}		$gPP\ gPAO^{-1}\ d^{-1}$	1.126	1.209	1.740	1.315	1.483	1.367
$f_{S_{up}}$		$mgCOD\ mgCOD^{-1}$	0.154	0.056	0.260	0.155	0.235	0.206
Influent	Sti (Meas)	$mg\ l^{-1}$	958.41	1112.17	912.44	993.50	956.30	943.98
	Xs (Sim)	$mg\ l^{-1}$	443.07	576.50	357.88	443.70	360.77	390.59
	Xi (Sim)	$mg\ l^{-1}$	136.09	57.83	218.07	144.06	197.00	184.08
	S_A (Sim)	$mg\ l^{-1}$	105.21	135.37	145.75	152.47	218.47	141.35
	S_F (Sim)	$mg\ l^{-1}$	244.33	301.31	157.89	210.55	140.86	187.37
	S_I (Sim)	$mg\ l^{-1}$	29.71	41.15	32.85	42.72	39.21	40.59
	Sti (Sim)	$mg\ l^{-1}$	958.41	1112.17	912.44	993.50	956.30	943.98
	ISS (Sim)	$mg\ l^{-1}$	20.12	0.0010	0.0010	0.0001	0.0001	0.0001
Anaer	VSS (Sim)	$mg\ l^{-1}$	5022.30	4890.54	5374.32	5241.22	5687.16	5293.24
	VSS (Meas)	$mg\ l^{-1}$	6309.78	7012.50	6174.50	6063.25	6069.14	6296.00
	TSS (Sim)	$mg\ l^{-1}$	5940.00	6069.00	6765.00	6598.00	7279.00	6480.00
	TSS (Meas)	$mg\ l^{-1}$	7953.20	8251.11	7523.09	7494.25	7195.11	7646.56
Anox	VSS (Sim)	$mg\ l^{-1}$	9824.32	9567.57	10466.22	10236.49	11074.32	10324.32
	VSS (Meas)	$mg\ l^{-1}$	10123.11	10670.22	10735.17	10443.33	10888.00	10646.10
	TSS (Sim)	$mg\ l^{-1}$	12100.00	12480.00	13530.00	13460.00	14780.00	13100.00
	TSS (Meas)	$mg\ l^{-1}$	13068.40	13059.78	13357.50	13292.22	13197.62	13170.30
Aero	ISS (Sim)	$mg\ l^{-1}$	3191.00	4074.00	4189.00	4471.00	5313.00	3827.00
	ISS (Meas)	$mg\ l^{-1}$	3197.33	2812.00	3344.67	3796.40	3179.30	3156.04
	VSS (Sim)	$mg\ l^{-1}$	13014.00	12682.00	13865.00	13561	14662.00	13682.00
	VSS (Meas)	$mg\ l^{-1}$	13006.00	12726.44	13856.33	13519.60	14640.30	13661.43
	TSS (Sim)	$mg\ l^{-1}$	16200.00	16760.00	18050.00	18030.00	19780.00	17510.00
	TSS (Meas)	$mg\ l^{-1}$	16203.33	15538.44	17201.00	17316.00	17819.60	16817.47
	OUR_c (Sim)	$mgO\ l^{-1}\ h^{-1}$	65.29	83.11	51.16	117.90	103.60	116.80
	OUR_c (Sim)	$mgO\ l^{-1}\ h^{-1}$	117.50	160.90	125.50	66.72	58.84	57.97
	OUR_c (Meas)	$mgO\ l^{-1}\ h^{-1}$				81.00	140.00	
	S_A (Sim)	$mg\ l^{-1}$	0.00	0.00	0.00	0.00	0.00	0.00
	S_F (Sim)	$mg\ l^{-1}$	0.58	0.57	0.53	0.59	0.59	0.56
	S_I (Sim)	$mg\ l^{-1}$	29.71	41.15	32.85	42.72	39.21	40.59
	Xs (Sim)	$mg\ l^{-1}$	125.40	160.60	93.75	126.80	105.60	108.20
	Xi (Sim)	$mg\ l^{-1}$	10860.00	8282.00	14150.00	11280.00	13370.00	12780.00
	PAO (Sim)	$mg\ l^{-1}$	4667.00	5575.00	2864.00	5085.00	5186.00	3958.00
	OHO (Sim)	$mg\ l^{-1}$	3316.00	4339.00	3016.00	3288.00	2766.00	3073.00
	ANO (Sim)	$mg\ l^{-1}$	294.50	433.50	416.30	288.90	254.10	331.30
	PHA (Sim)	$mg\ l^{-1}$	117.60	141.90	72.65	128.00	130.20	99.81
	PP (Sim)	$mg\ l^{-1}$	444.20	934.10	1093.00	1102.00	1311.00	947.70
Waste	Q_w (Sim)	$mg\ l^{-1}$	2.883	2.876	2.893	2.882	2.884	2.887
	Q_w (Meas)	$mg\ l^{-1}$		2.46	3.00	2.80	2.90	3.00
MS_{ti}		$mgCOD\ d^{-1}$	134177	155704	127742	139090	133882	132158
MS_{te}		$mgCOD\ d^{-1}$	4074	5643	4504	5858	5376	5566
MS_w		$mgCOD\ d^{-1}$	55025	53202	58428	57374	62173	57795
$MS_{w(s)}$		$mgCOD\ d^{-1}$	87	120	97	125	115	119
MN_d		$mgO\ d^{-1}$	20136	27411	22270	19596	16605	20124
MO_t		$mgO\ d^{-1}$	98700	135156	105420	99036	87024	98112
MO_c		$mgO\ d^{-1}$	54844	69812	42974	56045	49426	48695
MO_n		$mgO\ d^{-1}$	43856	65344	62446	42991	37598	49417
COD Mass Balance		%	99.99	100.31	100.42	99.93	99.86	100.11

COMPUTATION OF COD MASS BALANCE

Formula for computing the COD mass balance

$MO_c = OUR_c \cdot V_{aer} \cdot 24$
$MO_d = 2,86 \cdot Q_i \cdot S_{N_2}$
$MS_{tw} = Q_w (PAO_w + OHO_w + [ANO_w] + PP_w + PHA_w + X_{I_w} + X_{S_w})$
$MS_{tw(s)} = Q_w \cdot S_I$
$MS_{te} = (Q_i - Q_w) \cdot S_I$
$MS_{ti} = Q_i \cdot S_{ti}$
$COD-MB (\%) = 100 \cdot (MO_c + MO_d + MS_w + MS_{w(s)} + MS_{te}) / MS_{ti}$

where

ANO_w	= Concentration of autotrophic nitrifying organisms in the waste sludge
MO_c	= Mass of carbonaceous oxygen demand
MO_d	= Mass of denitrification oxygen demand
MS_{te}	= Mass of effluent COD
MS_{tw}	= Mass of particulate COD in the waste sludge
$MS_{tw(s)}$	= Mass of soluble COD in the waste sludge
MS_{ti}	= Mass of influent COD
OHO_w	= Concentration of ordinary heterotrophic organisms in the waste sludge
OUR_c	= Carbonaceous oxygen utilization rate
PAO_w	= Concentration of phosphorus accumulating organisms in the waste sludge
PHA_w	= Concentration of polyhydroxyalkanoates in the waste sludge
PP_w	= Concentration of poly phosphate in the waste sludge
Q_i	= Influent flow
Q_w	= Waste flow
S_I	= Concentration of unbiodegradable soluble COD
S_{N_2}	= Denitrogen
S_{ti}	= Influent COD
V_{acr}	= Volume of the aerobic reactor
X_{I_w}	= Concentration of unbiodegradable particulate COD in the waste sludge
X_{S_w}	= Concentration of slowly biodegradable particulate COD in the waste sludge
$COD-MB (\%)$	= COD mass balance (in percentage)

APPENDIX A.5

Parameter		Unit	Sewage Batch Number					
			SB-1	SB-2	SB-5	SB-26	SB-28	SB-30
q_{Fe}		gCOD gCOD ⁻¹	0.830	1.430	650.000	3.600	75.000	6.400
$f_{S^{sup}}$		mgCOD mgCOD ⁻¹	0.207	0.092	0.218	0.162	0.208	0.200
Influent	Sti (Meas)	mg l ⁻¹	958.41	1112.17	912.44	993.50	956.30	943.98
	Xs (Sim)	mg l ⁻¹	409.31	551.19	369.73	431.13	358.37	384.95
	Xi (Sim)	mg l ⁻¹	196.47	102.32	196.17	166.91	201.78	194.46
	S A (Sim)	mg l ⁻¹	97.20	129.43	150.57	148.15	217.02	139.31
	S F (Sim)	mg l ⁻¹	225.72	288.08	163.12	204.59	139.92	184.67
	S I (Sim)	mg l ⁻¹	29.71	41.15	32.85	42.72	39.21	40.59
	Sti (Sim)	mg l ⁻¹	958.41	1112.17	912.44	993.50	956.30	943.98
	PO ₄ -P (Meas)	mg l ⁻¹	18.25	30.94	25.19	29.30	31.00	26.10
	PO ₄ -P (Sim)	mg l ⁻¹	18.25	30.94	25.19	29.30	31.00	26.10
	ISS (Sim)	mg l ⁻¹	22.00	0.0010	0.0010	0.0001	0.0001	0.0001
P content of Influent	Xs (Sim)	mg l ⁻¹	4.09	5.51	3.70	4.31	3.58	3.85
	Xi (Sim)	mg l ⁻¹	1.96	1.02	1.96	1.67	2.02	1.94
	S F (Sim)	mg l ⁻¹	2.26	2.88	1.63	2.05	1.40	1.85
	S I (Sim)	mg l ⁻¹	0.00	0.00	0.00	0.00	0.00	0.00
	P _{Biom} (Sim)	mg l ⁻¹	0.00	0.00	0.00	0.00	0.00	0.00
Anox	N ₂ (Sim)	mg l ⁻¹	54.82	79.17	54.21	53.26	43.63	53.17
Aero	ISS (Sim)	mg l ⁻¹	3177.00	3927.00	4149.00	4335.00	5074.00	3798.00
	ISS (Meas)	mg l ⁻¹	3197.33	2812.00	3344.67	3796.40	3179.30	3156.04
	VSS (Sim)	mg l ⁻¹	13034.00	12689.00	13831.00	13561.00	14615.00	13662.00
	VSS (Meas)	mg l ⁻¹	13006.00	12726.44	13856.33	13519.60	14640.30	13661.43
P content of Effluent	S F (Sim)	mg l ⁻¹	0.01	0.01	0.01	0.01	0.01	0.01
	S I (Sim)	mg l ⁻¹	0.00	0.00	0.00	0.00	0.00	0.00
Effluent	PO ₄ -P (Meas)	mg l ⁻¹	11.60	15.41	4.60	9.00	4.70	8.44
	PO ₄ -P (Sim)	mg l ⁻¹	11.47	15.21	5.06	9.09	4.94	8.47
P content of Waste	Xs (Sim)	mg l ⁻¹	1.41	1.56	0.88	1.27	1.05	1.07
	Xi (Sim)	mg l ⁻¹	135.40	102.70	132.00	123.20	136.00	132.40
	PAO (Sim)	mg l ⁻¹	34.00	66.84	77.44	78.06	96.30	68.22
	OHO (Sim)	mg l ⁻¹	74.38	93.00	57.74	69.12	56.70	63.04
	ANO (Sim)	mg l ⁻¹	5.86	8.64	8.34	5.77	5.10	6.62
Sludge Wasted	Q _w (Sim)	mg l ⁻¹	2.894	2.884	2.89	2.885	2.885	2.889
	Q _w (Meas)	mg l ⁻¹		2.46	3.00	2.80	2.90	3.00
MP _i		mgP d ⁻¹	3719.10	5649.83	4547.23	5225.68	5320.10	4723.57
MP _e		mgP d ⁻¹	1573.41	2086.28	694.63	1246.89	677.45	1161.95
MP _w		mgP d ⁻¹	2147.15	3566.23	3859.49	3977.01	4639.32	3562.49
P Mass Balance		%	100.04	100.05	100.15	99.97	99.94	100.02

APPENDIX A.6

Parameter		Unit	Sewage Batch Number					
			SB-1	SB-2	SB-5	SB-26	SB-28	SB-30
q_{PP}		gCOD gCOD ⁻¹	1.126	1.209	1.740	1.351	1.483	1.367
$f_{S'up}$		mgCOD mgCOD ⁻¹	0.154	0.056	0.260	0.179	0.235	0.206
Influent	Sti (Meas)	mg l ⁻¹	958.41	1112.17	912.44	993.50	956.30	943.98
	Xs (Sim)	mg l ⁻¹	443.07	576.50	357.88	443.70	360.77	390.59
	Xi (Sim)	mg l ⁻¹	136.09	57.83	218.07	144.06	197.00	184.08
	S _A (Sim)	mg l ⁻¹	105.21	135.37	145.75	152.47	218.47	141.35
	S _F (Sim)	mg l ⁻¹	244.33	301.31	157.89	210.55	140.86	187.37
	S _I (Sim)	mg l ⁻¹	29.71	41.15	32.85	42.72	39.21	40.59
	Sti (Sim)	mg l ⁻¹	958.41	1112.17	912.44	993.50	956.30	943.98
	PO ₄ -P (Meas)	mg l ⁻¹	18.25	30.94	25.19	29.30	31.00	26.10
	PO ₄ -P (Sim)	mg l ⁻¹	18.25	30.94	25.19	29.30	31.00	26.10
	ISS (Sim)	mg l ⁻¹	20.12	0.0010	0.0010	0.0001	0.0001	0.0001
P content of Influent	Xs (Sim)	mg l ⁻¹	4.43	5.77	3.58	4.44	3.61	3.91
	Xi (Sim)	mg l ⁻¹	1.36	0.58	2.18	1.44	1.97	1.84
	S _F (Sim)	mg l ⁻¹	2.44	3.01	1.58	2.11	1.41	1.87
	S _I (Sim)	mg l ⁻¹	0.00	0.00	0.00	0.00	0.00	0.00
	P _{Biom} (Sim)	mg l ⁻¹	0.00	0.00	0.00	0.00	0.00	0.00
Anox	N ₂ (Sim)	mg l ⁻¹	50.29	68.46	55.62	48.94	41.47	50.26
Aero	ISS (Sim)	mg l ⁻¹	3191.00	4074.00	4189.00	4471.00	5313.00	3827.00
	ISS (Meas)	mg l ⁻¹	3197.33	2812.00	3344.67	3796.40	3179.30	3156.04
	VSS (Sim)	mg l ⁻¹	13014.00	12682.00	13865.00	13561	14662.00	13682.00
	VSS (Meas)	mg l ⁻¹	13006.00	12726.44	13856.33	13519.60	14640.30	13661.43
P content of Effluent	S _F (Sim)	mg l ⁻¹	0.01	0.01	0.01	0.01	0.01	0.01
	S _I (Sim)	mg l ⁻¹	0.00	0.00	0.00	0.00	0.00	0.00
Effluent	PO ₄ -P (Meas)	mg l ⁻¹	11.60	15.41	4.60	9.00	4.70	8.44
	PO ₄ -P (Sim)	mg l ⁻¹	11.66	15.12	4.42	8.67	4.74	8.46
P content of Waste	Xs (Sim)	mg l ⁻¹	1.25	1.61	0.94	1.27	1.06	1.08
	Xi (Sim)	mg l ⁻¹	108.60	82.82	141.50	112.80	133.70	127.80
	PAO (Sim)	mg l ⁻¹	93.34	111.50	57.28	101.70	103.72	79.16
	OHO (Sim)	mg l ⁻¹	66.32	86.78	60.32	65.76	55.32	61.46
	ANO (Sim)	mg l ⁻¹	5.89	8.67	8.33	5.78	5.08	6.63
Sludge Wasted	Q _w (Sim)	mg l ⁻¹	2.883	2.876	2.893	2.882	2.884	2.887
	Q _w (Meas)	mg l ⁻¹		2.46	3.00	2.80	2.90	3.00
MPi		mgP d ⁻¹	3707.88	5641.51	4553.98	5219.63	5318.07	4720.71
MPe		mgP d ⁻¹	1599.58	2074.10	607.28	1189.48	651.01	1161.02
MPw		mgP d ⁻¹	2108.25	3567.97	3951.24	4028.98	4656.58	3557.64
P Mass Balance		%	100.00	100.01	100.10	99.98	99.80	99.96

COMPUTATION OF P MASS BALANCE

Formula for computing the P mass balance

$MP_{tw} = Q_w \{ i_{PBM} * (PAO_w + OHO_w + ANO_w) + (i_{PXs} * X_{S_w}) + (i_{PXi} * X_{I_w}) + PP_w \}$
$MP_{tw(s)} = Q_w * (S_{PO_{4eff}} + (i_{PSf} * S_{F_{eff}}) + (i_{PSi} * S_I))$
$MP_{te} = (Q_i - Q_w) * (S_{PO_{4eff}} + (i_{PSf} * S_{F_{eff}}) + (i_{PSi} * S_I))$
$MP_{ti} = Q_i * P_{ti}$
$P\text{-MB (\%)} = 100 * (MP_{tw} + MP_{tw(s)} + MP_{te}) / MP_{ti}$

where

ANO_w	= Concentration of autotrophic nitrifying organisms in the waste sludge
i_{PBM}	= Phosphorus content of the biomass
i_{PSf}	= Phosphorus content of F-RBCOD
i_{PSi}	= Phosphorus content of inert soluble COD
i_{PXi}	= Phosphorus content of inert particulate COD
i_{PXs}	= Phosphorus content of particulate COD
MP_{te}	= Mass of phosphorus in the effluent
MP_{ti}	= Mass of phosphorus in the influent
MP_{tw}	= Mass of organic phosphorus in the waste sludge
$MP_{tw(s)}$	= Mass of ortho phosphate in the waste sludge
OHO_w	= Concentration of ordinary heterotrophic organisms in the waste sludge
PAO_w	= Concentration of phosphorus accumulating organisms in the waste sludge
PP_w	= Concentration of poly phosphate in the waste sludge
P_{ti}	= Influent phosphorus
Q_i	= Influent flow
Q_w	= Waste flow
$S_{F_{eff}}$	= Effluent unbiodegradable soluble COD concentration
S_I	= Unbiodegradable soluble COD concentration
$S_{PO_{4eff}}$	= Effluent orthophosphate concentration
X_{I_w}	= Concentration of unbiodegradable particulate COD in the waste sludge
X_{S_w}	= Concentration of slowly biodegradable particulate COD in the waste sludge
$P\text{-MB (\%)}$	= Phosphorus mass balance (in percentage)

APPENDIX B**Raw Data of the Aerobic Digestion of WAS**

Appendix	Type	Page
B1	pH and sodium bicarbonate added	A13
B2	VSS	A14
B3	TSS	A15
B4	Filtered COD	A16
B5	Total COD	A17
B6	FSA	A18
B7	NO ₃	A19
B8	TKN	A20
B9	OP	A21
B10	TP	A22
B11	Calcium and Magnesium	A23

APPENDIX B1

Retention Time (d)	pH					NaHCO ₃ added (mg l ⁻¹)				
	BT-2	BT-3	BT-4	BT-5	BT-6	BT-2	BT-3	BT-4	BT-5	BT-6
1		7.43	7.60	7.62	7.35		0.00	0.00	0.00	0.00
2		7.44	7.54	7.58	7.26	0.00	0.00	0.00	0.00	0.00
3	7.56	7.09	7.31	7.42	7.20	0.00	0.00	0.00	36.63	209.31
4	7.20	7.13	7.19	7.02	7.20	0.00	67.64	0.00	178.57	162.34
5	7.35	7.20	7.18	7.05	7.20	660.71	196.08	24.35	196.08	201.68
6	7.20	7.20	7.31	7.05	7.20	267.86	261.32	0.00	284.55	150.99
7	7.29	7.22	7.31	7.05	7.20	357.14	248.64	0.00	120.55	253.16
8	7.02		7.04	7.05	7.20	178.57	0.00	66.31	175.44	162.91
9		7.33	7.14	6.99	7.24		122.31	187.97	267.45	208.74
10		7.20	7.25	7.05	7.20		34.01	130.46	68.03	40.82
11		7.19	7.20		7.20		133.26	68.03		156.36
12		7.21	7.22		7.20		18.60	106.61		59.52
13		7.21	7.20		7.20		29.27	74.40		78.06
14		7.21	7.20		7.20		123.15	101.48		119.05
15		7.22	7.24				21.65	82.10		
16			7.24				68.68	43.29		
17		7.23	7.21				48.59	0.00		
18			7.19				0.00	48.59		
19		7.19	7.19				69.21	51.76		
20			7.19				0.00	0.00		
21		7.17	7.20				80.44	0.00		
22		7.29					52.52			
23		7.20					38.40			
24		7.21					0.00			
25		7.21					0.00			

APPENDIX B2

Retention Time (d)	VSS (mg l ⁻¹)							
	BT-1	BT-2	BT-3	BT-4	BT-5	BT-6	BT-7	BT-8
1	12983.12	12947.04	14299.67	13401.17	14646.83	13189.31	15557.75	2984.75
2	12487.00	12819.67	13500.00	13131.83	12854.00	12980.67	14471.75	2782.50
3	12931.33	12615.17	15396.50	12739.50	12561.17	12560.33	14223.75	2778.25
4	12601.33	12632.33	12889.67	12466.50	12271.50	10820.50	13895.07	2694.83
5	10828.67	12953.33	12908.83	11940.00	11874.00	10744.83	13361.75	2620.25
6	10888.00^j	11878.33	14868.83	11448.50	10527.33	10276.67	12330.00	2401.00
7	10636.67		11356.67	11368.00	10382.50	10484.67	12295.50	2372.75
8	10112.67		11575.50	10848.00	9698.83	9397.00	11507.50	2287.25
9			11040.17	10390.00	10179.50	9774.33	11424.00	
10			10850.17	10043.00	9730.00	9649.17		
11			10894.00	9858.17	8889.33	10148.83		
12			11571.67	9560.50		9877.50		
13			11453.83	9205.33		9699.00		
14			11106.50	8994.50		9675.33		
15			10933.50	9348.67				
16			10574.50	9065.50				
17			10362.33	8945.00				
18			10376.67	8775.33				
19			10006.33	8589.33				
20			9672.33	8640.50				
21			8263.83	8772.00				
22			7759.67					
23			7545.83					
24			7243.17					
25			7124.50					

^j The outliers are designated by bold faced italics.

APPENDIX B3

Retention Time (d)	TSS (mg l ⁻¹)							
	BT-1	BT-2	BT-3	BT-4	BT-5	BT-6	BT-7	BT-8
1	16819.04	15956.67	17421.33	16992.08	18380.67	17543.83	19656.50	3770.00
2	16619.00	15990.00	17003.17	16630.83	17046.67	17068.17	18814.25	3544.25
3	16494.00	15947.67	19040.67	16211.00	16910.50	16454.00	18009.48	3431.75
4	15965.33	15946.33	16208.33	15928.83	16374.67	15332.50	17142.50	3327.04
5	13612.00	12953.33	16230.67	15157.83	15551.67	14982.67	17147.75	3215.75
6	13983.33	14910.83	18110.33	14668.33	14029.83	14109.83	15879.00	2981.25
7	13385.33		14582.33	14458.33	13902.00	13804.17	15609.50	2889.75
8	12979.33		14746.00	13803.67	12747.50	12814.83	14307.50	2833.50
9			14073.67	13335.50	13135.83	12809.67	14270.00	
10			13724.83	12918.83	12669.83	12642.17		
11			13802.67	12688.00	11519.17	13276.83		
12			14769.00	12281.50		12927.17		
13			14548.33	11891.67		12473.50		
14			14172.33	11637.33		12353.83		
15			13905.67	12069.83				
16			13536.50	11765.67				
17			13224.00	11570.17				
18			13281.67	11374.83				
19			12746.67	11166.00				
20			12315.50	11204.33				
21			10495.67	11280.50				
22			9790.83					
23			9605.17					
24			9184.00					
25			8969.17					

APPENDIX B4

Retention Time (d)	Filtered COD (mg l ⁻¹)					
	BT-1	BT-2	BT-3	BT-4	BT-5	BT-6
1	103.8	78.9	151.5	51.9	91.3	62.3
2	203.4	62.3	76.8	56.1	336.3	54.0
3	66.4	70.6	97.6	60.2	294.8	62.3
4	76.8	64.4	72.7	60.2	386.1	78.9
5		81.0	78.9	68.5	74.7	99.6
6	272.0	89.3	83.0	68.5	62.3	116.3
7	118.3		103.8	72.7	87.2	99.6
8	85.1		99.6	95.5	97.6	95.5
9	97.6		103.8	89.3	83.0	95.5
10	120.4		103.8	83.0	70.6	91.3
11	124.6		95.5	85.1	78.9	97.6
12			112.1	87.2		230.4
13			105.9	91.3		205.5
14			93.4	95.5		110.0
15			101.7	95.5		85.1
16			110.0	83.0		
17			105.9	83.0		
18			105.9	95.5		
19			114.2	83.0		
20			109.0	87.2		
21			79.9	89.3		
22			92.4			
23			109.0			
24			96.5			
25			84.1			

APPENDIX B5

Retention Time (d)	Total COD (mg l ⁻¹)							
	BT-1	BT-2	BT-3	BT-4	BT-5	BT-6	BT-7	BT-8
1		17874.4	19832.0	19661.8	16682.7	17193.4	19661.8	4019.1
2		18044.6	18980.9	19151.1	40004.5	20598.1	19236.2	3813.6
3		20087.4	20002.3	18640.4	14469.7	15661.3	17704.1	3379.7
4		17789.2	18129.7	18470.2	14129.3	19406.4	16342.3	3334.1
5	15746.5	18810.6	17533.9	18299.9	15661.3	14640.0	16001.8	3242.7
6	3830.2	17448.8	17363.7	17704.1	12937.6	14299.5	14299.5	3082.9
7	15406.0		16001.8	17619.0	12086.5	13618.6	14095.2	2877.3
8	13193.0		17023.2	17448.8	11575.8	12597.2	13107.9	2786.0
9			16597.6	16001.8	11065.1	12767.4	12937.6	2786.0
10			15320.9	15746.5	11405.5	12597.2		
11			15491.1	15320.9	10894.8	12001.4		
12			17023.2	14980.4		12171.6		
13			15235.8	13618.6		12001.4		
14			15746.5	13448.3		11150.2		
15			15065.5	13959.0		10980.0		
16			14554.8	13278.1				
17			14725.1	12937.6				
18			14384.6	12597.2				
19			15065.5	12937.6				
20			13831.4	12256.7				
21			11448.1	12171.6				
22			10596.9					
23			10596.9					
24			10086.2					
25			10086.2					

APPENDIX B6

Retention Time (d)	FSA (mg l ⁻¹)					
	BT-1	BT-2	BT-3	BT-4	BT-5	BT-6
1	1.54	1.54		1.12		
2	4.48	0.42	0.14	1.68		
3	2.24	0.14		1.26	21.70	
4	7.84	3.92	0.42			
5	4.20	0.42	0.56	1.82	1.12	3.50
6	1.40	0.42	4.34	1.12	4.06	3.08
7	1.40		0.56	1.40	6.86	
8	0.84		0.42	2.40		1.40
9	0.28		0.28	1.54	6.44	2.52
10	0.21		0.28	0.84		3.92
11			0.28	2.50	0.14	1.68
12			0.14	1.26		
13			0.28	1.12		1.82
14			0.42	0.28		1.40
15			0.56	0.14		
16			0.70	0.14		
17			0.28	0.14		
18			0.14	0.14		
19			0.28	0.14		
20				0.14		
21			0.28	0.14		
22			0.56			
23			0.70			
24						
25			0.28			

APPENDIX B7

Retention Time (d)	NO ₃ (mg l ⁻¹)					
	BT-3	BT-4	BT-5	BT-6	BT-7	BT-8
1	13.56	20.85	39.85	31.43	13.93	4.35
2	49.87	7.66	41.67	35.83	57.49	12.68
3	48.14	56.80	65.36	53.71	97.61	22.14
4	77.53	73.60	87.77	114.26	139.90	34.84
5	138.04	64.18	129.13	156.33	175.98	46.80
6	184.72	23.36	167.39	187.27	218.15	60.76
7	222.76	14.42	212.95	211.66	236.99	68.65
8	253.88	67.64	227.52	249.91	256.59	76.35
9	255.61	99.98	244.11	268.20	263.90	80.80
10	274.62	147.23	253.58	280.40		
11	291.91	174.87	262.14	281.13		
12	291.91	207.21		285.63		
13	314.39	185.86		288.24		
14	309.20	219.84		293.03		
15	316.12	233.14		299.41		
16	329.95	262.49				
17	359.34	261.63				
18	361.07	272.72				
19	366.25	287.22				
20		277.84				
21		286.88				

APPENDIX B8

Retention Time (d)	TKN (mg l ⁻¹)					
	BT-3	BT-4	BT-5	BT-6	BT-7	BT-8
1	1450.80	1308.72	1043.20	1320.20	1479.40	291.06
2	1400.98	797.90	1038.94	1308.72	1417.78	283.36
3	1370.62	1234.10	1038.94	1274.28	1412.04	274.12
4	1228.36	1217.46	493.60	1222.62	1357.60	264.88
5	1125.04	1193.92	906.92	1130.78	1285.76	263.34
6	1084.86	700.30	947.10	826.60	1234.10	258.72
7	1044.68	763.40	883.96	1090.60	1228.36	242.56
8	1067.64	677.30	792.12	884.00	1115.04	232.37
9	1102.08	958.58	774.90	958.60	1093.02	220.00
10	970.06	918.40	436.20	884.00		
11	1188.18	906.92	683.06	1015.98		
12	660.10	975.80		987.28		
13	941.36	889.70		993.02		
14	964.32	820.82		935.62		
15	895.44	849.52		901.18		
16	832.30	740.46				
17	809.34	769.16				
18	826.56	803.60				
19	401.80	482.20				
20	338.66	677.32				
21	688.80	596.96				
22	551.04					
23	114.80					
24	596.96					
25	487.90					

APPENDIX B9

Retention Time (d)	Ortho-P (mg l ⁻¹)							
	BT-1	BT-2	BT-3	BT-4	BT-5	BT-6	BT-7	BT-8
1	39.38	1.25	247.32	0.31	6.18	2.06	2.36	0.87
2	54.38	8.49	47.84	5.03	18.61	8.63	28.63	7.73
3	110.63	23.86	128.36	12.81	31.03	23.49	32.81	11.91
4	147.63	35.77	36.94	29.19	48.30	51.21	58.50	21.00
5		51.49	63.17	42.25	77.09	86.36	93.19	31.94
6	198.13	66.34	88.10	57.81	113.76	113.94	149.44	46.94
7	203.63		115.64	67.25	157.09	148.18	179.44	53.19
8	251.63		134.34	83.88	209.97	192.12	199.13	58.81
9	289.65		172.00	100.12	243.76	220.61	208.50	61.63
10	352.26		191.22	113.45	261.33	246.67		
11			197.19	121.57	289.52	277.19		
12			210.44	129.39		305.85		
13			245.15	142.43		330.33		
14			253.34	147.72		355.70		
15			258.26	157.44		378.09		
16			272.36	166.33				
17			294.98	176.33				
18			300.23	198.37				
19			296.30	207.10				
20			319.00	213.01				
21			288.71	218.65				
22			272.24					
23			278.71					
24			289.59					
25			296.06					

APPENDIX B10

Retention Time (d)	Total-P (mg l ⁻¹)			
	BT-5	BT-6	BT-7	BT-8
1	934.40	905.34	794.30	598.48
2	932.40	845.77	769.82	574.00
3	930.49	798.91	745.34	561.76
4	927.77	956.67	848.19	668.81
5	892.63	944.24	809.75	604.75
6	887.49	944.24	796.94	617.56
7	885.77	906.97	822.56	617.56
8	885.77	906.97	784.13	617.56
9	874.06	882.12	771.31	619.24
10	874.06	882.12		
11	873.90	974.21		
12		925.25		
13		802.87		
14		815.10		
15		864.06		

APPENDIX B11

Retention time (d)	Ca (mg l ⁻¹)				Mg (mg l ⁻¹)			
	BT-3	BT-4	BT-5	BT-6	BT-3	BT-4	BT-5	BT-6
1		33.91	31.22	27.72		0.43	0.13	12.26
2	27.66	40.32	33.63	35.94	3.13	0.26	0.13	10.94
3		33.02	38.28	34.76		1.14	0.71	13.11
4	29.71	39.04	35.23	24.82	2.79	3.81	3.31	18.39
5	34.81	37.79	36.5	31.59	6.65	6.31	8.5	24.54
6	22.13	33.52	39.76	25.52	11.41	8.57	15.46	29.44
7	22.23	29.69	44.93	26.03	14.41	9.72	22.46	36.37
8	26.26	32.43	41.02	30.91	18.28	13.40	32.67	43.55
9	19.39	32.48	32.27	26.44	21.84	16.88	38.88	49.39
10	26.16	28.91	28.5	25.38	26.14	20.28	42.21	55.6
11	32.68	31.56	26.14	12.34	29.23	22.47	46.07	56.41
12	31.70	29.29		28.47	30.85	24.72		64.28
13	33.47	30.24		20.16	34.80	27.22		68.69
14	27.39	24.58		25.49	35.78	28.53		72.34
15	24.99	25.39		27.64	36.06	31.15		77.23
16	25.28	16.40			38.93	32.03		
17	20.46	32.07			43.49	36.60		
18	24.84	34.61			46.85	41.36		
19	25.77	27.12			50.49	41.24		
20	26.24	33.91			52.14	44.53		
21	25.56	32.60			48.59	46.33		
22	24.62				47.89			
23	24.72				50.01			
24	24.93				53.50			
25	25.42				56.55			

APPENDIX C**Matrix Representation of ASM-2 and Program Listing for the Simulation of the MBR
UCT System and Batch Aerobic Digestion**

Appendix	Type	Page
C1	Matrix representation of ASM-2	A25
C2	Program Listing of ASM-2 for the Simulation of the MBR UCT System	A27
C3	Program Listing of ASM-2 and SSM for the Simulation of the Aerobic Batch Digestion	A169

APPENDIX C1

Matrix representation of ASM-2

COMPOUND / PROCESS	1 X_I	2 X_S	3 X_H	4 X_{PAO}	5 X_{PP}	6 X_{PHA}	7 X_{AUT}	8 S_{O_2}	9 S_F	10 S_A	11 S_{NH_4}	12 S_{NO_3}	13 S_{PO_4}	14 S_I	15 S_{N_2}	PROCESS RATES, P_i
Hydrolysis																
1 Aerobic hydrolysis		-1							$(1-f_{SI})$		A^*		B^*	f_{SI}		$K_H \left(\frac{(X_S/X_H)}{K_X + (X_S/X_H)} \right) \left(\frac{Air}{On} \right) X_H$
2 Anoxic hydrolysis		-1							$(1-f_{SI})$		A^*		B^*	f_{SI}		$\eta_{NO_3} K_H \left(\frac{(X_S/X_H)}{K_X + (X_S/X_H)} \right) \left(\frac{Air}{Off} \right) \left(\frac{NO_3}{Limit} \right) X_H$
3 Anaerobic hydrolysis		-1							$(1-f_{SI})$		A^*		B^*	f_{SI}		$\eta_{N_2} K_H \left(\frac{(X_S/X_H)}{K_X + (X_S/X_H)} \right) \left(\frac{Air}{Off} \right) \left(\frac{1-NO_3}{Limit} \right) X_H$
Heterotrophic organisms: X_H																
4 Aerobic growth of X_H on S_F			1					$\frac{1-Y_H}{Y_H}$	$-1/Y_H$		$1/Y_H \cdot i_{NSF}$ $-i_{NBM}$		$1/Y_H \cdot i_{PSF}$ $-i_{PBM}$			$\mu_H \left(\frac{S_F}{K_F + S_F} \right) \left(\frac{S_F}{S_F + S_A} \right) \left(\frac{Air}{On} \right) \left(\frac{NH_4}{Limit} \right) \left(\frac{PO_4}{Limit} \right) X_H$
5 Aerobic growth of X_H on S_A			1					$\frac{1-Y_H}{Y_H}$	$-1/Y_H$		$-i_{NBM}$		$-i_{PBM}$			$\mu_H \left(\frac{S_A}{K_A + S_A} \right) \left(\frac{S_A}{S_F + S_A} \right) \left(\frac{Air}{On} \right) \left(\frac{NH_4}{Limit} \right) \left(\frac{PO_4}{Limit} \right) X_H$
6 Anoxic growth of X_H on S_F			1					$-1/Y_H$			$1/Y_H \cdot i_{NSF}$ $-i_{NBM}$	$\frac{1-Y_H}{2.86 Y_H}$	$1/Y_H \cdot i_{PSF}$ $-i_{PBM}$		$\frac{1-Y_H}{2.86 Y_H}$	$\eta_{NO_3} \mu_H \left(\frac{S_F}{K_F + S_F} \right) \left(\frac{S_F}{S_F + S_A} \right) \left(\frac{Air}{Off} \right) \left(\frac{NO_3}{Limit} \right) \left(\frac{NH_4}{Limit} \right) \left(\frac{PO_4}{Limit} \right) X_H$
7 Anoxic growth of X_H on S_A			1					$-1/Y_H$			$-i_{NBM}$	$\frac{1-Y_H}{2.86 Y_H}$	$-i_{PBM}$		$\frac{1-Y_H}{2.86 Y_H}$	$\eta_{NO_3} \mu_H \left(\frac{S_A}{K_A + S_A} \right) \left(\frac{S_A}{S_F + S_A} \right) \left(\frac{Air}{Off} \right) \left(\frac{NO_3}{Limit} \right) \left(\frac{NH_4}{Limit} \right) \left(\frac{PO_4}{Limit} \right) X_H$
8 Fermentation									-1	1	i_{NSF}		i_{PSF}			$q_F \left(\frac{S_F}{K_{F_0} + S_F} \right) \left(\frac{Air}{Off} \right) \left(\frac{1-NO_3}{Limit} \right) X_H$
9 Death/lysis of X_H	f_{XI}	$(1-f_{XI})$	-1								C^*		D^*			$d_H X_H$
Phosphorus accumulating organisms (PAO): X_{PAO}																
10 Sequestration of S_A / storage of X_{PPH}					$-Y_{PO_4}$	1				-1			Y_{PO_4}			$q_{PHA} \left(\frac{S_A}{K_A + S_A} \right) \left(\frac{(X_{PP}/X_{PAO})}{K_{PP} + (X_{PP}/X_{PAO})} \right) X_{PAO}$
11 Storage of X_{PP}					1	$-Y_{PHA}$		$-Y_{PHA}$					-1			$q_{PP} \left(\frac{(X_{PP}/X_{PAO})}{K_{PP} + (X_{PP}/X_{PAO})} \right) \left(\frac{K_{MAX} - (X_{PP}/X_{PAO})}{K_{PP} + K_{MAX} - (X_{PP}/X_{PAO})} \right) \left(\frac{Air}{On} \right) \left(\frac{PO_4}{Limit} \right) X_{PAO}$
12 Aerobic growth of X_{PAO} on X_{PHA}				1		$-1/Y_{PAO}$		$\frac{1-Y_{PAO}}{Y_{PAO}}$			$-i_{NBM}$		$-i_{PBM}$			$\mu_{PAO} \left(\frac{(X_{PHA}/X_{PAO})}{K_{PHA} + (X_{PHA}/X_{PAO})} \right) \left(\frac{Air}{On} \right) \left(\frac{NH_4}{Limit} \right) \left(\frac{PO_4}{Limit} \right) X_{PAO}$
13 Death/lysis of X_{PAO}	f_{XI}	$(1-f_{XI})$		-1							C^*		D^*			$d_{PAO} X_{PAO}$
14 Lysis of X_{PP}					-1								1			$b_{PP} X_{PP}$
15 Lysis of X_{PHA}						-1				1						$b_{PHA} X_{PHA}$
Autotrophic organisms: X_{AUT}																
16 Growth of X_{AUT}							1	$\frac{4.57-Y_{AUT}}{Y_{AUT}}$			$-1/Y_{AUT}$ $-i_{NBM}$	$1/Y_{AUT}$	$-i_{PBM}$			$\mu_{AUT} \left(\frac{S_{NH_4}}{K_{NH_4} + S_{NH_4}} \right) \left(\frac{Air}{On} \right) \left(\frac{PO_4}{Limit} \right) X_{AUT}$
17 Death/lysis of X_{AUT}	f_{XI}	$(1-f_{XI})$					-1				C^*		D^*			$d_{AUT} X_{AUT}$
Inert mass	- M (COD) L^{-3}															
Slowly biodegradable particulate substrate	- M (COD) L^{-3}															
Biological (active) heterotrophic mass	- M (COD) L^{-3}															
Biological (active) PAO mass	- M (COD) L^{-3}															
Stored polyphosphate	- M (P) L^{-3}															
Stored polyhydroxyalkanoate	- M (COD) L^{-3}															
Biological (active) autotrophic mass	- M (COD) L^{-3}															
Oxygen	- M (COD) L^{-3}															
Fermentable readily biodegradable substrate	- M (COD) L^{-3}															
Fermentation products substrate	- M (COD) L^{-3}															
Ammoniacal nitrogen	- M (N) L^{-3}															
Nitrate nitrogen	- M (N) L^{-3}															
Soluble phosphate	- M (P) L^{-3}															
Unbiodegradable soluble substrate	- M (COD) L^{-3}															
Dinitrogen gas	- M (N) L^{-3}															

KEY	
$A^* = i_{NXS} - (1-f_{SI}) \cdot i_{NSF} - f_{SI} \cdot i_{NSI}$	
$B^* = i_{PKS} - (1-f_{SI}) \cdot i_{PSF} - f_{SI} \cdot i_{PSI}$	
$C^* = i_{NBM} - f_{XI} \cdot i_{NXI} - (1-f_{XI}) \cdot i_{NXS}$	
$D^* = i_{PBM} - f_{XI} \cdot i_{PKI} - (1-f_{XI}) \cdot i_{PKS}$	

APPENDIX C2

Program Listing of ASM-2 for the Simulation of the MBR UCT System

AQUASIM Version 2.0 (win/mfc) - Listing of System Definition

Date and time of listing: 02/12/2007 21:37:15

Variables

b_AUT:	Description:	Maximum growth rate of autotrophs
	Type:	Formula Variable
	Unit:	per day
	Expression:	b_AUT20*exp(the_bAUT*(T-20))

b_AUT20:	Description:	Decay coefficient for autotrophic b iomass
	Type:	Constant Variable
	Unit:	per day
	Value:	0.04
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

b_H:	Description:	Rate constant for lysis of heterotr ophs
	Type:	Formula Variable
	Unit:	per day
	Expression:	b_H20*exp(the_bH*(T-20))

b_H20:	Description:	Rate constant for lysis of heterotr ophs
	Type:	Constant Variable
	Unit:	per day
	Value:	0.62
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

b_PAO:	Description:	Rate constant for lysis of X_PAO
	Type:	Formula Variable
	Unit:	per day
	Expression:	b_PAO20*exp(the_bPAO*(T-20))

b_PAO20:	Description:	Rate constant for lysis of X_PAO
	Type:	Constant Variable
	Unit:	per day
	Value:	0.04
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive

Parameter Estimation: inactive

b_PHA:	Description:	Rate constant for lysis of X_PHA
	Type:	Formula Variable
	Unit:	per day
	Expression:	b_PHA20*exp(the_bPHA*(T-20))
b_PHA20:	Description:	Rate constant for lysis of X_PHA
	Type:	Constant Variable
	Unit:	per day
	Value:	0.04
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
b_PP:	Description:	Rate constant for lysis of X_PP
	Type:	Formula Variable
	Unit:	per day
	Expression:	b_PP20*exp(the_bPP*(T-20))
b_PP20:	Description:	Rate constant for lysis of X_PP
	Type:	Constant Variable
	Unit:	per day
	Value:	0.04
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
Calcnum:	Description:	Calculation number
	Type:	Program Variable
	Unit:	
	Reference to:	Calculation Number
CODf:	Description:	Filtered COD
	Type:	Formula Variable
	Unit:	mgCOD/l
	Expression:	S_I
CODf_m:	Description:	Measured effluent filtered COD
	Type:	Variable List Variable
	Unit:	mgCOD/l
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (6 pairs):	
	1	CODf_m1
	2	CODf_m2
	3	CODf_m3
	4	CODf_m4
	5	CODf_m5
	6	CODf_m6
CODf_m1:	Description:	Measured effluent filtered COD B-1
	Type:	Real List Variable
	Unit:	mgCOD/l
	Argument:	t
	Standard Deviations:	global
	Rel. Stand. Deviat.:	0

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Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (1 pairs):
 1 0

CODf_m2: Description: Measured effluent filtered COD B-2
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (1 pairs):
 1 0

CODf_m3: Description: Measured effluent filtered COD B-5
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (1 pairs):
 1 0

CODf_m4: Description: Measured effluent filtered COD B-26
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (1 pairs):
 1 80.7

CODf_m5: Description: Measured effluent filtered COD B-28
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive

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Real Data Pairs (1 pairs):

1	95

CODf_m6: Description: Measured effluent filtered COD B-30
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (1 pairs):
 1 87.85

CODt: Description: Total COD
 Type: Formula Variable
 Unit: mgCOD/l
 Expression: S_A+S_F+S_I+X_I+X_S+X_H+X_PAO+X_PHA
 +X_AUT

CODt_m: Description: Measured effluent total COD
 Type: Variable List Variable
 Unit: mgCOD/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (6 pairs):
 1 CODt_m1
 2 CODt_m2
 3 CODt_m3
 4 CODt_m4
 5 CODt_m5
 6 CODt_m6

CODt_m1: Description: Measured effluent total COD B-1
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (1 pairs):
 1 1

CODt_m2: Description: Measured effluent total COD B-2
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive

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Real Data Pairs (1 pairs):

1 1

```

-----
CODt_m3:      Description:      Measured effluent total COD B-5
              Type:             Real List Variable
              Unit:             mgCOD/l
              Argument:         t
              Standard Deviations: global
              Rel. Stand. Deviat.: 0
              Abs. Stand. Deviat.: 1
              Minimum:          0
              Maximum:          1e+009
              Interpolation Method: linear interpolation
              Sensitivity Analysis: inactive
              Real Data Pairs (1 pairs):
                1                89.4
-----

CODt_m4:      Description:      Measured effluent total COD B-26
              Type:             Real List Variable
              Unit:             mgCOD/l
              Argument:         t
              Standard Deviations: global
              Rel. Stand. Deviat.: 0
              Abs. Stand. Deviat.: 1
              Minimum:          0
              Maximum:          1e+009
              Interpolation Method: linear interpolation
              Sensitivity Analysis: inactive
              Real Data Pairs (1 pairs):
                1                134.1
-----

CODt_m5:      Description:      Measured effluent total COD B-28
              Type:             Real List Variable
              Unit:             mgCOD/l
              Argument:         t
              Standard Deviations: global
              Rel. Stand. Deviat.: 0
              Abs. Stand. Deviat.: 1
              Minimum:          0
              Maximum:          1e+009
              Interpolation Method: linear interpolation
              Sensitivity Analysis: inactive
              Real Data Pairs (1 pairs):
                1                143.5
-----

CODt_m6:      Description:      Measured effluent total COD B-30
              Type:             Real List Variable
              Unit:             mgCOD/l
              Argument:         t
              Standard Deviations: global
              Rel. Stand. Deviat.: 0
              Abs. Stand. Deviat.: 1
              Minimum:          0
              Maximum:          1e+009
              Interpolation Method: linear interpolation
              Sensitivity Analysis: inactive
              Real Data Pairs (1 pairs):
                1                122.33
-----

eta_fe:       Description:      Anaerobic hydrolysis reduction fact
                                or

```

	Type:	Constant Variable
	Unit:	
	Value:	0.1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

eta_NO3:	Description:	Anoxic hydrolysis reduction factor
	Type:	Constant Variable
	Unit:	
	Value:	0.6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

eta_NO3d:	Description:	Reduction factor for denitrification by heterotrophs
	Type:	Constant Variable
	Unit:	
	Value:	1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_ac:	Description:	Fraction of short chain fatty acids (acetate) wrt biodegradable soluble COD
	Type:	Variable List Variable
	Unit:	gCOD/gCOD
	Argument:	Calnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (12 pairs):	
	1	f_ac1a
	2	f_ac2a
	3	f_ac3a
	4	f_ac4a
	5	f_ac5a
	6	f_ac6a
	11	f_ac1b
	12	f_ac2b
	13	f_ac3b
	14	f_ac4b
	15	f_ac5b
	16	f_ac6b

f_ac1a:	Description:	Fraction of short chain fatty acids (acetate) wrt biodegradable soluble COD (B1)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.301
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive

Parameter Estimation: inactive

f_ac1b:	Description:	Fraction of short chain fatty acids (acetate) wrt biodegradable soluble COD (B1)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.301
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_ac2a:	Description:	Fraction of short chain fatty acids (acetate) wrt biodegradable soluble COD (B2)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.31
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_ac2b:	Description:	Fraction of short chain fatty acids (acetate) wrt biodegradable soluble COD (B2)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.31
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_ac3a:	Description:	Fraction of short chain fatty acids (acetate) wrt biodegradable soluble COD (B5)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.48
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_ac3b:	Description:	Fraction of short chain fatty acids (acetate) wrt biodegradable soluble COD (B5)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.48
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_ac4a:	Description:	Fraction of short chain fatty acids (acetate) wrt biodegradable soluble COD (B26)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.42
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_ac4b:	Description:	Fraction of short chain fatty acids (acetate) wrt biodegradable soluble COD (B26)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.42
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_ac5a:	Description:	Fraction of short chain fatty acids (acetate) wrt biodegradable soluble COD (B28)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.608
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_ac5b:	Description:	Fraction of short chain fatty acids (acetate) wrt biodegradable soluble COD (B28)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.608
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_ac6a:	Description:	Fraction of short chain fatty acids (acetate) wrt biodegradable soluble COD (B30)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.43
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

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f_ac6b:	Description:	Fraction of short chain fatty acids (acetate) wrt biodegradable soluble COD (B30)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.43
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_avOHO:	Description:	Fraction of the VSS concentration which is OHO
	Type:	Formula Variable
	Unit:	mgVSS/mgVSS
	Expression:	X_H/mVSS

f_avPAO:	Description:	Fraction of the VSS concentration which is PAO
	Type:	Formula Variable
	Unit:	mgVSS/mgVSS
	Expression:	X_PAO/mVSS

f_bs:	Description:	Fraction of biodegradable soluble wrt biodegradable COD
	Type:	Variable List Variable
	Unit:	gCOD/gCOD
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (12 pairs):	
	1	f_bs1a
	2	f_bs2a
	3	f_bs3a
	4	f_bs4a
	5	f_bs5a
	6	f_bs6a
	11	f_bs1b
	12	f_bs2b
	13	f_bs3b
	14	f_bs4b
	15	f_bs5b
	16	f_bs6b

f_bs1a:	Description:	Fraction of biodegradable soluble wrt biodegradable COD (B1)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.441
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_bs1b:	Description:	Fraction of biodegradable soluble wrt biodegradable COD (B1)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.441
	Standard Deviation:	0.1

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	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_bs2a:	Description:	Fraction of biodegradable soluble w rt biodegradable COD (B2)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.431
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_bs2b:	Description:	Fraction of biodegradable soluble w rt biodegradable COD (B2)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.431
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_bs3a:	Description:	Fraction of biodegradable soluble w rt biodegradable COD (B5)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.459
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_bs3b:	Description:	Fraction of biodegradable soluble w rt biodegradable COD (B5)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.459
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_bs4a:	Description:	Fraction of biodegradable soluble w rt biodegradable COD (B26)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.45
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_bs4b:	Description:	Fraction of biodegradable soluble w

Type: rt biodegradable COD (B26)
 Constant Variable
 Unit: gCOD/gCOD
 Value: 0.45
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

f_bs5a: Description: Fraction of biodegradable soluble w
 rt biodegradable COD (B28)
 Type: Constant Variable
 Unit: gCOD/gCOD
 Value: 0.499
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

f_bs5b: Description: Fraction of biodegradable soluble w
 rt biodegradable COD (B28)
 Type: Constant Variable
 Unit: gCOD/gCOD
 Value: 0.499
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

f_bs6a: Description: Fraction of biodegradable soluble w
 rt biodegradable COD (B30)
 Type: Constant Variable
 Unit: gCOD/gCOD
 Value: 0.457
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

f_bs6b: Description: Fraction of biodegradable soluble w
 rt biodegradable COD (B30)
 Type: Constant Variable
 Unit: gCOD/gCOD
 Value: 0.457
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

f_cv: Description: COD/VSS ratio
 Type: Formula Variable
 Unit: mgCOD/mgVSS
 Expression: 1.48

f_na: Description: Measured NH4/TKN ratio
 Type: Formula Variable

	Unit:	mgNH ₄ -N/mgN
	Expression:	S_NH4in/N_ti
f_SI:	Description:	Fraction of inert COD in particulate substrate
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_up:	Description:	Fraction of unbiodegradable particulate wrt influent COD
	Type:	Variable List Variable
	Unit:	gCOD/gCOD
	Argument:	Calcnm
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (12 pairs):	
	1	f_up1a
	2	f_up2a
	3	f_up3a
	4	f_up4a
	5	f_up5a
	6	f_up6a
	11	f_up1b
	12	f_up2b
	13	f_up3b
	14	f_up4b
	15	f_up5b
	16	f_up6b
f_up1a:	Description:	Fraction of unbiodegradable particulate wrt influent COD B-1
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.205
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_up1b:	Description:	Fraction of unbiodegradable particulate wrt influent COD B-1
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.142
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_up2a:	Description:	Fraction of unbiodegradable particulate wrt influent COD B-2
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.092

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Standard Deviation: 0.1
Minimum: 0
Maximum: 1
Sensitivity Analysis: inactive
Parameter Estimation: inactive
```

f_up2b:	Description:	Fraction of unbiodegradable particulate wrt influent COD B-2
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.052
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_up3a:	Description:	Fraction of unbiodegradable particulate wrt influent COD B-5
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.215
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_up3b:	Description:	Fraction of unbiodegradable particulate wrt influent COD B-5
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.239
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_up4a:	Description:	Fraction of unbiodegradable particulate wrt influent COD B-26
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.168
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_up4b:	Description:	Fraction of unbiodegradable particulate wrt influent COD B-26
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.145
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

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f_up5a:	Description:	Fraction of unbiodegradable particulate wrt influent COD B-28
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.211
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_up5b:	Description:	Fraction of unbiodegradable particulate wrt influent COD B-28
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.206
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_up6a:	Description:	Fraction of unbiodegradable particulate wrt influent COD B-30
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.206
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_up6b:	Description:	Fraction of unbiodegradable particulate wrt influent COD B-30
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.195
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_us:	Description:	Fraction of unbiodegradable soluble wrt influent COD
	Type:	Variable List Variable
	Unit:	gCOD/gCOD
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (12 pairs):	
	1	f_us1a
	2	f_us2a
	3	f_us3a
	4	f_us4a
	5	f_us5a
	6	f_us6a
	11	f_us1b
	12	f_us2b
	13	f_us3b
	14	f_us4b

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15	f_us5b
16	f_us6b
f_us1a:	Description: Fraction of unbiodegradable soluble wrt influent COD (B1) Type: Constant Variable Unit: gCOD/gCOD Value: 0.031 Standard Deviation: 0.1 Minimum: 0 Maximum: 1 Sensitivity Analysis: inactive Parameter Estimation: inactive
f_us1b:	Description: Fraction of unbiodegradable soluble wrt influent COD (B1) Type: Constant Variable Unit: gCOD/gCOD Value: 0.031 Standard Deviation: 0.1 Minimum: 0 Maximum: 1 Sensitivity Analysis: inactive Parameter Estimation: inactive
f_us2a:	Description: Fraction of unbiodegradable soluble wrt influent COD (B2) Type: Constant Variable Unit: gCOD/gCOD Value: 0.037 Standard Deviation: 0.1 Minimum: 0 Maximum: 1 Sensitivity Analysis: inactive Parameter Estimation: inactive
f_us2b:	Description: Fraction of unbiodegradable soluble wrt influent COD (B2) Type: Constant Variable Unit: gCOD/gCOD Value: 0.037 Standard Deviation: 0.1 Minimum: 0 Maximum: 1 Sensitivity Analysis: inactive Parameter Estimation: inactive
f_us3a:	Description: Fraction of unbiodegradable soluble wrt influent COD (B5) Type: Constant Variable Unit: gCOD/gCOD Value: 0.036 Standard Deviation: 0.1 Minimum: 0 Maximum: 1 Sensitivity Analysis: inactive Parameter Estimation: inactive
f_us3b:	Description: Fraction of unbiodegradable soluble wrt influent COD (B5) Type: Constant Variable

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	Unit:	gCOD/gCOD
	Value:	0.036
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_us4a:	Description:	Fraction of unbiodegradable soluble wrt influent COD (B26)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.043
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_us4b:	Description:	Fraction of unbiodegradable soluble wrt influent COD (B26)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.043
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_us5a:	Description:	Fraction of unbiodegradable soluble wrt influent COD (B28)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.041
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_us5b:	Description:	Fraction of unbiodegradable soluble wrt influent COD (B28)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.041
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_us6a:	Description:	Fraction of unbiodegradable soluble wrt influent COD (B30)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.043
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive

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Parameter Estimation: inactive

f_us6b:	Description:	Fraction of unbiodegradable soluble wrt influent COD (B30)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.043
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
Parameter Estimation: inactive		
f_vTG:	Description:	VSS/TSS for PAOs
	Type:	Formula Variable
	Unit:	mgCOD/mgTSS
	Expression:	0.46
f_vTH:	Description:	VSS/TSS for OHOs
	Type:	Formula Variable
	Unit:	mgCOD/mgTSS
	Expression:	0.75
f_XiAUT:	Description:	Fraction of inert COD in biomass (f or AUT)
	Type:	Constant Variable
	Unit:	gCOD(gCOD)-1
	Value:	0.08
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
Parameter Estimation: inactive		
f_XiOHO:	Description:	Fraction of inert COD in biomass (f or OHO)
	Type:	Constant Variable
	Unit:	gCOD(gCOD)-1
	Value:	0.08
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
Parameter Estimation: inactive		
f_XiPAO:	Description:	Fraction of inert COD in biomass (f or PAO)
	Type:	Constant Variable
	Unit:	gCOD(gCOD)-1
	Value:	0.25
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
Parameter Estimation: inactive		
ISS_AeroM:	Description:	Measured ISS in the reactor
	Type:	Variable List Variable
	Unit:	mgISS/l
	Argument:	Calcnum
	Interpolation Method:	linear interpolation

Real-Variable Data Pairs (6 pairs):

1	ISS_AeroM1
2	ISS_AeroM2
3	ISS_AeroM3
4	ISS_AeroM4
5	ISS_AeroM5
6	ISS_AeroM6

ISS_AeroM1: Description: Measured ISS (Inorganic Suspended Solids) in the reactor (B-1)

 Type: Constant Variable

 Unit: mgISS/l

 Value: 3769

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 10000

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

ISS_AeroM2: Description: Measured ISS (Inorganic Suspended Solids) in the reactor (B-2)

 Type: Constant Variable

 Unit: mgISS/l

 Value: 2812

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 10000

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

ISS_AeroM3: Description: Measured ISS (Inorganic Suspended Solids) in the reactor (B-3)

 Type: Constant Variable

 Unit: mgISS/l

 Value: 3345

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 10000

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

ISS_AeroM4: Description: Measured ISS (Inorganic Suspended Solids) in the reactor (B-26)

 Type: Constant Variable

 Unit: mgISS/l

 Value: 3796

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 10000

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

ISS_AeroM5: Description: Measured ISS (Inorganic Suspended Solids) in the reactor (B-28)

 Type: Constant Variable

 Unit: mgISS/l

 Value: 3179

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 10000

 Sensitivity Analysis: inactive

Parameter Estimation: inactive

ISS_AeroM6: Description: Measured ISS (Inorganic Suspended Solids) in the reactor (B-30)

 Type: Constant Variable

 Unit: mgISS/l

 Value: 3284

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 10000

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

ISS_AnaerM: Description: Measured ISS in the reactor

 Type: Variable List Variable

 Unit: mgISS/l

 Argument: Calcnum

 Interpolation Method: linear interpolation

 Real-Variable Data Pairs (6 pairs):

 1 ISS_AnaerM1

 2 ISS_AnaerM2

 3 ISS_AnaerM3

 4 ISS_AnaerM4

 5 ISS_AnaerM5

 6 ISS_AnaerM6

ISS_AnaerM1: Description: Measured ISS (Inorganic Suspended Solids) in the reactor (B-1)

 Type: Constant Variable

 Unit: mgISS/l

 Value: 1643.4

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 10000

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

ISS_AnaerM2: Description: Measured ISS (Inorganic Suspended Solids) in the reactor (B-2)

 Type: Constant Variable

 Unit: mgISS/l

 Value: 1238.6

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 10000

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

ISS_AnaerM3: Description: Measured ISS (Inorganic Suspended Solids) in the reactor (B-5)

 Type: Constant Variable

 Unit: mgISS/l

 Value: 1348.6

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 10000

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

ISS_AnaerM4: Description: Measured ISS (Inorganic Suspended Solids) in the reactor (B-26)

	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	1431
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

ISS_AnaerM5:	Description:	Measured ISS (Inorganic Suspended Solids) in the reactor (B-28)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	1126
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

ISS_AnaerM6:	Description:	Measured ISS (Inorganic Suspended Solids) in the reactor (B-30)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	1352.6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

ISS_AnoxM:	Description:	Measured ISS in the reactor
	Type:	Variable List Variable
	Unit:	mgISS/l
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (6 pairs):	
	1	ISS_AnoxM1
	2	ISS_AnoxM2
	3	ISS_AnoxM3
	4	ISS_AnoxM4
	5	ISS_AnoxM5
	6	ISS_AnoxM6

ISS_AnoxM1:	Description:	Measured ISS (Inorganic Suspended Solids) in the reactor (B-1)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	2945.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

ISS_AnoxM2:	Description:	Measured ISS (Inorganic Suspended Solids) in the reactor (B-2)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	2389.6
	Standard Deviation:	0.1

Minimum: 0
Maximum: 10000
Sensitivity Analysis: inactive
Parameter Estimation: inactive

ISS_AnoxM3: Description: Measured ISS (Inorganic Suspended Solids) in the reactor (B-5)
Type: Constant Variable
Unit: mgISS/l
Value: 2622.3
Standard Deviation: 0.1
Minimum: 0
Maximum: 10000
Sensitivity Analysis: inactive
Parameter Estimation: inactive

ISS_AnoxM4: Description: Measured ISS (Inorganic Suspended Solids) in the reactor (B-26)
Type: Constant Variable
Unit: mgISS/l
Value: 2848.9
Standard Deviation: 0.1
Minimum: 0
Maximum: 10000
Sensitivity Analysis: inactive
Parameter Estimation: inactive

ISS_AnoxM5: Description: Measured ISS (Inorganic Suspended Solids) in the reactor (B-28)
Type: Constant Variable
Unit: mgISS/l
Value: 2309.6
Standard Deviation: 0.1
Minimum: 0
Maximum: 10000
Sensitivity Analysis: inactive
Parameter Estimation: inactive

ISS_AnoxM6: Description: Measured ISS (Inorganic Suspended Solids) in the reactor (B-30)
Type: Constant Variable
Unit: mgISS/l
Value: 2524.2
Standard Deviation: 0.1
Minimum: 0
Maximum: 10000
Sensitivity Analysis: inactive
Parameter Estimation: inactive

ISS_fiOHO: Description: Inorganic content of the OHO cell mass
Type: Formula Variable
Unit: mgISS/mgOHOVSS
Expression: 0.15

ISS_fiPAO: Description: Total inorganic solids content of the PAOs
Type: Formula Variable
Unit: mgISS/mgPAOVSS
Expression: $3.286 * (X_{PP} / (X_{PAO} / f_{cv})) + ISS_{fiPAO}$
BM

ISS_fiPAOBM:	Description:	Inorganic material content of the P AO active biomass
	Type:	Formula Variable
	Unit:	mgISS/mgPAOVSS
	Expression:	0.15
ISS_Xioi:	Description:	Reactor ISS from influent ISS (inor ganic suspended solids)
	Type:	Dyn. Volume State Var.
	Unit:	mgISS/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006
ISS_Xioin:	Description:	Inorganic Suspended Solids in the i nfluent
	Type:	Variable List Variable
	Unit:	mgISS/l
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (12 pairs):	
	1	ISS_Xioin1a
	2	ISS_Xioin2a
	3	ISS_Xioin3a
	4	ISS_Xioin4a
	5	ISS_Xioin5a
	6	ISS_Xioin6a
	11	ISS_Xioin1b
	12	ISS_Xioin2b
	13	ISS_Xioin3b
	14	ISS_Xioin4b
	15	ISS_Xioin5b
	16	ISS_Xioin6b
ISS_Xioin1a:	Description:	Inorganic Suspended Solids in the i nfluent (B-1)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	22
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
ISS_Xioin1b:	Description:	Inorganic Suspended Solids in the i nfluent (B-1)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	20.12
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
ISS_Xioin2a:	Description:	Inorganic Suspended Solids in the i nfluent (B-2)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	0.001

Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioin2b: Description: Inorganic Suspended Solids in the i
 nfluent (B-2)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 0.001
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioin3a: Description: Inorganic Suspended Solids in the i
 nfluent (B-5)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 0.001
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioin3b: Description: Inorganic Suspended Solids in the i
 nfluent (B-5)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 0.001
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioin4a: Description: Inorganic Suspended Solids in the i
 nfluent (B-26)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 0.001
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioin4b: Description: Inorganic Suspended Solids in the i
 nfluent (B-26)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 0.0001
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

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ISS_Xioin5a:	Description:	Inorganic Suspended Solids in the influent (B-28)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	0.0001
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

ISS_Xioin5b:	Description:	Inorganic Suspended Solids in the influent (B-28)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	0.0001
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

ISS_Xioin6a:	Description:	Inorganic Suspended Solids in the influent (B-30)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	0.0001
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

ISS_Xioin6b:	Description:	Inorganic Suspended Solids in the influent (B-30)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	0.0001
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

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ISS_Xioini:      Description:      Initial concentration of Inorganic
                                Suspended Solids in the influent
Type:            Variable List Variable
Unit:            mgISS/l
Argument:        Calcnum
Interpolation Method: linear interpolation
Real-Variable Data Pairs (12 pairs):
1                ISS_Xioinila
2                ISS_Xioini2a
3                ISS_Xioini3a
4                ISS_Xioini4a
5                ISS_Xioini5a
6                ISS_Xioini6a
11               ISS_Xioinila
12               ISS_Xioini2b
13               ISS_Xioini3b
14               ISS_Xioini4b

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16ISS_Xioini5b
ISS_Xioini6b

ISS_Xioinila:	Description: Initial concentration of Inorganic Suspended Solids in the influent (B-I) Type: Constant Variable Unit: mgISS/l Value: 805 Standard Deviation: 0.1 Minimum: 0 Maximum: 30000 Sensitivity Analysis: inactive Parameter Estimation: inactive

ISS_Xioinilb:	Description: Initial concentration of Inorganic Suspended Solids in the influent (B-I) Type: Constant Variable Unit: mgISS/l Value: 656 Standard Deviation: 0.1 Minimum: 0 Maximum: 30000 Sensitivity Analysis: inactive Parameter Estimation: inactive

ISS_Xioini2a:	Description: Initial concentration of Inorganic Suspended Solids in the influent (B-2) Type: Constant Variable Unit: mgISS/l Value: 0.0375 Standard Deviation: 0.1 Minimum: 0 Maximum: 30000 Sensitivity Analysis: inactive Parameter Estimation: inactive

ISS_Xioini2b:	Description: Initial concentration of Inorganic Suspended Solids in the influent (B-2) Type: Constant Variable Unit: mgISS/l Value: 0.0377 Standard Deviation: 0.1 Minimum: 0 Maximum: 30000 Sensitivity Analysis: inactive Parameter Estimation: inactive

ISS_Xioini3a:	Description: Initial concentration of Inorganic Suspended Solids in the influent (B-5) Type: Constant Variable Unit: mgISS/l Value: 0.0372 Standard Deviation: 0.1 Minimum: 0 Maximum: 30000 Sensitivity Analysis: inactive

Parameter Estimation: inactive

ISS_Xioini3b: Description: Initial concentration of Inorganic
Suspended Solids in the influent (B-5)

Type: Constant Variable

Unit: mgISS/l

Value: 0.0375

Standard Deviation: 0.1

Minimum: 0

Maximum: 30000

Sensitivity Analysis: inactive

Parameter Estimation: inactive

ISS_Xioini4a: Description: Initial concentration of Inorganic
Suspended Solids in the influent (B-26)

Type: Constant Variable

Unit: mgISS/l

Value: 0.0373

Standard Deviation: 0.1

Minimum: 0

Maximum: 30000

Sensitivity Analysis: inactive

Parameter Estimation: inactive

ISS_Xioini4b: Description: Initial concentration of Inorganic
Suspended Solids in the influent (B-26)

Type: Constant Variable

Unit: mgISS/l

Value: 0.0173

Standard Deviation: 0.1

Minimum: 0

Maximum: 30000

Sensitivity Analysis: inactive

Parameter Estimation: inactive

ISS_Xioini5a: Description: Initial concentration of Inorganic
Suspended Solids in the influent (B-28)

Type: Constant Variable

Unit: mgISS/l

Value: 0.0173

Standard Deviation: 0.1

Minimum: 0

Maximum: 30000

Sensitivity Analysis: inactive

Parameter Estimation: inactive

ISS_Xioini5b: Description: Initial concentration of Inorganic
Suspended Solids in the influent (B-28)

Type: Constant Variable

Unit: mgISS/l

Value: 0.0173

Standard Deviation: 0.1

Minimum: 0

Maximum: 30000

Sensitivity Analysis: inactive

Parameter Estimation: inactive

ISS_Xioini6a:	Description:	Initial concentration of Inorganic Suspended Solids in the influent (B-30)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	0.0173
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
ISS_Xioini6b:	Description:	Initial concentration of Inorganic Suspended Solids in the influent (B-30)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	0.0173
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
ISS_Xoi:	Description:	Total ISS (Inorganic Suspended Solids) in the reactor
	Type:	Formula Variable
	Unit:	mgISS/l
	Expression:	$ISS\_Xioi + (ISS\_fiOHO * (X\_H / f\_cv)) + (ISS\_fiPAO * (X\_PAO / f\_cv))$
i_NBM:	Description:	Nitrogen content of biomass, X_H , X_PAO , X_AUT
	Type:	Constant Variable
	Unit:	gN(gCOD)-1
	Value:	0.07
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
i_NSf:	Description:	Nitrogen content of soluble substrate, S_F
	Type:	Constant Variable
	Unit:	gN(gCOD)-1
	Value:	0.03
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
i_NSi:	Description:	Nitrogen content of inert soluble COD, S_I
	Type:	Constant Variable
	Unit:	gN/gCOD
	Value:	0.01
	Standard Deviation:	0.1
	Minimum:	0

	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
i_NXi:	Description:	Nitrogen content of inert particulate COD, X_I
	Type:	Constant Variable
	Unit:	gN(gCOD)-1
	Value:	0.07
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
i_NXs:	Description:	Nitrogen content of particulate substrate, X_S
	Type:	Constant Variable
	Unit:	gN(gCOD)-1
	Value:	0.04
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
i_PBM:	Description:	P content of biomass, X_H, X_PAO, X_AUT
	Type:	Constant Variable
	Unit:	gP(gCOD)-1
	Value:	0.02
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
i_Psf:	Description:	P content of soluble substrate S_F
	Type:	Constant Variable
	Unit:	gP(gCOD)-1
	Value:	0.01
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
i_PSi:	Description:	P content of inert soluble COD S_I
	Type:	Constant Variable
	Unit:	gP(gCOD)-1
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
i_PXi:	Description:	P content of inert particulate COD, X_I
	Type:	Constant Variable
	Unit:	gP(gCOD)-1

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Value: 0.01
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

i_PXs: Description: P content of particulate substrate, X_S
 Type: Constant Variable
 Unit: gP(gCOD)⁻¹
 Value: 0.01
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

i_TSSBM: Description: TSS to biomass ratio for X_H, X_{PA} O, X_{UAT}
 Type: Constant Variable
 Unit: gTSS(gCOD)⁻¹
 Value: 0.9
 Standard Deviation: 1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

i_TSSXi: Description: TSS to X_I ratio
 Type: Constant Variable
 Unit: gTSS(gCOD)⁻¹
 Value: 0.75
 Standard Deviation: 1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

i_TSSXs: Description: TSS to X_S ratio
 Type: Constant Variable
 Unit: gTSS(gCOD)⁻¹
 Value: 0.75
 Standard Deviation: 1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

K_ALK: Description: Saturation coefficient for alkalinity
 Type: Constant Variable
 Unit: mole HCO₃⁻(m)⁻³
 Value: 0.1
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

K_ALKAUT: Description: Saturation coefficient for alkalinity

	Type:	ty (Autotrophs)
	Unit:	Constant Variable
	Value:	mole HCO ₃ (m) ⁻³
	Standard Deviation:	0.5
	Minimum:	0.1
	Maximum:	0
	Sensitivity Analysis:	1
	Parameter Estimation:	inactive
K_ALKPRE:	Description:	Saturation coefficient for alkalinity (precipitation)
	Type:	Constant Variable
	Unit:	mole HCO ₃ (m) ⁻³
	Value:	0.5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
K_AOHO:	Description:	Saturation coefficient for S _A (acetate) (heterotrophs)
	Type:	Constant Variable
	Unit:	gCOD(m) ⁻³
	Value:	4
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
K_APAO:	Description:	Saturation coefficient for S _A (acetate) (PAO)
	Type:	Constant Variable
	Unit:	gCOD(m) ⁻³
	Value:	1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
K_F:	Description:	Saturation coefficient for growth of heterotrophs on S _F
	Type:	Constant Variable
	Unit:	gCOD(m) ⁻³
	Value:	4
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
K_fe:	Description:	Saturation coefficient for fermentation of S _F (heterotrophs)
	Type:	Constant Variable
	Unit:	gCOD(m) ⁻³
	Value:	150
	Standard Deviation:	0.1
	Minimum:	0

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Maximum: 200
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

K_h:	Description:	Hydrolysis rate constant
	Type:	Formula Variable
	Unit:	d-1
	Expression:	$K_{h20} \cdot \exp(\text{the\_Kh} \cdot (T - 20))$
K_h20:	Description:	Hydrolysis rate constant
	Type:	Constant Variable
	Unit:	d-1
	Value:	2
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
K_IPP:	Description:	Inhibition coefficient for X_PP storage
	Type:	Constant Variable
	Unit:	gPP(gPAO) ⁻¹
	Value:	0.02
	Standard Deviation:	1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
K_La:	Description:	Oxygen mass transfer coefficient
	Type:	Constant Variable
	Unit:	per day
	Value:	700
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
K_Max:	Description:	Maximum ratio of X_PP/X_PAO
	Type:	Constant Variable
	Unit:	gPP(gPAO) ⁻¹
	Value:	1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
K_NH4AUT:	Description:	Saturation coefficient for ammonium (nutrient)
	Type:	Constant Variable
	Unit:	gN(m) ⁻³
	Value:	1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

K_NH4OHO:	Description:	Saturation coefficient for ammonium (nutrient)
	Type:	Constant Variable
	Unit:	gN(m) ⁻³
	Value:	0.01
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

K_NH4PAO:	Description:	Saturation coefficient for ammonium (nutrient)
	Type:	Constant Variable
	Unit:	gN(m) ⁻³
	Value:	0.001
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

K_NO3:	Description:	Saturation/inhibition coefficient/factor for nitrate
	Type:	Constant Variable
	Unit:	gN(m) ⁻³
	Value:	0.1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

K_O2:	Description:	Saturation/inhibition coefficient/factor for oxygen
	Type:	Constant Variable
	Unit:	gO2(m) ⁻³
	Value:	0.02
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

K_P:	Description:	Saturation coefficient for phosphorus (nutrient) in X_PP
	Type:	Constant Variable
	Unit:	gP(m) ⁻³
	Value:	0.01
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

K_PHA:	Description:	Saturation coefficient for PHA
	Type:	Constant Variable
	Unit:	gPHA(gPAO) ⁻¹
	Value:	0.18
	Standard Deviation:	0.1
	Minimum:	0

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Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

K_PP: Description: Saturation coefficient for poly-phosphate
 Type: Constant Variable
 Unit: gPP(gPAO)-1
 Value: 0.001
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

k_PRE: Description: Rate constant for P precipitation
 Type: Constant Variable
 Unit: m3 / (gFe(OH)3) / d
 Value: 1
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

K_PS: Description: Saturation coefficient for phosphorus in PP storage
 Type: Constant Variable
 Unit: gP(m)-3
 Value: 0.1
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

k_RED: Description: Rate constant for redissolution
 Type: Constant Variable
 Unit: /d
 Value: 0.6
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

K_X: Description: Saturation coefficient for particulate COD
 Type: Formula Variable
 Unit: gCOD(gcellCOD)-1
 Expression: K_X20*exp(the_KX*(T-20))

K_X20: Description: Saturation coefficient for particulate COD
 Type: Constant Variable
 Unit: gCOD(gcellCOD)-1
 Value: 0.03
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive

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Parameter Estimation: inactive

mue_AUT:	Description:	Maximum growth rate of autotrophs
	Type:	Formula Variable
	Unit:	per day
	Expression:	$\text{mue\_AUT20} \cdot \exp(\text{the\_mueAUT} \cdot (T-20))$
mue_AUT20:	Description:	Maximum specific growth rate of ANO
	Type:	Constant Variable
	Unit:	per day
	Value:	0.45
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
mue_H:	Description:	Maximum growth rate of heterotrophs
	Type:	Formula Variable
	Unit:	per day
	Expression:	$\text{mue\_H20} \cdot \exp(\text{the\_mueH} \cdot (T-20))$
mue_H20:	Description:	Maximum growth rate on substrate (O HO)
	Type:	Constant Variable
	Unit:	per day
	Value:	6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
mue_PAO:	Description:	Maximum growth rate
	Type:	Formula Variable
	Unit:	per day
	Expression:	$\text{mue\_PAO20} \cdot \exp(\text{the\_muePAO} \cdot (T-20))$
mue_PAO20:	Description:	Maximum growth rate (PAO)
	Type:	Constant Variable
	Unit:	per day
	Value:	1.2
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
mVSS:	Description:	Model VSS in COD units
	Type:	Formula Variable
	Unit:	mgCOD/l
	Expression:	$X\_AUT + X\_H + X\_PAO + X\_PHA + X\_I$
N_ti:	Description:	Influent TKN
	Type:	Variable List Variable
	Unit:	mgN/l
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (12 pairs):	
	1	N_tila
	2	N_ti2a

3	N_ti3a
4	N_ti4a
5	N_ti5a
6	N_ti6a
11	N_tilb
12	N_ti2b
13	N_ti3b
14	N_ti4b
15	N_ti5b
16	N_ti6b

N_tila: Description: Influent TKN B-1
 Type: Constant Variable
 Unit: mgN/l
 Value: 101.42
 Standard Deviation: 1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

N_tilb: Description: Influent TKN B-1
 Type: Constant Variable
 Unit: mgN/l
 Value: 101.42
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

N_ti2a: Description: Influent TKN B-2
 Type: Constant Variable
 Unit: mgN/l
 Value: 134.84
 Standard Deviation: 1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

N_ti2b: Description: Influent TKN B-2
 Type: Constant Variable
 Unit: mgN/l
 Value: 134.84
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

N_ti3a: Description: Influent TKN B-5
 Type: Constant Variable
 Unit: mgN/l
 Value: 133.6
 Standard Deviation: 1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

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N_ti3b:	Description:	Influent TKN B-5
	Type:	Constant Variable
	Unit:	mgN/l
	Value:	133.6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

N_ti4a:	Description:	Influent TKN B-26
	Type:	Constant Variable
	Unit:	mgN/l
	Value:	101.2
	Standard Deviation:	1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

N_ti4b:	Description:	Influent TKN B-26
	Type:	Constant Variable
	Unit:	mgN/l
	Value:	101.2
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

N_ti5a:	Description:	Influent TKN B-28
	Type:	Constant Variable
	Unit:	mgN/l
	Value:	95
	Standard Deviation:	1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

N_ti5b:	Description:	Influent TKN B-28
	Type:	Constant Variable
	Unit:	mgN/l
	Value:	95
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

N_ti6a:	Description:	Influent TKN B-30
	Type:	Constant Variable
	Unit:	mgN/l
	Value:	112.136
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

N_ti6b:	Description:	Influent TKN B-30

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Type:	Constant Variable
Unit:	mgN/l
Value:	112.136
Standard Deviation:	0.1
Minimum:	0
Maximum:	1000
Sensitivity Analysis:	inactive
Parameter Estimation:	inactive

OUR_AUT:	Description:	OUR for autotrophic growth (Nitrification OUR)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	$(-1/24) * (- (4.57 - Y_{AUT}) / Y_{AUT}) * \mu_{AUT} * (S_{O2} / (K_{O2} + S_{O2})) * (S_{NH4} / (K_{NH4AUT} + S_{NH4})) * (S_{PO4} / (K_P + S_{PO4})) * X_{AUT}$
OUR_c:	Description:	Total OUR (B-I)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	$OUR_{HSF} + OUR_{HSA} + OUR_{PAO} + OUR_{PP}$
OUR_HSA:	Description:	OUR for heterotrophic growth on S_A
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	$(-1/24) * (- (1 - Y_H) / Y_H) * \mu_H * (S_A / (S_F + S_A)) * (S_{O2} / (K_{O2} + S_{O2})) * (S_A / (K_{AOHO} + S_A)) * (S_{NH4} / (K_{NH4OHO} + S_{NH4})) * (S_{PO4} / (K_P + S_{PO4})) * (X_H)$
OUR_HSF:	Description:	OUR for heterotrophic growth on S_F
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	$(-1/24) * (- (1 - Y_H) / Y_H) * \mu_H * (S_F / (S_F + S_A)) * (S_{O2} / (K_{O2} + S_{O2})) * (S_F / (K_F + S_F)) * (S_{NH4} / (K_{NH4OHO} + S_{NH4})) * (S_{PO4} / (K_P + S_{PO4})) * (X_H)$
OUR_PAO:	Description:	OUR for PAO growth
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	$(-1/24) * (- (1 - Y_{PAO}) / Y_{PAO}) * \mu_{PAO} * (S_{O2} / (K_{O2} + S_{O2})) * (S_{NH4} / (K_{NH4PAO} + S_{NH4})) * (S_{PO4} / (K_P + S_{PO4})) * ((X_{PHA} / X_{PAO}) / (K_{PHA} + (X_{PHA} / X_{PAO}))) * X_{PAO}$
OUR_PP:	Description:	OUR for X_PP storage
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	$(-1/24) * (- Y_{PHA}) * q_{PP} * (S_{O2} / (K_{O2} + S_{O2})) * (S_{PO4} / (K_{PS} + S_{PO4})) * ((X_{PHA} / X_{PAO}) / (K_{PHA} + (X_{PHA} / X_{PAO}))) * ((K_{Max} - (X_{PP} / X_{PAO})) / (K_{IPP} + K_{Max} - (X_{PP} / X_{PAO}))) * X_{PAO}$
OUR_t:	Description:	Total OUR
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	$OUR_{HSF} + OUR_{HSA} + OUR_{AUT} + OUR_{PAO} + OUR_{PP}$

_PP

OUR_t_meas: Description: Measured OUR (B-I)
 Type: Variable List Variable
 Unit: mg/l/h
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (6 pairs):
 1 OUR_t_meas1
 2 OUR_t_meas2
 3 OUR_t_meas3
 4 OUR_t_meas4
 5 OUR_t_meas5
 6 OUR_t_meas6

OUR_t_meas1: Description: Measured OUR (B-1)
 Type: Constant Variable
 Unit: mg/l/h
 Value: 129
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

OUR_t_meas2: Description: Measured OUR (B-2)
 Type: Constant Variable
 Unit: mg/l/h
 Value: 129
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

OUR_t_meas3: Description: Measured OUR (B-5)
 Type: Constant Variable
 Unit: mg/l/h
 Value: 129
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

OUR_t_meas4: Description: Measured OUR (B-26)
 Type: Constant Variable
 Unit: mg/l/h
 Value: 81
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

OUR_t_meas5: Description: Measured OUR (B-28)
 Type: Constant Variable
 Unit: mg/l/h
 Value: 140
 Standard Deviation: 0.1
 Minimum: 0

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Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

OUR_t_meas6: Description: Measured OUR (B-30)
 Type: Constant Variable
 Unit: mg/l/h
 Value: 129
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

P_i: Description: Influent P
 Type: Variable List Variable
 Unit: mgP/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (12 pairs):

1	P_ila
2	P_i2a
3	P_i3a
4	P_i4a
5	P_i5a
6	P_i6a
11	P_ilb
12	P_i2b
13	P_i3b
14	P_i4b
15	P_i5b
16	P_i6b

P_ila: Description: Influent P B-1
 Type: Constant Variable
 Unit: mgP/l
 Value: 18.25
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

P_ilb: Description: Influent P B-1
 Type: Constant Variable
 Unit: mgP/l
 Value: 18.25
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

P_i2a: Description: Influent P B-2
 Type: Constant Variable
 Unit: mgP/l
 Value: 30.94
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive

Parameter Estimation: inactive

P_i2b:	Description:	Influent P B-2
	Type:	Constant Variable
	Unit:	mgP/l
	Value:	30.94
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

P_i3a:	Description:	Influent P B-5
	Type:	Constant Variable
	Unit:	mgP/l
	Value:	25.19
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

P_i3b:	Description:	Influent P B-5
	Type:	Constant Variable
	Unit:	mgP/l
	Value:	25.19
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

P_i4a:	Description:	Influent P B-26
	Type:	Constant Variable
	Unit:	mgP/l
	Value:	29.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

P_i4b:	Description:	Influent P B-26
	Type:	Constant Variable
	Unit:	mgP/l
	Value:	29.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

P_i5a:	Description:	Influent P B-28
	Type:	Constant Variable
	Unit:	mgP/l
	Value:	31
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

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P_i5b:	Description:	Influent P B-28
	Type:	Constant Variable
	Unit:	mgP/l
	Value:	31
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
P_i6a:	Description:	Influent P B-30
	Type:	Constant Variable
	Unit:	mgP/l
	Value:	26.099
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
P_i6b:	Description:	Influent P B-30
	Type:	Constant Variable
	Unit:	mgP/l
	Value:	26.099
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
Q:	Description:	Total flow
	Type:	Program Variable
	Unit:	l/d
	Reference to:	Discharge
Q_as:	Description:	(a+s)-recycle flow from aerobic to anoxic
	Type:	Formula Variable
	Unit:	l/d
	Expression:	$(2+1)*Q_i$
Q_e:	Description:	Effluent flow
	Type:	Formula Variable
	Unit:	l/d
	Expression:	$Q_i - Q_w$
q_fe:	Description:	Maximum rate of fermentation for heterotrophs
	Type:	Formula Variable
	Unit:	gCOD(g.COD)-1
	Expression:	$q_{fe20} * \exp(\text{the\_qfe} * (T - 20))$
q_fe20:	Description:	Maximum rate of fermentation
	Type:	Variable List Variable
	Unit:	gCOD(g.COD)-1
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (12 pairs):	
	1	q_fe20_1a
	2	q_fe20_2a

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3	q_fe20_3a
4	q_fe20_4a
5	q_fe20_5a
6	q_fe20_6a
11	q_fe20_1b
12	q_fe20_2b
13	q_fe20_3b
14	q_fe20_4b
15	q_fe20_5b
16	q_fe20_6b

q_fe20_1a: Description: Maximum rate of fermentation B-1
 Type: Constant Variable
 Unit: gCOD(g.COD)-1
 Value: 0.001
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

q_fe20_1b: Description: Maximum rate of fermentation B-1
 Type: Constant Variable
 Unit: gCOD(g.COD)-1
 Value: 5
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

q_fe20_2a: Description: Maximum rate of fermentation B-2
 Type: Constant Variable
 Unit: gCOD(g.COD)-1
 Value: 0.586
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

q_fe20_2b: Description: Maximum rate of fermentation B-2
 Type: Constant Variable
 Unit: gCOD(g.COD)-1
 Value: 5
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

q_fe20_3a: Description: Maximum rate of fermentation B-5
 Type: Constant Variable
 Unit: gCOD(g.COD)-1
 Value: 158
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 200
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

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q_fe20_3b:	Description:	Maximum rate of fermentation B-5
	Type:	Constant Variable
	Unit:	gCOD(g.COD) ⁻¹
	Value:	5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

q_fe20_4a:	Description:	Maximum rate of fermentation B-26
	Type:	Constant Variable
	Unit:	gCOD(g.COD) ⁻¹
	Value:	1.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

q_fe20_4b:	Description:	Maximum rate of fermentation B-26
	Type:	Constant Variable
	Unit:	gCOD(g.COD) ⁻¹
	Value:	5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

q_fe20_5a:	Description:	Maximum rate of fermentation B-28
	Type:	Constant Variable
	Unit:	gCOD(g.COD) ⁻¹
	Value:	2.129
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

q_fe20_5b:	Description:	Maximum rate of fermentation B-28
	Type:	Constant Variable
	Unit:	gCOD(g.COD) ⁻¹
	Value:	5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

q_fe20_6a:	Description:	Maximum rate of fermentation B-30
	Type:	Constant Variable
	Unit:	gCOD(g.COD) ⁻¹
	Value:	1.65
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

q_fe20_6b:	Description:	Maximum rate of fermentation B-30

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	Type:	Constant Variable
	Unit:	gCOD(g.COD)-1
	Value:	5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
Q_i:	Description:	Influent flow
	Type:	Formula Variable
	Unit:	1/d
	Expression:	140
q_PHA:	Description:	Rate constant for storage of PHA (base: X_PP)
	Type:	Formula Variable
	Unit:	gCOD (gPAO)-1 d-1
	Expression:	q_PHA20*exp(the_qPHA*(T-20))
q_PHA20:	Description:	Rate constant for storage of PHA (base: X_PP)
	Type:	Constant Variable
	Unit:	gCOD (gPAO)-1 d-1
	Value:	6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
q_PP:	Description:	Rate constant for storage of PP
	Type:	Formula Variable
	Unit:	gPP (gPAO)-1 d-1
	Expression:	q_PP20*exp(the_qPP*(T-20))
q_PP20:	Description:	Rate constant for storage of PP
	Type:	Variable List Variable
	Unit:	gPP (gPAO)-1 d-1
	Argument:	Calcnun
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (12 pairs):	
	1	q_PP20_1a
	2	q_PP20_2a
	3	q_PP20_3a
	4	q_PP20_4a
	5	q_PP20_5a
	6	q_PP20_6a
	11	q_PP20_1b
	12	q_PP20_2b
	13	q_PP20_3b
	14	q_PP20_4b
	15	q_PP20_5b
	16	q_PP20_6b
q_PP20_1a:	Description:	Rate constant for storage of PP B-1
	Type:	Constant Variable
	Unit:	gPP (gPAO)-1 d-1
	Value:	1.35
	Standard Deviation:	0.1
	Minimum:	0

Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

q_PP20_1b: Description: Rate constant for storage of PP B-1
 Type: Constant Variable
 Unit: gPP (gPAO)-1 d-1
 Value: 1.108
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

q_PP20_2a: Description: Rate constant for storage of PP B-2
 Type: Constant Variable
 Unit: gPP (gPAO)-1 d-1
 Value: 1.35
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

q_PP20_2b: Description: Rate constant for storage of PP B-2
 Type: Constant Variable
 Unit: gPP (gPAO)-1 d-1
 Value: 1.199
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

q_PP20_3a: Description: Rate constant for storage of PP B-5
 Type: Constant Variable
 Unit: gPP (gPAO)-1 d-1
 Value: 1.35
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

q_PP20_3b: Description: Rate constant for storage of PP B-5
 Type: Constant Variable
 Unit: gPP (gPAO)-1 d-1
 Value: 1.5
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

q_PP20_4a: Description: Rate constant for storage of PP B-2
 Type: Constant Variable
 Unit: gPP (gPAO)-1 d-1
 Value: 1.35
 Standard Deviation: 0.1
 Minimum: 0

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	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
q_PP20_4b:	Description:	Rate constant for storage of PP B-2 6
	Type:	Constant Variable
	Unit:	gPP (gPAO)-1 d-1
	Value:	1.268
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
q_PP20_5a:	Description:	Rate constant for storage of PP B-2 8
	Type:	Constant Variable
	Unit:	gPP (gPAO)-1 d-1
	Value:	1.35
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
q_PP20_5b:	Description:	Rate constant for storage of PP B-2 8
	Type:	Constant Variable
	Unit:	gPP (gPAO)-1 d-1
	Value:	1.326
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
q_PP20_6a:	Description:	Rate constant for storage of PP B-3 0
	Type:	Constant Variable
	Unit:	gPP (gPAO)-1 d-1
	Value:	1.35
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
q_PP20_6b:	Description:	Rate constant for storage of PP B-3 0
	Type:	Constant Variable
	Unit:	gPP (gPAO)-1 d-1
	Value:	1.298
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
Q_r:	Description:	r_recycle flow from anoxic to anaerobic

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	Type:	Formula Variable
	Unit:	1/d
	Expression:	1*Q_i
Q_rec:	Description:	"Underflow recycle"
	Type:	Formula Variable
	Unit:	1/d
	Expression:	1*Q_i
Q_w:	Description:	Waste flow
	Type:	Formula Variable
	Unit:	1/d
	Expression:	((V_anaer*X_tanaer)+(V_anox*X_tanox)+(V_aero*X_taero))/(R_s*X_taero)
Q_wm:	Description:	Measured waste flow
	Type:	Variable List Variable
	Unit:	1/d
	Argument:	Calcnm
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (6 pairs):	
	1	Q_wm1
	2	Q_wm2
	3	Q_wm3
	4	Q_wm4
	5	Q_wm5
	6	Q_wm6
Q_wm1:	Description:	Measured waste flow for B-1
	Type:	Constant Variable
	Unit:	1/d
	Value:	2.9
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
Q_wm2:	Description:	Measured waste flow for B-2
	Type:	Constant Variable
	Unit:	1/d
	Value:	2.46
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
Q_wm3:	Description:	Measured waste flow for B-5
	Type:	Constant Variable
	Unit:	1/d
	Value:	3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
Q_wm4:	Description:	Measured waste flow for B-26
	Type:	Constant Variable
	Unit:	1/d

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	Value:	2.8
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
Q_wm5:	Description:	Measured waste flow for B-28
	Type:	Constant Variable
	Unit:	1/d
	Value:	2.9
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
Q_wm6:	Description:	Measured waste flow for B-30
	Type:	Constant Variable
	Unit:	1/d
	Value:	2.832
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
R_hn:	Description:	Nominal hydraulic retention time
	Type:	Constant Variable
	Unit:	d
	Value:	0.5357
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	20
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
R_s:	Description:	Sludge age
	Type:	Constant Variable
	Unit:	d
	Value:	20
	Standard Deviation:	1
	Minimum:	0
	Maximum:	20
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_A:	Description:	Fermentable products (acetate)
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006
S_Ain:	Description:	Influent concentration of fermentable products (acetate)
	Type:	Formula Variable
	Unit:	mg/l
	Expression:	$(f_{ac} * f_{bs}) * S_{ti} * (1 - f_{us} - f_{up})$
S_Aini:	Description:	Initial concentration of fermentable products (acetate)

	Type:	Formula Variable
	Unit:	mg/l
	Expression:	$(f_{ac} * f_{bs}) * S_{ti} * (1 - f_{us} - f_{up})$
S_F:	Description:	Fermentable, readily biodegradable organic substrate
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006
S_Fin:	Description:	Influent concentration of fermentable, readily biodegradable organic substrate
	Type:	Formula Variable
	Unit:	mg/l
	Expression:	$(1 - f_{ac}) * f_{bs} * S_{ti} * (1 - f_{us} - f_{up})$
S_Fini:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate
	Type:	Formula Variable
	Unit:	mg/l
	Expression:	$(1 - f_{ac}) * f_{bs} * S_{ti} * (1 - f_{us} - f_{up})$
S_I:	Description:	Inert soluble organic material
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006
S_Iin:	Description:	Influent concentration of inert soluble organic material
	Type:	Formula Variable
	Unit:	mg/l
	Expression:	$f_{us} * S_{ti}$
S_Iini:	Description:	Initial concentration of inert soluble organic material
	Type:	Formula Variable
	Unit:	mg/l
	Expression:	$f_{us} * S_{ti}$
S_N2:	Description:	Denitrogen gas
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006
S_N2in:	Description:	Influent concentration of denitrogen
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_N2ini:	Description:	Initial concentration of denitrogen

Type:	Constant Variable
Unit:	mg/l
Value:	0
Standard Deviation:	0.1
Minimum:	0
Maximum:	10
Sensitivity Analysis:	inactive
Parameter Estimation:	inactive

S_NH4:	Description:	Ammonium plus ammonia nitrogen
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006

S_NH4in:	Description:	Influent concentration of ammonium plus ammonia nitrogen
	Type:	Variable List Variable
	Unit:	mg/l
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (12 pairs):	
	1	S_NH4in1a
	2	S_NH4in2a
	3	S_NH4in3a
	4	S_NH4in4a
	5	S_NH4in5a
	6	S_NH4in6a
	11	S_NH4in1b
	12	S_NH4in2b
	13	S_NH4in3b
	14	S_NH4in4b
	15	S_NH4in5b
	16	S_NH4in6b

S_NH4in1a:	Description:	Influent concentration of ammonium plus ammonia nitrogen B-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	62.64
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4in1b:	Description:	Influent concentration of ammonium plus ammonia nitrogen B-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	64.46
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4in2a:	Description:	Influent concentration of ammonium plus ammonia nitrogen B-2
	Type:	Constant Variable
	Unit:	mg/l

Value: 94.43
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NH4in2b: Description: Influent concentration of ammonium plus ammonia nitrogen B-2
 Type: Constant Variable
 Unit: mg/l
 Value: 95.87
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NH4in3a: Description: Influent concentration of ammonium plus ammonia nitrogen B-5
 Type: Constant Variable
 Unit: mg/l
 Value: 96.32
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NH4in3b: Description: Influent concentration of ammonium plus ammonia nitrogen B-5
 Type: Constant Variable
 Unit: mg/l
 Value: 94.94
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NH4in4a: Description: Influent concentration of ammonium plus ammonia nitrogen B-26
 Type: Constant Variable
 Unit: mg/l
 Value: 62.61
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NH4in4b: Description: Influent concentration of ammonium plus ammonia nitrogen B-26
 Type: Constant Variable
 Unit: mg/l
 Value: 63.17
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NH4in5a:	Description:	Influent concentration of ammonium plus ammonia nitrogen B-28
	Type:	Constant Variable
	Unit:	mg/l
	Value:	56.27
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4in5b:	Description:	Influent concentration of ammonium plus ammonia nitrogen B-28
	Type:	Constant Variable
	Unit:	mg/l
	Value:	55.34
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4in6a:	Description:	Influent concentration of ammonium plus ammonia nitrogen B-30
	Type:	Constant Variable
	Unit:	mg/l
	Value:	74.18
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4in6b:	Description:	Influent concentration of ammonium plus ammonia nitrogen B-30
	Type:	Constant Variable
	Unit:	mg/l
	Value:	73.97
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini:	Description:	Initial concentration of ammonium plus ammonia nitrogen
	Type:	Variable List Variable
	Unit:	mg/l
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (12 pairs):	
	1	S_NH4inila
	2	S_NH4ini2a
	3	S_NH4ini3a
	4	S_NH4ini4a
	5	S_NH4ini5a
	6	S_NH4ini6a
	11	S_NH4ini1b
	12	S_NH4ini2b
	13	S_NH4ini3b

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14 S_NH4ini4b
15 S_NH4ini5b
16 S_NH4ini6b

S_NH4inila:	Description:	Initial concentration of ammonium p lus ammonia nitrogen B-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	62.64
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4inilb:	Description:	Initial concentration of ammonium p lus ammonia nitrogen B-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	64.46
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini2a:	Description:	Initial concentration of ammonium p lus ammonia nitrogen B-2
	Type:	Constant Variable
	Unit:	mg/l
	Value:	94.43
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini2b:	Description:	Initial concentration of ammonium plus ammonia nitrogen B-2
	Type:	Constant Variable
	Unit:	mg/l
	Value:	95.87
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini3a:	Description:	Initial concentration of ammonium plus ammonia nitrogen B-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	96.32
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini3b:	Description:	Initial concentration of ammonium plus ammonia nitrogen B-5

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	Type:	Constant Variable
	Unit:	mg/l
	Value:	94.94
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini4a:	Description:	Initial concentration of ammonium p lus ammonia nitrogen B-26
	Type:	Constant Variable
	Unit:	mg/l
	Value:	62.61
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini4b:	Description:	Initial concentration of ammonium p lus ammonia nitrogen B-26
	Type:	Constant Variable
	Unit:	mg/l
	Value:	63.17
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini5a:	Description:	Initial concentration of ammonium p lus ammonia nitrogen B-28
	Type:	Constant Variable
	Unit:	mg/l
	Value:	56.27
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini5b:	Description:	Initial concentration of ammonium p lus ammonia nitrogen B-28
	Type:	Constant Variable
	Unit:	mg/l
	Value:	55.34
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini6a:	Description:	Initial concentration of ammonium p lus ammonia nitrogen B-30
	Type:	Constant Variable
	Unit:	mg/l
	Value:	74.18
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000

Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NH4ini6b: Description: Initial concentration of ammonium plus ammonia nitrogen B-30
 Type: Constant Variable
 Unit: mg/l
 Value: 73.97
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NH4meas: Description: Measured soluble ammonia in the effluent
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (6 pairs):
 1 S_NH4meas1
 2 S_NH4meas2
 3 S_NH4meas3
 4 S_NH4meas4
 5 S_NH4meas5
 6 S_NH4meas6

S_NH4meas1: Description: Measured soluble ammonia in the effluent (B-1)
 Type: Constant Variable
 Unit: mg/l
 Value: 1.16
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NH4meas2: Description: Measured soluble ammonia in the effluent (B-2)
 Type: Constant Variable
 Unit: mg/l
 Value: 2.35
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NH4meas3: Description: Measured soluble ammonia in the effluent (B-5)
 Type: Constant Variable
 Unit: mg/l
 Value: 1
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

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S_NH4meas4:	Description:	Measured soluble ammonia in the effluent (B-26)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.4
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4meas5:	Description:	Measured soluble ammonia in the effluent (B-28)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4meas6:	Description:	Measured soluble ammonia in the effluent (B-30)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1.107
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NO3:	Description:	Nitrate plus nitrite nitrogen
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006

S_NO3in:	Description:	Influent concentration of nitrate plus nitrite nitrogen
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NO3ini:	Description:	Initial concentration of nitrate plus nitrite nitrogen
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

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S_NO3meas: Description: Measured nitrate in the effluent
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (6 pairs):
 1 S_NO3meas1
 2 S_NO3meas2
 3 S_NO3meas3
 4 S_NO3meas4
 5 S_NO3meas5
 6 S_NO3meas6

S_NO3meas1: Description: Measured nitrate in the effluent (B
 -I)
 Type: Constant Variable
 Unit: mg/l
 Value: 24.85
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NO3meas2: Description: Measured nitrate in the effluent (B
 -2)
 Type: Constant Variable
 Unit: mg/l
 Value: 23.81
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NO3meas3: Description: Measured nitrate in the effluent (B
 -5)
 Type: Constant Variable
 Unit: mg/l
 Value: 18.7
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NO3meas4: Description: Measured nitrate in the effluent (B
 -26)
 Type: Constant Variable
 Unit: mg/l
 Value: 19.2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NO3meas5: Description: Measured nitrate in the effluent (B
 -28)
 Type: Constant Variable
 Unit: mg/l

Value: 12.4
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NO3meas6: Description: Measured nitrate in the effluent (B-30)
 Type: Constant Variable
 Unit: mg/l
 Value: 19.774
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_O2: Description: Dissolved oxygen
 Type: Dyn. Volume State Var.
 Unit: mg/l
 Relative Accuracy: 1e-006
 Absolute Accuracy: 1e-006

S_O2sat: Description: Saturation dissolved oxygen concentration
 Type: Constant Variable
 Unit: mg/l
 Value: 8.5
 Standard Deviation: 0.1
 Minimum: 2
 Maximum: 9
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4: Description: Phosphate
 Type: Dyn. Volume State Var.
 Unit: mg/l
 Relative Accuracy: 1e-006
 Absolute Accuracy: 1e-006

S_PO4in: Description: Influent concentration of PO4-P
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (12 pairs):

1	S_PO4in1a
2	S_PO4in2a
3	S_PO4in3a
4	S_PO4in4a
5	S_PO4in5a
6	S_PO4in6a
11	S_PO4in1b
12	S_PO4in2b
13	S_PO4in3b
14	S_PO4in4b
15	S_PO4in5b
16	S_PO4in6b

S_PO4in1a: Description: Influent concentration of PO4-P (B-

	1)
Type:	Constant Variable
Unit:	mg/l
Value:	18.25
Standard Deviation:	0.1
Minimum:	0
Maximum:	100
Sensitivity Analysis:	inactive
Parameter Estimation:	inactive

S_PO4in1b:	Description: Influent concentration of PO4-P (B-1)
Type:	Constant Variable
Unit:	mg/l
Value:	18.25
Standard Deviation:	0.1
Minimum:	0
Maximum:	100
Sensitivity Analysis:	inactive
Parameter Estimation:	inactive

S_PO4in2a:	Description: Influent concentration of PO4-P (B-2)
Type:	Constant Variable
Unit:	mg/l
Value:	30.94
Standard Deviation:	0.1
Minimum:	0
Maximum:	100
Sensitivity Analysis:	inactive
Parameter Estimation:	inactive

S_PO4in2b:	Description: Influent concentration of PO4-P (B-2)
Type:	Constant Variable
Unit:	mg/l
Value:	30.94
Standard Deviation:	0.1
Minimum:	0
Maximum:	100
Sensitivity Analysis:	inactive
Parameter Estimation:	inactive

S_PO4in3a:	Description: Influent concentration of PO4-P (B-5)
Type:	Constant Variable
Unit:	mg/l
Value:	25.19
Standard Deviation:	0.1
Minimum:	0
Maximum:	100
Sensitivity Analysis:	inactive
Parameter Estimation:	inactive

S_PO4in3b:	Description: Influent concentration of PO4-P (B-5)
Type:	Constant Variable
Unit:	mg/l
Value:	25.19
Standard Deviation:	0.1
Minimum:	0

Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4in4a: Description: Influent concentration of PO4-P (B-26)
 Type: Constant Variable
 Unit: mg/l
 Value: 29.3
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4in4b: Description: Influent concentration of PO4-P (B-26)
 Type: Constant Variable
 Unit: mg/l
 Value: 29.3
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4in5a: Description: Influent concentration of PO4-P (B-28)
 Type: Constant Variable
 Unit: mg/l
 Value: 31
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4in5b: Description: Influent concentration of PO4-P (B-28)
 Type: Constant Variable
 Unit: mg/l
 Value: 31
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4in6a: Description: Influent concentration of PO4-P (B-30)
 Type: Constant Variable
 Unit: mg/l
 Value: 26.099
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4in6b: Description: Influent concentration of PO4-P (B-30)

Type: Constant Variable
 Unit: mg/l
 Value: 26.099
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4ini: Description: Initial concentration
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (12 pairs):

1	S_PO4inila
2	S_PO4ini2a
3	S_PO4ini3a
4	S_PO4ini4a
5	S_PO4ini5a
6	S_PO4ini6a
11	S_PO4inilb
12	S_PO4ini2b
13	S_PO4ini3b
14	S_PO4ini4b
15	S_PO4ini5b
16	S_PO4ini6b

S_PO4inila: Description: Initial concentration of orthophosphate (B-1)
 Type: Constant Variable
 Unit: mg/l
 Value: 18.25
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4inilb: Description: Initial concentration of orthophosphate (B-1)
 Type: Constant Variable
 Unit: mg/l
 Value: 18.25
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4ini2a: Description: Initial concentration of orthophosphate (B-2)
 Type: Constant Variable
 Unit: mg/l
 Value: 30.94
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4ini2b:	Description:	Initial concentration of orthophosphate (B-2)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	30.94
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_PO4ini3a:	Description:	Initial concentration of orthophosphate (B-5)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	25.19
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_PO4ini3b:	Description:	Initial concentration of orthophosphate (B-5)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	25.19
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_PO4ini4a:	Description:	Initial concentration of orthophosphate (B-26)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	29.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_PO4ini4b:	Description:	Initial concentration of orthophosphate (B-26)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	29.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_PO4ini5a:	Description:	Initial concentration of orthophosphate (B-28)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	31
	Standard Deviation:	0.1

Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4ini5b: Description: Initial concentration of orthophosphate (B-28)
 Type: Constant Variable
 Unit: mg/l
 Value: 31
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4ini6a: Description: Initial concentration of orthophosphate (B-30)
 Type: Constant Variable
 Unit: mg/l
 Value: 26.099
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4ini6b: Description: Initial concentration of orthophosphate (B-30)
 Type: Constant Variable
 Unit: mg/l
 Value: 26.099
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4meas: Description: Measured soluble phosphorus in the effluent
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (6 pairs):
 1 S_PO4meas1
 2 S_PO4meas2
 3 S_PO4meas3
 4 S_PO4meas4
 5 S_PO4meas5
 6 S_PO4meas6

S_PO4meas1: Description: Measured soluble phosphorus in the effluent (B-1)
 Type: Constant Variable
 Unit: mg/l
 Value: 11.6
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive

Parameter Estimation: inactive

S_PO4meas2:	Description:	Measured soluble phosphorus in the effluent (B-2)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	15.41
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_PO4meas3:	Description:	Measured soluble phosphorus in the effluent (B-5)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	4.6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_PO4meas4:	Description:	Measured soluble phosphorus in the effluent (B-26)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	9
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_PO4meas5:	Description:	Measured soluble phosphorus in the effluent (B-28)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	4.7
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_PO4meas6:	Description:	Measured soluble phosphorus in the effluent (B-30)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	8.437
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_ti:	Description:	Influent COD
	Type:	Variable List Variable
	Unit:	mgCOD/l
	Argument:	Calcnum

Interpolation Method: linear interpolation
 Real-Variable Data Pairs (12 pairs):

1	S_tila
2	S_ti2a
3	S_ti3a
4	S_ti4a
5	S_ti5a
6	S_ti6a
11	S_tilb
12	S_ti2b
13	S_ti3b
14	S_ti4b
15	S_ti5b
16	S_ti6b

S_tila:	Description:	Influent COD (B-1)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	958.41
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_tilb:	Description:	Influent COD (B-1)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	958.41
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_ti2a:	Description:	Influent COD (B-2)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	1112.17
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_ti2b:	Description:	Influent COD (B-2)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	1112.17
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_ti3a:	Description:	Influent COD (B-5)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	912.44
	Standard Deviation:	0.1
	Minimum:	0

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	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_ti3b:	Description:	Influent COD (B-5)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	912.44
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_ti4a:	Description:	Influent COD (B-26)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	993.5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_ti4b:	Description:	Influent COD (B-26)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	993.5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_ti5a:	Description:	Influent COD (B-28)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	956.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_ti5b:	Description:	Influent COD (B-28)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	956.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_ti6a:	Description:	Influent COD (B-30)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	943.983
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000

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Sensitivity Analysis: inactive
Parameter Estimation: inactive

S_ti6b:	Description:	Influent COD (B-30)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	943.983
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
T:	Description:	Temperature
	Type:	Formula Variable
	Unit:	degC
	Expression:	20
t:	Description:	Time
	Type:	Program Variable
	Unit:	d
	Reference to:	Time
the_bAUT:	Description:	Arrhenius constant for the decay rate of autotrophs
	Type:	Constant Variable
	Unit:	
	Value:	1.029
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
the_bH:	Description:	Arrhenius constant for the rate constant for lysis of heterotrophs
	Type:	Constant Variable
	Unit:	
	Value:	1.029
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
the_bPAO:	Description:	Arrhenius constant for the rate constant for lysis of X_PAO
	Type:	Constant Variable
	Unit:	
	Value:	1.029
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
the_bPHA:	Description:	Arrhenius constant for the rate constant for lysis of X_PHA
	Type:	Constant Variable
	Unit:	
	Value:	1.029

	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
the_bPP:	Description:	Arrhenius constant for the rate constant for lysis of X_PP
	Type:	Constant Variable
	Unit:	
	Value:	1.029
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
the_Kh:	Description:	Arrhenius constant
	Type:	Constant Variable
	Unit:	
	Value:	1.08
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
the_KX:	Description:	Arrhenius constant for saturation coefficient for particulate COD
	Type:	Constant Variable
	Unit:	
	Value:	0.91
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
the_mueAUT:	Description:	Arrhenius constant for maximum growth rate of autotrophs
	Type:	Constant Variable
	Unit:	/d
	Value:	1.123
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
the_mueH:	Description:	Arrhenius constant for maximum growth rate of heterotrophs
	Type:	Constant Variable
	Unit:	/d
	Value:	1.2
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
the_muePAO:	Description:	Arrhenius constant for maximum growth rate of autotrophs

	th rate of PAOs
Type:	Constant Variable
Unit:	/d
Value:	1.08
Standard Deviation:	0.1
Minimum:	0
Maximum:	10
Sensitivity Analysis:	inactive
Parameter Estimation:	inactive
the_qfe:	Description: Arrhenius constant for maximum rate of fermentation
Type:	Constant Variable
Unit:	/d
Value:	1.016
Standard Deviation:	0.1
Minimum:	0
Maximum:	10
Sensitivity Analysis:	inactive
Parameter Estimation:	inactive
the_qPHA:	Description: Arrhenius constant for rate constant for storage of PHA (base: Xpp)
Type:	Constant Variable
Unit:	/d
Value:	1
Standard Deviation:	0.1
Minimum:	0
Maximum:	10
Sensitivity Analysis:	inactive
Parameter Estimation:	inactive
the_qPP:	Description: Arrhenius constant for rate constant for storage of PP
Type:	Constant Variable
Unit:	/d
Value:	1
Standard Deviation:	0.1
Minimum:	0
Maximum:	10
Sensitivity Analysis:	inactive
Parameter Estimation:	inactive
TKN:	Description: Total Kjeldahl Nitrogen
Type:	Formula Variable
Unit:	mgN/l
Expression:	$S_{NH4} + (S_I \cdot i_{NSi}) + (S_F \cdot i_{NSf}) + (X_I \cdot i_{NXi}) + (X_S \cdot i_{NXs}) + ((X_H + X_{PAO} + X_{AUT}) \cdot i_{NBM})$
TKN_meas:	Description: Measured TKN
Type:	Variable List Variable
Unit:	mg/l
Argument:	Calcnum
Interpolation Method:	linear interpolation
Real-Variable Data Pairs (6 pairs):	
1	TKN_meas1
2	TKN_meas2
3	TKN_meas3
4	TKN_meas4
5	TKN_meas5

6	TKN_meas6
TKN_meas1:	Description: Measured TKN (B-1) Type: Constant Variable Unit: mg/l Value: 3.11 Standard Deviation: 0.1 Minimum: 0 Maximum: 100 Sensitivity Analysis: inactive Parameter Estimation: inactive
TKN_meas2:	Description: Measured TKN (B-2) Type: Constant Variable Unit: mg/l Value: 3.92 Standard Deviation: 0.1 Minimum: 0 Maximum: 100 Sensitivity Analysis: inactive Parameter Estimation: inactive
TKN_meas3:	Description: Measured TKN (B-5) Type: Constant Variable Unit: mg/l Value: 1.62 Standard Deviation: 0.1 Minimum: 0 Maximum: 100 Sensitivity Analysis: inactive Parameter Estimation: inactive
TKN_meas4:	Description: Measured TKN (B-26) Type: Constant Variable Unit: mg/l Value: 1.3 Standard Deviation: 0.1 Minimum: 0 Maximum: 100 Sensitivity Analysis: inactive Parameter Estimation: inactive
TKN_meas5:	Description: Measured TKN (B-28) Type: Constant Variable Unit: mg/l Value: 1.3 Standard Deviation: 0.1 Minimum: 0 Maximum: 100 Sensitivity Analysis: inactive Parameter Estimation: inactive
TKN_meas6:	Description: Measured TKN (B-30) Type: Constant Variable Unit: mg/l Value: 1.89 Standard Deviation: 0.1 Minimum: 0 Maximum: 100 Sensitivity Analysis: inactive Parameter Estimation: inactive

TSS:	Description:	TSS
	Type:	Formula Variable
	Unit:	mgTSS/l
	Expression:	VSS+ISS_Xoi

TSS_measAero:	Description:	Measured TSS (aerobic)
	Type:	Variable List Variable
	Unit:	mgTSS/l
	Argument:	Calcnun
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (6 pairs):	
	1	TSS_measAero1
	2	TSS_measAero2
	3	TSS_measAero3
	4	TSS_measAero4
	5	TSS_measAero5
	6	TSS_measAero6

TSS_measAero1:	Description:	Measured TSS (B-1) (aerobic)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	16774.8
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	20000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

TSS_measAero2:	Description:	Measured TSS (B-2) (aerobic)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	15538.44
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	20000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

TSS_measAero3:	Description:	Measured TSS (B-5) (aerobic)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	17201
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	20000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

TSS_measAero4:	Description:	Measured TSS (B-26) (aerobic)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	17316
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	20000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

TSS_measAero5:	Description:	Measured TSS (B-28) (aerobic)
	Type:	Constant Variable

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Unit: mgTSS/l
 Value: 17819.6
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

TSS_measAero6: Description: Measured TSS (B-30) (aerobic)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 16945.1
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

TSS_measAnaer: Description: Measured TSS (anaerobic)
 Type: Variable List Variable
 Unit: mgTSS/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (6 pairs):
 1 TSS_measAnaer1
 2 TSS_measAnaer2
 3 TSS_measAnaer3
 4 TSS_measAnaer4
 5 TSS_measAnaer5
 6 TSS_measAnaer6

TSS_measAnaer1: Description: Measured TSS (B-1) (anaerobic)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 7953.2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

TSS_measAnaer2: Description: Measured TSS (B-2) (anaerobic)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 8251.11
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

TSS_measAnaer3: Description: Measured TSS (B-5) (anaerobic)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 7523.09
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

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TSS_measAnaer4: Description: Measured TSS (B-26) (anaerobic)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 7494.2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

TSS_measAnaer5: Description: Measured TSS (B-28) (anaerobic)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 7195.1
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

TSS_measAnaer6: Description: Measured TSS (B-30) (anaerobic)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 7648.56
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

TSS_measAnox: Description: Measured TSS (anoxic)
 Type: Variable List Variable
 Unit: mgTSS/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (6 pairs):
 1 TSS_measAnox1
 2 TSS_measAnox2
 3 TSS_measAnox3
 4 TSS_measAnox4
 5 TSS_measAnox5
 6 TSS_measAnox6

TSS_measAnox1: Description: Measured TSS (B-1) (anoxic)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 13068.4
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

TSS_measAnox2: Description: Measured TSS (B-2) (anoxic)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 13059.78
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive

Parameter Estimation: inactive

TSS_measAnox3: Description: Measured TSS (B-5) (anoxic)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 13357.45
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

TSS_measAnox4: Description: Measured TSS (B-26) (anoxic)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 13292.2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

TSS_measAnox5: Description: Measured TSS (B-28) (anoxic)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 13197.6
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

TSS_measAnox6: Description: Measured TSS (B-30) (anoxic)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 13170.28
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

t_mode: Description:
 Type: Formula Variable
 Unit:
 Expression: $t \bmod 10$

Volume: Description: Volume
 Type: Program Variable
 Unit: l
 Reference to: Reactor Volume

VSS: Description: Actual VSS
 Type: Formula Variable
 Unit: mgVSS/l
 Expression: $mVSS/f_{cv}$

VSS_measAero: Description: Measured VSS (aerobic)
 Type: Variable List Variable
 Unit: mgCOD/l
 Argument: Calcnum

Interpolation Method: linear interpolation

Real-Variable Data Pairs (6 pairs):

1	VSS_measAero1
2	VSS_measAero2
3	VSS_measAero3
4	VSS_measAero4
5	VSS_measAero5
6	VSS_measAero6

VSS_measAero1:	Description:	Measured VSS (B-1) (aerobic)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	19248.88
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	20000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

VSS_measAero2:	Description:	Measured VSS (B-2) (aerobic)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	18835.138
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	20000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

VSS_measAero3:	Description:	Measured VSS (B-5) (aerobic)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	20507.373
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	25000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

VSS_measAero4:	Description:	Measured VSS (B-26) (aerobic)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	20008.94
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	25000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

VSS_measAero5:	Description:	Measured VSS (B-29) (aerobic)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	21667.644
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	25000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

VSS_measAero6:	Description:	Measured VSS (B-30) (aerobic)
	Type:	Constant Variable

Unit: mgCOD/l
 Value: 20218.92
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 25000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

VSS_measAnaer: Description: Measured VSS (anaerobic)
 Type: Variable List Variable
 Unit: mgCOD/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (6 pairs):
 1 VSS_measAnaer1
 2 VSS_measAnaer2
 3 VSS_measAnaer3
 4 VSS_measAnaer4
 5 VSS_measAnaer5
 6 VSS_measAnaer6

VSS_measAnaer1: Description: Measured VSS (B-1) (anaerobic)
 Type: Constant Variable
 Unit: mgCOD/l
 Value: 9338.4711
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

VSS_measAnaer2: Description: Measured VSS (B-2) (anaerobic)
 Type: Constant Variable
 Unit: mgCOD/l
 Value: 10378.5
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

VSS_measAnaer3: Description: Measured VSS (B-5) (anaerobic)
 Type: Constant Variable
 Unit: mgCOD/l
 Value: 9138.26
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

VSS_measAnaer4: Description: Measured VSS (B-26) (anaerobic)
 Type: Constant Variable
 Unit: mgCOD/l
 Value: 8973.61
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

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VSS_measAnaer5: Description: Measured VSS (B-28) (anaerobic)
 Type: Constant Variable
 Unit: mgCOD/l
 Value: 8982.268
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

VSS_measAnaer6: Description: Measured VSS (B-30) (anaerobic)
 Type: Constant Variable
 Unit: mgCOD/l
 Value: 9318.084
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

VSS_measAnox: Description: Measured VSS (anoxic)
 Type: Variable List Variable
 Unit: mgCOD/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (6 pairs):
 1 VSS_measAnox1
 2 VSS_measAnox2
 3 VSS_measAnox3
 4 VSS_measAnox4
 5 VSS_measAnox5
 6 VSS_measAnox6

VSS_measAnox1: Description: Measured VSS (B-1) (anoxic)
 Type: Constant Variable
 Unit: mgCOD/l
 Value: 14982.204
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

VSS_measAnox2: Description: Measured VSS (B-2) (anoxic)
 Type: Constant Variable
 Unit: mgCOD/l
 Value: 15791.929
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

VSS_measAnox3: Description: Measured VSS (B-5) (anoxic)
 Type: Constant Variable
 Unit: mgCOD/l
 Value: 15888.047
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 20000
 Sensitivity Analysis: inactive

Parameter Estimation: inactive

VSS_measAnox4:	Description:	Measured VSS (B-26) (anoxic)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	15456.13
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	20000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
VSS_measAnox5:	Description:	Measured VSS (B-28) (anoxic)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	16114.24
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	20000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
VSS_measAnox6:	Description:	Measured VSS (B-30) (anoxic)
	Type:	Constant Variable
	Unit:	mgCOD/l
	Value:	15756.19
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	20000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
V_aero:	Description:	Volume of aerobic reactor
	Type:	Formula Variable
	Unit:	l
	Expression:	35
V_anaer:	Description:	Volume of anaerobic reactor
	Type:	Formula Variable
	Unit:	l
	Expression:	19
V_anox:	Description:	Volume of anoxic reactor
	Type:	Formula Variable
	Unit:	l
	Expression:	21
X_AUT:	Description:	Nitrifying organisms
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006
X_AUTin:	Description:	Influent concentration of nitrifyin g organisms
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10

Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_AUTini: Description: Initial concentration of nitrifying organisms

Type: Variable List Variable

Unit: mg/l

Argument: Calcnum

Interpolation Method: linear interpolation

Real-Variable Data Pairs (12 pairs):

1	X_AUTinila
2	X_AUTini2a
3	X_AUTini3a
4	X_AUTini4a
5	X_AUTini5a
6	X_AUTini6a
11	X_AUTinilb
12	X_AUTini2b
13	X_AUTini3b
14	X_AUTini4b
15	X_AUTini5b
16	X_AUTini6b

X_AUTinila: Description: Initial concentration of nitrifying organisms (B-1)

Type: Constant Variable

Unit: mg/l

Value: 221

Standard Deviation: 0.1

Minimum: 0

Maximum: 1000

Sensitivity Analysis: inactive

Parameter Estimation: inactive

X_AUTinilb: Description: Initial concentration of nitrifying organisms (B-1)

Type: Constant Variable

Unit: mg/l

Value: 221

Standard Deviation: 0.1

Minimum: 0

Maximum: 1000

Sensitivity Analysis: inactive

Parameter Estimation: inactive

X_AUTini2a: Description: Initial concentration of nitrifying organisms (B-2)

Type: Constant Variable

Unit: mg/l

Value: 327

Standard Deviation: 0.1

Minimum: 0

Maximum: 1000

Sensitivity Analysis: inactive

Parameter Estimation: inactive

X_AUTini2b: Description: Initial concentration of nitrifying organisms (B-2)

Type: Constant Variable

Unit: mg/l

Value: 328

Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_AUTini3a: Description: Initial concentration of nitrifying
 organisms (B-5)
 Type: Constant Variable
 Unit: mg/l
 Value: 313
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_AUTini3b: Description: Initial concentration of nitrifying
 organisms (B-5)
 Type: Constant Variable
 Unit: mg/l
 Value: 314
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_AUTini4a: Description: Initial concentration of nitrifying
 organisms (B-26)
 Type: Constant Variable
 Unit: mg/l
 Value: 217
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_AUTini4b: Description: Initial concentration of nitrifying
 organisms (B-26)
 Type: Constant Variable
 Unit: mg/l
 Value: 218
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_AUTini5a: Description: Initial concentration of nitrifying
 organisms (B-28)
 Type: Constant Variable
 Unit: mg/l
 Value: 192
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

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X_AUTini5b:	Description:	Initial concentration of nitrifying organisms (B-28)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	191
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_AUTini6a:	Description:	Initial concentration of nitrifying organisms (B-30)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	249
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_AUTini6b:	Description:	Initial concentration of nitrifying organisms (B-30)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	249
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_H:	Description:	Heterotrophic organisms
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006

X_Hin:	Description:	Influent concentration of heterotrophic organisms
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Hini:	Description:	Initial concentration of heterotrophic organisms
	Type:	Variable List Variable
	Unit:	mg/l
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (12 pairs):	
	1	X_Hinila
	2	X_Hini2a
	3	X_Hini3a
	4	X_Hini4a

5	X_Hini5a
6	X_Hini6a
11	X_Hini1b
12	X_Hini2b
13	X_Hini3b
14	X_Hini4b
15	X_Hini5b
16	X_Hini6b

X_Hinila:	Description:	Initial concentration of heterotrophic organisms (B-1)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	2567
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Hini1b:	Description:	Initial concentration of heterotrophic organisms (B-1)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	2261
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Hini2a:	Description:	Initial concentration of heterotrophic organisms (B-2)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	3195
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Hini2b:	Description:	Initial concentration of heterotrophic organisms (B-2)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	3018
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Hini3a:	Description:	Initial concentration of heterotrophic organisms (B-5)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	2020
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000

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Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Hini3b: Description: Initial concentration of heterotrophic organisms (B-5)
 Type: Constant Variable
 Unit: mg/l
 Value: 2130
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Hini4a: Description: Initial concentration of heterotrophic organisms (B-26)
 Type: Constant Variable
 Unit: mg/l
 Value: 2370
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Hini4b: Description: Initial concentration of heterotrophic organisms (B-26)
 Type: Constant Variable
 Unit: mg/l
 Value: 2252
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Hini5a: Description: Initial concentration of heterotrophic organisms (B-28)
 Type: Constant Variable
 Unit: mg/l
 Value: 1940
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Hini5b: Description: Initial concentration of heterotrophic organisms (B-28)
 Type: Constant Variable
 Unit: mg/l
 Value: 1905
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Hini6a: Description: Initial concentration of heterotrophic organisms (B-30)
 Type: Constant Variable

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Unit: mg/l
 Value: 2160
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Hini6b: Description: Initial concentration of heterotrophic organisms (B-30)
 Type: Constant Variable
 Unit: mg/l
 Value: 2117
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_I: Description: Inert particulate organic material
 Type: Dyn. Volume State Var.
 Unit: mg/l
 Relative Accuracy: 1e-006
 Absolute Accuracy: 1e-006

X_Iin: Description: Influent particulate inert organic matter
 Type: Formula Variable
 Unit: mg/l
 Expression: $f_{up} \cdot S_{ti}$

X_Iini: Description: Initial particulate inert organic matter
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (12 pairs):

1	X_Iinila
2	X_Iini2a
3	X_Iini3a
4	X_Iini4a
5	X_Iini5a
6	X_Iini6a
11	X_Iinilb
12	X_Iini2b
13	X_Iini3b
14	X_Iini4b
15	X_Iini5b
16	X_Iini6b

X_Iinila: Description: Initial particulate inert organic matter (B-1)
 Type: Constant Variable
 Unit: mg/l
 Value: 10500
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Iini1b:	Description:	Initial particulate inert organic matter (B-1)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	8432
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iini2a:	Description:	Initial particulate inert organic matter (B-2)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	7949
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iini2b:	Description:	Initial particulate inert organic matter (B-2)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	6412
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iini3a:	Description:	Initial particulate inert organic matter (B-5)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	10240
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iini3b:	Description:	Initial particulate inert organic matter (B-5)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	10962
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iini4a:	Description:	Initial particulate inert organic matter (B-26)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	9547

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Standard Deviation: 0.1
Minimum: 0
Maximum: 100000
Sensitivity Analysis: inactive
Parameter Estimation: inactive
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X_Iini4b:	Description:	Initial particulate inert organic matter (B-26)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	8725
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iini5a:	Description:	Initial particulate inert organic matter (B-28)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	10565
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iini5b:	Description:	Initial particulate inert organic matter (B-28)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	10365
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iini6a:	Description:	Initial particulate inert organic matter (B-30)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	10255
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iini6b:	Description:	Initial particulate inert organic matter (B-30)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	9900
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

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X_PAO:	Description:	Phosphate accumulating organisms
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006
X_PAOin:	Description:	Influent concentration of PAO
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_PAOini:	Description:	Initial concentration of PAO
	Type:	Variable List Variable
	Unit:	mg/l
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (12 pairs):	
	1	X_PAOinila
	2	X_PAOini2a
	3	X_PAOini3a
	4	X_PAOini4a
	5	X_PAOini5a
	6	X_PAOini6a
	11	X_PAOinila
	12	X_PAOini2b
	13	X_PAOini3b
	14	X_PAOini4b
	15	X_PAOini5b
	16	X_PAOini6b
X_PAOinila:	Description:	Initial concentration of PAO (B-1)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1253
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_PAOinila:	Description:	Initial concentration of PAO (B-1)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	3540
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_PAOini2a:	Description:	Initial concentration of PAO (B-2)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	2507
	Standard Deviation:	0.1
	Minimum:	0

	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PAOini2b:	Description:	Initial concentration of PAO (B-2)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	4173
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PAOini3a:	Description:	Initial concentration of PAO (B-5)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	2890
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PAOini3b:	Description:	Initial concentration of PAO (B-5)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	2097
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PAOini4a:	Description:	Initial concentration of PAO (B-26)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	2953
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PAOini4b:	Description:	Initial concentration of PAO (B-26)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	3854
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PAOini5a:	Description:	Initial concentration of PAO (B-28)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	3640
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000

Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PAOini5b: Description: Initial concentration of PAO (B-28)
 Type: Constant Variable
 Unit: mg/l
 Value: 3910
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PAOini6a: Description: Initial concentration of PAO (B-30)
 Type: Constant Variable
 Unit: mg/l
 Value: 2560
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PAOini6b: Description: Initial concentration of PAO (B-30)
 Type: Constant Variable
 Unit: mg/l
 Value: 2976
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PHA: Description: A cell internal storage product of
 phosphate accumulating organisms
 Type: Dyn. Volume State Var.
 Unit: mg/l
 Relative Accuracy: 1e-006
 Absolute Accuracy: 1e-006

X_PHAin: Description: Influent concentration of PHA
 Type: Constant Variable
 Unit: mg/l
 Value: 0
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PHAini: Description: Initial concentration of PHA
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (12 pairs):
 1 X_PHAinila
 2 X_PHAini2a
 3 X_PHAini3a
 4 X_PHAini4a
 5 X_PHAini5a

6	X_PHAini6a
11	X_PHAini1b
12	X_PHAini2b
13	X_PHAini3b
14	X_PHAini4b
15	X_PHAini5b
16	X_PHAini6b

X_PHAini1a:	Description:	Initial concentration of PHA (B-1)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	59
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini1b:	Description:	Initial concentration of PHA (B-1)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	54
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini2a:	Description:	Initial concentration of PHA (B-2)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	64
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini2b:	Description:	Initial concentration of PHA (B-2)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	60
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini3a:	Description:	Initial concentration of PHA (B-5)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	34
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini3b:	Description:	Initial concentration of PHA (B-5)
	Type:	Constant Variable
	Unit:	mg/l

Value: 60
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PHAINi4a: Description: Initial concentration of PHA (B-26)
 Type: Constant Variable
 Unit: mg/l
 Value: 59
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PHAINi4b: Description: Initial concentration of PHA (B-26)
 Type: Constant Variable
 Unit: mg/l
 Value: 59
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PHAINi5a: Description: Initial concentration of PHA (B-28)
 Type: Constant Variable
 Unit: mg/l
 Value: 58
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PHAINi5b: Description: Initial concentration of PHA (B-28)
 Type: Constant Variable
 Unit: mg/l
 Value: 58
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PHAINi6a: Description: Initial concentration of PHA (B-30)
 Type: Constant Variable
 Unit: mg/l
 Value: 62
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PHAINi6b: Description: Initial concentration of PHA (B-30)
 Type: Constant Variable
 Unit: mg/l
 Value: 60

Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PP: Description: Poly-phosphate
 Type: Dyn. Volume State Var.
 Unit: mg/l
 Relative Accuracy: 1e-006
 Absolute Accuracy: 1e-006

X_PPin: Description: Influent concentration of PP
 Type: Constant Variable
 Unit: mg/l
 Value: 0
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PPini: Description: Initial concentration of PP
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (12 pairs):

1	X_PPini1a
2	X_PPini2a
3	X_PPini3a
4	X_PPini4a
5	X_PPini5a
6	X_PPini6a
11	X_PPini1b
12	X_PPini2b
13	X_PPini3b
14	X_PPini4b
15	X_PPini5b
16	X_PPini6b

X_PPinila: Description: Initial concentration of PP (B-1)
 Type: Constant Variable
 Unit: mg/l
 Value: 352
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PPinilb: Description: Initial concentration of PP (B-1)
 Type: Constant Variable
 Unit: mg/l
 Value: 357
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

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X_PPini2a:	Description:	Initial concentration of PP (B-2)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	722
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_PPini2b:	Description:	Initial concentration of PP (B-2)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	737
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_PPini3a:	Description:	Initial concentration of PP (B-5)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	834
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_PPini3b:	Description:	Initial concentration of PP (B-5)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	848
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_PPini4a:	Description:	Initial concentration of PP (B-26)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	839
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_PPini4b:	Description:	Initial concentration of PP (B-26)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	860
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_PPini5a:	Description:	Initial concentration of PP (B-28)

	Type:	Constant Variable
	Unit:	mg/l
	Value:	1015
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PPini5b:	Description:	Initial concentration of PP (B-28)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1018
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PPini6a:	Description:	Initial concentration of PP (B-30)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	733
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PPini6b:	Description:	Initial concentration of PP (B-30)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	734
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_S:	Description:	Slowly biodegradable substrate
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006

X_Sin:	Description:	Influent concentration of slowly biodegradable substrate
	Type:	Formula Variable
	Unit:	mg/l
	Expression:	$(1-f_{bs}) \cdot S_{ti} \cdot (1-f_{us}-f_{up})$

X_Sini:	Description:	Initial concentration of slowly biodegradable substrate
	Type:	Formula Variable
	Unit:	mg/l
	Expression:	$(1-f_{bs}) \cdot S_{ti} \cdot (1-f_{us}-f_{up})$

X_taero:	Description:	TSS concentration in aerobic reactor
	Type:	Variable List Variable
	Unit:	mgTSS/l

Argument: X_{taero} Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (12 pairs):

1	$X_{taerola}$
2	$X_{taero2a}$
3	$X_{taero3a}$
4	$X_{taero4a}$
5	$X_{taero5a}$
6	$X_{taero6a}$
11	$X_{taerolb}$
12	$X_{taero2b}$
13	$X_{taero3b}$
14	$X_{taero4b}$
15	$X_{taero5b}$
16	$X_{taero6b}$

$X_{taerola}$:	Description:	TSS concentration in aerobic reactor (B-1)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	16210
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

$X_{taerolb}$:	Description:	TSS concentration in aerobic reactor (B-1)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	16200
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

$X_{taero2a}$:	Description:	TSS concentration in aerobic reactor (B-2)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	16610
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

$X_{taero2b}$:	Description:	TSS concentration in aerobic reactor (B-2)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	16760
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

$X_{taero3a}$:	Description:	TSS concentration in aerobic reactor

Type: r (B-5)
 Unit: Constant Variable
 Unit: mgTSS/l
 Value: 17980
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_taero3b: Description: TSS concentration in aerobic reactor (B-5)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 18050
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_taero4a: Description: TSS concentration in aerobic reactor (B-26)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 17890
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_taero4b: Description: TSS concentration in aerobic reactor (B-26)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 18030
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_taero5a: Description: TSS concentration in aerobic reactor (B-28)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 19690
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_taero5b: Description: TSS concentration in aerobic reactor (B-28)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 19780
 Standard Deviation: 0.1
 Minimum: 0

Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_taero6a: Description: TSS concentration in aerobic reactor (B-30)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 17460
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_taero6b: Description: TSS concentration in aerobic reactor (B-30)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 17510
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_tanaer: Description: TSS concentration in anaerobic reactor
 Type: Variable List Variable
 Unit: mgTSS/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (12 pairs):

1	X_tanaer1a
2	X_tanaer2a
3	X_tanaer3a
4	X_tanaer4a
5	X_tanaer5a
6	X_tanaer6a
11	X_tanaer1b
12	X_tanaer2b
13	X_tanaer3b
14	X_tanaer4b
15	X_tanaer5b
16	X_tanaer6b

X_tanaer1a: Description: TSS concentration in anaerobic reactor (B-1)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 6068
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_tanaer1b: Description: TSS concentration in anaerobic reactor (B-1)
 Type: Constant Variable
 Unit: mgTSS/l

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	Value:	5941
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_tanaer2a:	Description:	TSS concentration in anaerobic reactor (B-2)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	6095
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_tanaer2b:	Description:	TSS concentration in anaerobic reactor (B-2)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	6069
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_tanaer3a:	Description:	TSS concentration in anaerobic reactor (B-5)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	6697
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_tanaer3b:	Description:	TSS concentration in anaerobic reactor (B-5)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	6765
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_tanaer4a:	Description:	TSS concentration in anaerobic reactor (B-26)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	6590
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_tanaer4b:	Description:	TSS concentration in anaerobic reactor (B-26)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	6598
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_tanaer5a:	Description:	TSS concentration in anaerobic reactor (B-28)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	7255
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_tanaer5b:	Description:	TSS concentration in anaerobic reactor (B-28)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	7279
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_tanaer6a:	Description:	TSS concentration in anaerobic reactor (B-30)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	6482
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_tanaer6b:	Description:	TSS concentration in anaerobic reactor (B-30)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	6480
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_tanox:	Description:	TSS concentration in anoxic reactor
	Type:	Variable List Variable
	Unit:	mgTSS/l
	Argument:	Calcnum
	Interpolation Method:	linear interpolation

Real-Variable Data Pairs (12 pairs):

1	X_tanox1a
2	X_tanox2a
3	X_tanox3a
4	X_tanox4a
5	X_tanox5a
6	X_tanox6a
11	X_tanox1b
12	X_tanox2b
13	X_tanox3b
14	X_tanox4b
15	X_tanox5b
16	X_tanox6b

X_tanox1a:	Description:	TSS concentration in anoxic reactor (B-1)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	12170
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_tanox1b:	Description:	TSS concentration in anoxic reactor (B-1)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	12100
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_tanox2a:	Description:	TSS concentration in anoxic reactor (B-2)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	12430
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_tanox2b:	Description:	TSS concentration in anoxic reactor (B-2)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	12480
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_tanox3a:	Description:	TSS concentration in anoxic reactor (B-5)
	Type:	Constant Variable

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Unit: mgTSS/l
 Value: 13460
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_tanox3b: Description: TSS concentration in anoxic reactor (B-5)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 13530
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_tanox4a: Description: TSS concentration in anoxic reactor (B-26)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 13380
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_tanox4b: Description: TSS concentration in anoxic reactor (B-26)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 13460
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_tanox5a: Description: TSS concentration in anoxic reactor (B-28)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 14720
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_tanox5b: Description: TSS concentration in anoxic reactor (B-28)
 Type: Constant Variable
 Unit: mgTSS/l
 Value: 14780
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 30000
 Sensitivity Analysis: inactive

Parameter Estimation: inactive

X_tanox6a:	Description:	TSS concentration in anoxic reactor (B-30)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	13080
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_tanox6b:	Description:	TSS concentration in anoxic reactor (B-30)
	Type:	Constant Variable
	Unit:	mgTSS/l
	Value:	13100
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

Y_AUT:	Description:	Yield coefficient (biomass/nitrate) of ANO
	Type:	Constant Variable
	Unit:	gCOD(gN)-1
	Value:	0.15
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

Y_H:	Description:	Yield of OHO
	Type:	Constant Variable
	Unit:	/d
	Value:	0.67
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

Y_PAO:	Description:	Yield coefficient (biomass/PHA) of PAO
	Type:	Constant Variable
	Unit:	per day
	Value:	0.67
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

Y_PHA:	Description:	PHA requirement for PP storage
	Type:	Constant Variable
	Unit:	per day
	Value:	0.03
	Standard Deviation:	0.1

Minimum: 0
Maximum: 1
Sensitivity Analysis: inactive
Parameter Estimation: inactive

Y_PO4: Description: Yield of P release/PHA storage (PP requirement (S_PO4 release) for PHA storage)

 Type: Constant Variable

 Unit: per day

 Value: 0.52

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 1

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

Processes

Aeration: Description: Dynamic Process

 Type: Dynamic Process

 Rate: $K_{La} \cdot (S_{O2sat} - S_{O2})$

 Stoichiometry:

 Variable : Stoichiometric Coefficient

 S_O2 : 1

AerobicHydrolysis: Description: Aerobic hydrolysis

 Type: Dynamic Process

 Rate: $K_h \cdot (S_{O2} / (K_{O2} + S_{O2})) \cdot ((X_S / X_H) / (K_X + (X_S / X_H))) \cdot X_H$

 Stoichiometry:

 Variable : Stoichiometric Coefficient

 S_F : $1 - f_{SI}$

 S_I : f_{SI}

 X_S : -1

 S_PO4 : $i_{PXs} - ((1 - f_{SI}) \cdot i_{PSf}) - (f_{SI} \cdot i_{PSi})$

 S_NH4 : $i_{NXs} - ((1 - f_{SI}) \cdot i_{NSf}) - (f_{SI} \cdot i_{NSi})$

AeroGrowthS_A: Description: Aerobic growth on fermentable products, S_A

 Type: Dynamic Process

 Rate: $\mu_{H_A} \cdot (S_{O2} / (K_{O2} + S_{O2})) \cdot (S_A / (K_{AO} + S_A)) \cdot (S_A / (S_F + S_A)) \cdot (S_{NH4} / (K_{NH4OH} + S_{NH4})) \cdot (S_{PO4} / (K_P + S_{PO4})) \cdot (X_H)$

 Stoichiometry:

 Variable : Stoichiometric Coefficient

 S_O2 : $-(1 - Y_H) / Y_H$

 S_A : $-1 / Y_H$

 X_H : 1

 S_NH4 : $-i_{NBM}$

 S_PO4 : $-i_{PBM}$

AeroGrowthS_F: Description: Aerobic growth on fermentable subst

rate, S_F
 Type: Dynamic Process
 Rate: $\text{mue\_H} * (\text{S\_O2} / (\text{K\_O2} + \text{S\_O2})) * (\text{S\_F} / (\text{K\_F} + \text{S\_F})) * (\text{S\_F} / (\text{S\_F} + \text{S\_A})) * (\text{S\_NH4} / (\text{K\_NH4} + \text{S\_NH4})) * (\text{S\_PO4} / (\text{K\_P} + \text{S\_PO4})) * (\text{X\_H})$

Stoichiometry:
 Variable : Stoichiometric Coefficient
 S_O2 : $-(1 - \text{Y\_H}) / \text{Y\_H}$
 S_F : $-1 / \text{Y\_H}$
 X_H : 1
 S_NH4 : $((1 / \text{Y\_H}) * \text{i\_NSf}) - \text{i\_NBM}$
 S_PO4 : $((1 / \text{Y\_H}) * (\text{i\_PSf})) - \text{i\_PBM}$

AeroGrowthX_PAO:

Description: Aerobic growth of X_PAO on X_PHA
 Type: Dynamic Process
 Rate: $\text{mue\_PAO} * (\text{S\_O2} / (\text{K\_O2} + \text{S\_O2})) * (\text{S\_NH4} / (\text{K\_NH4PAO} + \text{S\_NH4})) * (\text{S\_PO4} / (\text{K\_P} + \text{S\_PO4})) * ((\text{X\_PHA} / \text{X\_PAO}) / (\text{K\_PHA} + (\text{X\_PHA} / \text{X\_PAO}))) * \text{X\_PAO}$

Stoichiometry:
 Variable : Stoichiometric Coefficient
 S_O2 : $-(1 - \text{Y\_PAO}) / \text{Y\_PAO}$
 S_PO4 : $-i\_PBM$
 X_PAO : 1
 X_PHA : $-1 / \text{Y\_PAO}$
 S_NH4 : $-i\_NBM$

Anaerobichydrolysis:

Description: Anaerobic hydrolysis
 Type: Dynamic Process
 Rate: $\text{K\_h} * \text{eta\_fe} * (\text{K\_O2} / (\text{K\_O2} + \text{S\_O2})) * (\text{K\_NO3} / (\text{K\_NO3} + \text{S\_NO3})) * ((\text{X\_S} / \text{X\_H}) / (\text{K\_X} + (\text{X\_S} / \text{X\_H}))) * \text{X\_H}$

Stoichiometry:
 Variable : Stoichiometric Coefficient
 S_F : $1 - \text{f\_SI}$
 S_NH4 : $\text{i\_NXs} - ((1 - \text{f\_SI}) * \text{i\_NSf}) - (\text{f\_SI} * \text{i\_NSi})$
 S_I : f_SI
 X_S : -1
 S_PO4 : $\text{i\_PXs} - ((1 - \text{f\_SI}) * \text{i\_PSf}) - (\text{f\_SI} * \text{i\_PSi})$

AnoxicGrowthS_A:

Description: Aerobic growth on fermentable products, S_A (Denitrification)
 Type: Dynamic Process
 Rate: $\text{mue\_H} * \text{eta\_NO3d} * (\text{K\_O2} / (\text{K\_O2} + \text{S\_O2})) * (\text{S\_A} / (\text{K\_AOHO} + \text{S\_A})) * (\text{S\_A} / (\text{S\_F} + \text{S\_A})) * (\text{S\_NH4} / (\text{K\_NH4OHO} + \text{S\_NH4})) * (\text{S\_NO3} / (\text{K\_NO3} + \text{S\_NO3})) * (\text{S\_PO4} / (\text{K\_P} + \text{S\_PO4})) * (\text{X\_H})$

Stoichiometry:
 Variable : Stoichiometric Coefficient
 S_A : $-1 / \text{Y\_H}$
 X_H : 1
 S_NH4 : $-i\_NBM$
 S_PO4 : $-i\_PBM$
 S_NO3 : $-(1 - \text{Y\_H}) / (2.86 * \text{Y\_H})$
 S_N2 : $(1 - \text{Y\_H}) / (2.86 * \text{Y\_H})$

AnoxicGrowthS_F:

Description: Anoxic growth on fermentable substrates, S_F Denitrification
 Type: Dynamic Process
 Rate: $\mu_{H^*} \eta_{NO3d} * (K_{O2} / (K_{O2} + S_{O2})) * (S_F / (K_F + S_F)) * (S_F / (S_F + S_A)) * (S_{NH4} / (K_{NH4OHO} + S_{NH4})) * (S_{NO3} / (K_{NO3} + S_{NO3})) * (S_{PO4} / (K_P + S_{PO4})) * (X_H)$
 Stoichiometry:
 Variable : Stoichiometric Coefficient
 $S_F : -1/Y_H$
 $X_H : 1$
 $S_{NH4} : ((1/Y_H) * i_{NSf}) - i_{NBM}$
 $S_{PO4} : ((1/Y_H) * i_{PSf}) - i_{PBM}$
 $S_{NO3} : -(1 - Y_H) / (2.86 * Y_H)$
 $S_{N2} : (1 - Y_H) / (2.86 * Y_H)$

Anoxichydrolysis:

Description: Anoxic hydrolysis
 Type: Dynamic Process
 Rate: $K_h * \eta_{NO3} * (K_{O2} / (K_{O2} + S_{O2})) * (S_{NO3} / (K_{NO3} + S_{NO3})) * ((X_S / X_H) / (K_X + (X_S / X_H))) * X_H$
 Stoichiometry:
 Variable : Stoichiometric Coefficient
 $S_F : 1 - f_{SI}$
 $S_{NH4} : i_{NXs} - ((1 - f_{SI}) * i_{NSf}) - (f_{SI} * i_{NSi})$
 $X_S : -1$
 $S_{PO4} : i_{PXs} - ((1 - f_{SI}) * i_{PSf}) - (f_{SI} * i_{PSi})$
 $S_I : f_{SI}$

Fermentation:

Description: Fermentation
 Type: Dynamic Process
 Rate: $q_{fe} * (K_{O2} / (K_{O2} + S_{O2})) * (K_{NO3} / (K_{NO3} + S_{NO3})) * (S_F / (K_{fe} + S_F)) * X_H$
 Stoichiometry:
 Variable : Stoichiometric Coefficient
 $S_F : -1$
 $S_A : 1$
 $S_{NH4} : i_{NSf}$
 $S_{PO4} : i_{PSf}$

GrowthX_AUT:

Description: Growth of nitrifying organisms (autotrophic organisms)
 Type: Dynamic Process
 Rate: $\mu_{AUT} * (S_{O2} / (K_{O2} + S_{O2})) * (S_{NH4} / (K_{NH4AUT} + S_{NH4})) * (S_{PO4} / (K_P + S_{PO4})) * X_{AUT}$
 Stoichiometry:
 Variable : Stoichiometric Coefficient
 $S_{O2} : -(4.57 - Y_{AUT}) / Y_{AUT}$
 $S_{NH4} : -(1/Y_{AUT}) - i_{NBM}$
 $S_{NO3} : 1/Y_{AUT}$
 $S_{PO4} : -i_{PBM}$
 $X_{AUT} : 1$

LysisX_AUT:

Description: Lysis/death of autotrophic (nitrifying) organisms
 Type: Dynamic Process
 Rate: $b_{AUT} * X_{AUT}$
 Stoichiometry:

Variable : Stoichiometric Coefficient

$S_{NH4} : i_{NBM} - (f_{XiAUT} * i_{NXi}) - ((1 - f_{XiAUT}) * i_{NXs})$

$S_{PO4} : i_{PBM} - (f_{XiAUT} * i_{PXi}) - ((1 - f_{XiAUT}) * i_{PXs})$

$X_I : f_{XiAUT}$

$X_S : 1 - f_{XiAUT}$

$X_{AUT} : -1$

LysisX_H: Description: Lysis/death of heterotrophic organisms

Type: Dynamic Process

Rate: $b_H * X_H$

Stoichiometry:

Variable : Stoichiometric Coefficient

$X_I : f_{XiOHO}$

$X_S : 1 - f_{XiOHO}$

$X_H : -1$

$S_{NH4} : i_{NBM} - (f_{XiOHO} * i_{NXi}) - ((1 - f_{XiOHO}) * i_{NXs})$

$S_{PO4} : i_{PBM} - (f_{XiOHO} * i_{PXi}) - ((1 - f_{XiOHO}) * i_{PXs})$

LysisX_PAO: Description: Lysis/death of X_PAO

Type: Dynamic Process

Rate: $b_{PAO} * X_{PAO}$

Stoichiometry:

Variable : Stoichiometric Coefficient

$S_{PO4} : i_{PBM} - (f_{XiPAO} * i_{PXi}) - ((1 - f_{XiPAO}) * i_{PXs})$

$X_I : f_{XiPAO}$

$X_S : 1 - f_{XiPAO}$

$X_{PAO} : -1$

$S_{NH4} : i_{NBM} - (f_{XiPAO} * i_{NXi}) - ((1 - f_{XiPAO}) * i_{NXs})$

LysisX_PHA: Description: Lysis of X_PHA

Type: Dynamic Process

Rate: $b_{PHA} * X_{PHA}$

Stoichiometry:

Variable : Stoichiometric Coefficient

$S_A : 1$

$X_{PHA} : -1$

LysisX_PP: Description: Lysis of X_PP

Type: Dynamic Process

Rate: $b_{PP} * X_{PP}$

Stoichiometry:

Variable : Stoichiometric Coefficient

$S_{PO4} : 1$

$X_{PP} : -1$

StorageX_PHA: Description: Sequestration of S_A / Storage of X_{PHA}

Type: Dynamic Process

Rate: $q_{PHA} * (S_A / (K_{APAO} + S_A)) * ((X_{PP} / X_{PAO}) / (K_{PP} + (X_{PP} / X_{PAO}))) * X_{PAO}$

Stoichiometry:

Variable : Stoichiometric Coefficient

$S_A : -1$

$S_{PO4} : Y_{PO4}$

$X_{PP} : -Y_{PO4}$

$X_{PHA} : 1$

StorageX_PP: Description: Storage of X_{PP}

Type: Dynamic Process

Rate: $q_{PP} * (S_{O2} / (K_{O2} + S_{O2})) * (S_{PO4} / (K_P$

$$\frac{(S+S_{PO4}) * ((X_{PHA}/X_{PAO}) / (K_{PHA} + (X_{PHA}/X_{PAO}))) * ((K_{Max} - (X_{PP}/X_{PAO})) / (K_{IPP} + K_{Max} - (X_{PP}/X_{PAO}))) * X_{PAO}}{}$$

Stoichiometry:

Variable : Stoichiometric Coefficient

S_O2 : -Y_PHA

S_PO4 : -1

X_PP : 1

X_PHA : -Y_PHA

Compartments

AerobicR:

Description:

Type:

Mixed Reactor Compartment

Compartment Index:

0

Active Variables:

b_AUT, b_AUT20, b_H, b_H2O, b_PAO, b_PAO20, b_PHA, b_PHA20, b_PP, b_PP20, Calcnum, CODf, CODf_m, CODf_m1, CODf_m2, CODf_m3, CODf_m4, CODf_m5, CODf_m6, CODt, CODt_m, CODt_m1, CODt_m2, CODt_m3, CODt_m4, CODt_m5, CODt_m6, eta_fe, eta_NO3, eta_NO3d, f_ac, f_ac1a, f_ac1b, f_ac2a, f_ac2b, f_ac3a, f_ac3b, f_ac4a, f_ac4b, f_ac5a, f_ac5b, f_ac6a, f_ac6b, f_avOHO, f_avPAO, f_bs, f_bs1a, f_bs1b, f_bs2a, f_bs2b, f_bs3a, f_bs3b, f_bs4a, f_bs4b, f_bs5a, f_bs5b, f_bs6a, f_bs6b, f_cv, f_na, f_SI, f_up, f_up1a, f_up1b, f_up2a, f_up2b, f_up3a, f_up3b, f_up4a, f_up4b, f_up5a, f_up5b, f_up6a, f_up6b, f_us, f_us1a, f_us1b, f_us2a, f_us2b, f_us3a, f_us3b, f_us4a, f_us4b, f_us5a, f_us5b, f_us6a, f_us6b, f_vTG, f_vTH, f_XiAUT, f_XiOHO, f_XiPAO, ISS_AeroM, ISS_AeroM1, ISS_AeroM2, ISS_AeroM3, ISS_AeroM4, ISS_AeroM5, ISS_AeroM6, ISS_AnaerM, ISS_AnaerM1, ISS_AnaerM2, ISS_AnaerM3, ISS_AnaerM4, ISS_AnaerM5, ISS_AnaerM6, ISS_AnoxM, ISS_AnoxM1, ISS_AnoxM2, ISS_AnoxM3, ISS_AnoxM4, ISS_AnoxM5, ISS_AnoxM6, ISS_fiOHO, ISS_fiPAO, ISS_fiPAOBM, ISS_Xioi, ISS_Xioin, ISS_Xioin1a, ISS_Xioin1b, ISS_Xioin2a, ISS_Xioin2b, ISS_Xioin3a, ISS_Xioin3b, ISS_Xioin4a, ISS_Xioin4b, ISS_Xioin5a, ISS_Xioin5b, ISS_Xioin6a, ISS_Xioin6b, ISS_Xioini, ISS_Xioinila, ISS_Xioinilb, ISS_Xioini2a, ISS_Xioini2b, ISS_Xioini3a, ISS_Xioini3b, ISS_Xioini4a, ISS_Xioini4b, ISS_Xioini5a, ISS_Xioini5b, ISS_Xioini6a, ISS_Xioini6b, ISS_Xoi, i_NBM, i_NSf

, i_NSi, i_NXi, i_NXs, i_PBM, i_Psf
 , i_PSi, i_PXi, i_PXs, i_TSSBM, i_T
 SSXi, i_TSSXs, K_ALK, K_ALKAUT, K_A
 LKPRE, K_AOHO, K_APAO, K_F, K_fe, K
 _h, K_h20, K_IPP, K_La, K_Max, K_NH
 4AUT, K_NH4OHO, K_NH4PAO, K_NO3, K_
 O2, K_P, K_PHA, K_PP, k_PRE, K_PS,
 k_RED, K_X, K_X20, mue_AUT, mue_AUT
 20, mue_H, mue_H20, mue_PAO, mue_PA
 O20, mVSS, N_ti, N_tila, N_tilb, N_
 ti2a, N_ti2b, N_ti3a, N_ti3b, N_ti4
 a, N_ti4b, N_ti5a, N_ti5b, N_ti6a,
 N_ti6b, OUR_AUT, OUR_c, OUR_HSA, OU
 R_HSF, OUR_PAO, OUR_PP, OUR_t, OUR_
 t_meas, OUR_t_meas1, OUR_t_meas2, O
 UR_t_meas3, OUR_t_meas4, OUR_t_meas
 5, OUR_t_meas6, P_i, P_ila, P_ilb,
 P_i2a, P_i2b, P_i3a, P_i3b, P_i4a,
 P_i4b, P_i5a, P_i5b, P_i6a, P_i6b,
 Q, Q_as, Q_e, q_fe, q_fe20, q_fe20_
 1a, q_fe20_1b, q_fe20_2a, q_fe20_2b
 , q_fe20_3a, q_fe20_3b, q_fe20_4a,
 q_fe20_4b, q_fe20_5a, q_fe20_5b, q_
 fe20_6a, q_fe20_6b, Q_i, q_PHA, q_P
 HA20, q_PP, q_PP20, q_PP20_1a, q_PP
 20_1b, q_PP20_2a, q_PP20_2b, q_PP20
 _3a, q_PP20_3b, q_PP20_4a, q_PP20_4
 b, q_PP20_5a, q_PP20_5b, q_PP20_6a,
 q_PP20_6b, Q_r, Q_rec, Q_w, Q_wm,
 Q_wm1, Q_wm2, Q_wm3, Q_wm4, Q_wm5,
 Q_wm6, R_hn, R_s, S_A, S_Ain, S_Ain
 i, S_F, S_Fin, S_Fini, S_I, S_Iin,
 S_Iini, S_N2, S_N2in, S_N2ini, S_NH
 4, S_NH4in, S_NH4in1a, S_NH4in1b, S_
 NH4in2a, S_NH4in2b, S_NH4in3a, S_N
 H4in3b, S_NH4in4a, S_NH4in4b, S_NH4
 in5a, S_NH4in5b, S_NH4in6a, S_NH4in
 6b, S_NH4ini, S_NH4inila, S_NH4inil
 b, S_NH4ini2a, S_NH4ini2b, S_NH4ini
 3a, S_NH4ini3b, S_NH4ini4a, S_NH4in
 i4b, S_NH4ini5a, S_NH4ini5b, S_NH4i
 ni6a, S_NH4ini6b, S_NH4meas, S_NH4m
 eas1, S_NH4meas2, S_NH4meas3, S_NH4
 meas4, S_NH4meas5, S_NH4meas6, S_NO
 3, S_NO3in, S_NO3ini, S_NO3meas, S_
 NO3meas1, S_NO3meas2, S_NO3meas3, S_
 NO3meas4, S_NO3meas5, S_NO3meas6,
 S_O2, S_O2sat, S_PO4, S_PO4in, S_PO
 4in1a, S_PO4in1b, S_PO4in2a, S_PO4i
 n2b, S_PO4in3a, S_PO4in3b, S_PO4in4
 a, S_PO4in4b, S_PO4in5a, S_PO4in5b,
 S_PO4in6a, S_PO4in6b, S_PO4ini, S_
 PO4inila, S_PO4inilb, S_PO4ini2a, S_
 PO4ini2b, S_PO4ini3a, S_PO4ini3b,
 S_PO4ini4a, S_PO4ini4b, S_PO4ini5a,
 S_PO4ini5b, S_PO4ini6a, S_PO4ini6b
 , S_PO4meas, S_PO4meas1, S_PO4meas2
 , S_PO4meas3, S_PO4meas4, S_PO4meas
 5, S_PO4meas6, S_ti, S_tila, S_tilb
 , S_ti2a, S_ti2b, S_ti3a, S_ti3b, S_
 ti4a, S_ti4b, S_ti5a, S_ti5b, S_ti

6a, S_{ti6b}, T, t, the_{bAUT}, the_{bH},
 the_{bPAO}, the_{bPHA}, the_{bPP}, the_K
 h, the_{KX}, the_{mueAUT}, the_{mueH}, th
 e_{muePAO}, the_{qfe}, the_{qPHA}, the_{qP}
 P, TKN, TKN_{meas}, TKN_{meas1}, TKN_{mea}
 as2, TKN_{meas3}, TKN_{meas4}, TKN_{meas}
 5, TKN_{meas6}, TSS, TSS_{measAero}, TS
 S_{measAero1}, TSS_{measAero2}, TSS_{mea}
 sAero3, TSS_{measAero4}, TSS_{measAero}
 5, TSS_{measAero6}, TSS_{measAnaer}, TS
 S_{measAnaer1}, TSS_{measAnaer2}, TSS_m
 easAnaer3, TSS_{measAnaer4}, TSS_{meas}
 Anaer5, TSS_{measAnaer6}, TSS_{measAno}
 x, TSS_{measAnox1}, TSS_{measAnox2}, TS
 S_{measAnox3}, TSS_{measAnox4}, TSS_{mea}
 sAnox5, TSS_{measAnox6}, t_{mode}, Volu
 me, VSS, VSS_{measAero}, VSS_{measAero}
 1, VSS_{measAero2}, VSS_{measAero3}, VS
 S_{measAero4}, VSS_{measAero5}, VSS_{mea}
 sAero6, VSS_{measAnaer}, VSS_{measAnaer}
 1, VSS_{measAnaer2}, VSS_{measAnaer3},
 VSS_{measAnaer4}, VSS_{measAnaer5}, VS
 S_{measAnaer6}, VSS_{measAnox}, VSS_{mea}
 sAnox1, VSS_{measAnox2}, VSS_{measAnox}
 3, VSS_{measAnox4}, VSS_{measAnox5}, VS
 S_{measAnox6}, V_{aero}, V_{anaer}, V_{ano}
 x, X_{AUT}, X_{AUTin}, X_{AUTini}, X_{AUTi}
 nila, X_{AUTinilb}, X_{AUTini2a}, X_{AUT}
 ini2b, X_{AUTini3a}, X_{AUTini3b}, X_{AU}
 Tini4a, X_{AUTini4b}, X_{AUTini5a}, X_A
 UTini5b, X_{AUTini6a}, X_{AUTini6b}, X_H
 , X_{Hin}, X_{Hini}, X_{Hinila}, X_{Hinil}
 b, X_{Hini2a}, X_{Hini2b}, X_{Hini3a}, X_H
 ini3b, X_{Hini4a}, X_{Hini4b}, X_{Hini5}
 a, X_{Hini5b}, X_{Hini6a}, X_{Hini6b}, X_I
 , X_{Iin}, X_{Iini}, X_{Iinila}, X_{Iinil}
 b, X_{Iini2a}, X_{Iini2b}, X_{Iini3a}, X_I
 ini3b, X_{Iini4a}, X_{Iini4b}, X_{Iini5}
 a, X_{Iini5b}, X_{Iini6a}, X_{Iini6b}, X_{PAO}
 , X_{PAOin}, X_{PAOini}, X_{PAOinila},
 X_{PAOinilb}, X_{PAOini2a}, X_{PAOini2b}
 , X_{PAOini3a}, X_{PAOini3b}, X_{PAOini4}
 a, X_{PAOini4b}, X_{PAOini5a}, X_{PAOini}
 5b, X_{PAOini6a}, X_{PAOini6b}, X_{PHA},
 X_{PHAIN}, X_{PHAINi}, X_{PHAINila}, X_{PH}
 Aini1b, X_{PHAINi2a}, X_{PHAINi2b}, X_P
 HAINi3a, X_{PHAINi3b}, X_{PHAINi4a}, X_{PH}
 Aini4b, X_{PHAINi5a}, X_{PHAINi5b}, X_{PH}
 Aini6a, X_{PHAINi6b}, X_{PP}, X_{PPin}
 , X_{PPini}, X_{PPinila}, X_{PPinilb}, X_{PP}
 ini2a, X_{PPini2b}, X_{PPini3a}, X_{PP}
 ini3b, X_{PPini4a}, X_{PPini4b}, X_{PPin}
 i5a, X_{PPini5b}, X_{PPini6a}, X_{PPini6}
 b, X_S, X_{Sin}, X_{Sini}, X_{taero}, X_t
 aero1a, X_{taero1b}, X_{taero2a}, X_{tae}
 ro2b, X_{taero3a}, X_{taero3b}, X_{taero}
 4a, X_{taero4b}, X_{taero5a}, X_{taero5b}
 , X_{taero6a}, X_{taero6b}, X_{tanaer}, X_t
 anaer1a, X_{tanaer1b}, X_{tanaer2a},
 X_{tanaer2b}, X_{tanaer3a}, X_{tanaer3b},
 X_{tanaer4a}, X_{tanaer4b}, X_{tanaer5a}

Active Processes:

, X_tanaer5b, X_tanaer6a, X_tanaer6b, X_tanox, X_tanoxla, X_tanoxlb, X_tanox2a, X_tanox2b, X_tanox3a, X_tanox3b, X_tanox4a, X_tanox4b, X_tanox5a, X_tanox5b, X_tanox6a, X_tanox6b, Y_AUT, Y_H, Y_PAO, Y_PHA, Y_PO4
 Aeration, AerobicHydrolysis, AeroGrowthS_A, AeroGrowthS_F, AeroGrowthX_PAO, Anaerobichydrolysis, AnoxicGrowthS_A, AnoxicGrowthS_F, Anoxichydrolysis, Fermentation, GrowthX_AUT, LysisX_AUT, LysisX_H, LysisX_PAO, LysisX_PHA, LysisX_PP, StorageX_PHA, StorageX_PP

Initial Conditions:

Variable(Zone) : Initial Condition

S_I(Bulk Volume) : S_Iini
 S_NH4(Bulk Volume) : S_NH4ini
 X_AUT(Bulk Volume) : X_AUTini
 X_H(Bulk Volume) : X_Hini
 X_I(Bulk Volume) : X_Iini
 X_PAO(Bulk Volume) : X_PAOini
 X_S(Bulk Volume) : X_Sini
 S_A(Bulk Volume) : S_Aini
 S_NO3(Bulk Volume) : S_NO3ini
 S_PO4(Bulk Volume) : S_PO4ini
 X_PHA(Bulk Volume) : X_PHAini
 X_PP(Bulk Volume) : X_PPini
 S_F(Bulk Volume) : S_Fini
 S_N2(Bulk Volume) : S_N2ini
 ISS_Xioi(Bulk Volume) : ISS_Xioini

Inflow: 0

Loadings:

Volume: 35

Accuracies:

Rel. Acc. Q: 0.001
 Abs. Acc. Q: 0.001
 Rel. Acc. V: 0.001
 Abs. Acc. V: 0.001

 AnearobicR:

Description:

Type:

Mixed Reactor Compartment

Compartment Index:

0

Active Variables:

b_AUT, b_AUT20, b_H, b_H20, b_PAO, b_PAO20, b_PHA, b_PHA20, b_PP, b_PP20, Calcnum, CODf, CODf_m, CODf_m1, CODf_m2, CODf_m3, CODf_m4, CODf_m5, CODf_m6, CODt, CODt_m, CODt_m1, CODt_m2, CODt_m3, CODt_m4, CODt_m5, CODt_m6, eta_fe, eta_NO3, eta_NO3d, f_ac, f_ac1a, f_ac1b, f_ac2a, f_ac2b, f_ac3a, f_ac3b, f_ac4a, f_ac4b, f_ac5a, f_ac5b, f_ac6a, f_ac6b, f_avOHO, f_avPAO, f_bs, f_bs1a, f_bs1b, f_bs2a, f_bs2b, f_bs3a, f_bs3b, f_bs4a, f_bs4b, f_bs5a, f_bs5b, f_bs6a, f_bs6b, f_cv, f_na, f_SI, f_up, f_up1a, f_up1b, f_up2a, f_up2b, f_up3a, f_up3b, f_up4a, f_up4b, f_up5a, f_up5b, f_up6a, f_up6b, f_us, f_us1a, f_us1b, f_us2a, f_us2b, f_us

3a, f_us3b, f_us4a, f_us4b, f_us5a,
 f_us5b, f_us6a, f_us6b, f_vTG, f_v
 TH, f_XiAUT, f_XiOHO, f_XiPAO, ISS_
 AeroM, ISS_AeroM1, ISS_AeroM2, ISS_
 AeroM3, ISS_AeroM4, ISS_AeroM5, ISS_
 AeroM6, ISS_AnaerM, ISS_AnaerM1, I
 SS_AnaerM2, ISS_AnaerM3, ISS_AnaerM
 4, ISS_AnaerM5, ISS_AnaerM6, ISS_An
 oxM, ISS_AnoxM1, ISS_AnoxM2, ISS_An
 oxM3, ISS_AnoxM4, ISS_AnoxM5, ISS_A
 noxM6, ISS_fiOHO, ISS_fiPAO, ISS_fi
 PAOBM, ISS_Xioi, ISS_Xioin, ISS_Xio
 inla, ISS_Xioinlb, ISS_Xioin2a, ISS_
 Xioin2b, ISS_Xioin3a, ISS_Xioin3b,
 ISS_Xioin4a, ISS_Xioin4b, ISS_Xioi
 n5a, ISS_Xioin5b, ISS_Xioin6a, ISS_
 Xioin6b, ISS_Xioini, ISS_Xioinila,
 ISS_Xioinilb, ISS_Xioini2a, ISS_Xio
 ini2b, ISS_Xioini3a, ISS_Xioini3b,
 ISS_Xioini4a, ISS_Xioini4b, ISS_Xio
 ini5a, ISS_Xioini5b, ISS_Xioini6a,
 ISS_Xioini6b, ISS_Xoi, i_NBM, i_Nsf
 , i_NSi, i_NXi, i_NXs, i_PBM, i_Psf
 , i_PSi, i_PXi, i_PXs, i_TSSBM, i_T
 SSXi, i_TSSXs, K_ALK, K_ALKAUT, K_A
 LKPRE, K_AOHO, K_APAO, K_F, K_fe, K
 _h, K_h20, K_IPP, K_La, K_Max, K_NH
 4AUT, K_NH4OHO, K_NH4PAO, K_NO3, K_
 O2, K_P, K_PHA, K_PP, k_PRE, K_PS,
 k_RED, K_X, K_X20, mue_AUT, mue_AUT
 20, mue_H, mue_H20, mue_PAO, mue_PA
 O20, mVSS, N_ti, N_tila, N_tilb, N_
 ti2a, N_ti2b, N_ti3a, N_ti3b, N_ti4
 a, N_ti4b, N_ti5a, N_ti5b, N_ti6a,
 N_ti6b, OUR_AUT, OUR_c, OUR_HSA, OU
 R_HSF, OUR_PAO, OUR_PP, OUR_t, OUR_
 t_meas, OUR_t_meas1, OUR_t_meas2, O
 UR_t_meas3, OUR_t_meas4, OUR_t_meas
 5, OUR_t_meas6, P_i, P_ila, P_ilb,
 P_i2a, P_i2b, P_i3a, P_i3b, P_i4a,
 P_i4b, P_i5a, P_i5b, P_i6a, P_i6b,
 Q, Q_as, Q_e, q_fe, q_fe20, q_fe20_
 la, q_fe20_lb, q_fe20_2a, q_fe20_2b
 , q_fe20_3a, q_fe20_3b, q_fe20_4a,
 q_fe20_4b, q_fe20_5a, q_fe20_5b, q_
 fe20_6a, q_fe20_6b, Q_i, q_PHA, q_P
 HA20, q_PP, q_PP20, q_PP20_1a, q_PP
 20_1b, q_PP20_2a, q_PP20_2b, q_PP20
 _3a, q_PP20_3b, q_PP20_4a, q_PP20_4
 b, q_PP20_5a, q_PP20_5b, q_PP20_6a,
 q_PP20_6b, Q_r, Q_rec, Q_w, Q_wm,
 Q_wm1, Q_wm2, Q_wm3, Q_wm4, Q_wm5,
 Q_wm6, R_hn, R_s, S_A, S_Ain, S_Ain
 i, S_F, S_Fin, S_Fini, S_I, S_Iin,
 S_Iini, S_N2, S_N2in, S_N2ini, S_NH
 4, S_NH4in, S_NH4inla, S_NH4inlb, S_
 NH4in2a, S_NH4in2b, S_NH4in3a, S_N
 H4in3b, S_NH4in4a, S_NH4in4b, S_NH4
 in5a, S_NH4in5b, S_NH4in6a, S_NH4in
 6b, S_NH4ini, S_NH4inila, S_NH4inil
 b, S_NH4ini2a, S_NH4ini2b, S_NH4ini

3a, S_NH4ini3b, S_NH4ini4a, S_NH4ini4b, S_NH4ini5a, S_NH4ini5b, S_NH4ini6a, S_NH4ini6b, S_NH4meas, S_NH4meas1, S_NH4meas2, S_NH4meas3, S_NH4meas4, S_NH4meas5, S_NH4meas6, S_NO3, S_NO3in, S_NO3ini, S_NO3meas, S_NO3meas1, S_NO3meas2, S_NO3meas3, S_NO3meas4, S_NO3meas5, S_NO3meas6, S_O2, S_O2sat, S_PO4, S_PO4in, S_PO4in1a, S_PO4in1b, S_PO4in2a, S_PO4in2b, S_PO4in3a, S_PO4in3b, S_PO4in4a, S_PO4in4b, S_PO4in5a, S_PO4in5b, S_PO4in6a, S_PO4in6b, S_PO4ini, S_PO4inila, S_PO4inilb, S_PO4ini2a, S_PO4ini2b, S_PO4ini3a, S_PO4ini3b, S_PO4ini4a, S_PO4ini4b, S_PO4ini5a, S_PO4ini5b, S_PO4ini6a, S_PO4ini6b, S_PO4meas, S_PO4meas1, S_PO4meas2, S_PO4meas3, S_PO4meas4, S_PO4meas5, S_PO4meas6, S_ti, S_tila, S_tilb, S_ti2a, S_ti2b, S_ti3a, S_ti3b, S_ti4a, S_ti4b, S_ti5a, S_ti5b, S_ti6a, S_ti6b, T, t, the_bAUT, the_bH, the_bPAO, the_bPHA, the_bPP, the_Kh, the_KX, the_mueAUT, the_mueH, the_muePAO, the_qfe, the_qPHA, the_qPP, TKN, TKN_meas, TKN_meas1, TKN_meas2, TKN_meas3, TKN_meas4, TKN_meas5, TKN_meas6, TSS, TSS_measAero, TSS_measAero1, TSS_measAero2, TSS_measAero3, TSS_measAero4, TSS_measAero5, TSS_measAero6, TSS_measAnaer, TSS_measAnaer1, TSS_measAnaer2, TSS_measAnaer3, TSS_measAnaer4, TSS_measAnaer5, TSS_measAnaer6, TSS_measAnox, TSS_measAnox1, TSS_measAnox2, TSS_measAnox3, TSS_measAnox4, TSS_measAnox5, TSS_measAnox6, t_mode, Volume, VSS, VSS_measAero, VSS_measAero1, VSS_measAero2, VSS_measAero3, VSS_measAero4, VSS_measAero5, VSS_measAero6, VSS_measAnaer, VSS_measAnaer1, VSS_measAnaer2, VSS_measAnaer3, VSS_measAnaer4, VSS_measAnaer5, VSS_measAnaer6, VSS_measAnox, VSS_measAnox1, VSS_measAnox2, VSS_measAnox3, VSS_measAnox4, VSS_measAnox5, VSS_measAnox6, V_aero, V_anaer, V_anox, X_AUT, X_AUTin, X_AUTini, X_AUTinila, X_AUTinilb, X_AUTini2a, X_AUTini2b, X_AUTini3a, X_AUTini3b, X_AUTini4a, X_AUTini4b, X_AUTini5a, X_AUTini5b, X_AUTini6a, X_AUTini6b, X_H, X_Hin, X_Hini, X_Hinila, X_Hinilb, X_Hini2a, X_Hini2b, X_Hini3a, X_Hini3b, X_Hini4a, X_Hini4b, X_Hini5a, X_Hini5b, X_Hini6a, X_Hini6b, X_I, X_Iin, X_Iini, X_Iinila, X_Iinilb, X_Iini2a, X_Iini2b, X_Iini3a, X_Iini3b, X_Iini4a, X_Iini4b, X_Iini5a, X_Iini5b, X_Iini6a, X_Iini6b, X_

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PAO, X_PAOin, X_PAOini, X_PAOinila,
X_PAOinilb, X_PAOini2a, X_PAOini2b,
X_PAOini3a, X_PAOini3b, X_PAOini4
a, X_PAOini4b, X_PAOini5a, X_PAOini
5b, X_PAOini6a, X_PAOini6b, X_PHA,
X_PHAin, X_PHAini, X_PHAinila, X_PH
Ainilb, X_PHAini2a, X_PHAini2b, X_P
HAini3a, X_PHAini3b, X_PHAini4a, X_
PHAini4b, X_PHAini5a, X_PHAini5b, X_
PHAini6a, X_PHAini6b, X_PP, X_PPin
, X_PPini, X_PPinila, X_PPinilb, X_
PPini2a, X_PPini2b, X_PPini3a, X_PP
ini3b, X_PPini4a, X_PPini4b, X_PPin
i5a, X_PPini5b, X_PPini6a, X_PPini6
b, X_S, X_Sin, X_Sini, X_taero, X_t
aerola, X_taerolb, X_taero2a, X_tae
ro2b, X_taero3a, X_taero3b, X_taero
4a, X_taero4b, X_taero5a, X_taero5b
, X_taero6a, X_taero6b, X_tanaer, X_
tanaerla, X_tanaerlb, X_tanaer2a,
X_tanaer2b, X_tanaer3a, X_tanaer3b,
X_tanaer4a, X_tanaer4b, X_tanaer5a
, X_tanaer5b, X_tanaer6a, X_tanaer6
b, X_tanox, X_tanoxla, X_tanoxlb, X_
tanox2a, X_tanox2b, X_tanox3a, X_t
anox3b, X_tanox4a, X_tanox4b, X_tan
ox5a, X_tanox5b, X_tanox6a, X_tanox
6b, Y_AUT, Y_H, Y_PAO, Y_PHA, Y_PO4
Active Processes: AerobicHydrolysis, AeroGrowthS_A, A
eroGrowthS_F, AeroGrowthX_PAO, Anaer
obichydrolysis, AnoxicGrowthS_A, A
noxicGrowthS_F, Anoxichydrolysis, F
ermentation, GrowthX_AUT, LysisX_AU
T, LysisX_H, LysisX_PAO, LysisX_PHA
, LysisX_PP, StorageX_PHA, StorageX
_PP

Initial Conditions:
Variable(Zone) : Initial Condition
S_I(Bulk Volume) : S_Iini
S_NH4(Bulk Volume) : S_NH4ini
X_AUT(Bulk Volume) : X_AUTini
X_H(Bulk Volume) : X_Hini
X_I(Bulk Volume) : X_Iini
X_PAO(Bulk Volume) : X_PAOini
X_S(Bulk Volume) : X_Sini
S_A(Bulk Volume) : S_Aini
S_NO3(Bulk Volume) : S_NO3ini
S_PO4(Bulk Volume) : S_PO4ini
X_PHA(Bulk Volume) : X_PHAini
X_PP(Bulk Volume) : X_PPini
S_F(Bulk Volume) : S_Fini
S_N2(Bulk Volume) : S_N2ini
ISS_Xioi(Bulk Volume) : ISS_Xioini
Inflow: Q_i
Loadings:
Variable : Loading
S_A : Q_i*S_Ain
S_F : Q_i*S_Fin
S_I : Q_i*S_Iin
S_N2 : Q_i*S_N2in
S_NH4 : Q_i*S_NH4in

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$S_{NO3} : Q_i \cdot S_{NO3in}$
 $S_{PO4} : Q_i \cdot S_{PO4in}$
 $X_{AUT} : Q_i \cdot X_{AUTin}$
 $X_H : Q_i \cdot X_{Hin}$
 $X_I : Q_i \cdot X_{Iin}$
 $X_{PAO} : Q_i \cdot X_{PAOin}$
 $X_{PHA} : Q_i \cdot X_{PHAin}$
 $X_{PP} : Q_i \cdot X_{PPin}$
 $X_S : Q_i \cdot X_{Sin}$
 $ISS_{Xioi} : Q_i \cdot ISS_{Xioin}$
 Volume: 19

Accuracies:
 Rel. Acc. Q: 0.001
 Abs. Acc. Q: 0.001
 Rel. Acc. V: 0.001
 Abs. Acc. V: 0.001

AnoxicR:

Description:

Type:

Mixed Reactor Compartment

Compartment Index:

0

Active Variables:

b_{AUT} , b_{AUT20} , b_H , b_{H20} , b_{PAO} ,
 b_{PAO20} , b_{PHA} , b_{PHA20} , b_{PP} , b_{PP}
 20, Calcnum, CODf, CODf_m, CODf_m1,
 CODf_m2, CODf_m3, CODf_m4, CODf_m5,
 CODf_m6, CODt, CODt_m, CODt_m1, C
 ODt_m2, CODt_m3, CODt_m4, CODt_m5,
 CODt_m6, eta_fe, eta_NO3, eta_NO3d,
 f_ac, f_ac1a, f_ac1b, f_ac2a, f_ac
 2b, f_ac3a, f_ac3b, f_ac4a, f_ac4b,
 f_ac5a, f_ac5b, f_ac6a, f_ac6b, f_
 avOHO, f_avPAO, f_bs, f_bs1a, f_bs1
 b, f_bs2a, f_bs2b, f_bs3a, f_bs3b,
 f_bs4a, f_bs4b, f_bs5a, f_bs5b, f_b
 s6a, f_bs6b, f_cv, f_na, f_SI, f_up
 , f_up1a, f_up1b, f_up2a, f_up2b, f_
 up3a, f_up3b, f_up4a, f_up4b, f_up
 5a, f_up5b, f_up6a, f_up6b, f_us, f_
 us1a, f_us1b, f_us2a, f_us2b, f_us
 3a, f_us3b, f_us4a, f_us4b, f_us5a,
 f_us5b, f_us6a, f_us6b, f_vTG, f_v
 TH, f_XiAUT, f_XiOHO, f_XiPAO, ISS_
 AeroM, ISS_AeroM1, ISS_AeroM2, ISS_
 AeroM3, ISS_AeroM4, ISS_AeroM5, ISS_
 AeroM6, ISS_AnaerM, ISS_AnaerM1, I
 SS_AnaerM2, ISS_AnaerM3, ISS_AnaerM
 4, ISS_AnaerM5, ISS_AnaerM6, ISS_An
 oxM, ISS_AnoxM1, ISS_AnoxM2, ISS_An
 oxM3, ISS_AnoxM4, ISS_AnoxM5, ISS_A
 noxM6, ISS_fiOHO, ISS_fiPAO, ISS_fi
 PAOBM, ISS_Xioi, ISS_Xioin, ISS_Xio
 in1a, ISS_Xioin1b, ISS_Xioin2a, ISS_
 Xioin2b, ISS_Xioin3a, ISS_Xioin3b,
 ISS_Xioin4a, ISS_Xioin4b, ISS_Xioi
 n5a, ISS_Xioin5b, ISS_Xioin6a, ISS_
 Xioin6b, ISS_Xioini, ISS_Xioinila,
 ISS_Xioinilb, ISS_Xioini2a, ISS_Xio
 ini2b, ISS_Xioini3a, ISS_Xioini3b,
 ISS_Xioini4a, ISS_Xioini4b, ISS_Xio
 ini5a, ISS_Xioini5b, ISS_Xioini6a,
 ISS_Xioini6b, ISS_Xoi, i_NBM, i_NSf
 , i_NSi, i_NXi, i_NXs, i_PBM, i_Psf

, i_PSi, i_PXi, i_PXs, i_TSSBM, i_TSSXi, i_TSSXs, K_ALK, K_ALKAUT, K_ALKPRE, K_AOHO, K_APAO, K_F, K_fe, K_h, K_h20, K_IPP, K_La, K_Max, K_NH4AUT, K_NH4OHO, K_NH4PAO, K_NO3, K_O2, K_P, K_PHA, K_PP, k_PRE, K_PS, k_RED, K_X, K_X20, mue_AUT, mue_AUT20, mue_H, mue_H20, mue_PAO, mue_PAO20, mVSS, N_ti, N_tila, N_tilb, N_ti2a, N_ti2b, N_ti3a, N_ti3b, N_ti4a, N_ti4b, N_ti5a, N_ti5b, N_ti6a, N_ti6b, OUR_AUT, OUR_c, OUR_HSA, OUR_HSF, OUR_PAO, OUR_PP, OUR_t, OUR_t_meas, OUR_t_meas1, OUR_t_meas2, OUR_t_meas3, OUR_t_meas4, OUR_t_meas5, OUR_t_meas6, P_i, P_ila, P_ilb, P_i2a, P_i2b, P_i3a, P_i3b, P_i4a, P_i4b, P_i5a, P_i5b, P_i6a, P_i6b, Q, Q_as, Q_e, q_fe, q_fe20, q_fe20_1a, q_fe20_1b, q_fe20_2a, q_fe20_2b, q_fe20_3a, q_fe20_3b, q_fe20_4a, q_fe20_4b, q_fe20_5a, q_fe20_5b, q_fe20_6a, q_fe20_6b, Q_i, q_PHA, q_PHA20, q_PP, q_PP20, q_PP20_1a, q_PP20_1b, q_PP20_2a, q_PP20_2b, q_PP20_3a, q_PP20_3b, q_PP20_4a, q_PP20_4b, q_PP20_5a, q_PP20_5b, q_PP20_6a, q_PP20_6b, Q_r, Q_rec, Q_w, Q_wm, Q_wm1, Q_wm2, Q_wm3, Q_wm4, Q_wm5, Q_wm6, R_hn, R_s, S_A, S_Ain, S_Aini, S_F, S_Fin, S_Fini, S_I, S_Iin, S_Iini, S_N2, S_N2in, S_N2ini, S_NH4, S_NH4in, S_NH4in1a, S_NH4in1b, S_NH4in2a, S_NH4in2b, S_NH4in3a, S_NH4in3b, S_NH4in4a, S_NH4in4b, S_NH4in5a, S_NH4in5b, S_NH4in6a, S_NH4in6b, S_NH4ini, S_NH4inila, S_NH4inilb, S_NH4ini2a, S_NH4ini2b, S_NH4ini3a, S_NH4ini3b, S_NH4ini4a, S_NH4ini4b, S_NH4ini5a, S_NH4ini5b, S_NH4ini6a, S_NH4ini6b, S_NH4meas, S_NH4meas1, S_NH4meas2, S_NH4meas3, S_NH4meas4, S_NH4meas5, S_NH4meas6, S_NO3, S_NO3in, S_NO3ini, S_NO3meas, S_NO3meas1, S_NO3meas2, S_NO3meas3, S_NO3meas4, S_NO3meas5, S_NO3meas6, S_O2, S_O2sat, S_PO4, S_PO4in, S_PO4in1a, S_PO4in1b, S_PO4in2a, S_PO4in2b, S_PO4in3a, S_PO4in3b, S_PO4in4a, S_PO4in4b, S_PO4in5a, S_PO4in5b, S_PO4in6a, S_PO4in6b, S_PO4ini, S_PO4inila, S_PO4inilb, S_PO4ini2a, S_PO4ini2b, S_PO4ini3a, S_PO4ini3b, S_PO4ini4a, S_PO4ini4b, S_PO4ini5a, S_PO4ini5b, S_PO4ini6a, S_PO4ini6b, S_PO4meas, S_PO4meas1, S_PO4meas2, S_PO4meas3, S_PO4meas4, S_PO4meas5, S_PO4meas6, S_ti, S_tila, S_tilb, S_ti2a, S_ti2b, S_ti3a, S_ti3b, S_ti4a, S_ti4b, S_ti5a, S_ti5b, S_ti6a, S_ti6b, T, t, the_bAUT, the_bH,

the_bPAO, the_bPHA, the_bPP, the_K
 h, the_KX, the_mueAUT, the_mueH, th
 e_muePAO, the_qfe, the_qPHA, the_qP
 P, TKN, TKN_meas, TKN_meas1, TKN_me
 as2, TKN_meas3, TKN_meas4, TKN_meas
 5, TKN_meas6, TSS, TSS_measAero, TS
 S_measAero1, TSS_measAero2, TSS_mea
 sAero3, TSS_measAero4, TSS_measAero
 5, TSS_measAero6, TSS_measAnaer, TS
 S_measAnaer1, TSS_measAnaer2, TSS_m
 easAnaer3, TSS_measAnaer4, TSS_meas
 Anaer5, TSS_measAnaer6, TSS_measAno
 x, TSS_measAnox1, TSS_measAnox2, TS
 S_measAnox3, TSS_measAnox4, TSS_mea
 sAnox5, TSS_measAnox6, t_mode, Volu
 me, VSS, VSS_measAero, VSS_measAero
 1, VSS_measAero2, VSS_measAero3, VS
 S_measAero4, VSS_measAero5, VSS_mea
 sAero6, VSS_measAnaer, VSS_measAnaer
 1, VSS_measAnaer2, VSS_measAnaer3,
 VSS_measAnaer4, VSS_measAnaer5, VS
 S_measAnaer6, VSS_measAnox, VSS_me
 sAnox1, VSS_measAnox2, VSS_measAnox
 3, VSS_measAnox4, VSS_measAnox5, VS
 S_measAnox6, V_aero, V_anaer, V_ano
 x, X_AUT, X_AUTin, X_AUTini, X_AUTi
 nila, X_AUTinilb, X_AUTini2a, X_AUT
 ini2b, X_AUTini3a, X_AUTini3b, X_AU
 Tini4a, X_AUTini4b, X_AUTini5a, X_A
 UTini5b, X_AUTini6a, X_AUTini6b, X_
 H, X_Hin, X_Hini, X_Hinila, X_Hinil
 b, X_Hini2a, X_Hini2b, X_Hini3a, X_
 Hini3b, X_Hini4a, X_Hini4b, X_Hini5
 a, X_Hini5b, X_Hini6a, X_Hini6b, X_
 I, X_Iin, X_Iini, X_Iinila, X_Iinil
 b, X_Iini2a, X_Iini2b, X_Iini3a, X_
 Iini3b, X_Iini4a, X_Iini4b, X_Iini5
 a, X_Iini5b, X_Iini6a, X_Iini6b, X_
 PAO, X_PAOin, X_PAOini, X_PAOinila,
 X_PAOinilb, X_PAOini2a, X_PAOini2b
 , X_PAOini3a, X_PAOini3b, X_PAOini4
 a, X_PAOini4b, X_PAOini5a, X_PAOini
 5b, X_PAOini6a, X_PAOini6b, X_PHA,
 X_PHAin, X_PHAini, X_PHAinila, X_PH
 Ainilb, X_PHAini2a, X_PHAini2b, X_P
 HAINi3a, X_PHAini3b, X_PHAini4a, X_
 PHAINi4b, X_PHAini5a, X_PHAini5b, X_
 PHAINi6a, X_PHAini6b, X_PP, X_PP
 in, X_PPini, X_PPinila, X_PPinilb, X_
 PPini2a, X_PPini2b, X_PPini3a, X_PP
 ini3b, X_PPini4a, X_PPini4b, X_PP
 ini5a, X_PPini5b, X_PPini6a, X_PPini6
 b, X_S, X_Sin, X_Sini, X_taero, X_t
 aerola, X_taerolb, X_taero2a, X_tae
 ro2b, X_taero3a, X_taero3b, X_taero
 4a, X_taero4b, X_taero5a, X_taero5b
 , X_taero6a, X_taero6b, X_tanaer, X_
 tanaerla, X_tanaerlb, X_tanaer2a,
 X_tanaer2b, X_tanaer3a, X_tanaer3b,
 X_tanaer4a, X_tanaer4b, X_tanaer5a
 , X_tanaer5b, X_tanaer6a, X_tanaer6

b, X_tanox, X_tanox1a, X_tanox1b, X_tanox2a, X_tanox2b, X_tanox3a, X_tanox3b, X_tanox4a, X_tanox4b, X_tanox5a, X_tanox5b, X_tanox6a, X_tanox6b, Y_AUT, Y_H, Y_PAO, Y_PHA, Y_PO4
 Active Processes: AerobicHydrolysis, AeroGrowthS_A, AeroGrowthS_F, AeroGrowthX_PAO, Anaerobichydrolysis, AnoxicGrowthS_A, AnoxicGrowthS_F, Anoxichydrolysis, Fermentation, GrowthX_AUT, LysisX_AUT, LysisX_H, LysisX_PAO, LysisX_PHA, LysisX_PP, StorageX_PHA, StorageX_PP
 Initial Conditions:
 Variable(Zone) : Initial Condition
 S_I(Bulk Volume) : S_Iini
 S_NH4(Bulk Volume) : S_NH4ini
 X_AUT(Bulk Volume) : X_AUTini
 X_H(Bulk Volume) : X_Hini
 X_I(Bulk Volume) : X_Iini
 X_PAO(Bulk Volume) : X_PAOini
 X_S(Bulk Volume) : X_Sini
 S_A(Bulk Volume) : S_Aini
 S_NO3(Bulk Volume) : S_NO3ini
 S_PO4(Bulk Volume) : S_PO4ini
 X_PHA(Bulk Volume) : X_PHAini
 X_PP(Bulk Volume) : X_PPini
 S_F(Bulk Volume) : S_Fini
 S_N2(Bulk Volume) : S_N2ini
 ISS_Xioi(Bulk Volume) : ISS_Xioini
 Inflow: 0
 Loadings:
 Volume: 21
 Accuracies:
 Rel. Acc. Q: 0.001
 Abs. Acc. Q: 0.001
 Rel. Acc. V: 0.001
 Abs. Acc. V: 0.001

Effluent: Description:
 Type: Mixed Reactor Compartment
 Compartment Index: 0
 Active Variables: b_AUT, b_AUT20, b_H, b_H20, b_PAO, b_PAO20, b_PHA, b_PHA20, b_PP, b_PP20, Calcnun, CODf, CODf_m, CODf_m1, CODf_m2, CODf_m3, CODf_m4, CODf_m5, CODf_m6, CODt, CODt_m, CODt_m1, CODt_m2, CODt_m3, CODt_m4, CODt_m5, CODt_m6, eta_fe, eta_NO3, eta_NO3d, f_ac, f_ac1a, f_ac1b, f_ac2a, f_ac2b, f_ac3a, f_ac3b, f_ac4a, f_ac4b, f_ac5a, f_ac5b, f_ac6a, f_ac6b, f_avOHO, f_avPAO, f_bs, f_bs1a, f_bs1b, f_bs2a, f_bs2b, f_bs3a, f_bs3b, f_bs4a, f_bs4b, f_bs5a, f_bs5b, f_bs6a, f_bs6b, f_cv, f_na, f_SI, f_up, f_up1a, f_up1b, f_up2a, f_up2b, f_up3a, f_up3b, f_up4a, f_up4b, f_up5a, f_up5b, f_up6a, f_up6b, f_us, f_us1a, f_us1b, f_us2a, f_us2b, f_us3a, f_us3b, f_us4a, f_us4b, f_us5a,

f_us5b, f_us6a, f_us6b, f_vTG, f_v
 TH, f_XiAUT, f_XiOHO, f_XiPAO, ISS_
 AeroM, ISS_AeroM1, ISS_AeroM2, ISS_
 AeroM3, ISS_AeroM4, ISS_AeroM5, ISS_
 AeroM6, ISS_AnaerM, ISS_AnaerM1, I
 SS_AnaerM2, ISS_AnaerM3, ISS_AnaerM
 4, ISS_AnaerM5, ISS_AnaerM6, ISS_An
 oxM, ISS_AnoxM1, ISS_AnoxM2, ISS_An
 oxM3, ISS_AnoxM4, ISS_AnoxM5, ISS_A
 noxM6, ISS_fiOHO, ISS_fiPAO, ISS_fi
 PAOBM, ISS_Xioi, ISS_Xioin, ISS_Xio
 inla, ISS_Xioinlb, ISS_Xioin2a, ISS_
 Xioin2b, ISS_Xioin3a, ISS_Xioin3b,
 ISS_Xioin4a, ISS_Xioin4b, ISS_Xioi
 n5a, ISS_Xioin5b, ISS_Xioin6a, ISS_
 Xioin6b, ISS_Xioini, ISS_Xioinila,
 ISS_Xioinilb, ISS_Xioini2a, ISS_Xio
 ini2b, ISS_Xioini3a, ISS_Xioini3b,
 ISS_Xioini4a, ISS_Xioini4b, ISS_Xio
 ini5a, ISS_Xioini5b, ISS_Xioini6a,
 ISS_Xioini6b, ISS_Xoi, i_NBM, i_NSf
 , i_NSi, i_NXi, i_NXs, i_PBM, i_Psf
 , i_PSi, i_PXi, i_PXs, i_TSSBM, i_T
 SSXi, i_TSSXs, K_ALK, K_ALKAUT, K_A
 LKPRE, K_AOHO, K_APAO, K_F, K_fe, K
 _h, K_h2O, K_IPP, K_La, K_Max, K_NH
 4AUT, K_NH4OHO, K_NH4PAO, K_NO3, K_
 O2, K_P, K_PHA, K_PP, k_PRE, K_PS,
 k_RED, K_X, K_X2O, mue_AUT, mue_AUT
 20, mue_H, mue_H2O, mue_PAO, mue_PA
 O20, mVSS, N_ti, N_tila, N_tilb, N_
 ti2a, N_ti2b, N_ti3a, N_ti3b, N_ti4
 a, N_ti4b, N_ti5a, N_ti5b, N_ti6a,
 N_ti6b, OUR_AUT, OUR_c, OUR_HSA, OU
 R_HSF, OUR_PAO, OUR_PP, OUR_t, OUR_
 t_meas, OUR_t_meas1, OUR_t_meas2, O
 UR_t_meas3, OUR_t_meas4, OUR_t_meas
 5, OUR_t_meas6, P_i, P_ila, P_ilb,
 P_i2a, P_i2b, P_i3a, P_i3b, P_i4a,
 P_i4b, P_i5a, P_i5b, P_i6a, P_i6b,
 Q, Q_as, Q_e, q_fe, q_fe20, q_fe20_
 la, q_fe20_lb, q_fe20_2a, q_fe20_2b
 , q_fe20_3a, q_fe20_3b, q_fe20_4a,
 q_fe20_4b, q_fe20_5a, q_fe20_5b, q_
 fe20_6a, q_fe20_6b, Q_i, q_PHA, q_P
 HA20, q_PP, q_PP20, q_PP20_1a, q_PP
 20_1b, q_PP20_2a, q_PP20_2b, q_PP20
 _3a, q_PP20_3b, q_PP20_4a, q_PP20_4
 b, q_PP20_5a, q_PP20_5b, q_PP20_6a,
 q_PP20_6b, Q_r, Q_rec, Q_w, Q_wm,
 Q_wm1, Q_wm2, Q_wm3, Q_wm4, Q_wm5,
 Q_wm6, R_hn, R_s, S_A, S_Ain, S_Ain
 i, S_F, S_Fin, S_Fini, S_I, S_Iin,
 S_Iini, S_N2, S_N2in, S_N2ini, S_NH
 4, S_NH4in, S_NH4inla, S_NH4inlb, S_
 NH4in2a, S_NH4in2b, S_NH4in3a, S_N
 H4in3b, S_NH4in4a, S_NH4in4b, S_NH4
 in5a, S_NH4in5b, S_NH4in6a, S_NH4in
 6b, S_NH4ini, S_NH4inila, S_NH4inil
 b, S_NH4ini2a, S_NH4ini2b, S_NH4ini
 3a, S_NH4ini3b, S_NH4ini4a, S_NH4in

i4b, S_NH4ini5a, S_NH4ini5b, S_NH4i
ni6a, S_NH4ini6b, S_NH4meas, S_NH4m
eas1, S_NH4meas2, S_NH4meas3, S_NH4
meas4, S_NH4meas5, S_NH4meas6, S_NO
3, S_NO3in, S_NO3ini, S_NO3meas, S_
NO3meas1, S_NO3meas2, S_NO3meas3, S_
NO3meas4, S_NO3meas5, S_NO3meas6,
S_O2, S_O2sat, S_PO4, S_PO4in, S_PO
4in1a, S_PO4in1b, S_PO4in2a, S_PO4i
n2b, S_PO4in3a, S_PO4in3b, S_PO4in4
a, S_PO4in4b, S_PO4in5a, S_PO4in5b,
S_PO4in6a, S_PO4in6b, S_PO4ini, S_
PO4inila, S_PO4inilb, S_PO4ini2a, S_
PO4ini2b, S_PO4ini3a, S_PO4ini3b,
S_PO4ini4a, S_PO4ini4b, S_PO4ini5a,
S_PO4ini5b, S_PO4ini6a, S_PO4ini6b
, S_PO4meas, S_PO4meas1, S_PO4meas2
, S_PO4meas3, S_PO4meas4, S_PO4meas
5, S_PO4meas6, S_ti, S_tila, S_tilb
, S_ti2a, S_ti2b, S_ti3a, S_ti3b, S_
ti4a, S_ti4b, S_ti5a, S_ti5b, S_ti
6a, S_ti6b, T, t, the_bAUT, the_bH,
the_bPAO, the_bPHA, the_bPP, the_K
h, the_KX, the_mueAUT, the_mueH, th
e_muePAO, the_qfe, the_qPHA, the_qP
P, TKN, TKN_meas, TKN_meas1, TKN_me
as2, TKN_meas3, TKN_meas4, TKN_meas
5, TKN_meas6, TSS, TSS_measAero, TS
S_measAero1, TSS_measAero2, TSS_mea
sAero3, TSS_measAero4, TSS_measAero
5, TSS_measAero6, TSS_measAnaer, TS
S_measAnaer1, TSS_measAnaer2, TSS_m
easAnaer3, TSS_measAnaer4, TSS_meas
Anaer5, TSS_measAnaer6, TSS_measAno
x, TSS_measAnox1, TSS_measAnox2, TS
S_measAnox3, TSS_measAnox4, TSS mea
sAnox5, TSS_measAnox6, t_mode, Volu
me, VSS, VSS_measAero, VSS_measAero
1, VSS_measAero2, VSS_measAero3, VS
S_measAero4, VSS_measAero5, VSS mea
sAero6, VSS_measAnaer, VSS_measAnaer
1, VSS_measAnaer2, VSS_measAnaer3,
VSS_measAnaer4, VSS_measAnaer5, VS
S_measAnaer6, VSS_measAnox, VSS mea
sAnox1, VSS_measAnox2, VSS_measAnox
3, VSS_measAnox4, VSS_measAnox5, VS
S_measAnox6, V_aero, V_anaer, V_ano
x, X_AUT, X_AUTin, X_AUTini, X_AUTi
nila, X_AUTinilb, X_AUTini2a, X_AUT
ini2b, X_AUTini3a, X_AUTini3b, X_AU
Tini4a, X_AUTini4b, X_AUTini5a, X_A
UTini5b, X_AUTini6a, X_AUTini6b, X_
H, X_Hin, X_Hini, X_Hinila, X_Hinil
b, X_Hini2a, X_Hini2b, X_Hini3a, X_
Hini3b, X_Hini4a, X_Hini4b, X_Hini5
a, X_Hini5b, X_Hini6a, X_Hini6b, X_
I, X_Iin, X_Iini, X_Iinila, X_Iinil
b, X_Iini2a, X_Iini2b, X_Iini3a, X_
Iini3b, X_Iini4a, X_Iini4b, X_Iini5
a, X_Iini5b, X_Iini6a, X_Iini6b, X_
PAO, X_PAOin, X_PAOini, X_PAOinila,

```
Active Processes:
Initial Conditions:
Inflow:          0
Loadings:
Volume:          0.001
Accuracies:
  Rel. Acc. Q:   0.001
  Abs. Acc. Q:   0.001
  Rel. Acc. V:   0.001
  Abs. Acc. V:   0.001
```

```
Separaorl:      Description:  
Type:           Mixed Reactor Compartment  
Compartment Index:    0  
Active Variables:   b_AUT, b_AUT20, b_H, b_H2O, b_PAO,  
                    b_PAO20, b_PHA, b_PHA20, b_PP, b_PP  
                    20, Calcnum, CODf, CODf_m, CODf_ml,  
                    CODf_m2, CODf_m3, CODf_m4, CODf_m5  
                    , CODf_m6, CODt, CODt_m, CODt_ml, C  
                    ODt_m2, CODt_m3, CODt_m4, CODt_m5,  
                    CODt_m6, eta_fe, eta_NO3, eta_NO3d,  
                    f_ac, f_aclla, f_acllb, f_ac2a, f_ac  
                    2b, f_ac3a, f_ac3b, f_ac4a, f_ac4b,  
                    f_ac5a, f_ac5b, f_ac6a, f_ac6b, f_  
                    avOHo, f_avPAO, f_bs, f_bsla, f_bsl  
                    b, f_bs2a, f_bs2b, f_bs3a, f_bs3b,  
                    f_bs4a, f_bs4b, f_bs5a, f_bs5b, f_b  
                    s6a, f bs6b, f_cv, f_na, f_SI, f_up  
                    , f_uplla, f_upllb, f_up2a, f_up2b, f_  
                    up3a, f_up3b, f_up4a, f_up4b, f_up  
                    5a, f_up5b, f_up6a, f_up6b, f_us, f_  
                    uslla, f_usllb, f_us2a, f_us2b, f_us  
                    3a, f_us3b, f_us4a, f_us4b, f_us5a,  
                    f us5b, f us6a, f us6b, f vTG, f v
```

TH, f_XiAUT, f_XiOHO, f_XiPAO, ISS_AeroM, ISS_AeroM1, ISS_AeroM2, ISS_AeroM3, ISS_AeroM4, ISS_AeroM5, ISS_AeroM6, ISS_AnaerM, ISS_AnaerM1, ISS_AnaerM2, ISS_AnaerM3, ISS_AnaerM4, ISS_AnaerM5, ISS_AnaerM6, ISS_AnoxM, ISS_AnoxM1, ISS_AnoxM2, ISS_AnoxM3, ISS_AnoxM4, ISS_AnoxM5, ISS_AnoxM6, ISS_fiOHO, ISS_fiPAO, ISS_fiPAOBM, ISS_Xioi, ISS_Xioin, ISS_Xioin1a, ISS_Xioin1b, ISS_Xioin2a, ISS_Xioin2b, ISS_Xioin3a, ISS_Xioin3b, ISS_Xioin4a, ISS_Xioin4b, ISS_Xioin5a, ISS_Xioin5b, ISS_Xioin6a, ISS_Xioin6b, ISS_Xioini, ISS_Xioinila, ISS_Xioinilb, ISS_Xioini2a, ISS_Xioini2b, ISS_Xioini3a, ISS_Xioini3b, ISS_Xioini4a, ISS_Xioini4b, ISS_Xioini5a, ISS_Xioini5b, ISS_Xioini6a, ISS_Xioini6b, ISS_Xoi, i_NBM, i_NSf, i_NSi, i_NXi, i_NXs, i_PBM, i_PSF, i_PSi, i_PXi, i_PXs, i_TSSBM, i_TSSXi, i_TSSXs, K_ALK, K_ALKAUT, K_ALKPRE, K_AOHO, K_APAO, K_F, K_fe, K_h, K_h20, K_IPP, K_La, K_Max, K_NH4AUT, K_NH4OHO, K_NH4PAO, K_NO3, K_O2, K_P, K_PHA, K_PP, k_PRE, K_PS, k_RED, K_X, K_X20, mue_AUT, mue_AUT20, mue_H, mue_H20, mue_PAO, mue_PAO20, mVSS, N_ti, N_tila, N_tilb, N_ti2a, N_ti2b, N_ti3a, N_ti3b, N_ti4a, N_ti4b, N_ti5a, N_ti5b, N_ti6a, N_ti6b, OUR_AUT, OUR_c, OUR_HSA, OUR_HSF, OUR_PAO, OUR_PP, OUR_t, OUR_t_meas, OUR_t_meas1, OUR_t_meas2, OUR_t_meas3, OUR_t_meas4, OUR_t_meas5, OUR_t_meas6, P_i, P_ila, P_ilb, P_i2a, P_i2b, P_i3a, P_i3b, P_i4a, P_i4b, P_i5a, P_i5b, P_i6a, P_i6b, Q, Q_as, Q_e, q_fe, q_fe20, q_fe20_1a, q_fe20_1b, q_fe20_2a, q_fe20_2b, q_fe20_3a, q_fe20_3b, q_fe20_4a, q_fe20_4b, q_fe20_5a, q_fe20_5b, q_fe20_6a, q_fe20_6b, Q_i, q_PHA, q_PHA20, q_PP, q_PP20, q_PP20_1a, q_PP20_1b, q_PP20_2a, q_PP20_2b, q_PP20_3a, q_PP20_3b, q_PP20_4a, q_PP20_4b, q_PP20_5a, q_PP20_5b, q_PP20_6a, q_PP20_6b, Q_r, Q_rec, Q_w, Q_wm, Q_wm1, Q_wm2, Q_wm3, Q_wm4, Q_wm5, Q_wm6, R_hn, R_s, S_A, S_Ain, S_Aini, S_F, S_Fin, S_Fini, S_I, S_Iin, S_Iini, S_N2, S_N2in, S_N2ini, S_NH4, S_NH4in, S_NH4in1a, S_NH4in1b, S_NH4in2a, S_NH4in2b, S_NH4in3a, S_NH4in3b, S_NH4in4a, S_NH4in4b, S_NH4in5a, S_NH4in5b, S_NH4in6a, S_NH4in6b, S_NH4ini, S_NH4inila, S_NH4inilb, S_NH4ini2a, S_NH4ini2b, S_NH4ini3a, S_NH4ini3b, S_NH4ini4a, S_NH4ini4b, S_NH4ini5a, S_NH4ini5b, S_NH4i

ni6a, S_NH4ini6b, S_NH4meas, S_NH4meas1, S_NH4meas2, S_NH4meas3, S_NH4meas4, S_NH4meas5, S_NH4meas6, S_NO3, S_NO3in, S_NO3ini, S_NO3meas, S_NO3meas1, S_NO3meas2, S_NO3meas3, S_NO3meas4, S_NO3meas5, S_NO3meas6, S_O2, S_O2sat, S_PO4, S_PO4in, S_PO4in1a, S_PO4in1b, S_PO4in2a, S_PO4in2b, S_PO4in3a, S_PO4in3b, S_PO4in4a, S_PO4in4b, S_PO4in5a, S_PO4in5b, S_PO4in6a, S_PO4in6b, S_PO4ini, S_PO4inila, S_PO4inilb, S_PO4ini2a, S_PO4ini2b, S_PO4ini3a, S_PO4ini3b, S_PO4ini4a, S_PO4ini4b, S_PO4ini5a, S_PO4ini5b, S_PO4ini6a, S_PO4ini6b, S_PO4meas, S_PO4meas1, S_PO4meas2, S_PO4meas3, S_PO4meas4, S_PO4meas5, S_PO4meas6, S_ti, S_tila, S_tilb, S_ti2a, S_ti2b, S_ti3a, S_ti3b, S_ti4a, S_ti4b, S_ti5a, S_ti5b, S_ti6a, S_ti6b, T, t, the_bAUT, the_bH, the_bPAO, the_bPHA, the_bPP, the_Kh, the_KX, the_mueAUT, the_mueH, the_muePAO, the_qfe, the_qPHA, the_qPP, TKN, TKN_meas, TKN_meas1, TKN_meas2, TKN_meas3, TKN_meas4, TKN_meas5, TKN_meas6, TSS, TSS_measAero, TSS_measAero1, TSS_measAero2, TSS_measAero3, TSS_measAero4, TSS_measAero5, TSS_measAero6, TSS_measAnaer, TSS_measAnaer1, TSS_measAnaer2, TSS_measAnaer3, TSS_measAnaer4, TSS_measAnaer5, TSS_measAnaer6, TSS_measAnox, TSS_measAnox1, TSS_measAnox2, TSS_measAnox3, TSS_measAnox4, TSS_measAnox5, TSS_measAnox6, t_mode, Volume, VSS, VSS_measAero, VSS_measAero1, VSS_measAero2, VSS_measAero3, VSS_measAero4, VSS_measAero5, VSS_measAero6, VSS_measAnaer, VSS_measAnaer1, VSS_measAnaer2, VSS_measAnaer3, VSS_measAnaer4, VSS_measAnaer5, VSS_measAnaer6, VSS_measAnox, VSS_measAnox1, VSS_measAnox2, VSS_measAnox3, VSS_measAnox4, VSS_measAnox5, VSS_measAnox6, V_aero, V_anaer, V_anox, X_AUT, X_AUTin, X_AUTini, X_AUTinila, X_AUTinilb, X_AUTini2a, X_AUTini2b, X_AUTini3a, X_AUTini3b, X_AUTini4a, X_AUTini4b, X_AUTini5a, X_AUTini5b, X_AUTini6a, X_AUTini6b, X_H, X_Hin, X_Hini, X_Hinila, X_Hinilb, X_Hini2a, X_Hini2b, X_Hini3a, X_Hini3b, X_Hini4a, X_Hini4b, X_Hini5a, X_Hini5b, X_Hini6a, X_Hini6b, X_I, X_Iin, X_Iini, X_Iinila, X_Iinilb, X_Iini2a, X_Iini2b, X_Iini3a, X_Iini3b, X_Iini4a, X_Iini4b, X_Iini5a, X_Iini5b, X_Iini6a, X_Iini6b, X_PAO, X_PAOin, X_PAOini, X_PAOinila, X_PAOinilb, X_PAOini2a, X_PAOini2b

, X_PAOini3a, X_PAOini3b, X_PAOini4a, X_PAOini4b, X_PAOini5a, X_PAOini5b, X_PAOini6a, X_PAOini6b, X_PHA, X_PHAin, X_PHAini, X_PHAinila, X_PHAinilb, X_PHAini2a, X_PHAini2b, X_PHAini3a, X_PHAini3b, X_PHAini4a, X_PHAini4b, X_PHAini5a, X_PHAini5b, X_PHAini6a, X_PHAini6b, X_PP, X_PPin, X_PPini, X_PPinila, X_PPinilb, X_PPini2a, X_PPini2b, X_PPini3a, X_PPini3b, X_PPini4a, X_PPini4b, X_PPini5a, X_PPini5b, X_PPini6a, X_PPini6b, X_S, X_Sin, X_Sini, X_taero, X_taerola, X_taerola, X_taerola, X_taero2a, X_taero2b, X_taero3a, X_taero3b, X_taero4a, X_taero4b, X_taero5a, X_taero5b, X_taero6a, X_taero6b, X_tanaer, X_tanaerla, X_tanaerlb, X_tanaer2a, X_tanaer2b, X_tanaer3a, X_tanaer3b, X_tanaer4a, X_tanaer4b, X_tanaer5a, X_tanaer5b, X_tanaer6a, X_tanaer6b, X_tanox, X_tanoxla, X_tanoxlb, X_tanox2a, X_tanox2b, X_tanox3a, X_tanox3b, X_tanox4a, X_tanox4b, X_tanox5a, X_tanox5b, X_tanox6a, X_tanox6b, Y_AUT, Y_H, Y_PAO, Y_PHA, Y_PO4

Active Processes:

Initial Conditions:

Variable(Zone) : Initial Condition

S_I(Bulk Volume) : S_Iini

S_NH4(Bulk Volume) : S_NH4inila

X_AUT(Bulk Volume) : X_AUTinila

X_H(Bulk Volume) : X_Hinila

X_I(Bulk Volume) : X_Iinila

X_PAO(Bulk Volume) : X_PAOinila

X_S(Bulk Volume) : X_Sini

S_A(Bulk Volume) : S_Aini

S_NO3(Bulk Volume) : S_NO3ini

S_PO4(Bulk Volume) : S_PO4inila

X_PHA(Bulk Volume) : X_PHAinila

X_PP(Bulk Volume) : X_PPinila

S_F(Bulk Volume) : S_Fini

S_N2(Bulk Volume) : S_N2ini

Inflow: 0

Loadings:

Volume: 0.0001

Accuracies:

Rel. Acc. Q: 0.001

Abs. Acc. Q: 0.001

Rel. Acc. V: 0.001

Abs. Acc. V: 0.001

Separator2:

Description:

Type:

Mixed Reactor Compartment

Compartment Index:

0

Active Variables:

b_AUT, b_AUT20, b_H, b_H20, b_PAO, b_PAO20, b_PHA, b_PHA20, b_PP, b_PP20, Calcnum, CODf, CODf_m, CODf_m1, CODf_m2, CODf_m3, CODf_m4, CODf_m5, CODf_m6, CODt, CODt_m, CODt_m1, CODt_m2, CODt_m3, CODt_m4, CODt_m5,

CODt_m6, eta_fe, eta_NO3, eta_NO3d,
 f_ac, f_ac1a, f_ac1b, f_ac2a, f_ac
 2b, f_ac3a, f_ac3b, f_ac4a, f_ac4b,
 f_ac5a, f_ac5b, f_ac6a, f_ac6b, f_
 avOHO, f_avPAO, f_bs, f_bs1a, f_bs1
 b, f_bs2a, f_bs2b, f_bs3a, f_bs3b,
 f_bs4a, f_bs4b, f_bs5a, f_bs5b, f_b
 s6a, f_bs6b, f_cv, f_na, f_SI, f_up
 , f_up1a, f_up1b, f_up2a, f_up2b, f_
 up3a, f_up3b, f_up4a, f_up4b, f_up
 5a, f_up5b, f_up6a, f_up6b, f_us, f_
 us1a, f_us1b, f_us2a, f_us2b, f_us
 3a, f_us3b, f_us4a, f_us4b, f_us5a,
 f_us5b, f_us6a, f_us6b, f_vTG, f_v
 TH, f_XiAUT, f_XiOHO, f_XiPAO, ISS_
 AeroM, ISS_AeroM1, ISS_AeroM2, ISS_
 AeroM3, ISS_AeroM4, ISS_AeroM5, ISS_
 AeroM6, ISS_AnaerM, ISS_AnaerM1, I
 SS_AnaerM2, ISS_AnaerM3, ISS_AnaerM
 4, ISS_AnaerM5, ISS_AnaerM6, ISS_An
 oxM, ISS_AnoxM1, ISS_AnoxM2, ISS_An
 oxM3, ISS_AnoxM4, ISS_AnoxM5, ISS_A
 noxM6, ISS_fiOHO, ISS_fiPAO, ISS_fi
 PAOBM, ISS_Xioi, ISS_Xioin, ISS_Xio
 in1a, ISS_Xioin1b, ISS_Xioin2a, ISS_
 Xioin2b, ISS_Xioin3a, ISS_Xioin3b,
 ISS_Xioin4a, ISS_Xioin4b, ISS_Xioi
 n5a, ISS_Xioin5b, ISS_Xioin6a, ISS_
 Xioin6b, ISS_Xioini, ISS_Xioinila,
 ISS_Xioinilb, ISS_Xioini2a, ISS_Xio
 ini2b, ISS_Xioini3a, ISS_Xioini3b,
 ISS_Xioini4a, ISS_Xioini4b, ISS_Xio
 ini5a, ISS_Xioini5b, ISS_Xioini6a,
 ISS_Xioini6b, ISS_Xoi, i_NBM, i_NSf
 , i_NSi, i_NXi, i_NXs, i_PBM, i_Psf
 , i_PSi, i_PXi, i_PXs, i_TSSBM, i_T
 SSXi, i_TSSXs, K_ALK, K_ALKAUT, K_A
 LKPRE, K_AOHO, K_APAO, K_F, K_fe, K
 _h, K_h2O, K_IPP, K_La, K_Max, K_NH
 4AUT, K_NH4OHO, K_NH4PAO, K_NO3, K_
 O2, K_P, K_PHA, K_PP, k_PRE, K_PS,
 k_RED, K_X, K_X2O, mue_AUT, mue_AUT
 20, mue_H, mue_H2O, mue_PAO, mue_PA
 O20, mVSS, N_ti, N_tila, N_tilb, N_
 ti2a, N_ti2b, N_ti3a, N_ti3b, N_ti4
 a, N_ti4b, N_ti5a, N_ti5b, N_ti6a,
 N_ti6b, OUR_AUT, OUR_c, OUR_HSA, OU
 R_HSF, OUR_PAO, OUR_PP, OUR_t, OUR_
 t_meas, OUR_t_meas1, OUR_t_meas2, O
 UR_t_meas3, OUR_t_meas4, OUR_t_meas
 5, OUR_t_meas6, P_i, P_ila, P_ilb,
 P_i2a, P_i2b, P_i3a, P_i3b, P_i4a,
 P_i4b, P_i5a, P_i5b, P_i6a, P_i6b,
 Q, Q_as, Q_e, q_fe, q_fe20, q_fe20_
 1a, q_fe20_1b, q_fe20_2a, q_fe20_2b
 , q_fe20_3a, q_fe20_3b, q_fe20_4a,
 q_fe20_4b, q_fe20_5a, q_fe20_5b, q_
 fe20_6a, q_fe20_6b, Q_i, q_PHA, q_P
 HA20, q_PP, q_PP20, q_PP20_1a, q_PP
 20_1b, q_PP20_2a, q_PP20_2b, q_PP20
 _3a, q_PP20_3b, q_PP20_4a, q_PP20_4

b, q_PP20_5a, q_PP20_5b, q_PP20_6a,
 q_PP20_6b, Q_r, Q_rec, Q_w, Q_wm,
 Q_wml, Q_wm2, Q_wm3, Q_wm4, Q_wm5,
 Q_wm6, R_hn, R_s, S_A, S_Ain, S_Ain
 i, S_F, S_Fin, S_Fini, S_I, S_Iin,
 S_Iini, S_N2, S_N2in, S_N2ini, S_NH
 4, S_NH4in, S_NH4in1a, S_NH4in1b, S
 _NH4in2a, S_NH4in2b, S_NH4in3a, S_N
 H4in3b, S_NH4in4a, S_NH4in4b, S_NH4
 in5a, S_NH4in5b, S_NH4in6a, S_NH4in
 6b, S_NH4ini, S_NH4inila, S_NH4inil
 b, S_NH4ini2a, S_NH4ini2b, S_NH4ini
 3a, S_NH4ini3b, S_NH4ini4a, S_NH4in
 i4b, S_NH4ini5a, S_NH4ini5b, S_NH4i
 ni6a, S_NH4ini6b, S_NH4meas, S_NH4m
 eas1, S_NH4meas2, S_NH4meas3, S_NH4
 meas4, S_NH4meas5, S_NH4meas6, S_NO
 3, S_NO3in, S_NO3ini, S_NO3meas, S_
 NO3meas1, S_NO3meas2, S_NO3meas3, S_
 _NO3meas4, S_NO3meas5, S_NO3meas6,
 S_O2, S_O2sat, S_PO4, S_PO4in, S_PO
 4in1a, S_PO4in1b, S_PO4in2a, S_PO4i
 n2b, S_PO4in3a, S_PO4in3b, S_PO4in4
 a, S_PO4in4b, S_PO4in5a, S_PO4in5b,
 S_PO4in6a, S_PO4in6b, S_PO4ini, S_
 PO4inila, S_PO4inilb, S_PO4ini2a, S_
 _PO4ini2b, S_PO4ini3a, S_PO4ini3b,
 S_PO4ini4a, S_PO4ini4b, S_PO4ini5a,
 S_PO4ini5b, S_PO4ini6a, S_PO4ini6b
 , S_PO4meas, S_PO4meas1, S_PO4meas2
 , S_PO4meas3, S_PO4meas4, S_PO4meas
 5, S_PO4meas6, S_ti, S_tila, S_tilb
 , S_ti2a, S_ti2b, S_ti3a, S_ti3b, S_
 _ti4a, S_ti4b, S_ti5a, S_ti5b, S_ti
 6a, S_ti6b, T, t, the_bAUT, the_bH,
 the_bPAO, the_bPHA, the_bPP, the_K
 h, the_KX, the_mueAUT, the_mueH, th
 e_muePAO, the_qfe, the_qPHA, the_qP
 P, TKN, TKN_meas, TKN_meas1, TKN_me
 as2, TKN_meas3, TKN_meas4, TKN_meas
 5, TKN_meas6, TSS, TSS_measAero, TS
 S_measAero1, TSS_measAero2, TSS_mea
 sAero3, TSS_measAero4, TSS_measAero
 5, TSS_measAero6, TSS_measAnaer, TS
 S_measAnaer1, TSS_measAnaer2, TSS_m
 easAnaer3, TSS_measAnaer4, TSS_meas
 Anaer5, TSS_measAnaer6, TSS_measAno
 x, TSS_measAnox1, TSS_measAnox2, TS
 S_measAnox3, TSS_measAnox4, TSS_mea
 sAnox5, TSS_measAnox6, t_mode, Volu
 me, VSS, VSS_measAero, VSS_measAero
 1, VSS_measAero2, VSS_measAero3, VS
 S_measAero4, VSS_measAero5, VSS_mea
 sAero6, VSS_measAnaer, VSS_measAnaer
 1, VSS_measAnaer2, VSS_measAnaer3,
 VSS_measAnaer4, VSS_measAnaer5, VS
 S_measAnaer6, VSS_measAnox, VSS_mea
 sAnox1, VSS_measAnox2, VSS_measAnox
 3, VSS_measAnox4, VSS_measAnox5, VS
 S_measAnox6, V_aero, V_anaer, V_ano
 x, X_AUT, X_AUTin, X_AUTini, X_AUTi

nila, X_AUTini1b, X_AUTini2a, X_AUT
 ini2b, X_AUTini3a, X_AUTini3b, X_AU
 Tini4a, X_AUTini4b, X_AUTini5a, X_A
 UTini5b, X_AUTini6a, X_AUTini6b, X_
 H, X_Hin, X_Hini, X_Hinila, X_Hini1
 b, X_Hini2a, X_Hini2b, X_Hini3a, X_
 Hini3b, X_Hini4a, X_Hini4b, X_Hini5
 a, X_Hini5b, X_Hini6a, X_Hini6b, X_
 I, X_Iin, X_Iini, X_Iinila, X_Iini1
 b, X_Iini2a, X_Iini2b, X_Iini3a, X_
 Iini3b, X_Iini4a, X_Iini4b, X_Iini5
 a, X_Iini5b, X_Iini6a, X_Iini6b, X_
 PAO, X_PAOin, X_PAOini, X_PAOinila,
 X_PAOinilb, X_PAOini2a, X_PAOini2b
 , X_PAOini3a, X_PAOini3b, X_PAOini4
 a, X_PAOini4b, X_PAOini5a, X_PAOini
 5b, X_PAOini6a, X_PAOini6b, X_PHA,
 X_PHAin, X_PHAini, X_PHAinila, X_PH
 Ainilb, X_PHAini2a, X_PHAini2b, X_P
 HAINi3a, X_PHAini3b, X_PHAini4a, X_
 PHAINi4b, X_PHAini5a, X_PHAini5b, X_
 PHAINi6a, X_PHAini6b, X_PP, X_PPin
 , X_PPini, X_PPinila, X_PPini1b, X_
 PPini2a, X_PPini2b, X_PPini3a, X_PP
 ini3b, X_PPini4a, X_PPini4b, X_PPin
 i5a, X_PPini5b, X_PPini6a, X_PPini6
 b, X_S, X_Sin, X_Sini, X_taero, X_t
 aerola, X_taerolb, X_taero2a, X_tae
 ro2b, X_taero3a, X_taero3b, X_taero
 4a, X_taero4b, X_taero5a, X_taero5b
 , X_taero6a, X_taero6b, X_tanaer, X_
 tanaerla, X_tanaerlb, X_tanaer2a,
 X_tanaer2b, X_tanaer3a, X_tanaer3b,
 X_tanaer4a, X_tanaer4b, X_tanaer5a
 , X_tanaer5b, X_tanaer6a, X_tanaer6
 b, X_tanox, X_tanoxla, X_tanoxlb, X_
 tanox2a, X_tanox2b, X_tanox3a, X_t
 anox3b, X_tanox4a, X_tanox4b, X_tan
 ox5a, X_tanox5b, X_tanox6a, X_tanox
 6b, Y_AUT, Y_H, Y_PAO, Y_PHA, Y_PO4

Active Processes:

Initial Conditions:

Variable(Zone) : Initial Condition

S_I(Bulk Volume) : S_Iini

S_NH4(Bulk Volume) : S_NH4inila

X_AUT(Bulk Volume) : X_AUTinila

X_H(Bulk Volume) : X_Hinila

X_I(Bulk Volume) : X_Iinila

X_PAO(Bulk Volume) : X_PAOinila

X_S(Bulk Volume) : X_Sini

S_A(Bulk Volume) : S_Aini

S_NO3(Bulk Volume) : S_NO3ini

S_PO4(Bulk Volume) : S_PO4inila

X_PHA(Bulk Volume) : X_PHAinila

X_PP(Bulk Volume) : X_PPinila

S_F(Bulk Volume) : S_Fini

S_N2(Bulk Volume) : S_N2ini

Inflow: 0

Loadings:

Volume: 0.0001

Accuracies:

Rel. Acc. Q: 0.001
Abs. Acc. Q: 0.001
Rel. Acc. V: 0.001
Abs. Acc. V: 0.001

Waste:	Description:	Mixed Reactor Compartment
	Type:	0
	Compartment Index:	0
	Active Variables:	b_AUT, b_AUT20, b_H, b_H20, b_PAO, b_PAO20, b_PHA, b_PHA20, b_PP, b_PP 20, Calcnum, CODf, CODf_m, CODf_m1, CODf_m2, CODf_m3, CODf_m4, CODf_m5 , CODf_m6, CODt, CODt_m, CODt_m1, C ODt_m2, CODt_m3, CODt_m4, CODt_m5, CODt_m6, eta_fe, eta_NO3, eta_NO3d, f_ac, f_ac1a, f_ac1b, f_ac2a, f_ac 2b, f_ac3a, f_ac3b, f_ac4a, f_ac4b, f_ac5a, f_ac5b, f_ac6a, f_ac6b, f avOHO, f_avPAO, f_bs, f_bs1a, f_bs1 b, f_bs2a, f_bs2b, f_bs3a, f_bs3b, f_bs4a, f_bs4b, f_bs5a, f_bs5b, f_b s6a, f_bs6b, f_cv, f_na, f_SI, f_up , f_up1a, f_up1b, f_up2a, f_up2b, f _up3a, f_up3b, f_up4a, f_up4b, f_up 5a, f_up5b, f_up6a, f_up6b, f_us, f _us1a, f_us1b, f_us2a, f_us2b, f_us 3a, f_us3b, f_us4a, f_us4b, f_us5a, f_us5b, f_us6a, f_us6b, f_vTG, f_v TH, f_XiAUT, f_XiOHO, f_XiPAO, ISS_ AeroM, ISS_AeroM1, ISS_AeroM2, ISS_ AeroM3, ISS_AeroM4, ISS_AeroM5, ISS_ AeroM6, ISS_AnaerM, ISS_AnaerM1, I SS_AnaerM2, ISS_AnaerM3, ISS_AnaerM 4, ISS_AnaerM5, ISS_AnaerM6, ISS_An oxM, ISS_AnoxM1, ISS_AnoxM2, ISS_An oxM3, ISS_AnoxM4, ISS_AnoxM5, ISS_A noxM6, ISS_fiOHO, ISS_fiPAO, ISS_fi PAOBM, ISS_Xioi, ISS_Xioin, ISS_Xio in1a, ISS_Xioin1b, ISS_Xioin2a, ISS_ Xioin2b, ISS_Xioin3a, ISS_Xioin3b, ISS_Xioin4a, ISS_Xioin4b, ISS_Xioi n5a, ISS_Xioin5b, ISS_Xioin6a, ISS_ Xioin6b, ISS_Xioini, ISS_Xioinila, ISS_Xioinilb, ISS_Xioini2a, ISS_Xio ini2b, ISS_Xioini3a, ISS_Xioini3b, ISS_Xioini4a, ISS_Xioini4b, ISS_Xio ini5a, ISS_Xioini5b, ISS_Xioini6a, ISS_Xioini6b, ISS_Xoi, i_NBM, i_NSf , i_NSi, i_NXi, i_NXs, i_PBM, i_PSF , i_PSi, i_PXi, i_PXs, i_TSSBM, i_T SSXi, i_TSSXs, K_ALK, K_ALKAUT, K_A LKPRE, K_AOHO, K_APAO, K_F, K_fe, K _h, K_h20, K_IPP, K_La, K_Max, K_NH 4AUT, K_NH4OHO, K_NH4PAO, K_NO3, K_ O2, K_P, K_PHA, K_PP, k_PRE, K_PS, k_RED, K_X, K_X20, mue_AUT, mue_AUT 20, mue_H, mue_H20, mue_PAO, mue_PA O20, mVSS, N_ti, N_tila, N_tilb, N_ ti2a, N_ti2b, N_ti3a, N_ti3b, N_ti4 a, N_ti4b, N_ti5a, N_ti5b, N_ti6a, N_ti6b, OUR_AUT, OUR_c, OUR_HSA, OU

R_HSF, OUR_PAO, OUR_PP, OUR_t, OUR_t_meas, OUR_t_meas1, OUR_t_meas2, OUR_t_meas3, OUR_t_meas4, OUR_t_meas5, OUR_t_meas6, P_i, P_ila, P_ilb, P_i2a, P_i2b, P_i3a, P_i3b, P_i4a, P_i4b, P_i5a, P_i5b, P_i6a, P_i6b, Q, Q_as, Q_e, q_fe, q_fe20, q_fe20_1a, q_fe20_1b, q_fe20_2a, q_fe20_2b, q_fe20_3a, q_fe20_3b, q_fe20_4a, q_fe20_4b, q_fe20_5a, q_fe20_5b, q_fe20_6a, q_fe20_6b, Q_i, q_PHA, q_PHA20, q_PP, q_PP20, q_PP20_1a, q_PP20_1b, q_PP20_2a, q_PP20_2b, q_PP20_3a, q_PP20_3b, q_PP20_4a, q_PP20_4b, q_PP20_5a, q_PP20_5b, q_PP20_6a, q_PP20_6b, Q_r, Q_rec, Q_w, Q_wm, Q_wm1, Q_wm2, Q_wm3, Q_wm4, Q_wm5, Q_wm6, R_hn, R_s, S_A, S_Ain, S_Aini, S_F, S_Fin, S_Fini, S_I, S_Iin, S_Iini, S_N2, S_N2in, S_N2ini, S_NH4, S_NH4in, S_NH4in1a, S_NH4in1b, S_NH4in2a, S_NH4in2b, S_NH4in3a, S_NH4in3b, S_NH4in4a, S_NH4in4b, S_NH4in5a, S_NH4in5b, S_NH4in6a, S_NH4in6b, S_NH4ini, S_NH4inila, S_NH4inilb, S_NH4ini2a, S_NH4ini2b, S_NH4ini3a, S_NH4ini3b, S_NH4ini4a, S_NH4ini4b, S_NH4ini5a, S_NH4ini5b, S_NH4ini6a, S_NH4ini6b, S_NH4meas, S_NH4meas1, S_NH4meas2, S_NH4meas3, S_NH4meas4, S_NH4meas5, S_NH4meas6, S_NO3, S_NO3in, S_NO3ini, S_NO3meas, S_NO3meas1, S_NO3meas2, S_NO3meas3, S_NO3meas4, S_NO3meas5, S_NO3meas6, S_O2, S_O2sat, S_PO4, S_PO4in, S_PO4in1a, S_PO4in1b, S_PO4in2a, S_PO4in2b, S_PO4in3a, S_PO4in3b, S_PO4in4a, S_PO4in4b, S_PO4in5a, S_PO4in5b, S_PO4in6a, S_PO4in6b, S_PO4ini, S_PO4inila, S_PO4inilb, S_PO4ini2a, S_PO4ini2b, S_PO4ini3a, S_PO4ini3b, S_PO4ini4a, S_PO4ini4b, S_PO4ini5a, S_PO4ini5b, S_PO4ini6a, S_PO4ini6b, S_PO4meas, S_PO4meas1, S_PO4meas2, S_PO4meas3, S_PO4meas4, S_PO4meas5, S_PO4meas6, S_ti, S_tila, S_tilb, S_ti2a, S_ti2b, S_ti3a, S_ti3b, S_ti4a, S_ti4b, S_ti5a, S_ti5b, S_ti6a, S_ti6b, T, t, the_bAUT, the_bH, the_bPAO, the_bPHA, the_bPP, the_Kh, the_KX, the_mueAUT, the_mueH, the_muePAO, the_qfe, the_qPHA, the_qPP, TKN, TKN_meas, TKN_meas1, TKN_meas2, TKN_meas3, TKN_meas4, TKN_meas5, TKN_meas6, TSS, TSS_measAero, TSS_measAero1, TSS_measAero2, TSS_measAero3, TSS_measAero4, TSS_measAero5, TSS_measAero6, TSS_measAnaer, TSS_measAnaer1, TSS_measAnaer2, TSS_measAnaer3, TSS_measAnaer4, TSS_measAnaer5, TSS_measAnaer6, TSS_measAno

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x, TSS_measAnox1, TSS_measAnox2, TS
S_measAnox3, TSS_measAnox4, TSS_measAnox5, TSS_measAnox6, t_mode, Volume, VSS, VSS_measAero, VSS_measAero1, VSS_measAero2, VSS_measAero3, VSS_measAero4, VSS_measAero5, VSS_measAero6, VSS_measAnaer, VSS_measAnaer1, VSS_measAnaer2, VSS_measAnaer3, VSS_measAnaer4, VSS_measAnaer5, VSS_measAnaer6, VSS_measAnox, VSS_measAnox1, VSS_measAnox2, VSS_measAnox3, VSS_measAnox4, VSS_measAnox5, VSS_measAnox6, V_aero, V_anaer, V_anox, X_AUT, X_AUTin, X_AUTini, X_AUTinila, X_AUTinilb, X_AUTini2a, X_AUTini2b, X_AUTini3a, X_AUTini3b, X_AUTini4a, X_AUTini4b, X_AUTini5a, X_AUTini5b, X_AUTini6a, X_AUTini6b, X_H, X_Hin, X_Hini, X_Hinila, X_Hinilb, X_Hini2a, X_Hini2b, X_Hini3a, X_Hini3b, X_Hini4a, X_Hini4b, X_Hini5a, X_Hini5b, X_Hini6a, X_Hini6b, X_I, X_Iin, X_Iini, X_Iinila, X_Iinilb, X_Iini2a, X_Iini2b, X_Iini3a, X_Iini3b, X_Iini4a, X_Iini4b, X_Iini5a, X_Iini5b, X_Iini6a, X_Iini6b, X_PAO, X_PAOin, X_PAOini, X_PAOinila, X_PAOinilb, X_PAOini2a, X_PAOini2b, X_PAOini3a, X_PAOini3b, X_PAOini4a, X_PAOini4b, X_PAOini5a, X_PAOini5b, X_PAOini6a, X_PAOini6b, X_PHA, X_PHAin, X_PHAini, X_PHAinila, X_PHAinilb, X_PHAini2a, X_PHAini2b, X_PHAini3a, X_PHAini3b, X_PHAini4a, X_PHAini4b, X_PHAini5a, X_PHAini5b, X_PHAini6a, X_PHAini6b, X_PP, X_PPin, X_PPini, X_PPinila, X_PPinilb, X_PPini2a, X_PPini2b, X_PPini3a, X_PPini3b, X_PPini4a, X_PPini4b, X_PPini5a, X_PPini5b, X_PPini6a, X_PPini6b, X_S, X_Sin, X_Sini, X_taero, X_taerola, X_taerolb, X_taero2a, X_taero2b, X_taero3a, X_taero3b, X_taero4a, X_taero4b, X_taero5a, X_taero5b, X_taero6a, X_taero6b, X_tanaer, X_tanaer1a, X_tanaer1b, X_tanaer2a, X_tanaer2b, X_tanaer3a, X_tanaer3b, X_tanaer4a, X_tanaer4b, X_tanaer5a, X_tanaer5b, X_tanaer6a, X_tanaer6b, X_tanox, X_tanox1a, X_tanox1b, X_tanox2a, X_tanox2b, X_tanox3a, X_tanox3b, X_tanox4a, X_tanox4b, X_tanox5a, X_tanox5b, X_tanox6a, X_tanox6b, Y_AUT, Y_H, Y_PAO, Y_PHA, Y_PO4

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Active Processes:
Initial Conditions:
Inflow: 0
Loadings:
Volume: 0.001
Accuracies:
Rel. Acc. Q: 0.001

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Abs. Acc. Q: 0.001
 Rel. Acc. V: 0.001
 Abs. Acc. V: 0.001

Links

linkR1R2: Type: Advective Link
 Link Index: 0
 Compartment In: AnearobicR
 Connection In: Outflow
 Compartment Out: AnoxicR
 Connection Out: Inflow
 Bifurcations:

linkR2R3: Description: r-recycle flow to anaerobic
 Type: Advective Link
 Link Index: 0
 Compartment In: AnoxicR
 Connection In: Outflow
 Compartment Out: AerobicR
 Connection Out: Inflow
 Bifurcations:
 Q_r:
 Description:
 Compartment Out: AnearobicR
 Connection Out: Inflow
 Water Flow: Q_r

linkR3S1: Type: Advective Link
 Link Index: 0
 Compartment In: AerobicR
 Connection In: Outflow
 Compartment Out: Separator1
 Connection Out: Inflow
 Bifurcations:
 Q_w:
 Description:Waste flow
 Compartment Out: Waste
 Connection Out: Inflow
 Water Flow: Q_w

linkS1S2: Type: Advective Link
 Link Index: 0
 Compartment In: Separator1
 Connection In: Outflow
 Compartment Out: Separator2
 Connection Out: Inflow
 Bifurcations:
 Q_as:
 Description:
 Compartment Out: AnoxicR
 Connection Out: Inflow
 Water Flow: Q_as

linkS2E: Type: Advective Link

Link Index: 0
 Compartment In: Separator2
 Connection In: Outflow
 Compartment Out: Effluent
 Connection Out: Inflow
 Bifurcations:

Q_rec:

Description:
 Compartment Out: AerobicR
 Connection Out: Inflow
 Water Flow: Q_rec

Mass Loadings:

Variable : Loading

S_A : Q_rec*S_A
 S_F : Q_rec*S_F
 S_I : Q_rec*S_I
 S_N2 : Q_rec*S_N2
 S_NH4 : Q_rec*S_NH4
 S_NO3 : Q_rec*S_NO3
 S_O2 : Q_rec*S_O2
 S_PO4 : Q_rec*S_PO4
 X_AUT : Q*X_AUT
 X_H : Q*X_H
 X_I : Q*X_I
 X_PAO : Q*X_PAO
 X_PHA : Q*X_PHA
 X_PP : Q*X_PP
 X_S : Q*X_S
 ISS_Xioi : Q*ISS_Xioi

Definitions of Calculations

calc01: Description:
 Calculation Number: 1
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 20000
 Status: active for simulation
 inactive for sensitivity analysis

calc02: Description:
 Calculation Number: 2
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 20000
 Status: active for simulation
 inactive for sensitivity analysis

calc03: Description:
 Calculation Number: 3
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001

Num. Steps:	20000
Status:	active for simulation inactive for sensitivity analysis

calc04:	Description:	
	Calculation Number:	4
	Initial Time:	0
	Initial State:	given, made consistent
	Step Size:	0.001
	Num. Steps:	20000
	Status:	active for simulation inactive for sensitivity analysis

calc05:	Description:	
	Calculation Number:	5
	Initial Time:	0
	Initial State:	given, made consistent
	Step Size:	0.001
	Num. Steps:	20000
	Status:	active for simulation inactive for sensitivity analysis

calc06:	Description:	
	Calculation Number:	6
	Initial Time:	0
	Initial State:	given, made consistent
	Step Size:	0.001
	Num. Steps:	20000
	Status:	active for simulation inactive for sensitivity analysis

calc11:	Description:	
	Calculation Number:	11
	Initial Time:	0
	Initial State:	given, made consistent
	Step Size:	0.001
	Num. Steps:	20000
	Status:	active for simulation inactive for sensitivity analysis

calc12:	Description:	
	Calculation Number:	12
	Initial Time:	0
	Initial State:	given, made consistent
	Step Size:	0.001
	Num. Steps:	20000
	Status:	active for simulation inactive for sensitivity analysis

calc13:	Description:	
	Calculation Number:	13
	Initial Time:	0
	Initial State:	given, made consistent
	Step Size:	0.001
	Num. Steps:	20000
	Status:	active for simulation inactive for sensitivity analysis

calc14:	Description:	
	Calculation Number:	14
	Initial Time:	0

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Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 20000
 Status: active for simulation
 inactive for sensitivity analysis

 calc15: Description:
 Calculation Number: 15
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 20000
 Status: active for simulation
 inactive for sensitivity analysis

calc16: Description:
 Calculation Number: 16
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 20000
 Status: active for simulation
 inactive for sensitivity analysis

Plot Definitions

ANO_01: Description: Autotrophic nitrifying organisms
 Abscissa: Time
 Title: Autotrophic nitrifying organisms
 Abscissa Label: Operation time (d)
 Ordinate Label: ANO (mgCOD/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : X_AUT [1,AnearobicR,Bulk Volume,0]
 Value : X_AUT [1,AnoxicR,Bulk Volume,0]
 Value : X_AUT [1,AerobicR,Bulk Volume,0]
 Value : X_AUT [11,AnearobicR,Bulk Volume,0]
 Value : X_AUT [11,AnoxicR,Bulk Volume,0]
 Value : X_AUT [11,AerobicR,Bulk Volume,0]

 CODf_01: Description: Filtered COD
 Abscissa: Time
 Title: Filtered COD
 Abscissa Label: Operation time (d)
 Ordinate Label: Filtered COD (mgCOD/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_I [1,AnearobicR,Bulk Volume,0]
 Value : S_I [1,AerobicR,Bulk Volume,0]
 Value : S_I [11,AnearobicR,Bulk Volume,0]
 Value : S_I [11,AerobicR,Bulk Volume,0]
 Value : CODf_m [1,AerobicR,Bulk Volume,0]

CODt_01: Description: Total COD
 Abscissa: Time

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Title: Total COD
 Abscissa Label: Operation time (d)
 Ordinate Label: Total COD (mgCOD/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : CODt [1,AnearobicR,Bulk Volume,0]
 Value : CODt [1,AerobicR,Bulk Volume,0]
 Value : CODt [11,AnearobicR,Bulk Volume,0]
 Value : CODt [11,AerobicR,Bulk Volume,0]
 Value : CODt_m [1,AerobicR,Bulk Volume,0]

DO: Description: Dissolved oxygen concentration
 Abscissa: Time
 Title: Dissolved oxygen concentration
 Abscissa Label: Operation time (d)
 Ordinate Label: DO (mgO/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_O2 [1,AerobicR,Bulk Volume,0]
 Value : S_O2 [2,AerobicR,Bulk Volume,0]
 Value : S_O2 [3,AerobicR,Bulk Volume,0]
 Value : S_O2 [4,AerobicR,Bulk Volume,0]

ISS_Xoi01: Description: Total ISS in the reactor
 Abscissa: Time
 Title: Total ISS in the reactor
 Abscissa Label: Operation time (d)
 Ordinate Label: ISS (mgISS/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : ISS_Xoi [1,AnearobicR,Bulk Volume,0]
 Value : ISS_Xoi [1,AnoxicR,Bulk Volume,0]
 Value : ISS_Xoi [1,AerobicR,Bulk Volume,0]
 Value : ISS_Xoi [11,AnearobicR,Bulk Volume,0]
 Value : ISS_Xoi [11,AnoxicR,Bulk Volume,0]
 Value : ISS_Xoi [11,AerobicR,Bulk Volume,0]

mVSS_01: Description: Model VSS (in COD/l)
 Abscissa: Time
 Title: Model VSS (in COD/l)
 Abscissa Label: Operation time (d)
 Ordinate Label: VSS (mgCOD/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : mVSS [1,AnearobicR,Bulk Volume,0]
 Value : mVSS [1,AnoxicR,Bulk Volume,0]
 Value : mVSS [1,AerobicR,Bulk Volume,0]
 Value : mVSS [11,AnearobicR,Bulk Volume,0]
 Value : mVSS [11,AnoxicR,Bulk Volume,0]
 Value : mVSS [11,AerobicR,Bulk Volume,0]
 Value : VSS_measAnaer1 [1,AnearobicR,Bulk Volume,0]
 Value : VSS_measAnox1 [1,AnoxicR,Bulk Volume,0]
 Value : VSS_measAerol [1,AerobicR,Bulk Volume,0]

mVSS_02: Description: Model VSS (in COD/l)
 Abscissa: Time
 Title: Model VSS (in COD/l)
 Abscissa Label: Operation time (d)
 Ordinate Label: VSS (mgCOD/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]

Value : mVSS [2,AnearobicR,Bulk Volume,0]
 Value : mVSS [2,AnoxicR,Bulk Volume,0]
 Value : mVSS [2,AerobicR,Bulk Volume,0]
 Value : mVSS [12,AnearobicR,Bulk Volume,0]
 Value : mVSS [12,AnoxicR,Bulk Volume,0]
 Value : mVSS [12,AerobicR,Bulk Volume,0]
 Value : VSS_measAnaer2 [2,AnearobicR,Bulk Volume,0]
 Value : VSS_measAnox2 [2,AnoxicR,Bulk Volume,0]
 Value : VSS_measAero2 [2,AerobicR,Bulk Volume,0]

mVSS_03: Description: Model VSS (in COD/l)
 Abscissa: Time
 Title: Model VSS (in COD/l)
 Abscissa Label: Operation time (d)
 Ordinate Label: VSS (mgCOD/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : mVSS [3,AnearobicR,Bulk Volume,0]
 Value : mVSS [3,AnoxicR,Bulk Volume,0]
 Value : mVSS [3,AerobicR,Bulk Volume,0]
 Value : mVSS [13,AnearobicR,Bulk Volume,0]
 Value : mVSS [13,AnoxicR,Bulk Volume,0]
 Value : mVSS [13,AerobicR,Bulk Volume,0]
 Value : VSS_measAnaer3 [3,AnearobicR,Bulk Volume,0]
 Value : VSS_measAnox3 [3,AnoxicR,Bulk Volume,0]
 Value : VSS_measAero3 [3,AerobicR,Bulk Volume,0]

mVSS_04: Description: Model VSS (in COD/l)
 Abscissa: Time
 Title: Model VSS (in COD/l)
 Abscissa Label: Operation time (d)
 Ordinate Label: VSS (mgCOD/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : mVSS [4,AnearobicR,Bulk Volume,0]
 Value : mVSS [4,AnoxicR,Bulk Volume,0]
 Value : mVSS [4,AerobicR,Bulk Volume,0]
 Value : mVSS [14,AnearobicR,Bulk Volume,0]
 Value : mVSS [14,AnoxicR,Bulk Volume,0]
 Value : mVSS [14,AerobicR,Bulk Volume,0]
 Value : VSS_measAnaer4 [4,AnearobicR,Bulk Volume,0]
 Value : VSS_measAnox4 [4,AnoxicR,Bulk Volume,0]
 Value : VSS_measAero4 [4,AerobicR,Bulk Volume,0]

mVSS_05: Description: Model VSS (in COD/l)
 Abscissa: Time
 Title: Model VSS (in COD/l)
 Abscissa Label: Operation time (d)
 Ordinate Label: VSS (mgCOD/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : mVSS [5,AnearobicR,Bulk Volume,0]
 Value : mVSS [5,AnoxicR,Bulk Volume,0]
 Value : mVSS [5,AerobicR,Bulk Volume,0]
 Value : mVSS [15,AnearobicR,Bulk Volume,0]
 Value : mVSS [15,AnoxicR,Bulk Volume,0]
 Value : mVSS [15,AerobicR,Bulk Volume,0]
 Value : VSS_measAnaer5 [5,AnearobicR,Bulk Volume,0]
 Value : VSS_measAnox5 [5,AnoxicR,Bulk Volume,0]
 Value : VSS_measAero5 [5,AerobicR,Bulk Volume,0]

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mVSS_06:      Description:      Model VSS (in COD/l)
               Abscissa:        Time
               Title:           Model VSS (in COD/l)
               Abscissa Label:   Operation time (d)
               Ordinate Label:   VSS (mgCOD/l)
               Curves:
                 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
                 Value : mVSS [6,AnearobicR,Bulk Volume,0]
                 Value : mVSS [6,AnoxicR,Bulk Volume,0]
                 Value : mVSS [6,AerobicR,Bulk Volume,0]
                 Value : mVSS [16,AnearobicR,Bulk Volume,0]
                 Value : mVSS [16,AnoxicR,Bulk Volume,0]
                 Value : mVSS [16,AerobicR,Bulk Volume,0]
                 Value : VSS_measAnaer6 [6,AnearobicR,Bulk Volume,0]
                 Value : VSS_measAnox6 [6,AnoxicR,Bulk Volume,0]
                 Value : VSS_measAero6 [6,AerobicR,Bulk Volume,0]
-----
OHO_01:      Description:      Ordinary heterotrophic organisms
               Abscissa:        Time
               Title:           Ordinary heterotrophic organisms
               Abscissa Label:   Operation time (d)
               Ordinate Label:   OHO (mgCOD/l)
               Curves:
                 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
                 Value : X_H [1,AnearobicR,Bulk Volume,0]
                 Value : X_H [1,AnoxicR,Bulk Volume,0]
                 Value : X_H [1,AerobicR,Bulk Volume,0]
                 Value : X_H [11,AnearobicR,Bulk Volume,0]
                 Value : X_H [11,AnoxicR,Bulk Volume,0]
                 Value : X_H [11,AerobicR,Bulk Volume,0]
-----
OUR_01:      Description:      OUR
               Abscissa:        Time
               Title:           OUR
               Abscissa Label:   Operation time (d)
               Ordinate Label:   OUR (mg/l/h)
               Curves:
                 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
                 Value : OUR_t [1,AerobicR,Bulk Volume,0]
                 Value : OUR_c [1,AerobicR,Bulk Volume,0]
                 Value : OUR_t [11,AerobicR,Bulk Volume,0]
                 Value : OUR_c [11,AerobicR,Bulk Volume,0]
                 Value : OUR_t_meas [1,AerobicR,Bulk Volume,0]
-----
PAO_01:      Description:      Phosphorus accumulating organisms
               Abscissa:        Time
               Title:           Phosphorus accumulating organisms
               Abscissa Label:   Operation time (d)
               Ordinate Label:   PAO (mgCOD/l)
               Curves:
                 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
                 Value : X_PAO [1,AnearobicR,Bulk Volume,0]
                 Value : X_PAO [1,AnoxicR,Bulk Volume,0]
                 Value : X_PAO [1,AerobicR,Bulk Volume,0]
                 Value : X_PAO [11,AnearobicR,Bulk Volume,0]
                 Value : X_PAO [11,AnoxicR,Bulk Volume,0]
                 Value : X_PAO [11,AerobicR,Bulk Volume,0]
-----
PHA_01:      Description:      PHA storage
               Abscissa:        Time
               Title:           PHA storage

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Abscissa Label: Operation time (d)
 Ordinate Label: PHA (mgCOD/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : X_PHA [1,AnearobicR,Bulk Volume,0]
 Value : X_PHA [1,AnoxicR,Bulk Volume,0]
 Value : X_PHA [1,AerobicR,Bulk Volume,0]
 Value : X_PHA [11,AnearobicR,Bulk Volume,0]
 Value : X_PHA [11,AnoxicR,Bulk Volume,0]
 Value : X_PHA [11,AerobicR,Bulk Volume,0]

PP_01: Description: Polyphosphate
 Abscissa: Time
 Title: Polyphosphate
 Abscissa Label: Operation time (d)
 Ordinate Label: PP (mgCOD/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : X_PP [1,AnearobicR,Bulk Volume,0]
 Value : X_PP [1,AnoxicR,Bulk Volume,0]
 Value : X_PP [1,AerobicR,Bulk Volume,0]
 Value : X_PP [11,AnearobicR,Bulk Volume,0]
 Value : X_PP [11,AnoxicR,Bulk Volume,0]
 Value : X_PP [11,AerobicR,Bulk Volume,0]

Q_w: Description: Waste sludge
 Abscissa: Time
 Title: Waste sludge
 Abscissa Label: Operation time (d)
 Ordinate Label: Qw (l/d)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : Q_w [1,AerobicR,Bulk Volume,0]
 Value : Q_w [11,AerobicR,Bulk Volume,0]
 Value : Q_wm [1,AerobicR,Bulk Volume,0]

S_A_01: Description: Acetate
 Abscissa: Time
 Title: Acetate
 Abscissa Label: Operation time (d)
 Ordinate Label: Acetate (mgCOD/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_A [1,AnearobicR,Bulk Volume,0]
 Value : S_A [1,AnoxicR,Bulk Volume,0]
 Value : S_A [1,AerobicR,Bulk Volume,0]
 Value : S_A [11,AnearobicR,Bulk Volume,0]
 Value : S_A [11,AnoxicR,Bulk Volume,0]
 Value : S_A [11,AerobicR,Bulk Volume,0]

S_F_01: Description: Fermentable, readily biodegradable
 organic substrate
 Abscissa: Time
 Title: Fermentable, readily biodegradable
 organic substrate
 Abscissa Label: Operation time (d)
 Ordinate Label: RBCOD (mgCOD/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_F [1,AnearobicR,Bulk Volume,0]
 Value : S_F [1,AnoxicR,Bulk Volume,0]

Value : S_F [1,AerobicR,Bulk Volume,0]
 Value : S_F [11,AnearobicR,Bulk Volume,0]
 Value : S_F [11,AnoxicR,Bulk Volume,0]
 Value : S_F [11,AerobicR,Bulk Volume,0]

S_N2_Anaer: Description: Denitrification_Anaerobic
 Abscissa: Time
 Title: S_N2_Anaer
 Abscissa Label: Operation time (d)
 Ordinate Label: S_N2 (mgN/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_N2 [1,AnearobicR,Bulk Volume,0]
 Value : S_N2 [2,AnearobicR,Bulk Volume,0]
 Value : S_N2 [3,AnearobicR,Bulk Volume,0]
 Value : S_N2 [4,AnearobicR,Bulk Volume,0]

S_N2_Anox: Description: Denitrification_Anoxic
 Abscissa: Time
 Title: S_N2_Anox
 Abscissa Label: Operation time (d)
 Ordinate Label: S_N2 (mgN/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_N2 [1,AnoxicR,Bulk Volume,0]
 Value : S_N2 [2,AnoxicR,Bulk Volume,0]
 Value : S_N2 [3,AnoxicR,Bulk Volume,0]
 Value : S_N2 [4,AnoxicR,Bulk Volume,0]

S_NH4_01: Description: FSA
 Abscissa: Time
 Title: FSA
 Abscissa Label: Operation time (d)
 Ordinate Label: FSA (mgN/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_NH4 [1,AnearobicR,Bulk Volume,0]
 Value : S_NH4 [1,AnoxicR,Bulk Volume,0]
 Value : S_NH4 [1,Effluent,Bulk Volume,0]
 Value : S_NH4 [11,AnearobicR,Bulk Volume,0]
 Value : S_NH4 [11,AnoxicR,Bulk Volume,0]
 Value : S_NH4 [11,Effluent,Bulk Volume,0]
 Value : S_NH4meas [1,AerobicR,Bulk Volume,0]

S_NO3_01: Description: Nitrate
 Abscissa: Time
 Title: Nitrate
 Abscissa Label: Operation time (d)
 Ordinate Label: Nitrate (mgN/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_NO3 [1,AnearobicR,Bulk Volume,0]
 Value : S_NO3 [1,AnoxicR,Bulk Volume,0]
 Value : S_NO3 [1,Effluent,Bulk Volume,0]
 Value : S_NO3 [11,AnearobicR,Bulk Volume,0]
 Value : S_NO3 [11,AnoxicR,Bulk Volume,0]
 Value : S_PO4 [11,Effluent,Bulk Volume,0]
 Value : S_NO3meas [1,AerobicR,Bulk Volume,0]

S_PO4_01: Description: Orthophosphate
 Abscissa: Time

Title: Orthophosphate
 Abscissa Label: Operation time (d)
 Ordinate Label: PO4-P (mgP/l)

Curves:

Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : S_PO4 [1, AnearobicR, Bulk Volume, 0]
 Value : S_PO4 [1, AnoxicR, Bulk Volume, 0]
 Value : S_PO4 [1, Effluent, Bulk Volume, 0]
 Value : S_PO4 [11, AnearobicR, Bulk Volume, 0]
 Value : S_PO4 [11, AnoxicR, Bulk Volume, 0]
 Value : S_PO4 [11, Effluent, Bulk Volume, 0]
 Value : S_PO4meas [1, AerobicR, Bulk Volume, 0]

S_PO4_02: Description: Orthophosphate
 Abscissa: Time
 Title: Orthophosphate
 Abscissa Label: Operation time (d)
 Ordinate Label: PO4-P (mgP/l)

Curves:

Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : S_PO4 [2, AnearobicR, Bulk Volume, 0]
 Value : S_PO4 [2, AnoxicR, Bulk Volume, 0]
 Value : S_PO4 [2, Effluent, Bulk Volume, 0]
 Value : S_PO4 [12, AnearobicR, Bulk Volume, 0]
 Value : S_PO4 [12, AnoxicR, Bulk Volume, 0]
 Value : S_PO4 [12, Effluent, Bulk Volume, 0]
 Value : S_PO4meas [2, AerobicR, Bulk Volume, 0]

S_PO4_03: Description: Orthophosphate
 Abscissa: Time
 Title: Orthophosphate
 Abscissa Label: Operation time (d)
 Ordinate Label: PO4-P (mgP/l)

Curves:

Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : S_PO4 [3, AnearobicR, Bulk Volume, 0]
 Value : S_PO4 [3, AnoxicR, Bulk Volume, 0]
 Value : S_PO4 [3, Effluent, Bulk Volume, 0]
 Value : S_PO4 [13, AnearobicR, Bulk Volume, 0]
 Value : S_PO4 [13, AnoxicR, Bulk Volume, 0]
 Value : S_PO4 [13, Effluent, Bulk Volume, 0]
 Value : S_PO4meas [3, AerobicR, Bulk Volume, 0]

S_PO4_04: Description: Orthophosphate
 Abscissa: Time
 Title: Orthophosphate
 Abscissa Label: Operation time (d)
 Ordinate Label: PO4-P (mgP/l)

Curves:

Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : S_PO4 [4, AnearobicR, Bulk Volume, 0]
 Value : S_PO4 [4, AnoxicR, Bulk Volume, 0]
 Value : S_PO4 [4, Effluent, Bulk Volume, 0]
 Value : S_PO4 [14, AnearobicR, Bulk Volume, 0]
 Value : S_PO4 [14, AnoxicR, Bulk Volume, 0]
 Value : S_PO4 [14, Effluent, Bulk Volume, 0]
 Value : S_PO4meas [4, AerobicR, Bulk Volume, 0]

S_PO4_05: Description: Orthophosphate
 Abscissa: Time
 Title: Orthophosphate

```

Abscissa Label:      Operation time (d)
Ordinate Label:      PO4-P (mgP/l)
Curves:
  Type : Variable [CalcNum,Comp.,Zone,Time/Space]
  Value : S_PO4 [5,AnearobicR,Bulk Volume,0]
  Value : S_PO4 [5,AnoxicR,Bulk Volume,0]
  Value : S_PO4 [5,Effluent,Bulk Volume,0]
  Value : S_PO4 [15,AnearobicR,Bulk Volume,0]
  Value : S_PO4 [15,AnoxicR,Bulk Volume,0]
  Value : S_PO4 [15,Effluent,Bulk Volume,0]
  Value : S_PO4meas [5,AerobicR,Bulk Volume,0]

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S_PO4_06:      Description:      Orthophosphate
                Abscissa:        Time
                Title:           Orthophosphate
                Abscissa Label:   Operation time (d)
                Ordinate Label:   PO4-P (mgP/l)
                Curves:
                    Type : Variable [CalcNum,Comp.,Zone,Time/Space]
                    Value : S_PO4 [6,AnearobicR,Bulk Volume,0]
                    Value : S_PO4 [6,AnoxicR,Bulk Volume,0]
                    Value : S_PO4 [6,Effluent,Bulk Volume,0]
                    Value : S_PO4 [16,AnearobicR,Bulk Volume,0]
                    Value : S_PO4 [16,AnoxicR,Bulk Volume,0]
                    Value : S_PO4 [16,Effluent,Bulk Volume,0]
                    Value : S_PO4meas [6,AerobicR,Bulk Volume,0]

```

```
TKN_01:      Description:      TKN
             Abscissa:         Time
             Title:            TKN
             Abscissa Label:    Operation time (d)
             Ordinate Label:    TKN (mgN/l)
             Curves:
                 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
                 Value : TKN [1,AnearobicR,Bulk Volume,0]
                 Value : TKN [1,AnoxicR,Bulk Volume,0]
                 Value : TKN [1,Effluent,Bulk Volume,0]
                 Value : TKN [11,AnearobicR,Bulk Volume,0]
                 Value : TKN [11,AnoxicR,Bulk Volume,0]
                 Value : TKN [11,Effluent,Bulk Volume,0]
                 Value : TKN meas [1,AerobicR,Bulk Volume,0]
```

```
TSS_01:      Description:      TSS
             Abscissa:        Time
             Title:           TSS
             Abscissa Label:   Operation time (d)
             Ordinate Label:   TSS (mgTSS/l)
             Curves:
               Type : Variable [CalcNum,Comp.,Zone,Time/Space]
               Value : TSS [1,AnearobicR,Bulk Volume,0]
               Value : TSS [1,AnoxicR,Bulk Volume,0]
               Value : TSS [1,AerobicR,Bulk Volume,0]
               Value : TSS [11,AnearobicR,Bulk Volume,0]
               Value : TSS [11,AnoxicR,Bulk Volume,0]
               Value : TSS [11,AerobicR,Bulk Volume,0]
               Value : TSS_measAnaer [1,AnearobicR,Bulk Volume,0]
               Value : TSS_measAnox [1,AnoxicR,Bulk Volume,0]
               Value : TSS_measAero [1,AerobicR,Bulk Volume,0]
```

X_I_01:	Description:	Inert material
	Abscissa:	Time

Title: Inert material
 Abscissa Label: Operation time (d)
 Ordinate Label: Inert (mgCOD/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : X_I [1,AnearobicR,Bulk Volume,0]
 Value : X_I [1,AnoxicR,Bulk Volume,0]
 Value : X_I [1,AerobicR,Bulk Volume,0]
 Value : X_I [11,AnearobicR,Bulk Volume,0]
 Value : X_I [11,AnoxicR,Bulk Volume,0]
 Value : X_I [11,AerobicR,Bulk Volume,0]

X_S_01: Description: Slowly biodegradable substrate
 Abscissa: Time
 Title: Slowly biodegradable substrate
 Abscissa Label: Operation time (d)
 Ordinate Label: SBCOD (mgCOD/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : X_S [1,AnearobicR,Bulk Volume,0]
 Value : X_S [1,AnoxicR,Bulk Volume,0]
 Value : X_S [1,AerobicR,Bulk Volume,0]
 Value : X_S [11,AnearobicR,Bulk Volume,0]
 Value : X_S [11,AnoxicR,Bulk Volume,0]
 Value : X_S [11,AerobicR,Bulk Volume,0]

 Calculation Parameters

 Numerical Parameters: Maximum Int. Step Size: 1
 Maximum Integrat. Order: 5
 Number of Codiagonals: 1000
 Maximum Number of Steps: 1000

 Fit Method: secant
 Max. Number of Iterat.: 100

APPENDIX C3

Program Listing of ASM-2 and SSM for the Simulation of the Aerobic Batch Digestion

AQUASIM Version 2.0 (win/mfc) - Listing of System Definition

Date and time of listing: 02/13/2007 00:14:39

Variables

b_AUT:	Description:	Maximum growth rate of autotrophs
	Type:	Formula Variable
	Unit:	per day
	Expression:	b_AUT20*exp(the_bAUT*(T-20))

b_AUT20:	Description:	Decay coefficient for autotrophic b iomass
	Type:	Constant Variable
	Unit:	per day
	Value:	0.04
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

b_AUT20_SS:	Description:	Decay coefficient for autotrophic b iomass (SSM)
	Type:	Constant Variable
	Unit:	per day
	Value:	0.04
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

b_H:	Description:	Rate constant for lysis of heterotr ophs
	Type:	Formula Variable
	Unit:	per day
	Expression:	b_H20*exp(the_bH*(T-20))

b_H20:	Description:	Rate constant for lysis of heterotr ophs
	Type:	Constant Variable
	Unit:	per day
	Value:	0.62
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

b_H20_SS:	Description:	Rate constant for lysis of heterotr ophs (SSM)

	Type:	Constant Variable
	Unit:	per day
	Value:	0.24
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
b_PAO:	Description:	Rate constant for lysis of X_PAO
	Type:	Formula Variable
	Unit:	per day
	Expression:	$b\_PAO20 \cdot \exp(\text{the\_bPAO} \cdot (T-20))$
b_PAO20:	Description:	Rate constant for lysis of X_PAO
	Type:	Constant Variable
	Unit:	per day
	Value:	0.04
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
b_PAO20_SS:	Description:	Rate constant for lysis of X_PAO (S SM)
	Type:	Constant Variable
	Unit:	per day
	Value:	0.04
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
b_PHA:	Description:	Rate constant for lysis of X_PHA
	Type:	Formula Variable
	Unit:	per day
	Expression:	$b\_PHA20 \cdot \exp(\text{the\_bPHA} \cdot (T-20))$
b_PHA20:	Description:	Rate constant for lysis of X_PHA
	Type:	Constant Variable
	Unit:	per day
	Value:	0.04
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
b_PP:	Description:	Rate constant for lysis of X_PP
	Type:	Formula Variable
	Unit:	per day
	Expression:	$b\_PP20 \cdot \exp(\text{the\_bPP} \cdot (T-20))$
b_PP20:	Description:	Rate constant for lysis of X_PP
	Type:	Constant Variable
	Unit:	per day
	Value:	0.04
	Standard Deviation:	0.1
	Minimum:	0

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Maximum: 10
Sensitivity Analysis: inactive
Parameter Estimation: inactive

b_PP20_SS: Description: Rate constant for lysis of X_PP (SS M)
Type: Constant Variable
Unit: per day
Value: 0.04
Standard Deviation: 0.1
Minimum: 0
Maximum: 10
Sensitivity Analysis: inactive
Parameter Estimation: inactive

Calcnum: Description: Calculation number
Type: Program Variable
Unit:
Reference to: Calculation Number

CODf: Description: Filtered COD
Type: Formula Variable
Unit: mg/l
Expression: S_I

CODf_m: Description: Measured filtered COD
Type: Variable List Variable
Unit: mg/l
Argument: Calcnum
Interpolation Method: linear interpolation
Real-Variable Data Pairs (6 pairs):
1 CODf_m1
2 CODf_m2
3 CODf_m3
4 CODf_m4
5 CODf_m5
6 CODf_m6

CODf_m1: Description: Measured CODf (BT-1)
Type: Real List Variable
Unit: mg/l
Argument: t
Standard Deviations: global
Rel. Stand. Deviat.: 0
Abs. Stand. Deviat.: 1
Minimum: 0
Maximum: 1e+009
Interpolation Method: linear interpolation
Sensitivity Analysis: inactive
Real Data Pairs (11 pairs):
1 103.8
2 203.4
3 66.4
4 76.8
6 272
7 118.3
8 85.1
9 97.6
10 120.4
11 124.6
12 141.2

```

-----
CODf_m2:      Description:      Measured CODf (BT-2)
              Type:             Real List Variable
              Unit:             mg/l
              Argument:        t
              Standard Deviations: global
              Rel. Stand. Deviat.: 0
              Abs. Stand. Deviat.: 1
              Minimum:         0
              Maximum:         1e+009
              Interpolation Method: linear interpolation
              Sensitivity Analysis: inactive
              Real Data Pairs (6 pairs):
                1              78.89
                2              62.28
                3              70.58
                4              64.36
                5              80.96
                6              89.27

```

```

-----
CODf_m3:      Description:      Measured CODf (BT-3)
              Type:             Real List Variable
              Unit:             mg/l
              Argument:        t
              Standard Deviations: global
              Rel. Stand. Deviat.: 0
              Abs. Stand. Deviat.: 1
              Minimum:         0
              Maximum:         1e+009
              Interpolation Method: linear interpolation
              Sensitivity Analysis: inactive
              Real Data Pairs (24 pairs):
                2              76.81
                3              97.57
                4              72.66
                5              78.89
                6              83.04
                .              .
                .              .
                21             79.93
                22             92.38
                23             108.99
                24             96.534
                25             84.078

```

```

-----
CODf_m4:      Description:      Measured CODf (BT-4)
              Type:             Real List Variable
              Unit:             mg/l
              Argument:        t
              Standard Deviations: global
              Rel. Stand. Deviat.: 0
              Abs. Stand. Deviat.: 1
              Minimum:         0
              Maximum:         1e+009
              Interpolation Method: linear interpolation
              Sensitivity Analysis: inactive
              Real Data Pairs (21 pairs):
                1              51.9
                2              56.05
                3              60.2
                4              60.2

```

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5	68.51
17	83.04
18	95.5
19	83.04
20	87.19
21	89.27

CODf_m5: Description: Measured CODf (BT-5)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (11 pairs):

1	91.344
2	336.312
3	294.792
4	386.136
5	74.736
6	62.28
7	87.192
8	97.572
9	83.04
10	70.584
11	78.888

CODf_m6: Description: Measured CODf (BT-6)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (15 pairs):

1	62.28
2	53.976
3	62.28
4	78.888
5	99.648
.	.
.	.
11	97.572
12	230.436
13	205.524
14	110.028
15	85.116

CODt: Description: Total COD
 Type: Formula Variable
 Unit: mg/l

Expression: S_A+S_F+S_I+X_I+X_S+X_H+X_PAO+X_PHA
+X_AUT

CODt_m: Description: Measured total COD
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (8 pairs):
 1 CODt_m1
 2 CODt_m2
 3 CODt_m3
 4 CODt_m4
 5 CODt_m5
 6 CODt_m6
 7 CODt_m7
 8 CODt_m8

CODt_m1: Description: Measured CODt (BT-1)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (4 pairs):
 5 15746.46
 7 15405.996
 8 13192.98
 9 14725.068

CODt_m2: Description: Measured CODt (BT-2)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (5 pairs):
 1 17874.36
 2 18044.592
 4 17789.244
 5 18810.636
 6 17448.78

CODt_m3: Description: Measured CODt (BT-3)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0

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Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (17 pairs):

1	19832.028
2	18980.868
4	18129.708
5	17533.896
6	17363.664
.	.
18	14384.604
20	13831.35
21	11448.102
22	10596.942
24	10086.246

CODt_m4: Description: Measured CODt (BT-4)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (19 pairs):

1	19661.796
2	19151.1
3	18640.404
4	18470.172
5	18299.94
.	.
16	13278.096
17	12937.632
18	12597.168
20	12256.704
21	12171.588

CODt_m5: Description: Measured CODt (BT-5)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (8 pairs):

1	16682.736
3	14469.72
4	14129.256
6	12937.632
7	12086.472
8	11575.776
9	11065.08

11

10894.848

CODt_m6: Description: Measured CODt (BT-6)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (12 pairs):

1	17193.432
3	15661.344
5	14639.952
6	14299.488
7	13618.56
8	12597.168
10	12597.168
11	12001.356
12	12171.588
13	12001.356
14	11150.196
15	10979.964

CODt_m7: Description: Measured CODt (BT-7) -Undiluted WAS
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (9 pairs):

1	19661.796
2	19236.216
3	17704.128
4	16342.272
5	16001.808
6	14299.488
7	14095.21
8	13107.864
9	12937.632

CODt_m8: Description: Measured CODt (BT-8) -Diluted WAS
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (9 pairs):

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1	4019.136
2	3813.612
3	3379.728
4	3334.056
5	3242.712
6	3082.86
7	2877.336
8	2785.992
9	2785.992

CODt_m8x5:	Description:	Measured CODt (BT-8) -(Diluted batc h*5)
	Type:	Real List Variable
	Unit:	mg/l
	Argument:	t
	Standard Deviations:	global
	Rel. Stand. Deviat.:	0
	Abs. Stand. Deviat.:	1
	Minimum:	0
	Maximum:	1e+009
	Interpolation Method:	linear interpolation
	Sensitivity Analysis:	inactive
	Real Data Pairs (9 pairs):	
	1	20095.68
	2	19068.06
	3	16898.64
	4	16670.28
	5	16213.56
	6	15414.3
	7	14386.68
	8	13929.96
	9	13929.96
deltaTSSSt_SS:	Description:	Reduction of TSS at time t (SSM)
	Type:	Formula Variable
	Unit:	mgTSS/l
	Expression:	$((X\_Hini/f\_cv\_SS)*(1-f\_H\_SS+ISS\_fiOHO)*(1-\exp(-b\_H2O\_SS*t)))+(X\_PAOini/f\_cv\_SS)*(1-f\_G\_SS+ISS\_fiPAO)*(1-\exp(-b\_PAO20\_SS*t)))$
deltaVSSSt_SS:	Description:	Reduction of VSS at time t (SSM)
	Type:	Formula Variable
	Unit:	mgVSS/l
	Expression:	$((X\_Hini)*(1-f\_H\_SS)*(1-\exp(-b\_H2O\_SS*t)))+(X\_PAOini)*(1-f\_G\_SS)*(1-\exp(-b\_PAO20\_SS*t)))$
eta_fe:	Description:	Anaerobic hydrolysis reduction fact or
	Type:	Constant Variable
	Unit:	
	Value:	0.1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
eta_NO3:	Description:	Anoxic hydrolysis reduction factor
	Type:	Constant Variable

	Unit:	
	Value:	0.6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
eta_NO3d:	Description:	Reduction factor for denitrification by heterotrophs
	Type:	Constant Variable
	Unit:	
	Value:	1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_aGTi_SS:	Description:	Initial active fraction of the PAOs (with respect to TSS)
	Type:	Formula Variable
	Unit:	mgVSS/mgTSS
	Expression:	$(X_{PAOini}/f_{cv\_SS})/X_{Ti\_SS}$
f_aGVi_SS:	Description:	Initial active fraction of the PAOs (with respect to VSS)
	Type:	Formula Variable
	Unit:	mgVSS/mgVSS
	Expression:	X_{PAOini}/X_{Vi_SS}
f_aHTi_SS:	Description:	Initial active fraction of the OHOs (with respect to TSS)
	Type:	Formula Variable
	Unit:	mgVSS/mgTSS
	Expression:	$(X_{Hini}/f_{cv\_SS})/X_{Ti\_SS}$
f_aHVi_SS:	Description:	Initial active fraction of the OHOs (with respect to VSS)
	Type:	Formula Variable
	Unit:	mgCOD/mgCOD
	Expression:	X_{Hini}/X_{Vi_SS}
f_avOHO:	Description:	Fraction of the VSS which is OHO
	Type:	Formula Variable
	Unit:	mgCOD/mgCOD
	Expression:	$X_H/mVSS$
f_avPAO:	Description:	Fraction of the VSS which is PAO
	Type:	Formula Variable
	Unit:	mgCOD/mgCOD
	Expression:	$X_{PAO}/mVSS$
f_cv:	Description:	COD/VSS ratio
	Type:	Variable List Variable
	Unit:	gCOD/gCOD
	Argument:	Calcnun
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (16 pairs):	
	1	f_cv1a
	2	f_cv2a

3	f_cv3a
4	f_cv4a
5	f_cv5a
6	f_cv6a
7	f_cv7a
8	f_cv8a
11	f_cv1b
12	f_cv2b
13	f_cv3b
14	f_cv4b
15	f_cv5b
16	f_cv6b
17	f_cv7b
18	f_cv8b

f_cv1a:	Description:	COD/VSS ratio for BT-1
	Type:	Formula Variable
	Unit:	gCOD/gVSS
	Expression:	CODt/VSS
f_cv1b:	Description:	COD/VSS ratio for BT-1
	Type:	Formula Variable
	Unit:	gCOD/gVSS
	Expression:	CODt/VSS
f_cv2a:	Description:	Constant COD/VSS ratio for BT-2
	Type:	Formula Variable
	Unit:	gCOD/gVSS
	Expression:	CODt/VSS
f_cv2b:	Description:	Constant COD/VSS ratio for BT-2
	Type:	Formula Variable
	Unit:	gCOD/gVSS
	Expression:	CODt/VSS
f_cv3a:	Description:	Constant COD/VSS ratio for BT-3
	Type:	Formula Variable
	Unit:	gCOD/gVSS
	Expression:	CODt/VSS
f_cv3b:	Description:	Constant COD/VSS ratio for BT-3
	Type:	Formula Variable
	Unit:	gCOD/gVSS
	Expression:	CODt/VSS
f_cv4a:	Description:	Constant COD/VSS ratio for BT-4
	Type:	Formula Variable
	Unit:	gCOD/gVSS
	Expression:	CODt/VSS
f_cv4b:	Description:	Constant COD/VSS ratio for BT-4
	Type:	Formula Variable
	Unit:	gCOD/gVSS
	Expression:	CODt/VSS
f_cv5a:	Description:	Constant COD/VSS ratio for BT-5
	Type:	Formula Variable
	Unit:	gCOD/gVSS
	Expression:	CODt/VSS
f_cv5b:	Description:	Constant COD/VSS ratio for BT-5

	Type:	Formula Variable
	Unit:	gCOD/gVSS
	Expression:	CODt/VSS

f_cv6a:	Description:	Constant COD/VSS ratio for BT-6
	Type:	Formula Variable
	Unit:	gCOD/gVSS
	Expression:	CODt/VSS

f_cv6b:	Description:	Constant COD/VSS ratio for BT-6
	Type:	Formula Variable
	Unit:	gCOD/gVSS
	Expression:	CODt/VSS

f_cv7a:	Description:	Constant COD/VSS ratio for BT-7
	Type:	Formula Variable
	Unit:	gCOD/gVSS
	Expression:	CODt/VSS

f_cv7b:	Description:	Constant COD/VSS ratio for BT-7
	Type:	Formula Variable
	Unit:	gCOD/gVSS
	Expression:	CODt/VSS

f_cv8a:	Description:	Constant COD/VSS ratio for BT-8
	Type:	Formula Variable
	Unit:	gCOD/gVSS
	Expression:	CODt/VSS

f_cv8b:	Description:	Constant COD/VSS ratio for BT-8
	Type:	Formula Variable
	Unit:	gCOD/gVSS
	Expression:	CODt/VSS

f_cvK:	Description:	Constant COD/VSS ratio
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	1.48
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	2
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_cvM:	Description:	Measured average COD/VSS ratio
	Type:	Variable List Variable
	Unit:	gCOD/gCOD
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (8 pairs):	
	1	f_cvM1
	2	f_cvM2
	3	f_cvM3
	4	f_cvM4
	5	f_cvM5
	6	f_cvM6
	7	f_cvM7
	8	f_cvM8

f_cvm:	Description:	Measured COD/VSS ratio
	Type:	Variable List Variable

Unit: gCOD/gVSS
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (8 pairs):

1	f_cvm1
2	f_cvm2
3	f_cvm3
4	f_cvm4
5	f_cvm5
6	f_cvm6
7	f_cvm7
8	f_cvm8

f_cvM1: Description: Measured average COD/VSS ratio for BT-1
 Type: Constant Variable
 Unit: gCOD/gVSS
 Value: 1.4
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 2
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

f_cvm1: Description: Measured COD/VSS ratio for BT-1
 Type: Real List Variable
 Unit: gCOD/gVSS
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (1 pairs):
 7 1.52

f_cvM2: Description: Measured average COD/VSS ratio for BT-2
 Type: Constant Variable
 Unit: gCOD/gVSS
 Value: 1.44
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 2
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

f_cvm2: Description: Measured COD/VSS ratio for BT-2
 Type: Real List Variable
 Unit: gCOD/gVSS
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (2 pairs):

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	4	1.41
	6	1.47
f_cvM3:	Description:	Measured average COD/VSS ratio for BT-3
	Type:	Constant Variable
	Unit:	gCOD/gVSS
	Value:	1.39
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	2
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_cvm3:	Description:	Measured COD/VSS ratio for BT-3
	Type:	Real List Variable
	Unit:	gCOD/gVSS
	Argument:	t
	Standard Deviations:	global
	Rel. Stand. Deviat.:	0
	Abs. Stand. Deviat.:	1
	Minimum:	0
	Maximum:	1e+009
	Interpolation Method:	linear interpolation
	Sensitivity Analysis:	inactive
	Real Data Pairs (13 pairs):	
	1	1.39
	2	1.41
	4	1.41
	5	1.36
	8	1.47
	13	1.3301891
	15	1.377924
	16	1.3764089
	18	1.3862452
	20	1.429991
	21	1.3853259
	22	1.365644
	24	1.3925188
f_cvM4:	Description:	Measured average COD/VSS ratio for BT-4
	Type:	Constant Variable
	Unit:	gCOD/gVSS
	Value:	1.5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	2
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_cvm4:	Description:	Measured COD/VSS ratio for BT-4
	Type:	Real List Variable
	Unit:	gCOD/gVSS
	Argument:	t
	Standard Deviations:	global
	Rel. Stand. Deviat.:	0
	Abs. Stand. Deviat.:	1
	Minimum:	0
	Maximum:	1e+009
	Interpolation Method:	linear interpolation

Sensitivity Analysis: inactive

Real Data Pairs (17 pairs):

1	1.47
2	1.46
3	1.46
4	1.48
5	1.53
.	.
.	.
16	1.46
17	1.45
18	1.44
20	1.42
21	1.39

f_cvM5:	Description:	Measured average COD/VSS ratio for BT-5
	Type:	Constant Variable
	Unit:	gCOD/gVSS
	Value:	1.16
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	2
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_cvM5:	Description:	Measured COD/VSS ratio for BT-5
	Type:	Real List Variable
	Unit:	gCOD/gVSS
	Argument:	t
	Standard Deviations:	global
	Rel. Stand. Deviat.:	0
	Abs. Stand. Deviat.:	1
	Minimum:	0
	Maximum:	1e+009
	Interpolation Method:	linear interpolation
	Sensitivity Analysis:	inactive
	Real Data Pairs (7 pairs):	
	1	1.14
	3	1.15
	4	1.15
	6	1.23
	7	1.16
	9	1.09
	11	1.23

f_cvM6:	Description:	Measured average COD/VSS ratio for BT-6
	Type:	Constant Variable
	Unit:	gCOD/gVSS
	Value:	1.26
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	2
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_cvM6:	Description:	Measured COD/VSS ratio for BT-6
	Type:	Real List Variable
	Unit:	gCOD/gVSS
	Argument:	t

Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (8 pairs):
 3 1.25
 5 1.36
 6 1.39
 7 1.3
 11 1.18
 12 1.23
 13 1.24
 14 1.15

f_cvm7: Description: Measured average COD/VSS ratio for
 BT-7 (Undiluted)
 Type: Constant Variable
 Unit: gCOD/gVSS
 Value: 1.2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 2
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

f_cvm7: Description: Measured COD/VSS ratio for BT-7 (Un
 diluted)
 Type: Real List Variable
 Unit: gCOD/gVSS
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (8 pairs):
 1 1.26
 2 1.33
 3 1.24
 5 1.2
 6 1.16
 7 1.15
 8 1.14
 9 1.13

f_cvm8: Description: Measured average COD/VSS ratio for
 BT-8 (Diluted)
 Type: Constant Variable
 Unit: gCOD/gVSS
 Value: 1.27
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 2
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

f_cvm8:	Description:	Measured COD/VSS ratio for BT-8 (Diluted)
	Type:	Real List Variable
	Unit:	gCOD/gVSS
	Argument:	t
	Standard Deviations:	global
	Rel. Stand. Deviat.:	0
	Abs. Stand. Deviat.:	1
	Minimum:	0
	Maximum:	1e+009
	Interpolation Method:	linear interpolation
	Sensitivity Analysis:	inactive
	Real Data Pairs (8 pairs):	
	1	1.35
	2	1.37
	3	1.22
	5	1.24
	6	1.28
	7	1.21
	8	1.22
	9	1.22

f_cv_SS:	Description:	COD/VSS ratio (SSM)
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	1.48
	Standard Deviation:	1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_GTrt_SS:	Description:	Fraction of PAOs (with respect to TSS) removed at time t
	Type:	Formula Variable
	Unit:	%
	Expression:	$100 * (f_{aGTi\_SS} * (1 - f_{G\_SS} + ISS_{fiPAO}) * (1 - (\exp(-b_{PAO20\_SS} * t))))$

f_GVrt_SS:	Description:	Fraction of PAOVSS removed at time t
	Type:	Formula Variable
	Unit:	%
	Expression:	$100 * (f_{aGVi\_SS} * (1 - (\exp(-b_{PAO20\_SS} * t))))$

f_G_SS:	Description:	
	Type:	Constant Variable
	Unit:	
	Value:	0.25
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	2
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_HTrt_SS:	Description:	Fraction of OHOs (with respect to TSS) removed at time t
	Type:	Formula Variable
	Unit:	%
	Expression:	$100 * (f_{aHTi\_SS} * (1 - f_{H\_SS} + ISS_{fiOHO}))$

*(1-(exp(-b_H20_SS*t))))		
f_HVrt_SS:	Description:	Fraction of OHOVSS removed at time t
	Type:	Formula Variable
	Unit:	%
	Expression:	100*(f_aHVi_SS*(1-(exp(-b_H20_SS*t))))
f_H_SS:	Description:	
	Type:	Constant Variable
	Unit:	
	Value:	0.2
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	2
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_i:	Description:	VSS/TSS ratio
	Type:	Variable List Variable
	Unit:	gVSS/gTSS
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (16 pairs):	
	1	f_i1a
	2	f_i2a
	3	f_i3a
	4	f_i4a
	5	f_i5a
	6	f_i6a
	7	f_i7a
	8	f_i8a
	11	f_i1b
	12	f_i2b
	13	f_i3b
	14	f_i4b
	15	f_i5b
	16	f_i6b
	17	f_i7b
	18	f_i8b
f_i1a:	Description:	VSS/TSS ratio for BT-1
	Type:	Formula Variable
	Unit:	gVSS/gTSS
	Expression:	VSS/TSS_ISS
f_i1b:	Description:	VSS/TSS ratio for BT-1
	Type:	Formula Variable
	Unit:	gVSS/gTSS
	Expression:	VSS/TSS_ISS
f_i2a:	Description:	VSS/TSS ratio for BT-2
	Type:	Formula Variable
	Unit:	gVSS/gTSS
	Expression:	VSS/TSS_ISS
f_i2b:	Description:	VSS/TSS ratio for BT-2
	Type:	Formula Variable
	Unit:	gVSS/gTSS
	Expression:	VSS/TSS_ISS

f_i3a:	Description:	VSS/TSS ratio for BT-3
	Type:	Formula Variable
	Unit:	gVSS/gTSS
	Expression:	VSS/TSS_ISS
f_i3b:	Description:	VSS/TSS ratio for BT-3
	Type:	Formula Variable
	Unit:	gVSS/gTSS
	Expression:	VSS/TSS_ISS
f_i4a:	Description:	VSS/TSS ratio for BT-4
	Type:	Formula Variable
	Unit:	gVSS/gTSS
	Expression:	VSS/TSS_ISS
f_i4b:	Description:	VSS/TSS ratio for BT-4
	Type:	Formula Variable
	Unit:	gVSS/gTSS
	Expression:	VSS/TSS_ISS
f_i5a:	Description:	VSS/TSS ratio for BT-5
	Type:	Formula Variable
	Unit:	gVSS/gTSS
	Expression:	VSS/TSS_ISS
f_i5b:	Description:	VSS/TSS ratio for BT-5
	Type:	Formula Variable
	Unit:	gVSS/gTSS
	Expression:	VSS/TSS_ISS
f_i6a:	Description:	VSS/TSS ratio for BT-6
	Type:	Formula Variable
	Unit:	gVSS/gTSS
	Expression:	VSS/TSS_ISS
f_i6b:	Description:	VSS/TSS ratio for BT-6
	Type:	Formula Variable
	Unit:	gVSS/gTSS
	Expression:	VSS/TSS_ISS
f_i7a:	Description:	VSS/TSS ratio for BT-7 (Undiluted WAS)
	Type:	Formula Variable
	Unit:	gVSS/gTSS
	Expression:	VSS/TSS_ISS
f_i7b:	Description:	VSS/TSS ratio for BT-7 (Undiluted WAS)
	Type:	Formula Variable
	Unit:	gVSS/gTSS
	Expression:	VSS/TSS_ISS
f_i8a:	Description:	VSS/TSS ratio for BT-8 (Diluted WAS)
	Type:	Formula Variable
	Unit:	gVSS/gTSS
	Expression:	VSS/TSS_ISS
f_i8b:	Description:	VSS/TSS ratio for BT-8 (Diluted WAS)

	Type:	Formula Variable
	Unit:	gVSS/gTSS
	Expression:	VSS/TSS_ISS
f_iM:	Description:	Average measured VSS/TSS ratio
	Type:	Variable List Variable
	Unit:	gVSS/gTSS
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (8 pairs):	
	1	f_iM1
	2	f_iM2
	3	f_iM3
	4	f_iM4
	5	f_iM5
	6	f_iM6
	7	f_iM7
	8	f_iM8
f_iM1:	Description:	Average measured VSS/TSS ratio for BT-1
	Type:	Constant Variable
	Unit:	gCOD/gTSS
	Value:	0.78
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_iM2:	Description:	Average measured VSS/TSS ratio for BT-2
	Type:	Constant Variable
	Unit:	gVSS/gTSS
	Value:	0.8
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_iM3:	Description:	Average measured VSS/TSS ratio for BT-3
	Type:	Constant Variable
	Unit:	gVSS/gTSS
	Value:	0.79
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_iM4:	Description:	Average measured VSS/TSS ratio for BT-4
	Type:	Constant Variable
	Unit:	gVSS/gTSS
	Value:	0.78
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive

Parameter Estimation: inactive

f_iM5:	Description:	Average measured VSS/TSS ratio for BT-5
	Type:	Constant Variable
	Unit:	gVSS/gTSS
	Value:	0.76
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_iM6:	Description:	Average measured VSS/TSS ratio for BT-6
	Type:	Constant Variable
	Unit:	gVSS/gTSS
	Value:	0.75
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_iM7:	Description:	Average measured VSS/TSS ratio for BT-7 (Undiluted)
	Type:	Constant Variable
	Unit:	gVSS/gTSS
	Value:	0.79
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_iM8:	Description:	Average measured VSS/TSS ratio for BT-8 (Diluted)
	Type:	Constant Variable
	Unit:	gVSS/gTSS
	Value:	0.81
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
f_imeas:	Description:	Daily values of measured VSS/TSS ratio
	Type:	Variable List Variable
	Unit:	gVSS/gTSS
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (8 pairs):	
	1	f_imeas1
	2	f_imeas2
	3	f_imeas3
	4	f_imeas4
	5	f_imeas5
	6	f_imeas6
	7	f_imeas7
	8	f_imeas8

f_imeas1: Description: Daily values of measured VSS/TSS ratio for BT-1

 Type: Real List Variable

 Unit: gVSS/gTSS

 Argument: t

 Standard Deviations: global

 Rel. Stand. Deviat.: 0

 Abs. Stand. Deviat.: 1

 Minimum: 0

 Maximum: 1e+009

 Interpolation Method: linear interpolation

 Sensitivity Analysis: inactive

 Real Data Pairs (6 pairs):

1	0.75
2	0.78
3	0.79
4	0.8
6	0.79
7	0.78

f_imeas2: Description: Daily values of measured VSS/TSS ratio for BT-2

 Type: Real List Variable

 Unit: gVSS/gTSS

 Argument: t

 Standard Deviations: global

 Rel. Stand. Deviat.: 0

 Abs. Stand. Deviat.: 1

 Minimum: 0

 Maximum: 1e+009

 Interpolation Method: linear interpolation

 Sensitivity Analysis: inactive

 Real Data Pairs (4 pairs):

2	0.8
3	0.79
4	0.79
6	0.8

f_imeas3: Description: Daily values of measured VSS/TSS ratio for BT-3

 Type: Real List Variable

 Unit: gVSS/gTSS

 Argument: t

 Standard Deviations: global

 Rel. Stand. Deviat.: 0

 Abs. Stand. Deviat.: 1

 Minimum: 0

 Maximum: 1e+009

 Interpolation Method: linear interpolation

 Sensitivity Analysis: inactive

 Real Data Pairs (20 pairs):

1	0.82
2	0.79
4	0.8
5	0.8
7	0.78
.	.
21	0.79
22	0.79

23	0.79
24	0.79
25	0.79

f_imeas4: Description: Daily values of measured VSS/TSS ratio for BT-4

 Type: Real List Variable

 Unit: gVSS/gTSS

 Argument: t

 Standard Deviations: global

 Rel. Stand. Deviat.: 0

 Abs. Stand. Deviat.: 1

 Minimum: 0

 Maximum: 1e+009

 Interpolation Method: linear interpolation

 Sensitivity Analysis: inactive

 Real Data Pairs (16 pairs):

2	0.79
3	0.79
4	0.78
5	0.79
6	0.78
.	.
.	.
17	0.77
18	0.77
19	0.77
20	0.77
21	0.78

f_imeas5: Description: Daily values of measured VSS/TSS ratio for BT-5

 Type: Real List Variable

 Unit: gVSS/gTSS

 Argument: t

 Standard Deviations: global

 Rel. Stand. Deviat.: 0

 Abs. Stand. Deviat.: 1

 Minimum: 0

 Maximum: 1e+009

 Interpolation Method: linear interpolation

 Sensitivity Analysis: inactive

 Real Data Pairs (10 pairs):

1	0.8
2	0.75
3	0.74
4	0.75
5	0.76
6	0.75
7	0.75
8	0
10	0.77
11	0.77

f_imeas6: Description: Daily values of measured VSS/TSS ratio for BT-6

 Type: Real List Variable

 Unit: gVSS/gTSS

 Argument: t

 Standard Deviations: global

 Rel. Stand. Deviat.: 0

Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (8 pairs):
 2 0.76
 3 0.76
 4 0.71
 5 0.72
 6 0.73
 7 0.76
 13 0.78
 14 0.78

f_imeas7: Description: Daily values of measured VSS/TSS ra
 tio for BT-7 (Undiluted)
 Type: Real List Variable
 Unit: gVSS/gTSS
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (7 pairs):
 1 0.79
 2 0.77
 5 0.78
 6 0.78
 7 0.79
 8 0.8
 9 0.8

f_imeas8: Description: Daily values of measured VSS/TSS ra
 tio for BT-8 (Diluted)
 Type: Real List Variable
 Unit: gVSS/gTSS
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (8 pairs):
 1 0.79
 2 0.79
 3 0.81
 5 0.81
 6 0.81
 7 0.82
 8 0.81
 9 0.83

f_n_SS: Description: N content of the VSS
 Type: Constant Variable
 Unit: gN/gVSS

Value: 0.1
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 2
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

f_pG_SS: Description: P content of the PAOs
 Type: Constant Variable
 Unit: gP/gPAOVSS
 Value: 0.38
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 2
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

f_pH_SS: Description: P content of the OHOs
 Type: Constant Variable
 Unit: gP/gOHVSS
 Value: 0.03
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 2
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

f_SI: Description: Fraction of inert COD in particulate substrate
 Type: Constant Variable
 Unit: gCOD/gCOD
 Value: 0
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

f_TrTMeas: Description: Measured fractions of TSS removed
 Type: Variable List Variable
 Unit: %
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (6 pairs):
 1 f_TrTMeas1
 2 f_TrTMeas2
 3 f_TrTMeas3
 4 f_TrTMeas4
 5 f_TrTMeas5
 6 f_TrTMeas6

f_TrTMeas1: Description: Measured fraction of TSS removed for BT-1
 Type: Real List Variable
 Unit: %
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009

Interpolation Method: linear interpolation
Sensitivity Analysis: inactive
Real Data Pairs (6 pairs):

2	1.19
3	1.93
4	5.08
5	19.07
7	20.42
8	22.83

```
f_TrTMeas2:      Description:      Measured fraction of TSS removed fo
                                     r BT-2
Type:            Real List Variable
Unit:            %
Argument:        t
Standard Deviations: global
Rel. Stand. Deviat.: 0
Abs. Stand. Deviat.: 1
Minimum:         0
Maximum:         1e+009
Interpolation Method: linear interpolation
Sensitivity Analysis: inactive
Real Data Pairs (3 pairs):
    4            0.06
    5            0.06
    7            6.55
```

```
f_TrTMeas3:      Description:      Measured fraction of TSS removed fo
                                         r BT-3
Type:            Real List Variable
Unit:            %
Argument:        t
Standard Deviations: global
Rel. Stand. Deviat.: 0
Abs. Stand. Deviat.: 1
Minimum:         0
Maximum:         1e+009
Interpolation Method: linear interpolation
Sensitivity Analysis: inactive
Real Data Pairs (19 pairs):
    2            2.4
    4            6.96
    5            6.83
    7            16.3
    8            15.36
    .            .
    .            .
    21           39.753942
    22           43.799747
    23           44.865491
    24           47.283025
    25           48.516187
```

f_TrMtMeas4:	Description:	Measured fraction of TSS removed for BT-4
	Type:	Real List Variable
	Unit:	%
	Argument:	t
	Standard Deviations:	global
	Rel. Stand. Deviat.:	0
	Abs. Stand. Deviat.:	1

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```

Minimum: 0
Maximum: 1e+009
Interpolation Method: linear interpolation
Sensitivity Analysis: inactive
Real Data Pairs (18 pairs):
  2      2.13
  3      2.52
  4      4.22
  5      8.86
  6     11.8
      .
      .
      .
 17    30.429423
 18    31.603948
 19    32.859648
 20    32.629153
 21    32.171168

```

```
f_TrTMeas5:      Description:      Measured fraction of TSS removed from  
                                         r BT-5  
Type:            Real List Variable  
Unit:            %  
Argument:        t  
Standard Deviations: global  
Rel. Stand. Deviat.: 0  
Abs. Stand. Deviat.: 1  
Minimum:         0  
Maximum:         1e+009  
Interpolation Method: linear interpolation  
Sensitivity Analysis: inactive  
Real Data Pairs (9 pairs):  
    2            7.26  
    3            8  
    4           10.91  
    5           15.39  
    6           23.67  
    7           24.37  
    8           30.65  
   10           31.07  
   11           37.33
```

```
f_TrTMeas6:      Description:      Measured fraction of TSS removed for
                                         BT-6
Type:            Real List Variable
Unit:            %
Argument:        t
Standard Deviations: global
Rel. Stand. Deviat.: 0
Abs. Stand. Deviat.: 1
Minimum:         0
Maximum:         1e+009
Interpolation Method: linear interpolation
Sensitivity Analysis: inactive
Real Data Pairs (11 pairs):
      2          2.71
      3          6.21
      4          12.6
      5          14.6
      6          19.57
      7          21.32
      8          26.96
```

9	26.98
10	27.94
13	28.900943
14	29.583044

f_Trt_SS:	Description:	Fraction of the TSS removed at time t
	Type:	Formula Variable
	Unit:	%
	Expression:	$100 * ((f\_aHTi\_SS * (1 - f\_H\_SS + ISS\_fiOHO) * (1 - (\exp(-b\_H20\_SS * t)))) + (f\_aGTi\_SS * (1 - f\_G\_SS + ISS\_fiPAO) * (1 - (\exp(-b\_PAO20\_SS * t)))))$

f_VrtMeas:	Description:	Measured fraction of VSS removed
	Type:	Variable List Variable
	Unit:	%
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (6 pairs):	
	1	f_VrtMeas1
	2	f_VrtMeas2
	3	f_VrtMeas3
	4	f_VrtMeas4
	5	f_VrtMeas5
	6	f_VrtMeas6

f_VrtMeas1:	Description:	Measured fraction of VSS removed for BT-1
	Type:	Real List Variable
	Unit:	%
	Argument:	t
	Standard Deviations:	global
	Rel. Stand. Deviat.:	0
	Abs. Stand. Deviat.:	1
	Minimum:	0
	Maximum:	1e+009
	Interpolation Method:	linear interpolation
	Sensitivity Analysis:	inactive
	Real Data Pairs (4 pairs):	
	2	0.98
	3	2.56
	4	2.43
	6	8.25

f_VrtMeas2:	Description:	Measured fraction of VSS removed for BT-2
	Type:	Real List Variable
	Unit:	%
	Argument:	t
	Standard Deviations:	global
	Rel. Stand. Deviat.:	0
	Abs. Stand. Deviat.:	1
	Minimum:	0
	Maximum:	1e+009
	Interpolation Method:	linear interpolation
	Sensitivity Analysis:	inactive
	Real Data Pairs (4 pairs):	
	2	0.98
	3	2.56
	4	2.43

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```
f_VrtMeas3:      Description:      Measured fraction of VSS removed fo
                                     r BT-3
Type:             Real List Variable
Unit:             %
Argument:         t
Standard Deviations: global
Rel. Stand. Deviat.: 0
Abs. Stand. Deviat.: 1
Minimum:          0
Maximum:          1e+009
Interpolation Method: linear interpolation
Sensitivity Analysis: inactive
Real Data Pairs (19 pairs):
    2              5.59
    4              9.86
    5              9.73
    7             20.58
    8             19.05
    .              .
    .              .
    21             42.209609
    22             45.735332
    23             47.230705
    24             49.347304
    25             50.17716
```

```

f_VrtMeas4:      Description:      Measured fraction of VSS removed fo
                                     r BT-4
Type:            Real List Variable
Unit:            %
Argument:        t
Standard Deviations:  global
Rel. Stand. Deviat.:  0
Abs. Stand. Deviat.:  1
Minimum:         0
Maximum:         1e+009
Interpolation Method: linear interpolation
Sensitivity Analysis: inactive
Real Data Pairs (18 pairs):
    2            2.01
    3            4.94
    4            6.97
    5           10.9
    6           14.57
    .
    .
    .
    17          33.25208
    18          34.518139
    19          35.906078
    20          35.52427
    21          34.543012

```

f_VrtMeas5:	Description:	Measured fraction of VSS removed from BT-5
	Type:	Real List Variable
	Unit:	%
	Argument:	t
	Standard Deviations:	global
	Rel. Stand. Deviat.:	0

```
Abs. Stand. Deviat.: 1
Minimum: 0
Maximum: 1e+009
Interpolation Method: linear interpolation
Sensitivity Analysis: inactive
Real Data Pairs (9 pairs):
  2 12.24
  3 14.24
  4 16.22
  5 18.93
  6 28.13
  7 29.11
  9 30.5
 10 33.57
 11 39.31
```

```
f_VrtMeas6:      Description:      Measured fraction of VSS removed fo
                                         r BT-6
Type:             Real List Variable
Unit:             %
Argument:         t
Standard Deviations: global
Rel. Stand. Deviat.: 0
Abs. Stand. Deviat.: 1
Minimum:          0
Maximum:          1e+009
Interpolation Method: linear interpolation
Sensitivity Analysis: inactive
Real Data Pairs (10 pairs):
    2              1.58
    3              4.77
    4              17.96
    5              18.53
    6              22.08
    7              20.51
   11              23.05
   12              25.11
   13              26.463174
   14              26.642612
```

f_Vrt_SS:	Description:	Fraction of VSS removed at time t
	Type:	Formula Variable
	Unit:	%
	Expression:	f GVrt SS+f HVrt SS

f_XiAUT:	Description:	Fraction of inert COD in biomass for AUT
	Type:	Constant Variable
	Unit:	gCOD(gCOD)-1
	Value:	0.08
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

f_XiOHO:	Description:	Fraction of inert COD in biomass for OHO
	Type:	Constant Variable
	Unit:	gCOD(gCOD) ⁻¹
	Value:	0.08

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```
Standard Deviation: 0.1
Minimum: 0
Maximum: 1
Sensitivity Analysis: inactive
Parameter Estimation: inactive
```

f_XiPAO:	Description:	Fraction of inert COD in biomass for PAO
	Type:	Constant Variable
	Unit:	gCOD(gCOD) ⁻¹
	Value:	0.25
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

ISS_fiOHO:	Description:	Inorganic content of OHO cell mass
	Type:	Formula Variable
	Unit:	mgISS/mgOHOVSS
	Expression:	0.15

ISS_fiPAO:	Description:	Inorganic content of PAOs
	Type:	Formula Variable
	Unit:	mgISS/mgPAOVSS
	Expression:	$3.286 * (X_{PP} / (X_{PAO} / t_{cv})) + ISS\_fiPAO_{BM}$

ISS_fiPAOBM:	Description:	Inorganic solids content of the PAO active biomass
	Type:	Formula Variable
	Unit:	mgISS/mgPAOVSS
	Expression:	0.15

```

ISS_meas:      Description:      Measured ISS
Type:          Variable List Variable
Unit:          mgISS/l
Argument:      Calcnum
Interpolation Method: linear interpolation
Real-Variable Data Pairs (8 pairs):
1              ISS_meas1
2              ISS_meas2
3              ISS_meas3
4              ISS_meas4
5              ISS_meas5
6              ISS_meas6
7              ISS_meas7
8              ISS_meas8

```

```
ISS_meas1:      Description:      Measured ISS (BT-1)
                Type:              Real List Variable
                Unit:              mgISS/1
                Argument:          t
                Standard Deviations: global
                Rel. Stand. Deviat.: 0
                Abs. Stand. Deviat.: 1
                Minimum:           0
                Maximum:           1e+009
                Interpolation Method: linear interpolation
                Sensitivity Analysis: inactive
                Real Data Pairs (6 pairs):
```

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2	4132
3	3562.67
4	3364
5	2783.33
7	2748.67
8	2866.67

ISS_meas2: Description: Measured ISS (BT-2)
 Type: Real List Variable
 Unit: mgISS/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (4 pairs):

2	3170.33
3	3332.5
4	3314
6	3032.5

ISS_meas3: Description: Measured ISS (BT-3)
 Type: Real List Variable
 Unit: mgISS/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (20 pairs):

1	3121.67
2	3503.17
4	3318.67
5	3321.83
7	3225.67
.	.
.	.
21	2231.83
22	2031.1667
23	2059.3333
24	1940.8333
25	1844.6667

ISS_meas4: Description: Measured ISS (BT-4)
 Type: Real List Variable
 Unit: mgISS/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (16 pairs):

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2	3499
3	3471.5
4	3462.33
5	3217.83
6	3219.83
.	.
.	.
17	2625.17
18	2599.5
19	2576.67
20	2563.83
21	2508.5

ISS_meas5: Description: Measured ISS (BT-5)
 Type: Real List Variable
 Unit: mgISS/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (9 pairs):

1	3733.83
2	4192.67
3	4349.33
4	4103.17
5	3677.67
6	3502.5
7	3519.5
10	2939.83
11	2629.83

ISS_meas6: Description: Measured ISS (BT-6)
 Type: Real List Variable
 Unit: mgISS/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (8 pairs):

2	4087.5
3	3893.67
4	4512
5	4237.83
6	3833.17
7	3319.5
13	2774.5
14	2678.5

ISS_meas7: Description: Measured ISS (BT-7) Undiluted WAS
 Type: Real List Variable
 Unit: mgISS/l
 Argument: t
 Standard Deviations: global

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Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (7 pairs):
 1 4098.75
 2 4342.5
 5 3786
 6 3549
 7 3314
 8 2800
 9 2846

ISS_meas8: Description: Measured ISS (BT-8) Diluted WAS
 Type: Real List Variable
 Unit: mgISS/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (8 pairs):
 1 785.25
 2 761.75
 3 653.5
 5 595.5
 6 580.25
 7 517
 8 546.25
 9 474.75

ISS_meas8x5: Description: Measured ISS (BT-8) Diluted batch*5
 Type: Real List Variable
 Unit: mgISS/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (8 pairs):
 1 3926.25
 2 3808.75
 3 3267.5
 5 2977.5
 6 2901.25
 7 2585
 8 2731.25
 9 2373.75

ISS_Xioi: Description: Inorganic suspended solids
 Type: Dyn. Volume State Var.
 Unit: mg/l
 Relative Accuracy: 1e-006

Absolute Accuracy: 1e-006

ISS_Xioin: Description: Influent inorganic suspended solids concentration entering the reactor

 Type: Constant Variable

 Unit: mg/l

 Value: 0

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 10

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

ISS_Xioini: Description: Initial concentration of the Inorganic suspended solids

 Type: Variable List Variable

 Unit: mg/l

 Argument: Calcnum

 Interpolation Method: linear interpolation

 Real-Variable Data Pairs (16 pairs):

1	ISS_Xioinila
2	ISS_Xioini2a
3	ISS_Xioini3a
4	ISS_Xioini4a
5	ISS_Xioini5a
6	ISS_Xioini6a
7	ISS_Xioini7a
8	ISS_Xioini8a
11	ISS_Xioinila
12	ISS_Xioini2b
13	ISS_Xioini3b
14	ISS_Xioini4b
15	ISS_Xioini5b
16	ISS_Xioini6b
17	ISS_Xioini7b
18	ISS_Xioini8b

ISS_Xioinila: Description: Initial concentration of Inorganic suspended solids (B-1)

 Type: Constant Variable

 Unit: mgISS/l

 Value: 6521.1

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 10000

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

ISS_Xioinila: Description: Initial concentration of Inorganic suspended solids (B-1)

 Type: Constant Variable

 Unit: mgISS/l

 Value: 6521.1

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 10000

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

ISS_Xioini2a: Description: Initial concentration of Inorganic suspended solids (B-2)

Type:	Constant Variable
Unit:	mgISS/l
Value:	5116.4
Standard Deviation:	0.1
Minimum:	0
Maximum:	10000
Sensitivity Analysis:	inactive
Parameter Estimation:	inactive

ISS_Xioini2b:	Description:	Initial concentration of Inorganic suspended solids (B-2)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	5116.4
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

ISS_Xioini3a:	Description:	Initial concentration of Inorganic suspended solids (B-3)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	5306.8
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

ISS_Xioini3b:	Description:	Initial concentration of Inorganic suspended solids (B-3)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	5306.8
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

ISS_Xioini4a:	Description:	Initial concentration of Inorganic suspended solids (B-4)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	6104.5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

ISS_Xioini4b:	Description:	Initial concentration of Inorganic suspended solids (B-4)
	Type:	Constant Variable
	Unit:	mgISS/l
	Value:	6104.5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000

Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini5a: Description: Initial concentration of Inorganic
 suspended solids (B-5)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 6347.5
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini5b: Description: Initial concentration of Inorganic
 suspended solids (B-5)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 6347.5
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini6a: Description: Initial concentration of Inorganic
 suspended solids (B-6)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 7402.7
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini6b: Description: Initial concentration of Inorganic
 suspended solids (B-6)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 7402.7
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini7a: Description: Initial concentration of Inorganic
 suspended solids, BT-7 (Undiluted)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 6968
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini7b: Description: Initial concentration of Inorganic
 suspended solids, BT-7 (Undiluted)
 Type: Constant Variable

Unit: mgISS/l
 Value: 6968
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini8a: Description: Initial concentration of Inorganic suspended solids, BT-8 (Diluted)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 942.7
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini8b: Description: Initial concentration of Inorganic suspended solids, BT-8 (Diluted)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 942.7
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini_SS: Description: Initial concentration of the Inorganic suspended solids (for SSM)
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (16 pairs):

1	ISS_Xioini_SS1a
2	ISS_Xioini_SS2a
3	ISS_Xioini_SS3a
4	ISS_Xioini_SS4a
5	ISS_Xioini_SS5a
6	ISS_Xioini_SS6a
7	ISS_Xioini_SS7a
8	ISS_Xioini_SS8a
11	ISS_Xioini_SS1b
12	ISS_Xioini_SS2b
13	ISS_Xioini_SS3b
14	ISS_Xioini_SS4b
15	ISS_Xioini_SS5b
16	ISS_Xioini_SS6b
17	ISS_Xioini_SS7b
18	ISS_Xioini_SS8b

ISS_Xioini_SS1a: Description: Initial concentration of Inorganic suspended solids (B-1)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 1150.8
 Standard Deviation: 0.1

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Minimum: 0
Maximum: 10000
Sensitivity Analysis: inactive
Parameter Estimation: inactive

ISS_Xioini_SS1b:

Description: Initial concentration of Inorganic suspended solids (B-1)
Type: Constant Variable
Unit: mgISS/l
Value: 1150.8
Standard Deviation: 0.1
Minimum: 0
Maximum: 10000
Sensitivity Analysis: inactive
Parameter Estimation: inactive

ISS_Xioini_SS2a:

Description: Initial concentration of Inorganic suspended solids (B-2)
Type: Constant Variable
Unit: mgISS/l
Value: 902.9
Standard Deviation: 0.1
Minimum: 0
Maximum: 10000
Sensitivity Analysis: inactive
Parameter Estimation: inactive

ISS_Xioini_SS2b:

Description: Initial concentration of Inorganic suspended solids (B-2)
Type: Constant Variable
Unit: mgISS/l
Value: 902.9
Standard Deviation: 0.1
Minimum: 0
Maximum: 10000
Sensitivity Analysis: inactive
Parameter Estimation: inactive

ISS_Xioini_SS3a:

Description: Initial concentration of Inorganic suspended solids (B-3)
Type: Constant Variable
Unit: mgISS/l
Value: 936.5
Standard Deviation: 0.1
Minimum: 0
Maximum: 10000
Sensitivity Analysis: inactive
Parameter Estimation: inactive

ISS_Xioini_SS3b:

Description: Initial concentration of Inorganic suspended solids (B-3)
Type: Constant Variable
Unit: mgISS/l
Value: 936.5
Standard Deviation: 0.1
Minimum: 0

Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini_SS4a:

Description: Initial concentration of Inorganic
 suspended solids (B-4)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 1077.3
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini_SS4b:

Description: Initial concentration of Inorganic
 suspended solids (B-4)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 1077.3
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini_SS5a:

Description: Initial concentration of Inorganic
 suspended solids (B-5)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 1120.1
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini_SS5b:

Description: Initial concentration of Inorganic
 suspended solids (B-5)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 1120.1
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini_SS6a:

Description: Initial concentration of Inorganic
 suspended solids (B-6)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 1306.4
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000

Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini_SS6b:

Description: Initial concentration of Inorganic
 suspended solids (B-6)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 1306.4
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini_SS7a:

Description: Initial concentration of Inorganic
 suspended solids (B-7)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 1229.6
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini_SS7b:

Description: Initial concentration of Inorganic
 suspended solids (B-7)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 1229.6
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini_SS8a:

Description: Initial concentration of Inorganic
 suspended solids (B-8, diluted)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 696.8
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

ISS_Xioini_SS8b:

Description: Initial concentration of Inorganic
 suspended solids (B-8, diluted)
 Type: Constant Variable
 Unit: mgISS/l
 Value: 696.8
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive

Parameter Estimation: inactive

ISS_Xoi:	Description:	Inorganic suspended solids in the reactor
	Type:	Formula Variable
	Unit:	mgISS/l
	Expression:	$(ISS\_Xioin) + (ISS\_fiOHO * (X\_H / f\_cv)) + (ISS\_fiPAO * (X\_PAO / f\_cv))$
i_NBM:	Description:	Nitrogen content of biomass, X_H, X_PAO, X_AUT
	Type:	Constant Variable
	Unit:	gN(gCOD)-1
	Value:	0.07
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
i_NSf:	Description:	Nitrogen content of soluble substrate, S_F
	Type:	Constant Variable
	Unit:	gN(gCOD)-1
	Value:	0.03
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
i_NSi:	Description:	Nitrogen content of inert soluble COD, S_I
	Type:	Constant Variable
	Unit:	gN/gCOD
	Value:	0.01
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
i_NXi:	Description:	Nitrogen content of inert particulate COD, X_I
	Type:	Constant Variable
	Unit:	gN(gCOD)-1
	Value:	0.07
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
i_NXs:	Description:	Nitrogen content of particulate substrate, X_S
	Type:	Constant Variable
	Unit:	gN(gCOD)-1
	Value:	0.04
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1

Sensitivity Analysis: inactive
 Parameter Estimation: inactive

i_PBM:	Description:	P content of biomass, X_H, X_PAO, X_AUT
	Type:	Constant Variable
	Unit:	gP(gCOD)-1
	Value:	0.02
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
i_PSF:	Description:	P content of soluble substrate S_F
	Type:	Constant Variable
	Unit:	gP(gCOD)-1
	Value:	0.01
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
i_PSi:	Description:	P content of inert soluble COD S_I
	Type:	Constant Variable
	Unit:	gP(gCOD)-1
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
i_PXi:	Description:	P content of inert particulate COD, X_I
	Type:	Constant Variable
	Unit:	gP(gCOD)-1
	Value:	0.01
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
i_PXs:	Description:	P content of particulate substrate, X_S
	Type:	Constant Variable
	Unit:	gP(gCOD)-1
	Value:	0.01
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
i_TSSBM:	Description:	TSS to biomass ratio for X_H, X_PA O, X_UAT
	Type:	Constant Variable
	Unit:	gTSS(gCOD)-1
	Value:	0.9

	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

i_TSSXi:	Description:	TSS to X_I ratio
	Type:	Constant Variable
	Unit:	gTSS(gCOD)-1
	Value:	0.75
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

i_TSSXs:	Description:	TSS to X_S ratio
	Type:	Constant Variable
	Unit:	gTSS(gCOD)-1
	Value:	0.75
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

K_ALK:	Description:	Saturation coefficient for alkalinity
	Type:	Constant Variable
	Unit:	mole HCO ₃ (m)-3
	Value:	0.1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

K_ALKAUT:	Description:	Saturation coefficient for alkalinity (Autotrophs)
	Type:	Constant Variable
	Unit:	mole HCO ₃ (m)-3
	Value:	0.5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

K_ALKPRE:	Description:	Saturation coefficient for alkalinity (precipitation)
	Type:	Constant Variable
	Unit:	mole HCO ₃ (m)-3
	Value:	0.5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

K_AOHO:	Description:	Saturation coefficient for S_A (acetate) (heterotrophs)

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Type: Constant Variable
 Unit: gCOD(m)-3
 Value: 4
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

K_APAO: Description: Saturation coefficient for S_A (acetate) (PAO)
 Type: Constant Variable
 Unit: gCOD(m)-3
 Value: 1
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

K_F: Description: Saturation coefficient for growth of heterotrophs on S_F
 Type: Constant Variable
 Unit: gCOD(m)-3
 Value: 4
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

K_fe: Description: Saturation coefficient for fermentation of S_F (heterotrophs)
 Type: Constant Variable
 Unit: gCOD(m)-3
 Value: 150
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 200
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

K_h: Description: Hydrolysis rate constant
 Type: Formula Variable
 Unit: per day
 Expression: $K_{h20} \cdot \exp(\text{the\_Kh} \cdot (T-20))$

K_h20: Description: Hydrolysis rate constant
 Type: Constant Variable
 Unit: per day
 Value: 2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

K_IPP: Description: Inhibition coefficient for X_PP storage
 Type: Constant Variable
 Unit: gPP(gPAO)-1

	Value:	0.02
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
K_La:	Description:	Oxygen mass transfer coefficient
	Type:	Constant Variable
	Unit:	per day
	Value:	220
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	5000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
K_Max:	Description:	Maximum ratio of X_PP/X_PAO
	Type:	Constant Variable
	Unit:	gPP(gPAO) ⁻¹
	Value:	1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
K_NH4AUT:	Description:	Saturation coefficient for ammonium (nutrient) (ANO)
	Type:	Constant Variable
	Unit:	gN(m) ⁻³
	Value:	1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
K_NH4OHO:	Description:	Saturation coefficient for ammonium (nutrient) (OHO)
	Type:	Constant Variable
	Unit:	gN(m) ⁻³
	Value:	0.01
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
K_NH4PAO:	Description:	Saturation coefficient for ammonium (nutrient) (PAO)
	Type:	Constant Variable
	Unit:	gN(m) ⁻³
	Value:	0.001
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
K_NO3:	Description:	Saturation/inhibition coefficient/f

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actor for nitrate
 Type: Constant Variable
 Unit: gN(m)^{-3}
 Value: 0.1
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

K_O2: Description: Saturation/inhibition coefficient/factor for oxygen
 Type: Constant Variable
 Unit: $\text{gO}_2(\text{m})^{-3}$
 Value: 0.02
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

K_P: Description: Saturation coefficient for phosphorus (nutrient) in X_PP
 Type: Constant Variable
 Unit: gP(m)^{-3}
 Value: 0.01
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

K_PHA: Description: Saturation coefficient for PHA
 Type: Constant Variable
 Unit: gPHA(gPAO)^{-1}
 Value: 0.18
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

K_PP: Description: Saturation coefficient for poly-phosphate
 Type: Constant Variable
 Unit: gPP(gPAO)^{-1}
 Value: 0.001
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

k_PRE: Description: Rate constant for P precipitation
 Type: Constant Variable
 Unit: $\text{m}^3 / (\text{gFe(OH)}_3) / \text{d}$
 Value: 1
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive

Parameter Estimation: inactive

K_PS:	Description:	Saturation coefficient for phosphorus in PP storage
	Type:	Constant Variable
	Unit:	gP(m) ⁻³
	Value:	0.1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
k_RED:	Description:	Rate constant for redissolution
	Type:	Constant Variable
	Unit:	per day
	Value:	0.6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
K_X:	Description:	Saturation coefficient for particulate COD
	Type:	Formula Variable
	Unit:	gCOD(gcellCOD) ⁻¹
	Expression:	$K_{X20} \cdot \exp(\text{the\_KX} \cdot (T-20))$
K_X20:	Description:	Saturation coefficient for particulate COD
	Type:	Constant Variable
	Unit:	gCOD(gcellCOD) ⁻¹
	Value:	0.03
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
mue_AUT:	Description:	Maximum growth rate of autotrophs
	Type:	Formula Variable
	Unit:	per day
	Expression:	$\text{mue\_AUT20} \cdot \exp(\text{the\_mueAUT} \cdot (T-20))$
mue_AUT20:	Description:	Maximum specific growth rate of ANO
	Type:	Constant Variable
	Unit:	per day
	Value:	0.45
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
mue_H:	Description:	Maximum growth rate of heterotrophs
	Type:	Formula Variable
	Unit:	per day
	Expression:	$\text{mue\_H20} \cdot \exp(\text{the\_mueH} \cdot (T-20))$
mue_H20:	Description:	Maximum growth rate on substrate

	Type:	Constant Variable
	Unit:	per day
	Value:	6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

mue_PAO:	Description:	Maximum growth rate
	Type:	Formula Variable
	Unit:	per day
	Expression:	mue_PAO20*exp(the_muePAO*(T-20))

mue_PAO20:	Description:	Maximum growth rate
	Type:	Constant Variable
	Unit:	per day
	Value:	1.2
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

mVSS:	Description:	Model VSS
	Type:	Formula Variable
	Unit:	mgCOD/l
	Expression:	X_AUT+X_H+X_PAO+X_I

Nnt_SS:	Description:	Nitrate at time t (SSM)
	Type:	Formula Variable
	Unit:	mg/l
	Expression:	f_n_SS*(((X_Hini/f_cv_SS)*(1-f_H_SS))*(1-(exp(-b_H20_SS*t))))+((X_PAOin i/f_cv_SS)*(1-f_G_SS)*(1-(exp(-b_PA O20_SS*t))))))

OUR_AUT:	Description:	OUR for autotrophic growth (Nitrifi cation OUR)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	(-1/24)*(-(4.57-Y_AUT)/Y_AUT)*mue_A UT*(S_O2/(K_O2+S_O2))*(S_NH4/(K_NH4 AUT+S_NH4))*(S_PO4/(K_P+S_PO4))*X_A UT

OUR_c:	Description:	Carbonaceous OUR
	Type:	Variable List Variable
	Unit:	mg/l/h
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (16 pairs):	
	1	OUR_c1a
	2	OUR_c2a
	3	OUR_c3a
	4	OUR_c4a
	5	OUR_c5a
	6	OUR_c6a
	7	OUR_c7a
	8	OUR_c8a
	11	OUR_c1b

12	OUR_c2b
13	OUR_c3b
14	OUR_c4b
15	OUR_c5b
16	OUR_c6b
17	OUR_c7b
18	OUR_c8b

OUR_c1a:	Description:	Carbonaceous OUR for BT-1
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_PAO+OUR_PP
OUR_c1b:	Description:	Carbonaceous OUR for BT-1
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_PAO+OUR_PP
OUR_c2a:	Description:	Carbonaceous OUR for BT-2
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_PAO+OUR_PP
OUR_c2b:	Description:	Carbonaceous OUR for BT-2
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_PAO+OUR_PP
OUR_c3a:	Description:	Carbonaceous OUR for BT-3
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_PAO+OUR_PP
OUR_c3b:	Description:	Carbonaceous OUR for BT-3
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_PAO+OUR_PP
OUR_c4a:	Description:	Carbonaceous OUR for BT-4
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_PAO+OUR_PP
OUR_c4b:	Description:	Carbonaceous OUR for BT-4
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_PAO+OUR_PP
OUR_c5a:	Description:	Carbonaceous OUR for BT-5
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_PAO+OUR_PP
OUR_c5b:	Description:	Carbonaceous OUR for BT-5
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_PAO+OUR_PP
OUR_c6a:	Description:	Carbonaceous OUR for BT-6
	Type:	Formula Variable
	Unit:	mg/l/h

Expression:		OUR_HSF+OUR_HSA+OUR_PAO+OUR_PP

OUR_c6b:	Description:	Carbonaceous OUR for BT-6
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_PAO+OUR_PP

OUR_c7a:	Description:	Carbonaceous OUR for BT-7 (Undiluted)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_PAO+OUR_PP

OUR_c7b:	Description:	Carbonaceous OUR for BT-7 (Undiluted)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_PAO+OUR_PP

OUR_c8a:	Description:	Carbonaceous OUR for BT-8 (Diluted)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_PAO+OUR_PP

OUR_c8b:	Description:	Carbonaceous OUR for BT-8 (Diluted)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_PAO+OUR_PP

OUR_H:	Description:	Heterotrophic OUR
	Type:	Variable List Variable
	Unit:	mg/l/h
	Argument:	Calcnm
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (16 pairs):	
	1	OUR_H1a
	2	OUR_H2a
	3	OUR_H3a
	4	OUR_H4a
	5	OUR_H5a
	6	OUR_H6a
	7	OUR_H7a
	8	OUR_H8a
	11	OUR_H1b
	12	OUR_H2b
	13	OUR_H3b
	14	OUR_H4b
	15	OUR_H5b
	16	OUR_H6b
	17	OUR_H7b
	18	OUR_H8b

OUR_H1a:	Description:	Heterotrophic OUR for BT-1
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA

OUR_H1b:	Description:	Heterotrophic OUR for BT-1
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA

OUR_H2a:	Description:	Heterotrophic OUR for BT-2
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA
OUR_H2b:	Description:	Heterotrophic OUR for BT-2
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA
OUR_H3a:	Description:	Heterotrophic OUR for BT-3
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA
OUR_H3b:	Description:	Heterotrophic OUR for BT-3
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA
OUR_H4a:	Description:	Heterotrophic OUR for BT-4
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA
OUR_H4b:	Description:	Heterotrophic OUR for BT-4
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA
OUR_H5a:	Description:	Heterotrophic OUR for BT-5
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA
OUR_H5b:	Description:	Heterotrophic OUR for BT-5
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA
OUR_H6a:	Description:	Heterotrophic OUR for BT-6
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA
OUR_H6b:	Description:	Heterotrophic OUR for BT-6
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA
OUR_H7a:	Description:	Heterotrophic OUR for BT-7 (Undiluted)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA
OUR_H7b:	Description:	Heterotrophic OUR for BT-7 (Undiluted)
	Type:	Formula Variable
	Unit:	mg/l/h

Expression:		OUR_HSF+OUR_HSA
OUR_H8a:	Description:	Heterotrophic OUR for BT-8 (Diluted)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA
OUR_H8b:	Description:	Heterotrophic OUR for BT-8 (Diluted)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA
OUR_HSA:	Description:	OUR for heterotrophic growth on S_A
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	$(-1/24) * (- (1-Y_H)/Y_H) * \text{mue}_H * (S_A / (S_F + S_A)) * (S_{O2} / (K_{O2} + S_{O2})) * (S_A / (K_{AOHO} + S_A)) * (S_{NH4} / (K_{NH4OHO} + S_{NH4})) * (S_{PO4} / (K_P + S_{PO4})) * (X_H)$
OUR_HSF:	Description:	OUR for heterotrophic growth on S_F
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	$(-1/24) * (- (1-Y_H)/Y_H) * \text{mue}_H * (S_F / (S_F + S_A)) * (S_{O2} / (K_{O2} + S_{O2})) * (S_F / (K_F + S_F)) * (S_{NH4} / (K_{NH4OHO} + S_{NH4})) * (S_{PO4} / (K_P + S_{PO4})) * (X_H)$
OUR_Meas:	Description:	Daily average measured OUR
	Type:	Variable List Variable
	Unit:	mg/l/h
	Argument:	Calcnm
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (8 pairs):	
	1	OUR_Meas1
	2	OUR_Meas2
	3	OUR_Meas3
	4	OUR_Meas4
	5	OUR_Meas5
	6	OUR_Meas6
	7	OUR_Meas7
	8	OUR_Meas8
OUR_meas:	Description:	Measured instantaneous OUR
	Type:	Variable List Variable
	Unit:	mg/l/h
	Argument:	Calcnm
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (6 pairs):	
	1	OUR_meas1
	2	OUR_meas2
	3	OUR_meas3
	4	OUR_meas4
	5	OUR_meas5
	6	OUR_meas6
OUR_Meas1:	Description:	Daily average measured OUR (BT-1)
	Type:	Real List Variable
	Unit:	mg/l/h

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Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (7 pairs):
 1 33.45
 2 25.92
 3 26.74
 5 24.84
 6 22.82
 7 16.65
 8 7.87

OUR_meas1: Description: Measured instantaneous OUR (BT-1)
 Type: Real List Variable
 Unit: mg/l/h
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (981 pairs):
 0.001194444 30.64
 1.0116776 30.64
 1.8508385 30.58
 2 33.98
 2.5609027 27.97
 . .
 . .
 24.833087 4.03
 24.877922 3.67
 24.918418 4.54
 24.9564 4.59
 25 3.5

OUR_Meas2: Description: Daily average measured OUR (BT-2)
 Type: Real List Variable
 Unit: mg/l/h
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (3 pairs):
 2 33.9
 3 26.44
 5 19.44

OUR_meas2: Description: Measured instantaneous OUR (BT-2)
 Type: Real List Variable
 Unit: mg/l/h

A.224

Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (70 pairs):
 0.176 48.93
 0.315 37.99
 0.325 34.46
 0.334 34.36
 0.345 32.28
 . .
 . .
 1.119 22.12
 1.128 29.59
 1.135 26.26
 1.144 30.65
 2.173 19.44

OUR_Meas3: Description: Daily average measured OUR (BT-3)
 Type: Real List Variable
 Unit: mg/l/h
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (19 pairs):
 4 31.55
 5 31.87
 6 38.93
 7 32.76
 8 32.76
 . .
 . .
 19 6.13
 20 7.59
 21 6.94
 22 9.55
 23 3.66

OUR_meas3: Description: Measured instantaneous OUR (BT-3)
 Type: Real List Variable
 Unit: mg/l/h
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (1115 pairs):
 3.0387 46.3
 3.0485 43.65

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3.0575	42.23
3.0652	41.3
3.0729	40.91
.	.
.	.
19.8879	6.11
19.9144	6.37
19.9493	6.61
19.9757	6.7
20	6.72

OUR_Meas4: Description: Daily average measured OUR (BT-4)

 Type: Real List Variable

 Unit: mg/l/h

 Argument: t

 Standard Deviations: global

 Rel. Stand. Deviat.: 0

 Abs. Stand. Deviat.: 1

 Minimum: 0

 Maximum: 1e+009

 Interpolation Method: linear interpolation

 Sensitivity Analysis: inactive

 Real Data Pairs (16 pairs):

1	43.75
2	39.56
3	39.26
4	34.96
5	34.15
.	.
.	.
13	10.6
14	10.7
15	10.76
16	7.58
17	6.11

OUR_meas4: Description: Measured instantaneous OUR (BT-4)

 Type: Real List Variable

 Unit: mg/l/h

 Argument: t

 Standard Deviations: global

 Rel. Stand. Deviat.: 0

 Abs. Stand. Deviat.: 1

 Minimum: 0

 Maximum: 1e+009

 Interpolation Method: linear interpolation

 Sensitivity Analysis: inactive

 Real Data Pairs (1151 pairs):

0.002	45.07
0.008	46.51
0.014	44.49
0.027	46.44
0.033	46.07
.	.
.	.
14.569	6.11
14.602	6.37
14.646	6.61
14.679	6.7
14.71	6.72

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OUR_Meas5: Description: Daily average measured OUR (BT-5)
 Type: Real List Variable
 Unit: mg/l/h
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (10 pairs):

1	31.83
2	35.83
3	33.57
4	35.06
5	32.5
6	27.49
7	22.21
8	18.51
9	14.36
10	7.44

OUR_meas5: Description: Measured instantaneous OUR (BT-5)
 Type: Real List Variable
 Unit: mg/l/h
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (1151 pairs):

0.002	45.07
0.008	46.51
0.014	44.49
0.027	46.44
0.033	46.07
.	.
.	.
14.569	6.11
14.602	6.37
14.646	6.61
14.679	6.7
14.71	6.72

OUR_Meas6: Description: Daily average measured OUR (BT-6)
 Type: Real List Variable
 Unit: mg/l/h
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (15 pairs):

1	34

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2	31.81
3	30.01
4	31.33
5	30.8
.	.
.	.
11	5.59
12	6.66
13	6.37
14	4.96
15	1.92

```

OUR_meas6:      Description:      Measured instantaneous OUR (BT-6)
Type:           Real List Variable
Unit:           mg/l/h
Argument:       t
Standard Deviations: global
Rel. Stand. Deviat.: 0
Abs. Stand. Deviat.: 1
Minimum:        0
Maximum:        1e+009
Interpolation Method: linear interpolation
Sensitivity Analysis: inactive
Real Data Pairs (1151 pairs):
    0.002      45.07
    0.008      46.51
    0.014      44.49
    0.027      46.44
    0.033      46.07
    .          .
    .          .
    14.569     6.11
    14.602     6.37
    14.646     6.61
    14.679     6.7
    14.71      6.72

```

```

OUR_Meas7:      Description:      Daily average measured OUR (BT-7, U
                                ndilued)
                                Type:      Real List Variable
                                Unit:      mg/l/h
                                Argument:    t
                                Standard Deviations:  global
                                Rel. Stand. Deviat.:  0
                                Abs. Stand. Deviat.:  1
                                Minimum:      0
                                Maximum:      1e+009
                                Interpolation Method: linear interpolation
                                Sensitivity Analysis: inactive
                                Real Data Pairs (8 pairs):
                                    1          64.67
                                    2          50.59
                                    3          50.53
                                    4          43.6
                                    5          39.98
                                    6          39.26
                                    7          36.7
                                    8          33.41

```

OUR_Meas8:	Description:	Daily average measured OUR (BT-8 -D iluted)

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Type: Real List Variable
Unit: mg/l/h
Argument: t
Standard Deviations: global
Rel. Stand. Deviat.: 0
Abs. Stand. Deviat.: 1
Minimum: 0
Maximum: 1e+009
Interpolation Method: linear interpolation
Sensitivity Analysis: inactive
Real Data Pairs (8 pairs):

1	11.7
2	9.39
3	8.54
4	6.57
5	5.98
6	5.27
7	4.15
8	2.15

OUR_Meas8x5: Description: Daily average measured OUR (BT-8 -D
iluted*5)
Type: Real List Variable
Unit: mg/l/h
Argument: t
Standard Deviations: global
Rel. Stand. Deviat.: 0
Abs. Stand. Deviat.: 1
Minimum: 0
Maximum: 1e+009
Interpolation Method: linear interpolation
Sensitivity Analysis: inactive
Real Data Pairs (8 pairs):

1	58.49
2	46.97
3	42.68
4	32.85
5	29.9
6	26.35
7	20.76
8	10.75

OUR_P: Description: PolyPhosphate OUR
Type: Variable List Variable
Unit: mg/l/h
Argument: Calcnum
Interpolation Method: linear interpolation
Real-Variable Data Pairs (16 pairs):

1	OUR_P1a
2	OUR_P2a
3	OUR_P3a
4	OUR_P4a
5	OUR_P5a
6	OUR_P6a
7	OUR_P7a
8	OUR_P8a
11	OUR_P1b
12	OUR_P2b
13	OUR_P3b
14	OUR_P4b
15	OUR_P5b

16	OUR_P6b
17	OUR_P7b
18	OUR_P8b

OUR_P1a:	Description:	PolyPhosphate OUR for BT-1
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_PAO+OUR_PP

OUR_P1b:	Description:	PolyPhosphate OUR for BT-1
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_PAO+OUR_PP

OUR_P2a:	Description:	PolyPhosphate OUR for BT-2
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_PAO+OUR_PP

OUR_P2b:	Description:	PolyPhosphate OUR for BT-2
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_PAO+OUR_PP

OUR_P3a:	Description:	PolyPhosphate OUR for BT-3
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_PAO+OUR_PP

OUR_P3b:	Description:	PolyPhosphate OUR for BT-3
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_PAO+OUR_PP

OUR_P4a:	Description:	PolyPhosphate OUR for BT-4
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_PAO+OUR_PP

OUR_P4b:	Description:	PolyPhosphate OUR for BT-4
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_PAO+OUR_PP

OUR_P5a:	Description:	PolyPhosphate OUR for BT-5
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_PAO+OUR_PP

OUR_P5b:	Description:	PolyPhosphate OUR for BT-5
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_PAO+OUR_PP

OUR_P6a:	Description:	PolyPhosphate OUR for BT-6
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_PAO+OUR_PP

OUR_P6b:	Description:	PolyPhosphate OUR for BT-6
	Type:	Formula Variable

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	Unit:	mg/l/h
	Expression:	OUR_PAO+OUR_PP

OUR_P7a:	Description:	PolyPhosphate OUR for BT-7 (Undiluted)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_PAO+OUR_PP

OUR_P7b:	Description:	PolyPhosphate OUR for BT-7 (Undiluted)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_PAO+OUR_PP

OUR_P8a:	Description:	PolyPhosphate OUR for BT-8 (Diluted)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_PAO+OUR_PP

OUR_P8b:	Description:	PolyPhosphate OUR for BT-8 (Diluted)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_PAO+OUR_PP

OUR_PAO:	Description:	OUR for PAO growth
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	$(-1/24)*(-(1-Y_{PAO})/Y_{PAO})*\mu_{ue\_PAO}*(S_{O2}/(K_{O2}+S_{O2}))*((S_{NH4}/(K_{NH4PAO}+S_{NH4}))*((S_{PO4}/(K_P+S_{PO4}))*((X_{PHA}/X_{PAO})/(K_{PHA}+(X_{PHA}/X_{PAO}))*X_{PAO})$

OUR_PP:	Description:	OUR for X_PP storage
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	$(-1/24)*(-Y_{PHA})*q_{PP}*(S_{O2}/(K_{O2}+S_{O2}))*((S_{PO4}/(K_{PS}+S_{PO4}))*((X_{PHA}/X_{PAO})/(K_{PHA}+(X_{PHA}/X_{PAO}))*((K_{Max}-(X_{PP}/X_{PAO}))/((K_{IPP}+K_{Max}-(X_{PP}/X_{PAO}))*X_{PAO})$

OUR_t:	Description:	Total OUR
	Type:	Variable List Variable
	Unit:	mg/l/h
	Argument:	Calcnm
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (16 pairs):	
	1	OUR_t1a
	2	OUR_t2a
	3	OUR_t3a
	4	OUR_t4a
	5	OUR_t5a
	6	OUR_t6a
	7	OUR_t7a
	8	OUR_t8a
	11	OUR_t1b
	12	OUR_t2b

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13	OUR_t3b
14	OUR_t4b
15	OUR_t5b
16	OUR_t6b
17	OUR_t7b
18	OUR_t8b

OUR_t1a:	Description:	Total OUR for BT-1
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_AUT+OUR_PAO+OUR_PP

OUR_t1b:	Description:	Total OUR for BT-1
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_AUT+OUR_PAO+OUR_PP

OUR_t2a:	Description:	Total OUR for BT-2
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_AUT+OUR_PAO+OUR_PP

OUR_t2b:	Description:	Total OUR for BT-2
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_AUT+OUR_PAO+OUR_PP

OUR_t3a:	Description:	Total OUR for BT-3
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_AUT+OUR_PAO+OUR_PP

OUR_t3b:	Description:	Total OUR for BT-3
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_AUT+OUR_PAO+OUR_PP

OUR_t4a:	Description:	Total OUR for BT-4
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_AUT+OUR_PAO+OUR_PP

OUR_t4b:	Description:	Total OUR for BT-4
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_AUT+OUR_PAO+OUR_PP

OUR_t5a:	Description:	Total OUR for BT-5
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_AUT+OUR_PAO+OUR_PP

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OUR_t5b:	Description:	Total OUR for BT-5
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_AUT+OUR_PAO+OUR_PP

OUR_t6a:	Description:	Total OUR for BT-6
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_AUT+OUR_PAO+OUR_PP

OUR_t6b:	Description:	Total OUR for BT-6
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_AUT+OUR_PAO+OUR_PP

OUR_t7a:	Description:	Total OUR for BT-7 (Undiluted)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_AUT+OUR_PAO+OUR_PP

OUR_t7b:	Description:	Total OUR for BT-7 (Undiluted)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_AUT+OUR_PAO+OUR_PP

OUR_t8a:	Description:	Total OUR for BT-8 (Diluted)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_AUT+OUR_PAO+OUR_PP

OUR_t8b:	Description:	Total OUR for BT-8 (Diluted)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	OUR_HSF+OUR_HSA+OUR_AUT+OUR_PAO+OUR_PP

O_c_SS:	Description:	Carbonaceous OUR (SSM)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	O_G_SS+O_H_SS

O_G_SS:	Description:	Carbonaceous OUR (PAO) - SSM
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	$(1/24) * (1-f_{G\_SS}) * f_{cv\_SS} * b_{PAO20\_SS} * X_{PAOini} * \exp(-b_{PAO20\_SS} * t)$

O_H_SS:	Description:	Carbonaceous OUR (OHO) - SSM
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	$(1/24) * (1-f_{H\_SS}) * f_{cv\_SS} * b_{H20\_SS} * X_{Hini} * \exp(-b_{H20\_SS} * t)$

O_n_SS:	Description:	Nitrification OUR (SSM)
	Type:	Formula Variable

	Unit:	mg/l/h
	Expression:	$((4.57/24)*f_{n\_SS})*((1-f_{H\_SS})*(b_{H2O\_SS}*(X_{Hini}/f_{cv\_SS})*(exp(-b_{H2O\_SS}*t))))+(1-f_{G\_SS})*(b_{PAO20\_SS}*(X_{PAOini}/f_{cv\_SS})*(exp(-b_{PAO20\_SS}*t))))$
O_T_SS:	Description:	Total OUR (SSM)
	Type:	Formula Variable
	Unit:	mg/l/h
	Expression:	$O_{c\_SS}+O_{n\_SS}$
Pst_G_SS:	Description:	Orthophosphate concentration at time t (due to PAOs)
	Type:	Formula Variable
	Unit:	mgP/l
	Expression:	$(f_{pG\_SS}*f_{aGVi\_SS}*(X_{Vi\_SS}/f_{cv\_SS}))* (1-(exp(-b_{PAO20\_SS}*t)))$
Pst_H_SS:	Description:	Orthophosphate concentration at time t (due to PAOs)
	Type:	Formula Variable
	Unit:	mgP/l
	Expression:	$(f_{pH\_SS}*f_{aHVi\_SS}*(X_{Vi\_SS}/f_{cv\_SS}))* (1-(exp(-b_{H2O\_SS}*t)))$
Pst_SS:	Description:	Total OP at time t
	Type:	Formula Variable
	Unit:	mgP/l
	Expression:	$Pst\_G\_SS+Pst\_H\_SS$
q_fe:	Description:	Maximum rate of fermentation for heterotrophs
	Type:	Formula Variable
	Unit:	gCOD(g.COD)-1
	Expression:	$q_{fe20a}*exp(the\_qfe*(T-20))$
q_fe20:	Description:	Maximum rate of fermentation
	Type:	Variable List Variable
	Unit:	gCOD(g.COD)-1
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (16 pairs):	
	1	q_fe20a
	2	q_fe20a
	3	q_fe20a
	4	q_fe20a
	5	q_fe20a
	6	q_fe20a
	7	q_fe20a
	8	q_fe20a
	11	q_fe20b
	12	q_fe20b
	13	q_fe20b
	14	q_fe20b
	15	q_fe20b
	16	q_fe20b
	17	q_fe20b
	18	q_fe20b
q_fe20a:	Description:	Maximum rate of fermentation

Type: Constant Variable
Unit: gCOD(g.COD)-1
Value: 5
Standard Deviation: 0.1
Minimum: 0
Maximum: 20
Sensitivity Analysis: inactive
Parameter Estimation: inactive

q_fe20b: Description: Maximum rate of fermentation
Type: Constant Variable
Unit: gCOD(g.COD)-1
Value: 5
Standard Deviation: 0.1
Minimum: 0
Maximum: 20
Sensitivity Analysis: inactive
Parameter Estimation: inactive

q_PHA: Description: Rate constant for storage of PHA (base:X_PP)
Type: Formula Variable
Unit: gCOD (gPAO)-1 d-1
Expression: q_PHA20*exp(the_qPHA*(T-20))

q_PHA20: Description: Rate constant for storage of PHA (base:X_PP)
Type: Constant Variable
Unit: gCOD (gPAO)-1 d-1
Value: 6
Standard Deviation: 0.1
Minimum: 0
Maximum: 10
Sensitivity Analysis: inactive
Parameter Estimation: inactive

q_PP: Description: Rate constant for storage of PP
Type: Formula Variable
Unit: gPP (gPAO)-1 d-1
Expression: q_PP20a*exp(the_qPP*(T-20))

q_PP20: Description: Rate constant for storage of PP
Type: Variable List Variable
Unit: gPP (gPAO)-1 d-1
Argument: Calcnum
Interpolation Method: linear interpolation
Real-Variable Data Pairs (16 pairs):

1	q_PP20a
2	q_PP20a
3	q_PP20a
4	q_PP20a
5	q_PP20a
6	q_PP20a
7	q_PP20a
8	q_PP20a
9	q_PP20b
10	q_PP20b
11	q_PP20b
12	q_PP20b
13	q_PP20b
14	q_PP20b

	15	q_PP20b
	16	q_PP20b
q_PP20a:	Description:	Rate constant for storage of PP
	Type:	Constant Variable
	Unit:	gPP (gPAO)-1 d-1
	Value:	1.35
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
q_PP20b:	Description:	Rate constant for storage of PP
	Type:	Constant Variable
	Unit:	gPP (gPAO)-1 d-1
	Value:	1.35
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
R_hn:	Description:	Nominal hydraulic retention time
	Type:	Variable List Variable
	Unit:	d
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (16 pairs):	
	1	R_hn1a
	2	R_hn2a
	3	R_hn3a
	4	R_hn4a
	5	R_hn5a
	6	R_hn6a
	7	R_hn7a
	8	R_hn8a
	11	R_hn1b
	12	R_hn2b
	13	R_hn3b
	14	R_hn4b
	15	R_hn5b
	16	R_hn6b
	17	R_hn7b
	18	R_hn8b
R_hn1a:	Description:	Hydraulic retention time (Retention time) for BT-1
	Type:	Formula Variable
	Unit:	d
	Expression:	12
R_hn1b:	Description:	Hydraulic retention time (Retention time) for BT-1
	Type:	Formula Variable
	Unit:	d
	Expression:	12
R_hn2a:	Description:	Hydraulic retention time (Retention time) for BT-2
	Type:	Formula Variable

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	Unit:	d
	Expression:	6

R_hn2b:	Description:	Hydraulic retention time (Retention time) for BT-2
	Type:	Formula Variable
	Unit:	d
	Expression:	6

R_hn3a:	Description:	Hydraulic retention time (Retention time) for BT-3
	Type:	Formula Variable
	Unit:	d
	Expression:	25

R_hn3b:	Description:	Hydraulic retention time (Retention time) for BT-3
	Type:	Formula Variable
	Unit:	d
	Expression:	25

R_hn4a:	Description:	Hydraulic retention time (Retention time) for BT-4
	Type:	Formula Variable
	Unit:	d
	Expression:	21

R_hn4b:	Description:	Hydraulic retention time (Retention time) for BT-4
	Type:	Formula Variable
	Unit:	d
	Expression:	21

R_hn5a:	Description:	Hydraulic retention time (Retention time) for BT-5
	Type:	Formula Variable
	Unit:	d
	Expression:	11

R_hn5b:	Description:	Hydraulic retention time (Retention time) for BT-5
	Type:	Formula Variable
	Unit:	d
	Expression:	11

R_hn6a:	Description:	Hydraulic retention time (Retention time) for BT-6
	Type:	Formula Variable
	Unit:	d
	Expression:	15

R_hn6b:	Description:	Hydraulic retention time (Retention time) for BT-6
	Type:	Formula Variable
	Unit:	d
	Expression:	15

R_hn7a:	Description:	Hydraulic retention time (Retention time) for BT-7 (Undiluted)
	Type:	Formula Variable
	Unit:	d

Expression:		9
R_hn7b:	Description:	Hydraulic retention time (Retention time) for BT-7 (Undiluted)
	Type:	Formula Variable
	Unit:	d
	Expression:	9
R_hn8a:	Description:	Hydraulic retention time (Retention time) for BT-8 (Diluted)
	Type:	Formula Variable
	Unit:	d
	Expression:	9
R_hn8b:	Description:	Hydraulic retention time (Retention time) for BT-8 (Diluted)
	Type:	Formula Variable
	Unit:	d
	Expression:	9
R_s:	Description:	Sludge age
	Type:	Variable List Variable
	Unit:	d
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (16 pairs):	
	1	R_s1a
	2	R_s2a
	3	R_s3a
	4	R_s4a
	5	R_s5a
	6	R_s6a
	7	R_s7a
	8	R_s8a
	11	R_s1b
	12	R_s2b
	13	R_s3b
	14	R_s4b
	15	R_s5b
	16	R_s6b
	17	R_s7b
	18	R_s8b
R_s1a:	Description:	Sludge age (Retention time) for BT-1
	Type:	Formula Variable
	Unit:	d
	Expression:	12
R_s1b:	Description:	Sludge age (Retention time) for BT-1
	Type:	Formula Variable
	Unit:	d
	Expression:	12
R_s2a:	Description:	Sludge age (Retention time) for BT-2
	Type:	Formula Variable
	Unit:	d
	Expression:	6

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R_s2b:	Description:	Sludge age (Retention time) for BT-2
	Type:	Formula Variable
	Unit:	d
	Expression:	6

R_s3a:	Description:	Sludge age (Retention time) for BT-3
	Type:	Formula Variable
	Unit:	d
	Expression:	25

R_s3b:	Description:	Sludge age (Retention time) for BT-3
	Type:	Formula Variable
	Unit:	d
	Expression:	25

R_s4a:	Description:	Sludge age (Retention time) for BT-4
	Type:	Formula Variable
	Unit:	d
	Expression:	21

R_s4b:	Description:	Sludge age (Retention time) for BT-4
	Type:	Formula Variable
	Unit:	d
	Expression:	21

R_s5a:	Description:	Sludge age (Retention time) for BT-5
	Type:	Formula Variable
	Unit:	d
	Expression:	11

R_s5b:	Description:	Sludge age (Retention time) for BT-5
	Type:	Formula Variable
	Unit:	d
	Expression:	11

R_s6a:	Description:	Sludge age (Retention time) for BT-6
	Type:	Formula Variable
	Unit:	d
	Expression:	15

R_s6b:	Description:	Sludge age (Retention time) for BT-6
	Type:	Formula Variable
	Unit:	d
	Expression:	15

R_s7a:	Description:	Sludge age (Retention time) for BT-7 (Undiluted)
	Type:	Formula Variable
	Unit:	d
	Expression:	9

R_s7b:	Description:	Sludge age (Retention time) for BT-

	Type:	7 (Undiluted)
	Unit:	Formula Variable
	Expression:	d
		9
R_s8a:	Description:	Sludge age (Retention time) for BT-8 (Diluted)
	Type:	Formula Variable
	Unit:	d
	Expression:	9
R_s8b:	Description:	Sludge age (Retention time) for BT-8 (Diluted)
	Type:	Formula Variable
	Unit:	d
	Expression:	9
S_A:	Description:	Fermentable products (acetate)
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006
S_Aini:	Description:	Initial concentration of fermentable products (acetate)
	Type:	Variable List Variable
	Unit:	mg/l
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (16 pairs):	
	1	S_Ainila
	2	S_Aini2a
	3	S_Aini3a
	4	S_Aini4a
	5	S_Aini5a
	6	S_Aini6a
	7	S_Aini7a
	8	S_Aini8a
	11	S_Ainilb
	12	S_Aini2b
	13	S_Aini3b
	14	S_Aini4b
	15	S_Aini5b
	16	S_Aini6b
	17	S_Aini7b
	18	S_Aini8b
S_Ainila:	Description:	Initial concentration of fermentable products (acetate) for BT-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.0001712
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_Ainilb:	Description:	Initial concentration of fermentable products (acetate) for BT-1
	Type:	Constant Variable

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Unit: mg/l
 Value: 0.0001712
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Aini2a: Description: Initial concentration of fermentabl
 e products (acetate) for BT-2
 Type: Constant Variable
 Unit: mg/l
 Value: 0.0001716
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Aini2b: Description: Initial concentration of fermentabl
 e products (acetate) for BT-2
 Type: Constant Variable
 Unit: mg/l
 Value: 0.0001716
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Aini3a: Description: Initial concentration of fermentabl
 e products (acetate) for BT-3
 Type: Constant Variable
 Unit: mg/l
 Value: 0.0001716
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Aini3b: Description: Initial concentration of fermentabl
 e products (acetate) for BT-3
 Type: Constant Variable
 Unit: mg/l
 Value: 0.0001716
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Aini4a: Description: Initial concentration of fermentabl
 e products (acetate) for BT-4
 Type: Constant Variable
 Unit: mg/l
 Value: 0.0001716
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive

Parameter Estimation: inactive

S_Aini4b:	Description:	Initial concentration of fermentable products (acetate) for BT-4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.0001716
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_Aini5a:	Description:	Initial concentration of fermentable products (acetate) for BT-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.0001716
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_Aini5b:	Description:	Initial concentration of fermentable products (acetate) for BT-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.0001716
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_Aini6a:	Description:	Initial concentration of fermentable products (acetate) for BT-6
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.0001716
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_Aini6b:	Description:	Initial concentration of fermentable products (acetate) for BT-6
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.0001716
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_Aini7a:	Description:	Initial concentration of fermentable products (acetate) for BT-7 (Undiluted)
	Type:	Constant Variable

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Unit: mg/l
 Value: 3.4e-005
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Aini7b: Description: Initial concentration of fermentable products (acetate) for BT-7 (Undiluted)
 Type: Constant Variable
 Unit: mg/l
 Value: 3.4e-005
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Aini8a: Description: Initial concentration of fermentable products (acetate) for BT-8 (Diluted)
 Type: Constant Variable
 Unit: mg/l
 Value: 0.0001716
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Aini8b: Description: Initial concentration of fermentable products (acetate) for BT-8 (Diluted)
 Type: Constant Variable
 Unit: mg/l
 Value: 0.0001716
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_F: Description: Fermentable, readily biodegradable organic substrate
 Type: Dyn. Volume State Var.
 Unit: mg/l
 Relative Accuracy: 1e-006
 Absolute Accuracy: 1e-006

S_Fini: Description: Initial concentration of fermentable, readily biodegradable organic substrate
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (16 pairs):
 1 S_Finila
 2 S_Fini2a

3	S_Fini3a
4	S_Fini4a
5	S_Fini5a
6	S_Fini6a
7	S_Fini7a
8	S_Fini8a
11	S_Fini1b
12	S_Fini2b
13	S_Fini3b
14	S_Fini4b
15	S_Fini5b
16	S_Fini6b
17	S_Fini7b
18	S_Fini8b

S_Fini1a:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate for BT-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.5855
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_Fini1b:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate for BT-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.5821
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_Fini2a:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate for BT-2
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.5467
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_Fini2b:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate for BT-2
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.5748
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive

Parameter Estimation: inactive

S_Fini3a:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate for BT-3
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.5467
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_Fini3b:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate for BT-3
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.5748
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_Fini4a:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate for BT-4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.519
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_Fini4b:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate for BT-4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.525
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
S_Fini5a:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate for BT-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.5751
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_Fini5b:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate for BT-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.5882
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_Fini6a:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate for BT-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.5766
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_Fini6b:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate for BT-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.5859
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_Fini7a:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate for BT-7 (Undiluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.5495
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_Fini7b:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate for BT-7 (Undiluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.5612
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

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S_Fini8a:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate for BT-8 (Diluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.1109
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_Fini8b:	Description:	Initial concentration of fermentable, readily biodegradable organic substrate for BT-8 (Diluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.1109
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_I:	Description:	Inert soluble organic material
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006

S_Iini:	Description:	Initial concentration of inert soluble organic material
	Type:	Variable List Variable
	Unit:	mg/l
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (16 pairs):	
	1	S_Iinila
	2	S_Iini2a
	3	S_Iini3a
	4	S_Iini4a
	5	S_Iini5a
	6	S_Iini6a
	7	S_Iini7a
	8	S_Iini8a
	11	S_Iini1b
	12	S_Iini2b
	13	S_Iini3b
	14	S_Iini4b
	15	S_Iini5b
	16	S_Iini6b
	17	S_Iini7b
	18	S_Iini8b

S_Iinila:	Description:	Initial concentration of inert soluble organic material for BT-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	29.7
	Standard Deviation:	0.1
	Minimum:	0

Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Iini1b: Description: Initial concentration of inert soluble organic material for BT-1
 Type: Constant Variable
 Unit: mg/l
 Value: 29.7
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Iini2a: Description: Initial concentration of inert soluble organic material for BT-2
 Type: Constant Variable
 Unit: mg/l
 Value: 41.2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Iini2b: Description: Initial concentration of inert soluble organic material for BT-2
 Type: Constant Variable
 Unit: mg/l
 Value: 41.2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Iini3a: Description: Initial concentration of inert soluble organic material for BT-3
 Type: Constant Variable
 Unit: mg/l
 Value: 41.2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Iini3b: Description: Initial concentration of inert soluble organic material for BT-3
 Type: Constant Variable
 Unit: mg/l
 Value: 41.2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Iini4a: Description: Initial concentration of inert soluble organic material for BT-4

Type: Constant Variable
 Unit: mg/l
 Value: 32.8
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Iini4b: Description: Initial concentration of inert soluble organic material for BT-4
 Type: Constant Variable
 Unit: mg/l
 Value: 32.8
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Iini5a: Description: Initial concentration of inert soluble organic material for BT-5
 Type: Constant Variable
 Unit: mg/l
 Value: 42.7
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Iini5b: Description: Initial concentration of inert soluble organic material for BT-5
 Type: Constant Variable
 Unit: mg/l
 Value: 42.7
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Iini6a: Description: Initial concentration of inert soluble organic material for BT-6
 Type: Constant Variable
 Unit: mg/l
 Value: 39.2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Iini6b: Description: Initial concentration of inert soluble organic material for BT-6
 Type: Constant Variable
 Unit: mg/l
 Value: 39.2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100

Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_Iini7a: Description: Initial concentration of inert soluble organic material for BT-7 (Undiluted)

 Type: Constant Variable

 Unit: mg/l

 Value: 40.59

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 100

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

S_Iini7b: Description: Initial concentration of inert soluble organic material for BT-7 (Undiluted)

 Type: Constant Variable

 Unit: mg/l

 Value: 40.59

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 100

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

S_Iini8a: Description: Initial concentration of inert soluble organic material for BT-8 (Diluted)

 Type: Constant Variable

 Unit: mg/l

 Value: 8.118

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 100

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

S_Iini8b: Description: Initial concentration of inert soluble organic material for BT-8 (Diluted)

 Type: Constant Variable

 Unit: mg/l

 Value: 8.118

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 100

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

S_N2: Description: Denitrogen gas

 Type: Dyn. Volume State Var.

 Unit: mg/l

 Relative Accuracy: 1e-006

 Absolute Accuracy: 1e-006

S_N2ini: Description: Initial concentration of denitrogen

 Type: Variable List Variable

 Unit: mg/l

 Argument: Calcium

Interpolation Method: linear interpolation
 Real-Variable Data Pairs (16 pairs):

1	S_N2inila
2	S_N2ini2a
3	S_N2ini3a
4	S_N2ini4a
5	S_N2ini5a
6	S_N2ini6a
7	S_N2ini7a
8	S_N2ini8a
11	S_N2inilb
12	S_N2ini2b
13	S_N2ini3b
14	S_N2ini4b
15	S_N2ini5b
16	S_N2ini6b
17	S_N2ini7b
18	S_N2ini8b

S_N2inila:	Description:	Initial concentration of denitrogen for BT-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_N2inilb:	Description:	Initial concentration of denitrogen for BT-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_N2ini2a:	Description:	Initial concentration of denitrogen for BT-2
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_N2ini2b:	Description:	Initial concentration of denitrogen for BT-2
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive

Parameter Estimation: inactive

S_N2ini3a:	Description:	Initial concentration of denitrogen for BT-3
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
Parameter Estimation: inactive		
S_N2ini3b:	Description:	Initial concentration of denitrogen for BT-3
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
Parameter Estimation: inactive		
S_N2ini4a:	Description:	Initial concentration of denitrogen for BT-4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
Parameter Estimation: inactive		
S_N2ini4b:	Description:	Initial concentration of denitrogen for BT-4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
Parameter Estimation: inactive		
S_N2ini5a:	Description:	Initial concentration of denitrogen for BT-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
Parameter Estimation: inactive		
S_N2ini5b:	Description:	Initial concentration of denitrogen for BT-5
	Type:	Constant Variable
	Unit:	mg/l

S_N2ini6a:	Description:	Initial concentration of denitrogen for BT-6
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_N2ini6b:	Description:	Initial concentration of denitrogen for BT-6
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_N2ini7a:	Description:	Initial concentration of denitrogen for BT-7 (Undiluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_N2ini7b:	Description:	Initial concentration of denitrogen for BT-7 (Undiluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_N2ini8a:	Description:	Initial concentration of denitroge for BT-8 (Diluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_N2ini8b:	Description:	Initial concentration of denitrogen for BT-8 (Diluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4:	Description:	Ammonium plus ammonia nitrogen
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006

```

S_NH4ini:      Description:      Initial concentration of ammonium p
                                     lus ammonia nitrogen
Type:          Variable List Variable
Unit:          mg/l
Argument:      Calcnum
Interpolation Method: linear interpolation
Real-Variable Data Pairs (16 pairs):
    1          S_NH4inila
    2          S_NH4ini2a
    3          S_NH4ini3a
    4          S_NH4ini4a
    5          S_NH4ini5a
    6          S_NH4ini6a
    7          S_NH4ini7a
    8          S_NH4ini8a
   11          S_NH4inilb
   12          S_NH4ini2b
   13          S_NH4ini3b
   14          S_NH4ini4b
   15          S_NH4ini5b
   16          S_NH4ini6b
   17          S_NH4ini7b
   18          S_NH4ini8b

```

S_NH4inila:	Description:	Initial concentration of ammonium plus ammonia nitrogen for BT-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1.54
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini1b:	Description:	Initial concentration of ammonium plus ammonia nitrogen for BT-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1.54
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10

Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NH4ini2a:	Description:	Initial concentration of ammonium p lus ammonia nitrogen for BT-2
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1.54
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini2b:	Description:	Initial concentration of ammonium p lus ammonia nitrogen for BT-2
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1.54
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini3a:	Description:	Initial concentration of ammonium p lus ammonia nitrogen for BT-3
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.4873
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini3b:	Description:	Initial concentration of ammonium p lus ammonia nitrogen for BT-3
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.4871
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini4a:	Description:	Initial concentration of ammonium p lus ammonia nitrogen for BT-4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1.12
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini4b:	Description:	Initial concentration of ammonium p lus ammonia nitrogen for BT-4
	Type:	Constant Variable

Unit: mg/l
 Value: 1.12
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NH4ini5a: Description: Initial concentration of ammonium p
 lus ammonia nitrogen for BT-5
 Type: Constant Variable
 Unit: mg/l
 Value: 0.4765
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NH4ini5b: Description: Initial concentration of ammonium p
 lus ammonia nitrogen for BT-5
 Type: Constant Variable
 Unit: mg/l
 Value: 0.4758
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NH4ini6a: Description: Initial concentration of ammonium p
 lus ammonia nitrogen for BT-6
 Type: Constant Variable
 Unit: mg/l
 Value: 0.4713
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NH4ini6b: Description: Initial concentration of ammonium p
 lus ammonia nitrogen for BT-6
 Type: Constant Variable
 Unit: mg/l
 Value: 0.4722
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NH4ini7a: Description: Initial concentration of ammonium p
 lus ammonia nitrogen for BT-7 (Undi
 luted)
 Type: Constant Variable
 Unit: mg/l
 Value: 0.478
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10

is: inactive

on: inactive

S_NH4ini7b:	Description:	Initial concentration of ammonium plus ammonia nitrogen for BT-7 (Undiluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.4778
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini8a:	Description:	Initial concentration of ammonium plus ammonia nitrogen for BT-8 (Diluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.0956
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_NH4ini8b:	Description:	Initial concentration of ammonium plus ammonia nitrogen for BT-8 (Diluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.0956
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

```

S_NH4meas:      Description:      Measured soluble ammonia
                  Type:              Variable List Variable
                  Unit:              mg/l
                  Argument:          Calcnum
                  Interpolation Method: linear interpolation
                  Real-Variable Data Pairs (8 pairs):
                    1                S_NH4meas1
                    2                S_NH4meas2
                    3                S_NH4meas3
                    4                S_NH4meas4
                    5                S_NH4meas5
                    6                S_NH4meas6
                    7                S_NH4meas7
                    8                S_NH4meas8

```

S_NH4meas1:	Description:	Measured soluble ammonia (BT-1)
	Type:	Real List Variable
	Unit:	mg/l
	Argument:	t
	Standard Deviations:	global
	Rel. Stand. Deviat.:	0
	Abs. Stand. Deviat.:	1

Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (6 pairs):
 1 1.54
 6 1.4
 7 1.4
 8 0.84
 9 0.28
 10 0.21

S_NH4meas2: Description: Measured soluble ammonia (BT-2)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (5 pairs):
 1 1.54
 2 0.42
 3 0.14
 5 0.42
 6 0.42

S_NH4meas3: Description: Measured soluble ammonia (BT-3)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (20 pairs):
 2 0.14
 4 0.42
 5 0.56
 7 0.56
 8 0.42
 .
 .
 .
 19 0.28
 21 0.28
 22 0.56
 23 0.7
 25 0.28

S_NH4meas4: Description: Measured soluble ammonia (BT-4)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0

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Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (18 pairs):

1	1.12
2	1.68
3	1.26
5	1.82
6	1.12
.	.
17	0.14
18	0.14
19	0.14
20	0.14
21	0.14

S_NH4meas5: Description: Measured soluble ammonia (BT-5)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (2 pairs):

5	1.12
11	0.14

S_NH4meas6: Description: Measured soluble ammonia (BT-6)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (5 pairs):

5	3.5
6	3.08
8	1.4
11	1.68
14	1.4

S_NH4meas7: Description: Measured soluble ammonia (BT-7) Undiluted
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0

Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (4 pairs):

2	2.52
5	4.76
8	3.78
9	2.8

S_NH4meas8: Description: Measured soluble ammonia (BT-8) Diluted

Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (6 pairs):

2	2.24
3	2.8
4	0.56
7	1.54
8	0.98
9	1.54

S_NO3: Description: Nitrate plus nitrite nitrogen

Type: Dyn. Volume State Var.
 Unit: mg/l
 Relative Accuracy: 1e-006
 Absolute Accuracy: 1e-006

S_NO3ini: Description: Initial concentration of nitrate plus nitrite nitrogen

Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (16 pairs):

1	S_NO3inila
2	S_NO3ini2a
3	S_NO3ini3a
4	S_NO3ini4a
5	S_NO3ini5a
6	S_NO3ini6a
7	S_NO3ini7a
8	S_NO3ini8a
11	S_NO3ini1b
12	S_NO3ini2b
13	S_NO3ini3b
14	S_NO3ini4b
15	S_NO3ini5b
16	S_NO3ini6b
17	S_NO3ini7b
18	S_NO3ini8b

S_NO3inila: Description: Initial concentration of nitrate plus nitrite nitrogen for BT-1

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Type: Constant Variable
 Unit: mg/l
 Value: 17.72
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NO3inilb: Description: Initial concentration of nitrate plus nitrite nitrogen for BT-1
 Type: Constant Variable
 Unit: mg/l
 Value: 22.54
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 100
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NO3ini2a: Description: Initial concentration of nitrate plus nitrite nitrogen for BT-2
 Type: Constant Variable
 Unit: mg/l
 Value: 27.45
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 50
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NO3ini2b: Description: Initial concentration of nitrate plus nitrite nitrogen for BT-2
 Type: Constant Variable
 Unit: mg/l
 Value: 38.31
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 50
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NO3ini3a: Description: Initial concentration of nitrate plus nitrite nitrogen for BT-3
 Type: Constant Variable
 Unit: mg/l
 Value: 13.56
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 50
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_NO3ini3b: Description: Initial concentration of nitrate plus nitrite nitrogen for BT-3
 Type: Constant Variable
 Unit: mg/l
 Value: 13.56
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 50

Real-Variable Data Pairs (8 pairs):

1	S_NO3meas1
2	S_NO3meas2
3	S_NO3meas3
4	S_NO3meas4
5	S_NO3meas5
6	S_NO3meas6
7	S_NO3meas7
8	S_NO3meas8

```

S_NO3meas1:      Description:      Measured nitrate (BT-1)
                  Type:              Real List Variable
                  Unit:              mg/l
                  Argument:          t
                  Standard Deviations: global
                  Rel. Stand. Deviat.: 0
                  Abs. Stand. Deviat.: 1
                  Minimum:           0
                  Maximum:           1e+009
                  Interpolation Method: linear interpolation
                  Sensitivity Analysis: inactive
                  Real Data Pairs (1 pairs):
                        1              0

```

```

S_NO3meas2:      Description:      Measured nitrate (BT-2)
                  Type:              Real List Variable
                  Unit:              mg/l
                  Argument:         t
                  Standard Deviations: global
                  Rel. Stand. Deviat.: 0
                  Abs. Stand. Deviat.: 1
                  Minimum:          0
                  Maximum:          1e+009
                  Interpolation Method: linear interpolation
                  Sensitivity Analysis: inactive
                  Real Data Pairs (1 pairs):
                        2              0

```

```

S_NO3meas3:      Description:      Measured nitrate (BT-3)
                  Type:              Real List Variable
                  Unit:              mg/l
                  Argument:          t
                  Standard Deviations: global
                  Rel. Stand. Deviat.: 0
                  Abs. Stand. Deviat.: 1
                  Minimum:           0
                  Maximum:           1e+009
                  Interpolation Method: linear interpolation
                  Sensitivity Analysis: inactive
                  Real Data Pairs (19 pairs):
                    1                13.564199
                    2                49.870416
                    3                48.141548
                    4                77.532295
                    5                138.04266
                    .                .
                    .                .
                    15               316.11601
                    16               329.94695
                    17               359.33769
                    18               361.06656

```

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S_NO3meas4: Description: Measured nitrate (BT-4)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (15 pairs):

1	20.851983
3	56.804381
5	64.183258
8	67.6372
9	99.978659
.	.
.	.
16	262.48645
17	261.63349
18	272.72198
20	277.83975
21	286.88113

S_NO3meas5: Description: Measured nitrate (BT-5)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (11 pairs):

1	39.846786
2	41.668895
3	65.356313
4	87.768254
5	129.13013
6	167.39442
7	212.94715
8	227.52402
9	244.10521
10	253.58018
11	262.14409

S_NO3meas6: Description: Measured nitrate (BT-6)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation

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Sensitivity Analysis: inactive

Real Data Pairs (15 pairs):

1	31.428883
2	35.827286
3	53.714122
4	114.26167
5	156.32847
.	.
.	.
11	281.13095
12	285.62759
13	288.23854
14	293.02528
15	299.40761

S_NO3meas7: Description: Measured nitrate (BT-7) (Undiluted)

 Type: Real List Variable

 Unit: mg/l

 Argument: t

 Standard Deviations: global

 Rel. Stand. Deviat.: 0

 Abs. Stand. Deviat.: 1

 Minimum: 0

 Maximum: 1e+009

 Interpolation Method: linear interpolation

 Sensitivity Analysis: inactive

 Real Data Pairs (9 pairs):

1	13.934025
2	57.487339
3	97.611258
4	139.8982
5	175.98381
6	218.14568
7	236.99451
8	256.58738
9	263.90371

S_NO3meas8: Description: Measured nitrate (BT-8) (Diluted)

 Type: Real List Variable

 Unit: mg/l

 Argument: t

 Standard Deviations: global

 Rel. Stand. Deviat.: 0

 Abs. Stand. Deviat.: 1

 Minimum: 0

 Maximum: 1e+009

 Interpolation Method: linear interpolation

 Sensitivity Analysis: inactive

 Real Data Pairs (9 pairs):

1	4.3518924
2	12.683305
3	22.1444
4	34.836079
5	46.795857
6	60.759368
7	68.649064
8	76.350911
9	80.796692

S_NO3meas8x5: Description: Measured nitrate (BT-8) (Diluted*5)

 Type: Real List Variable


```
Unit: mg/l
Argument: t
Standard Deviations: global
Rel. Stand. Deviat.: 0
Abs. Stand. Deviat.: 1
Minimum: 0
Maximum: 1e+009
Interpolation Method: linear interpolation
Sensitivity Analysis: inactive
Real Data Pairs (9 pairs):
1 21.759462
2 63.416523
3 110.722
4 174.1804
5 233.97929
6 303.79684
7 343.24532
8 381.75456
9 403.98346
```

S_O2:	Description:	Dissolved oxygen
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006

S_O2aer:	Description:	Aeration dissolved oxygen concentra tion
	Type:	Constant Variable
	Unit:	mg/l
	Value:	3
	Standard Deviation:	0.1
	Minimum:	1
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_O2sat:	Description:	Saturation dissolved oxygen concentration
	Type:	Constant Variable
	Unit:	mg/l
	Value:	6
	Standard Deviation:	0.1
	Minimum:	1
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_PO4:	Description:	Orthophosphate
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006

```

S_PO4ini:      Description:      Initial concentration of orthophosp
                                     hate
Type:          Variable List Variable
Unit:          mg/l
Argument:      Calcnum
Interpolation Method: linear interpolation
Real-Variable Data Pairs (16 pairs):

```

1	S_PO4inila
2	S_PO4ini2a
3	S_PO4ini3a
4	S_PO4ini4a
5	S_PO4ini5a
6	S_PO4ini6a
7	S_PO4ini7a
8	S_PO4ini8a
11	S_PO4inilb
12	S_PO4ini2b
13	S_PO4ini3b
14	S_PO4ini4b
15	S_PO4ini5b
16	S_PO4ini6b
17	S_PO4ini7b
18	S_PO4ini8b

S_PO4inila: Description: Initial concentration of orthophosphate for BT-1

 Type: Constant Variable

 Unit: mg/l

 Value: 39.38

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 100

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

S_PO4inilb: Description: Initial concentration of orthophosphate for BT-1

 Type: Constant Variable

 Unit: mg/l

 Value: 39.38

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 100

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

S_PO4ini2a: Description: Initial concentration of orthophosphate for BT-2

 Type: Constant Variable

 Unit: mg/l

 Value: 1.25

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 50

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

S_PO4ini2b: Description: Initial concentration of orthophosphate for BT-2

 Type: Constant Variable

 Unit: mg/l

 Value: 1.25

 Standard Deviation: 0.1

 Minimum: 0

 Maximum: 50

 Sensitivity Analysis: inactive

 Parameter Estimation: inactive

S_PO4ini3a:	Description:	Initial concentration of orthophosphate for BT-3
	Type:	Constant Variable
	Unit:	mg/l
	Value:	15.21
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	50
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_PO4ini3b:	Description:	Initial concentration of orthophosphate for BT-3
	Type:	Constant Variable
	Unit:	mg/l
	Value:	15.21
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	50
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_PO4ini4a:	Description:	Initial concentration of orthophosphate for BT-4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.31
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	40
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_PO4ini4b:	Description:	Initial concentration of orthophosphate for BT-4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	0.31
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	40
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_PO4ini5a:	Description:	Initial concentration of orthophosphate for BT-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	6.18
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	40
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

S_PO4ini5b:	Description:	Initial concentration of orthophosphate for BT-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	6.18
	Standard Deviation:	0.1

Minimum: 0
 Maximum: 40
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4ini6a: Description: Initial concentration of orthophosphate for BT-6
 Type: Constant Variable
 Unit: mg/l
 Value: 2.06
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 40
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4ini6b: Description: Initial concentration of orthophosphate for BT-6
 Type: Constant Variable
 Unit: mg/l
 Value: 2.06
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 40
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4ini7a: Description: Initial concentration of orthophosphate for BT-7 (Undiluted)
 Type: Constant Variable
 Unit: mg/l
 Value: 2.36
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 40
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4ini7b: Description: Initial concentration of orthophosphate for BT-7 (Undiluted)
 Type: Constant Variable
 Unit: mg/l
 Value: 2.36
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 40
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4ini8a: Description: Initial concentration of orthophosphate for BT-8 (Diluted)
 Type: Constant Variable
 Unit: mg/l
 Value: 0.87
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 40
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

S_PO4ini8b: Description: Initial concentration of orthophosphate for BT-8 (Diluted)

hate for BT-8 (Diluted)

```

S_PO4meas:      Description:      Measured orthophosphate concentration
                                     on
Type:           Variable List Variable
Unit:           mg/l
Argument:       Calcnum
Interpolation Method: linear interpolation
Real-Variable Data Pairs (8 pairs):
1               S_PO4meas1
2               S_PO4meas2
3               S_PO4meas3
4               S_PO4meas4
5               S_PO4meas5
6               S_PO4meas6
7               S_PO4meas7
8               S_PO4meas8

```

```

S_PO4meas2:      Description:      Measured soluble phosphorus (BT-2)
                  Type:              Real List Variable
                  Unit:              mg/l
                  Argument:         t
                  Standard Deviations: global
                  Rel. Stand. Deviat.: 0
                  Abs. Stand. Deviat.: 1
                  Minimum:          0
                  Maximum:          1e+009
                  Interpolation Method: linear interpolation
                  Sensitivity Analysis: inactive
                  Real Data Pairs (6 pairs):
                      1              1.25

```

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2	8.49
3	23.86
4	35.77
5	51.49
6	66.34

S_PO4meas3: Description: Measured soluble phosphorus (BT-3)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (22 pairs):

4	36.94
5	63.17
6	88.1
7	115.64
8	134.34
.	.
.	.
21	288.71
22	272.24
23	278.71
24	289.59
25	296.06

S_PO4meas4: Description: Measured soluble phosphorus (BT-4)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (21 pairs):

1	0.31
2	5.03
3	12.81
4	29.19
5	42.25
.	.
.	.
17	176.33
18	198.37
19	207.1
20	213.01
21	218.65

S_PO4meas5: Description: Measured soluble phosphorus (BT-5)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global

Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (11 pairs):

1	6.18
2	18.61
3	31.03
4	48.3
5	77.09
6	114.36
7	157.09
8	209.97
9	243.76
10	261.33
11	289.52

S_PO4meas6: Description: Measured soluble phosphorus (BT-6)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (15 pairs):

1	2.06
2	8.63
3	23.49
4	51.21
5	86.36
.	.
.	.
11	277.19
12	305.85
13	330.33
14	355.7
15	378.09

S_PO4meas7: Description: Measured soluble phosphorus (BT-7)
 Undiluted
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (9 pairs):

1	2.36
2	28.63
3	32.81
4	58.5

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5	93.19
6	149.44
7	179.44
8	199.13
9	208.5

S_PO4meas8: Description: Measured soluble phosphorus (BT-8)
 Diluted
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (9 pairs):

1	0.87
2	7.73
3	11.91
4	21
5	31.94
6	46.94
7	53.19
8	58.81
9	61.63

S_PO4meas8x5: Description: Measured soluble phosphorus (BT-8)
 (Diluted*5)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (9 pairs):

1	4.33
2	38.66
3	59.55
4	105
5	159.69
6	234.69
7	265.94
8	294.06
9	308.13

S_Ptmeas: Description: Measured total phosphate concentrat
 ion
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (4 pairs):

5	S_Ptmeas5
6	S_Ptmeas6

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	7	S_Ptmeas7
	8	S_Ptmeas8
S_Ptmeas5:	Description:	Measured total phosphorus (BT-5)
	Type:	Real List Variable
	Unit:	mg/l
	Argument:	t
	Standard Deviations:	global
	Rel. Stand. Deviat.:	0
	Abs. Stand. Deviat.:	1
	Minimum:	0
	Maximum:	1e+009
	Interpolation Method:	linear interpolation
	Sensitivity Analysis:	inactive
	Real Data Pairs (11 pairs):	
	1	1068.34
	2	962.91
	3	939.49
	4	927.77
	5	892.63
	6	857.49
	7	845.77
	8	845.77
	9	834.06
	10	834.06
	11	810.63
S_Ptmeas6:	Description:	Measured total phosphorus (BT-6)
	Type:	Real List Variable
	Unit:	mg/l
	Argument:	t
	Standard Deviations:	global
	Rel. Stand. Deviat.:	0
	Abs. Stand. Deviat.:	1
	Minimum:	0
	Maximum:	1e+009
	Interpolation Method:	linear interpolation
	Sensitivity Analysis:	inactive
	Real Data Pairs (15 pairs):	
	1	904.34
	2	845.77
	3	798.91
	4	956.67
	5	944.24
	.	.
	.	.
	11	974.21
	12	925.25
	13	802.87
	14	815.1
	15	864.06
S_Ptmeas7:	Description:	Measured total phosphorus (BT-7) Un diluted
	Type:	Real List Variable
	Unit:	mg/l
	Argument:	t
	Standard Deviations:	global
	Rel. Stand. Deviat.:	0
	Abs. Stand. Deviat.:	1
	Minimum:	0

Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (9 pairs):

1	794.3
2	769.82
3	745.34
4	848.19
5	809.75
6	796.94
7	822.56
8	784.13
9	771.31

S_Ptmeas8: Description: Measured total phosphorus (BT-8) Diluted
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (9 pairs):

1	598.48
2	574
3	561.76
4	668.81
5	604.75
6	617.56
7	617.56
8	617.56
9	656

T: Description: Temperature
 Type: Formula Variable
 Unit: degC
 Expression: 20

t: Description: Time
 Type: Program Variable
 Unit: d
 Reference to: Time

the_bAUT: Description: Arrhenius constant for the decay rate of autotrophs
 Type: Constant Variable
 Unit: .
 Value: 1.029
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

the_bH: Description: Arrhenius constant for the rate constant for lysis of heterotrophs
 Type: Constant Variable

Unit:
 Value: 1.029
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

the_bPAO: Description: Arrhenius constant for the rate constant for lysis of X_PAO
 Type: Constant Variable
 Unit:
 Value: 1.029
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

the_bPHA: Description: Arrhenius constant for the rate constant for lysis of X_PHA
 Type: Constant Variable
 Unit:
 Value: 1.029
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

the_bPP: Description: Arrhenius constant for the rate constant for lysis of X_PP
 Type: Constant Variable
 Unit:
 Value: 1.029
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

the_Kh: Description: Arrhenius constant
 Type: Constant Variable
 Unit:
 Value: 1.08
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

the_KX: Description: Arrhenius constant for saturation coefficient for particulate COD
 Type: Constant Variable
 Unit:
 Value: 0.91
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

the_mueAUT:	Description:	Arrhenius constant for maximum growth rate of autotrophs
	Type:	Constant Variable
	Unit:	/d
	Value:	1.123
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
the_mueH:	Description:	Arrhenius constant for maximum growth rate of heterotrophs
	Type:	Constant Variable
	Unit:	/d
	Value:	1.2
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
the_muePAO:	Description:	Arrhenius constant for maximum growth rate of PAOs
	Type:	Constant Variable
	Unit:	/d
	Value:	1.2
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
the_qfe:	Description:	Arrhenius constant for maximum rate of fermentation
	Type:	Constant Variable
	Unit:	/d
	Value:	1.016
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
the_qPHA:	Description:	Arrhenius constant for rate constant for storage of PHA (base: Xpp)
	Type:	Constant Variable
	Unit:	/d
	Value:	1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
the_qPP:	Description:	Arrhenius constant for rate constant for storage of PP
	Type:	Constant Variable
	Unit:	/d
	Value:	1

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Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

TKN: Description: Total Kjeldahl nitrogen
 Type: Formula Variable
 Unit: mgN/l
 Expression: $S_{NH4} + (S_I * i_{NSi}) + (S_F * i_{NSf}) + (X_I * i_{NXi}) + (X_S * i_{NXs}) + ((X_H + X_{PAO} + X_{AUT}) * i_{NBM})$

TKN_meas: Description: Measured TKN
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (8 pairs):

1	TKN_meas1
2	TKN_meas2
3	TKN_meas3
4	TKN_meas4
5	TKN_meas5
6	TKN_meas6
7	TKN_meas7
8	TKN_meas8

TKN_meas1: Description: Measured TKN (BT-1)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (1 pairs):

1	0

TKN_meas2: Description: Measured TKN (BT-2)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (1 pairs):

1	0

TKN_meas3: Description: Measured TKN (BT-3)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global

Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (19 pairs):

1	1450.8
2	1400.98
3	1370.62
4	1228.36
5	1125.04
.	.
.	.
17	809.34
18	826.56
21	688.8
22	551.04
25	487.9

TKN_meas4: Description: Measured TKN (BT-4)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (15 pairs):

1	1308.72
3	1234.1
4	1027.46
5	1193.92
9	958.58
.	.
.	.
15	849.52
16	740.46
17	769.16
20	677.32
21	596.96

TKN_meas5: Description: Measured TKN (BT-5)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (9 pairs):

1	1033.2
2	1038.94
3	1038.94
5	906.92

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6	947.1
7	883.96
8	792.12
9	774.9
11	683.06

TKN_meas6: Description: Measured TKN (BT-6)

Type: Real List Variable

Unit: mg/l

Argument: t

Standard Deviations: global

Rel. Stand. Deviat.: 0

Abs. Stand. Deviat.: 1

Minimum: 0

Maximum: 1e+009

Interpolation Method: linear interpolation

Sensitivity Analysis: inactive

Real Data Pairs (11 pairs):

1	1320.2
2	1308.72
3	1274.28
4	1222.62
5	1130.78
7	1090.6
11	1015.98
12	987.28
13	993.02
14	935.62
15	901.18

TKN_meas7: Description: Measured TKN (BT-7) Undiluted

Type: Real List Variable

Unit: mg/l

Argument: t

Standard Deviations: global

Rel. Stand. Deviat.: 0

Abs. Stand. Deviat.: 1

Minimum: 0

Maximum: 1e+009

Interpolation Method: linear interpolation

Sensitivity Analysis: inactive

Real Data Pairs (9 pairs):

1	1479.4
2	1417.78
3	1412.04
4	1357.6
5	1285.76
6	1234.1
7	1228.36
8	1115.04
9	1093.02

TKN_meas8: Description: Measured TKN (BT-8) Diluted

Type: Real List Variable

Unit: mg/l

Argument: t

Standard Deviations: global

Rel. Stand. Deviat.: 0

Abs. Stand. Deviat.: 1

Minimum: 0

Maximum: 1e+009

Interpolation Method: linear interpolation

Sensitivity Analysis: inactive

Real Data Pairs (9 pairs):

1	291.06
2	283.36
3	274.12
4	264.88
5	263.34
6	258.72
7	242.56
8	232.37
9	220

TKN_meas8x5:	Description:	Measured TKN (BT-8) (Diluted*5)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
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96		
97		
98		
99		
100		

Type: Real List Variable

Unit: mg/l

Argument: t

Standard Deviations: global

Rel. Stand. Deviat.: 0

Abs. Stand. Deviat.: 1

Minimum: 0

Maximum: 1e+009

Interpolation Method: linear interpolation

Sensitivity Analysis: inactive

Real Data Pairs (8 pairs):

1	1262.8
2	1455.3
3	1201.2
4	1370.6
5	1416.8
6	1293.6
7	1316.7
9	1324.4

TSS_fi:	Description:	TSS computed by dividing VSS by VSS /TSS ratio

Type:	Formula	Variable

Unit: mg/l

Expression: VSS/f_i

TSS_ISS:	Description:	TSS computed by adding ISS to VSS

Type:	Formula	Variable
1		
2		
3		
4		
5		
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96		
97		
98		
99		
100		

Unit: mg/l

Expression: VSS+ISS_Xoi

TSS_meas:	Description:	Measured TSS

Type: Variable List Variable

Unit: mg/l

Argument: Calcium

Interpolation Method: linear interpolation

Real-Variable Data Pairs (8 pairs):

1	TSS_meas1
2	TSS_meas2
3	TSS_meas3
4	TSS_meas4
5	TSS_meas5
6	TSS_meas6
7	TSS_meas7
8	TSS_meas8

TSS meas1:	Description:	Measured TSS (BT-1)

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Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (6 pairs):
 2 16619
 3 16494
 4 15965.33
 5 13612
 7 13385.33
 8 12979.33

TSS_meas2: Description: Measured TSS (BT-2)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (5 pairs):
 1 15956.67
 2 15990
 3 15947.67
 4 15946.33
 6 14910.83

TSS_meas3: Description: Measured TSS (BT-3)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (20 pairs):
 1 17421.33
 2 17003.17
 4 16208.33
 5 16230.67
 7 14582.33
 .
 .
 .
 21 10495.67
 22 9790.83
 23 9605.17
 24 9184
 25 8969.17

TSS_meas4: Description: Measured TSS (BT-4)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (19 pairs):

1	16992.08
2	16630.833
3	16211
4	15928.833
5	15157.833
.	.
17	11570.167
18	11374.833
19	11166
20	11204.333
21	11280.5

TSS_meas5: Description: Measured TSS (BT-5)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (10 pairs):

1	18380.67
2	17046.67
3	16910.5
4	16374.67
5	15551.67
6	14029.83
7	13902
8	12747.5
10	12669.83
11	11519.17

TSS_meas6: Description: Measured TSS (BT-6)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (12 pairs):

1	17543.83

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2	17068.17
3	16454
4	15332.5
5	14982.67
6	14109.83
7	13804.17
8	12814.83
9	12809.67
10	12642.17
13	12473.5
14	12353.83

TSS_meas7: Description: Measured TSS (BT-7) Undiluted
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (8 pairs):

1	19656.5
2	18814.25
4	17142.5
5	17147.75
6	15879
7	15609.5
8	14307.5
9	14270

TSS_meas8: Description: Measured TSS (BT-8) Diluted
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (8 pairs):

1	3770
2	3544.25
3	3431.75
5	3215.75
6	2981.25
7	2889.75
8	2833.5
9	2766.75

TSS_meas8x5: Description: Measured TSS (BT-8) (Diluted*5)
 Type: Real List Variable
 Unit: mg/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1

Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (8 pairs):

1	18850
2	17721.25
3	17158.75
5	16078.75
6	14906.25
7	14448.75
8	14167.5
9	13833.75

TSS_RedMeas: Description: Measured TSS reduction (delta TSS)
 Type: Variable List Variable
 Unit: mgTSS/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (6 pairs):

1	TSS_RedMeas1
2	TSS_RedMeas2
3	TSS_RedMeas3
4	TSS_RedMeas4
5	TSS_RedMeas5
6	TSS_RedMeas6

TSS_RedMeas1: Description: Measured TSS reduction (delta TSS)
 for BT-1
 Type: Real List Variable
 Unit: mgTSS/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (6 pairs):

2	200.04
3	325.04
4	853.71
5	3207.04
7	3433.71
8	3839.71

TSS_RedMeas2: Description: Measured TSS reduction (delta TSS)
 for BT-2
 Type: Real List Variable
 Unit: mgTSS/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (3 pairs):

3	9

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4	10.33
6	1045.83

TSS_RedMeas3: Description: Measured TSS reduction (delta TSS)
for BT-3

Type: Real List Variable
Unit: mgTSS/l
Argument: t
Standard Deviations: global
Rel. Stand. Deviat.: 0
Abs. Stand. Deviat.: 1
Minimum: 0
Maximum: 1e+009
Interpolation Method: linear interpolation
Sensitivity Analysis: inactive
Real Data Pairs (19 pairs):

2	418.17
4	1213
5	1190.67
7	2839
8	2675.33
.	.
.	.
21	6925.6667
22	7630.5
23	7816.1667
24	8237.3333
25	8452.1667

TSS_RedMeas4: Description: Measured TSS reduction (delta TSS)
for BT-4

Type: Real List Variable
Unit: mgTSS/l
Argument: t
Standard Deviations: global
Rel. Stand. Deviat.: 0
Abs. Stand. Deviat.: 1
Minimum: 0
Maximum: 1e+009
Interpolation Method: linear interpolation
Sensitivity Analysis: inactive
Real Data Pairs (18 pairs):

2	361.25
3	781.08
4	1063.25
5	1834.25
6	2323.75
.	.
.	.
17	5421.9133
18	5617.2467
19	5826.08
20	5787.7467
21	5711.58

TSS_RedMeas5: Description: Measured TSS reduction (delta TSS)
for BT-5

Type: Real List Variable
Unit: mgTSS/l
Argument: t
Standard Deviations: global

Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (9 pairs):

2	1334
3	1470.17
4	2006
5	2829
6	4350.83
7	4478.67
8	5633.17
10	5710.83
11	6861.5

TSS_RedMeas6: Description: Measured TSS reduction (delta TSS)
 for BT-6
 Type: Real List Variable
 Unit: mgTSS/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (11 pairs):

2	475.67
3	1089.83
4	2211.33
5	2561.17
6	3434
7	3739.67
8	4729
9	4734.17
10	4901.67
13	5070.3333
14	5190

VSS: Description: Actual VSS (mgVSS/l)
 Type: Formula Variable
 Unit: mgVSS/l
 Expression: mVSS/f_cvK

VSS_meas: Description: Measured VSS
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (8 pairs):

1	VSS_meas1
2	VSS_meas2
3	VSS_meas3
4	VSS_meas4
5	VSS_meas5
6	VSS_meas6
7	VSS_meas7
8	VSS_meas8

VSS_meas1: Description: Measured VSS (BT-1)
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (6 pairs):
 2 18480.76
 3 19138.373
 4 18649.973
 5 16026.427
 7 15742.267
 8 14966.747

VSS_meas2: Description: Measured VSS (BT-2)
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (4 pairs):
 2 18973.107
 3 18670.447
 4 18695.853
 6 17579.933

VSS_meas3: Description: Measured VSS (BT-3)
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (20 pairs):
 1 21163.51
 2 19980
 4 19076.71
 5 19105.07
 7 16807.87
 . .
 . .
 21 12230.47
 22 11484.31
 23 11167.83
 24 10719.89
 25 10544.26

VSS_meas4: Description: Measured VSS (BT-4)
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (19 pairs):

1	19833.727
2	19435.113
3	18854.46
4	18450.42
5	17671.2
.	.
17	13238.6
18	12987.493
19	12712.213
20	12787.94
21	12982.56

VSS_meas5: Description: Measured VSS (BT-5)
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (10 pairs):

1	21677.31
2	19023.92
3	18590.53
4	18161.82
5	17573.52
6	15580.45
7	15366.1
9	15065.66
10	14400.4
11	13156.21

VSS_meas6: Description: Measured VSS (BT-6)
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (11 pairs):

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1	19520.179
2	19211.387
3	18589.293
4	16014.34
5	15902.353
6	15209.467
7	15517.307
11	15020.273
12	14618.7
13	14354.52
14	14319.493

VSS_meas7: Description: Measured VSS (BT-7) (Undiluted)
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (8 pairs):

1	23025.47
2	21418.19
3	21051.15
5	19775.39
6	18248.4
7	18197.34
8	17031.1
9	16907.52

VSS_meas8: Description: Measured VSS (BT-8) (Diluted)
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (8 pairs):

1	4417.43
2	4118.1
3	4111.81
4	3988.35
5	3877.97
6	3553.48
7	3511.67
8	3385.13

VSS_meas8x5: Description: Measured VSS (BT-8) (Diluted*5)
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1

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Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (8 pairs):
 1 22087.15
 2 20590.5
 3 20559.05
 5 19389.85
 6 17767.4
 7 17558.35
 8 16925.65
 9 16960.8

VSS_RedMeas: Description: Measured VSS reduction (delta VSS)
 Type: Variable List Variable
 Unit: mgCOD/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (6 pairs):
 1 VSS_RedMeas1
 2 VSS_RedMeas2
 3 VSS_RedMeas3
 4 VSS_RedMeas4
 5 VSS_RedMeas5
 6 VSS_RedMeas6

VSS_RedMeas1: Description: Measured VSS reduction (delta VSS)
 for BT-1
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (6 pairs):
 2 734.26
 3 76.64
 4 565.04
 5 3188.59
 7 3472.75
 8 4248.27

VSS_RedMeas2: Description: Measured VSS reduction (delta VSS)
 for BT-2
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (4 pairs):
 2 188.51

3	491.17
4	465.77
6	1581.69

VSS_RedMeas3: Description: Measured VSS reduction (delta VSS)
for BT-3

Type: Real List Variable

Unit: mgCOD/l

Argument: t

Standard Deviations: global

Rel. Stand. Deviat.: 0

Abs. Stand. Deviat.: 1

Minimum: 0

Maximum: 1e+009

Interpolation Method: linear interpolation

Sensitivity Analysis: inactive

Real Data Pairs (19 pairs):

2	1183.51
4	2086.8
5	2058.43
7	4355.64
8	4031.77
.	.
21	8933.0333
22	9679.2
23	9995.6733
24	10443.62
25	10619.247

VSS_RedMeas4: Description: Measured VSS reduction (delta VSS)
for BT-4

Type: Real List Variable

Unit: mgCOD/l

Argument: t

Standard Deviations: global

Rel. Stand. Deviat.: 0

Abs. Stand. Deviat.: 1

Minimum: 0

Maximum: 1e+009

Interpolation Method: linear interpolation

Sensitivity Analysis: inactive

Real Data Pairs (18 pairs):

2	398.61
3	979.27
4	1383.31
5	2162.53
6	2889.95
.	.
17	6595.1267
18	6846.2333
19	7121.5133
20	7045.7867
21	6851.1667

VSS_RedMeas5: Description: Measured VSS reduction (delta VSS)
for BT-5

Type: Real List Variable

Unit: mgCOD/l

Argument: t

Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (9 pairs):

2	2653.39
3	3086.79
4	3515.49
5	4103.79
6	6096.86
7	6311.21
9	6611.65
10	7276.91
11	8521.1

VSS_RedMeas6: Description: Measured VSS reduction (delta VSS)
 for BT-6
 Type: Real List Variable
 Unit: mgCOD/l
 Argument: t
 Standard Deviations: global
 Rel. Stand. Deviat.: 0
 Abs. Stand. Deviat.: 1
 Minimum: 0
 Maximum: 1e+009
 Interpolation Method: linear interpolation
 Sensitivity Analysis: inactive
 Real Data Pairs (10 pairs):

2	308.79
3	930.89
4	3505.84
5	3617.83
6	4310.71
7	4002.87
11	4499.91
12	4901.48
13	5165.6588
14	5200.6855

X_AUT: Description: Nitrifying organisms
 Type: Dyn. Volume State Var.
 Unit: mg/l
 Relative Accuracy: 1e-006
 Absolute Accuracy: 1e-006

X_AUTini: Description: Initial concentration of nitrifying
 organisms
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (16 pairs):

1	X_AUTinila
2	X_AUTini2a
3	X_AUTini3a
4	X_AUTini4a
5	X_AUTini5a
6	X_AUTini6a

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7	X_AUTini7a
8	X_AUTini8a
11	X_AUTini1b
12	X_AUTini2b
13	X_AUTini3b
14	X_AUTini4b
15	X_AUTini5b
16	X_AUTini6b
17	X_AUTini7b
18	X_AUTini8b

X_AUTinila:	Description:	Initial concentration of nitrifying organisms for BT-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	291.9
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_AUTini1b:	Description:	Initial concentration of nitrifying organisms for BT-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	293.8
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_AUTini2a:	Description:	Initial concentration of nitrifying organisms for BT-2
	Type:	Constant Variable
	Unit:	mg/l
	Value:	440.8
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_AUTini2b:	Description:	Initial concentration of nitrifying organisms for BT-2
	Type:	Constant Variable
	Unit:	mg/l
	Value:	442.5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_AUTini3a:	Description:	Initial concentration of nitrifying organisms for BT-3
	Type:	Constant Variable
	Unit:	mg/l
	Value:	486.8
	Standard Deviation:	0.1

	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_AUTini3b:	Description:	Initial concentration of nitrifying organisms for BT-3
	Type:	Constant Variable
	Unit:	mg/l
	Value:	488.8
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_AUTini4a:	Description:	Initial concentration of nitrifying organisms for BT-4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	403.9
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_AUTini4b:	Description:	Initial concentration of nitrifying organisms for BT-4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	402.4
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_AUTini5a:	Description:	Initial concentration of nitrifying organisms for BT-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	311.4
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_AUTini5b:	Description:	Initial concentration of nitrifying organisms for BT-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	312
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_AUTini6a:	Description:	Initial concentration of nitrifying

		organisms for BT-6
	Type:	Constant Variable
	Unit:	mg/l
	Value:	229.9
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_AUTini6b:	Description:	Initial concentration of nitrifying organisms for BT-6
	Type:	Constant Variable
	Unit:	mg/l
	Value:	228.6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_AUTini7a:	Description:	Initial concentration of nitrifying organisms for BT-7 (Undiluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	377
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_AUTini7b:	Description:	Initial concentration of nitrifying organisms for BT-7 (Undiluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	376.7
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_AUTini8a:	Description:	Initial concentration of nitrifying organisms for BT-8 (Diluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	75.551
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_AUTini8b:	Description:	Initial concentration of nitrifying organisms for BT-8 (Diluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	75.551
	Standard Deviation:	0.1
	Minimum:	0

Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_eGt_SS:	Description:	Concentration of endogenous residue (PAO) at time t
	Type:	Formula Variable
	Unit:	mgCOD/l
	Expression:	$f\_G\_SS * X\_PAOini * (1 - (\exp(-b\_PAO20\_SS * t)))$
X_eHt_SS:	Description:	Concentration of endogenous residue (PAO) at time t
	Type:	Formula Variable
	Unit:	mgCOD/l
	Expression:	$f\_H\_SS * X\_Hini * (1 - (\exp(-b\_H20\_SS * t)))$
X_et_SS:	Description:	Total concentration of endogenous residue at time t
	Type:	Formula Variable
	Unit:	mgCOD/l
	Expression:	$X\_eGt\_SS + X\_eHt\_SS$
X_Gt_SS:	Description:	Concentration of PAOs at time t
	Type:	Formula Variable
	Unit:	mgCOD/l
	Expression:	$X\_PAOini * (\exp(-b\_PAO20\_SS * t))$
X_H:	Description:	Heterotrophic organisms
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006
X_Hini:	Description:	Initial concentration of heterotrophic organisms
	Type:	Variable List Variable
	Unit:	mg/l
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (16 pairs):	
	1	X_Hini1a
	2	X_Hini2a
	3	X_Hini3a
	4	X_Hini4a
	5	X_Hini5a
	6	X_Hini6a
	7	X_Hini7a
	8	X_Hini8a
	11	X_Hini1b
	12	X_Hini2b
	13	X_Hini3b
	14	X_Hini4b
	15	X_Hini5b
	16	X_Hini6b
	17	X_Hini7b
	18	X_Hini8b
X_Hini1a:	Description:	Initial concentration of heterotrophic organisms for BT-1

Type: Constant Variable
 Unit: mg/l
 Value: 3704.5
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Hini1b: Description: Initital concentration of heterotrophic organisms for BT-1
 Type: Constant Variable
 Unit: mg/l
 Value: 3308.3
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Hini2a: Description: Initital concentration of heterotrophic organisms for BT-2
 Type: Constant Variable
 Unit: mg/l
 Value: 4744.5
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Hini2b: Description: Initital concentration of heterotrophic organisms for BT-2
 Type: Constant Variable
 Unit: mg/l
 Value: 4429.5
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Hini3a: Description: Initital concentration of heterotrophic organisms for BT-3
 Type: Constant Variable
 Unit: mg/l
 Value: 5240.2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Hini3b: Description: Initital concentration of heterotrophic organisms for BT-3
 Type: Constant Variable
 Unit: mg/l
 Value: 4892.3
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000

Sensitivity Analysis: inactive
Parameter Estimation: inactive

X_Hini4a:	Description:	Initital concentration of heterotrophic organisms for BT-4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	2797.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_Hini4b:	Description:	Initital concentration of heterotrophic organisms for BT-4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	2915.1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_Hini5a:	Description:	Initital concentration of heterotrophic organisms for BT-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	3732.8
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_Hini5b:	Description:	Initital concentration of heterotrophic organisms for BT-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	3551.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_Hini6a:	Description:	Initital concentration of heterotrophic organisms for BT-6
	Type:	Constant Variable
	Unit:	mg/l
	Value:	2558.5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	10000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_Hini6b:	Description:	Initital concentration of heterotrophic organisms for BT-6
	Type:	Constant Variable

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Unit: mg/l
 Value: 2488.1
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Hini7a: Description: Initial concentration of heterotrophic organisms for BT-7 (Undiluted)
 Type: Constant Variable
 Unit: mg/l
 Value: 3589.3
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Hini7b: Description: Initial concentration of heterotrophic organisms for BT-7 (Undiluted)
 Type: Constant Variable
 Unit: mg/l
 Value: 3494.2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Hini8a: Description: Initial concentration of heterotrophic organisms for BT-8 (Diluted)
 Type: Constant Variable
 Unit: mg/l
 Value: 712.647
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Hini8b: Description: Initial concentration of heterotrophic organisms for BT-8 (Diluted)
 Type: Constant Variable
 Unit: mg/l
 Value: 712.647
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 10000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Ht_SS: Description: Concentration of OHOs at time t
 Type: Formula Variable
 Unit: mgCOD/l
 Expression: $X\_Hini * (\exp(-b\_H2O\_SS * t))$

X_I: Description: Inert particulate organic material
 Type: Dyn. Volume State Var.
 Unit: mg/l
 Relative Accuracy: 1e-006

Absolute Accuracy: 1e-006

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X_Iini:      Description:      Initial particulate inert organic m
                                atter
Type:        Variable List Variable
Unit:        mg/l
Argument:    Calcnum
Interpolation Method: linear interpolation
Real-Variable Data Pairs (16 pairs):
1            X_Iini1a
2            X_Iini2a
3            X_Iini3a
4            X_Iini4a
5            X_Iini5a
6            X_Iini6a
7            X_Iini7a
8            X_Iini8a
11           X_Iini1b
12           X_Iini2b
13           X_Iini3b
14           X_Iini4b
15           X_Iini5b
16           X_Iini6b
17           X_Iini7b
18           X_Iini8b

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X_Iinila:	Description:	Initial particulate inert organic m
		atter for BT-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	13487.4
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	25000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iinilb:	Description:	Initial particulate inert organic m
		atter for BT-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	10834.6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	25000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iini2a:	Description:	Initial particulate inert organic m atter for BT-2
	Type:	Constant Variable
	Unit:	mg/l
	Value:	10478.7
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	25000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iini2b:	Description:	Initial particulate inert organic matter for BT-2

Type: Constant Variable
 Unit: mg/l
 Value: 8454.8
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 25000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Iini3a: Description: Initial particulate inert organic matter for BT-3
 Type: Constant Variable
 Unit: mg/l
 Value: 11573.4
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 25000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Iini3b: Description: Initial particulate inert organic matter for BT-3
 Type: Constant Variable
 Unit: mg/l
 Value: 9338.1
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 25000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Iini4a: Description: Initial particulate inert organic matter for BT-4
 Type: Constant Variable
 Unit: mg/l
 Value: 12789.7
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 15000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Iini4b: Description: Initial particulate inert organic matter for BT-4
 Type: Constant Variable
 Unit: mg/l
 Value: 13676.8
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 15000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Iini5a: Description: Initial particulate inert organic matter for BT-5
 Type: Constant Variable
 Unit: mg/l
 Value: 13306.7
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 15000

Sensitivity Analysis: inactive

Parameter Estimation: inactive

X_Iini5b:	Description:	Initial particulate inert organic matter for BT-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	12183.4
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	15000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iini6a:	Description:	Initial particulate inert organic matter for BT-6
	Type:	Constant Variable
	Unit:	mg/l
	Value:	12273.4
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	15000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iini6b:	Description:	Initial particulate inert organic matter for BT-6
	Type:	Constant Variable
	Unit:	mg/l
	Value:	12026.9
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	15000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iini7a:	Description:	Initial particulate inert organic matter for BT-7 (Undiluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	15077
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iini7b:	Description:	Initial particulate inert organic matter for BT-7 (Undiluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	14531.6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	30000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Iini8a:	Description:	Initial particulate inert organic matter for BT-8 (Diluted)
	Type:	Constant Variable

Unit: mg/l
 Value: 3015.4
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 15000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Iini8b: Description: Initial particulate inert organic matter for BT-8 (Diluted)
 Type: Constant Variable
 Unit: mg/l
 Value: 2906.3
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 15000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PAO: Description: Phosphate accumulating organisms
 Type: Dyn. Volume State Var.
 Unit: mg/l
 Relative Accuracy: 1e-006
 Absolute Accuracy: 1e-006

X_PAOini: Description: Initial concentration of PAO
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: cubic spline interpolation
 Real-Variable Data Pairs (16 pairs):

1	X_PAOinila
2	X_PAOini2a
3	X_PAOini3a
4	X_PAOini4a
5	X_PAOini5a
6	X_PAOini6a
7	X_PAOini7a
8	X_PAOini8a
11	X_PAOinilb
12	X_PAOini2b
13	X_PAOini3b
14	X_PAOini4b
15	X_PAOini5b
16	X_PAOini6b
17	X_PAOini7b
18	X_PAOini8b

X_PAOinila: Description: Initial concentration of PAO for BT-1
 Type: Constant Variable
 Unit: mg/l
 Value: 1693.4
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 5000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PAOinilb: Description: Initial concentration of PAO for BT-1

Type: Constant Variable
 Unit: mg/l
 Value: 4656.1
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 5000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PAOini2a: Description: Initial concentration of PAO for BT
 -2
 Type: Constant Variable
 Unit: mg/l
 Value: 3409.9
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 5000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PAOini2b: Description: Initial concentration of PAO for BT
 -2
 Type: Constant Variable
 Unit: mg/l
 Value: 5691.3
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 7000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PAOini3a: Description: Initial concentration of PAO for BT
 -3
 Type: Constant Variable
 Unit: mg/l
 Value: 3766.2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 5000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PAOini3b: Description: Initial concentration of PAO for BT
 -3
 Type: Constant Variable
 Unit: mg/l
 Value: 6285.9
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 7000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PAOini4a: Description: Initial concentration of PAO for BT
 -4
 Type: Constant Variable
 Unit: mg/l
 Value: 3751.6
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 5000

Sensitivity Analysis: inactive
Parameter Estimation: inactive

X_PAOini4b:	Description:	Initial concentration of PAO for BT
		-4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	2768.2
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	5000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PAOini5a:	Description:	Initial concentration of PAO for BT
		-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	4215.6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	5000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PAOini5b:	Description:	Initial concentration of PAO for BT
		-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	5492.2
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	7000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PAOini6a:	Description:	Initial concentration of PAO for BT-6
	Type:	Constant Variable
	Unit:	mg/l
	Value:	4345.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	7000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PAOini6b:	Description:	Initial concentration of PAO for BT
		-6
	Type:	Constant Variable
	Unit:	mg/l
	Value:	4665.1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	7000
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PAOini7a:	Description:	Initial concentration of PAO for BT-7 (Undiluted)
	Type:	Constant Variable

Unit: mg/l
 Value: 3884.3
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 7000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PAOini7b: Description: Initial concentration of PAO for BT
 -7 (Undiluted)
 Type: Constant Variable
 Unit: mg/l
 Value: 4500.5
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 7000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PAOini8a: Description: Initial concentration of PAO for BT
 -8 (Diluted)
 Type: Constant Variable
 Unit: mg/l
 Value: 776.9
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 7000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PAOini8b: Description: Initial concentration of PAO for BT
 -8 (Diluted)
 Type: Constant Variable
 Unit: mg/l
 Value: 900.1
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 7000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PHA: Description: A cell internal storage product of
 phosphate accumulating organisms
 Type: Dyn. Volume State Var.
 Unit: mg/l
 Relative Accuracy: 1e-006
 Absolute Accuracy: 1e-006

X_PHAini: Description: Initial concentration of PHA
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (16 pairs):

1	X_PHAinila
2	X_PHAini2a
3	X_PHAini3a
4	X_PHAini4a
5	X_PHAini5a
6	X_PHAini6a
7	X_PHAini7a

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8	X_PHAini8a
11	X_PHAini1b
12	X_PHAini2b
13	X_PHAini3b
14	X_PHAini4b
15	X_PHAini5b
16	X_PHAini6b
17	X_PHAini7b
18	X_PHAini8b

X_PHAinila:	Description:	Initial concentration of PHA for BT -1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	42.8
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	100
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAinilb:	Description:	Initial concentration of PHA for BT -1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	117.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	150
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini2a:	Description:	Initial concentration of PHA for BT -2
	Type:	Constant Variable
	Unit:	mg/l
	Value:	86.8
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini2b:	Description:	Initial concentration of PHA for BT -2
	Type:	Constant Variable
	Unit:	mg/l
	Value:	144.9
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini3a:	Description:	Initial concentration of PHA for BT -3
	Type:	Constant Variable
	Unit:	mg/l
	Value:	95.8
	Standard Deviation:	0.1
	Minimum:	0

	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini3b:	Description:	Initial concentration of PHA for BT -3
	Type:	Constant Variable
	Unit:	mg/l
	Value:	160
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini4a:	Description:	Initial concentration of PHA for BT -4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	95.1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini4b:	Description:	Initial concentration of PHA for BT -4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	70.2
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini5a:	Description:	Initial concentration of PHA for BT -5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	106.2
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini5b:	Description:	Initial concentration of PHA for BT -5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	138.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini6a:	Description:	Initial concentration of PHA for BT -6

Type:	Constant Variable
Unit:	mg/l
Value:	109
Standard Deviation:	0.1
Minimum:	0
Maximum:	200
Sensitivity Analysis:	inactive
Parameter Estimation:	inactive

X_PHAini6b:	Description:	Initial concentration of PHA for BT -6
	Type:	Constant Variable
	Unit:	mg/l
	Value:	117.1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini7a:	Description:	Initial concentration of PHA for BT -7 (Undiluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	98.1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini7b:	Description:	Initial concentration of PHA for BT -7 (Undiluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	113.5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini8a:	Description:	Initial concentration of PHA for BT -8 (Diluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	20.946
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PHAini8b:	Description:	Initial concentration of PHA for BT -8 (Diluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	20.946
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200

Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PP: Description: Poly-phosphate
 Type: Dyn. Volume State Var.
 Unit: mg/l
 Relative Accuracy: 1e-006
 Absolute Accuracy: 1e-006

X_PPini: Description: Initial concentration of PP
 Type: Variable List Variable
 Unit: mg/l
 Argument: Calcnum
 Interpolation Method: linear interpolation
 Real-Variable Data Pairs (16 pairs):

1	X_PPini1a
2	X_PPini2a
3	X_PPini3a
4	X_PPini4a
5	X_PPini5a
6	X_PPini6a
7	X_PPini7a
8	X_PPini8a
11	X_PPini1b
12	X_PPini2b
13	X_PPini3b
14	X_PPini4b
15	X_PPini5b
16	X_PPini6b
17	X_PPini7b
18	X_PPini8b

X_PPini1a: Description: Initial concentration of PP for BT-
 1
 Type: Constant Variable
 Unit: mg/l
 Value: 477.5
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PPini1b: Description: Initial concentration of PP for BT-
 1
 Type: Constant Variable
 Unit: mg/l
 Value: 443.2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 1000
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_PPini2a: Description: Initial concentration of PP for BT-
 2
 Type: Constant Variable
 Unit: mg/l
 Value: 967.9
 Standard Deviation: 0.1
 Minimum: 0

1. *Phragmites australis* (Cav.) Trin. ex Steud.

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X_PPini2b:	Description:	Initial concentration of PP for BT-2
	Type:	Constant Variable
	Unit:	mg/l
	Value:	953.6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PPini3a:	Description:	Initial concentration of PP for BT-3
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1069
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PPini3b:	Description:	Initial concentration of PP for BT-3
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1053
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PPini4a:	Description:	Initial concentration of PP for BT-4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1021.2
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PPini4b:	Description:	Initial concentration of PP for BT-4
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1056.4
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PPini5a:	Description:	Initial concentration of PP for BT-5

	Type:	Constant Variable
	Unit:	mg/l
	Value:	1179.5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_PPini5b:	Description:	Initial concentration of PP for BT-5
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1190.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_PPini6a:	Description:	Initial concentration of PP for BT-6
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1180.4
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_PPini6b:	Description:	Initial concentration of PP for BT-6
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1179.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_PPini7a:	Description:	Initial concentration of PP for BT-7 (Undiluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1085.6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_PPini7b:	Description:	Initial concentration of PP for BT-7 (Undiluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	1077.6
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500

Sensitivity Analysis: inactive

Parameter Estimation: inactive

X_PPini8a:	Description:	Initial concentration of PP for BT-8 (Diluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	215.5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_PPini8b:	Description:	Initial concentration of PP for BT-8 (Diluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	215.5
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1500
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_S:	Description:	Slowly biodegradable substrate
	Type:	Dyn. Volume State Var.
	Unit:	mg/l
	Relative Accuracy:	1e-006
	Absolute Accuracy:	1e-006

X_Sini:	Description:	Initial concentration of slowly biodegradable substrate
	Type:	Variable List Variable
	Unit:	mg/l
	Argument:	Calcnum
	Interpolation Method:	linear interpolation
	Real-Variable Data Pairs (16 pairs):	
	1	X_Sinila
	2	X_Sini2a
	3	X_Sini3a
	4	X_Sini4a
	5	X_Sini5a
	6	X_Sini6a
	7	X_Sini7a
	8	X_Sini8a
	11	X_Sinilb
	12	X_Sini2b
	13	X_Sini3b
	14	X_Sini4b
	15	X_Sini5b
	16	X_Sini6b
	17	X_Sini7b
	18	X_Sini8b

X_Sinila:	Description:	Initial concentration of slowly biodegradable substrate for BT-1a
	Type:	Constant Variable
	Unit:	mg/l
	Value:	140.9
	Standard Deviation:	0.1

	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Sini1b:	Description:	Initial concentration of slowly bio degradable substrate for BT-1
	Type:	Constant Variable
	Unit:	mg/l
	Value:	125.1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Sini2a:	Description:	Initial concentration of slowly bio degradable substrate for BT-2a
	Type:	Constant Variable
	Unit:	mg/l
	Value:	159.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Sini2b:	Description:	Initial concentration of slowly bio degradable substrate for BT-2
	Type:	Constant Variable
	Unit:	mg/l
	Value:	164
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Sini3a:	Description:	Initial concentration of slowly bio degradable substrate for BT-3a
	Type:	Constant Variable
	Unit:	mg/l
	Value:	175.9
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Sini3b:	Description:	Initial concentration of slowly bio degradable substrate for BT-3
	Type:	Constant Variable
	Unit:	mg/l
	Value:	181.1
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

X_Sini4a:	Description:	Initial concentration of slowly bio

degradable substrate for BT-4a
 Type: Constant Variable
 Unit: mg/l
 Value: 85.2
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 200
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Sini4b: Description: Initial concentration of slowly bio degradable substrate for BT-4
 Type: Constant Variable
 Unit: mg/l
 Value: 90.6
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 200
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Sini5a: Description: Initial concentration of slowly bio degradable substrate for BT-5a
 Type: Constant Variable
 Unit: mg/l
 Value: 137.6
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 200
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Sini5b: Description: Initial concentration of slowly bio degradable substrate for BT-5
 Type: Constant Variable
 Unit: mg/l
 Value: 137
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 200
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Sini6a: Description: Initial concentration of slowly bio degradable substrate for BT-6
 Type: Constant Variable
 Unit: mg/l
 Value: 94.6
 Standard Deviation: 0.1
 Minimum: 0
 Maximum: 200
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

X_Sini6b: Description: Initial concentration of slowly bio degradable substrate for BT-6
 Type: Constant Variable
 Unit: mg/l
 Value: 95
 Standard Deviation: 0.1
 Minimum: 0

	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_Sini7a:	Description:	Initial concentration of slowly bio degradable substrate for BT-7 (Undiluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	121.3
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_Sini7b:	Description:	Initial concentration of slowly bio degradable substrate for BT-7 (Undiluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	123
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_Sini8a:	Description:	Initial concentration of slowly bio degradable substrate for BT-8 (Diluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	24.507
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_Sini8b:	Description:	Initial concentration of slowly bio degradable substrate for BT-8 (Diluted)
	Type:	Constant Variable
	Unit:	mg/l
	Value:	24.507
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	200
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
X_Ti_SS:	Description:	Initial TSS concentration
	Type:	Formula Variable
	Unit:	mgTSS/l
	Expression:	$(X_{Vi\_SS}/f_{cv\_SS}) + ((X_{Hini}/f_{cv\_SS}) * ISS_{fiOHO}) + ((X_{PAOini}/f_{cv\_SS}) * ISS_{fiPAO}) + ISS_{Xioini}$
X_Tt_SS:	Description:	TSS concentration at time t
	Type:	Formula Variable

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	Unit:	mgTSS/l
	Expression:	$((X\_Hini/f\_cv\_SS)*(f\_H\_SS+((1-f\_H\_SS+ISS\_fiOHO)*(exp(-b\_H20\_SS*t)))))+((X\_PAOini/f\_cv\_SS)*(f\_G\_SS+((1-f\_G\_SS+ISS\_fiPAO)*(exp(-b\_PAO20\_SS*t)))))+(X\_Iini/f\_cv\_SS)+ISS\_Xioini\_SS$
X_Vi_SS:	Description:	Initial VSS concentration
	Type:	Formula Variable
	Unit:	mgCOD/l
	Expression:	X_AUTini+X_Hini+X_PAOini+X_Iini
X_Vt_SS:	Description:	VSS concentration at time t
	Type:	Formula Variable
	Unit:	mgCOD/l
	Expression:	$((X\_Hini)*((1-f\_H\_SS)*(exp(-b\_H20\_SS*t))+f\_H\_SS))+((X\_PAOini)*((1-f\_G\_SS)*(exp(-b\_PAO20\_SS*t))+f\_G\_SS)))+(X\_Iini)$
Y_AUT:	Description:	Yield coefficient (biomass/nitrate) of ANO
	Type:	Constant Variable
	Unit:	gCOD(gN) ⁻¹
	Value:	0.15
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
Y_H:	Description:	Yield of OHO
	Type:	Constant Variable
	Unit:	per day
	Value:	0.67
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
Y_H_SS:	Description:	Yield of OHO (SSM)
	Type:	Constant Variable
	Unit:	per day
	Value:	0.45
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive
Y_PAO:	Description:	Yield coefficient (biomass/PHA)
	Type:	Constant Variable
	Unit:	per day
	Value:	0.67
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

Y_PAO_SS:	Description:	Yield coefficient (biomass/PHA) for PAO (SSM)
	Type:	Constant Variable
	Unit:	per day
	Value:	0.45
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

Y_PHA:	Description:	PHA requirement for PP storage
	Type:	Constant Variable
	Unit:	gCOD/gCOD
	Value:	0.03
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

Y_PO4:	Description:	Yield of P release/PHA storage (PP requirement (S_PO4 release) for PHA storage)
	Type:	Constant Variable
	Unit:	gP/gCOD
	Value:	0.52
	Standard Deviation:	0.1
	Minimum:	0
	Maximum:	1
	Sensitivity Analysis:	inactive
	Parameter Estimation:	inactive

Processes

Aeration:	Description:	
	Type:	Dynamic Process
	Rate:	$K_{La} \cdot (S_{O2sat} - S_{O2})$
	Stoichiometry:	
	Variable :	Stoichiometric Coefficient
	S_O2 :	1

AerobicHydrolysis:	Description:	Aerobic hydrolysis
	Type:	Dynamic Process
	Rate:	$K_h \cdot (S_{O2} / (K_{O2} + S_{O2})) \cdot ((X_S / X_H) / (K_X + (X_S / X_H))) \cdot X_H$
	Stoichiometry:	
	Variable :	Stoichiometric Coefficient
	S_F :	$1 - f_{SI}$
	S_I :	f_{SI}
	X_S :	-1
	S_PO4 :	$i_{PXs} - ((1 - f_{SI}) \cdot i_{PSf}) - (f_{SI} \cdot i_{PSi})$
	S_NH4 :	$i_{NXs} - ((1 - f_{SI}) \cdot i_{NSf}) - (f_{SI} \cdot i_{NSi})$

Type: Dynamic Process
 Rate: $\mu_{H\eta} \text{NO}_3 dS_A (K_{O_2} / (K_{O_2} + S_{O_2})) * (S_A / (K_{AOHO} + S_A)) * (S_{NH_4} / (K_{NH_4OHO} + S_{NH_4})) * (S_{NO_3} / (K_{NO_3} + S_{NO_3})) * (S_{PO_4} / (K_P + S_{PO_4})) * (X_H / (S_F + S_A))$

Stoichiometry:

Variable : Stoichiometric Coefficient

 $S_A : -1/Y_H$ $X_H : 1$ $S_{NH_4} : -i_{NBM}$ $S_{PO_4} : -i_{PBM}$ $S_{NO_3} : -(1-Y_H)/(2.86*Y_H)$ $S_{N_2} : (1-Y_H)/(2.86*Y_H)$

AnoxicGrowthS_F:

Description: Anoxic growth on fermentable substrates, S_F Denitrification

Type: Dynamic Process

Rate: $\mu_{H\eta} \text{NO}_3 dS_F (K_{O_2} / (K_{O_2} + S_{O_2})) * (S_F / (K_F + S_F)) * (S_{NH_4} / (K_{NH_4OHO} + S_{NH_4})) * (S_{NO_3} / (K_{NO_3} + S_{NO_3})) * (S_{PO_4} / (K_P + S_{PO_4})) * (X_H / (S_F + S_A))$

Stoichiometry:

Variable : Stoichiometric Coefficient

 $S_F : -1/Y_H$ $X_H : 1$ $S_{NH_4} : ((1/Y_H)*i_{NSf}) - i_{NBM}$ $S_{PO_4} : ((1/Y_H)*i_{PSf}) - i_{PBM}$ $S_{NO_3} : -(1-Y_H)/(2.86*Y_H)$ $S_{N_2} : (1-Y_H)/(2.86*Y_H)$

Anoxichydrolysis:

Description: Anoxic hydrolysis

Type: Dynamic Process

Rate: $K_h \eta \text{NO}_3 * (K_{O_2} / (K_{O_2} + S_{O_2})) * (S_{NO_3} / (K_{NO_3} + S_{NO_3})) * ((X_S/X_H) / (K_X + (X_S/X_H))) * X_H$

Stoichiometry:

Variable : Stoichiometric Coefficient

 $S_F : 1-f_{SI}$ $S_{NH_4} : i_{NXs} - ((1-f_{SI}) * i_{NSf}) - (f_{SI} * i_{NSi})$ $X_S : -1$ $S_{PO_4} : i_{PXs} - ((1-f_{SI}) * i_{PSf}) - (f_{SI} * i_{PSi})$ $S_I : f_{SI}$

Fermentation:

Description: Fermentation

Type: Dynamic Process

Rate: $q_{fe} * (K_{O_2} / (K_{O_2} + S_{O_2})) * (K_{NO_3} / (K_{NO_3} + S_{NO_3})) * (S_F / (K_{fe} + S_F)) * X_H$

Stoichiometry:

Variable : Stoichiometric Coefficient

 $S_F : -1$ $S_A : 1$ $S_{NH_4} : i_{NSf}$ $S_{PO_4} : i_{PSf}$

GrowthX_AUT:

Description: Growth of nitrifying organisms (autotrophic organisms)

Type: Dynamic Process

Rate: $\mu_{AUT} * (S_{O_2} / (K_{O_2} + S_{O_2})) * (S_{NH_4} / (K_{NH_4AUT} + S_{NH_4})) * (S_{PO_4} / (K_P + S_{PO_4}))$

StorageX PHA:	Description:	Sequestration of S A / Storage of X

PHA
 Type: Dynamic Process
 Rate: $q\_PHA * (S\_A / (K\_APAO + S\_A)) * ((X\_PP / X\_PAO) / (K\_PP + (X\_PP / X\_PAO))) * X\_PAO$
 Stoichiometry:
 Variable : Stoichiometric Coefficient
 S_A : -1
 S_PO4 : Y_PO4
 X_PP : -Y_PO4
 X_PHA : 1

StorageX_PP: Description: Storage of X_PP
 Type: Dynamic Process
 Rate: $q\_PP * (S\_O2 / (K\_O2 + S\_O2)) * (S\_PO4 / (K\_P + S\_PO4)) * ((X\_PHA / X\_PAO) / (K\_PHA + (X\_PHA / X\_PAO))) * ((K\_Max - (X\_PP / X\_PAO)) / (K\_IPP + K\_Max - (X\_PP / X\_PAO))) * X\_PAO$
 Stoichiometry:
 Variable : Stoichiometric Coefficient
 S_O2 : -Y_PHA
 S_PO4 : -1
 X_PP : 1
 X_PHA : -Y_PHA

Compartments

Reactor: Description: Mixed Reactor Compartment
 Type: 0
 Compartment Index: 0
 Active Variables: b_AUT, b_AUT20, b_AUT20_SS, b_H, b_H2O, b_H2O_SS, b_PAO, b_PAO20, b_PA
 O20_SS, b_PHA, b_PHA20, b_PP, b_PP20, b_PP20_SS, Calcnum, CODf, CODf_m, CODf_m1, CODf_m2, CODf_m3, CODf_m4, CODf_m5, CODf_m6, CODt, CODt_m, CODt_m1, CODt_m2, CODt_m3, CODt_m4, CODt_m5, CODt_m6, CODt_m7, CODt_m8, CODt_m8x5, deltaTSSst_SS, deltaVSS
 t_SS, eta_fe, eta_NO3, eta_NO3d, f_aGTi_SS, f_aGVi_SS, f_aHTi_SS, f_aHVi_SS, f_avOHO, f_avPAO, f_cv, f_cv1a, f_cv1b, f_cv2a, f_cv2b, f_cv3a, f_cv3b, f_cv4a, f_cv4b, f_cv5a, f_cv5b, f_cv6a, f_cv6b, f_cv7a, f_cv7b, f_cv8a, f_cv8b, f_cvK, f_cvM, f_cvm, f_cvm1, f_cvm1, f_cvm2, f_cvm2, f_cvm3, f_cvm3, f_cvm4, f_cvm4, f_cvm5, f_cvm5, f_cvm6, f_cvm6, f_cvm7, f_cvm7, f_cvm8, f_cvm8, f_cv_SS, f_GTrt_SS, f_GVrt_SS, f_G_SS, f_HTrt_SS, f_HVrt_SS, f_H_SS, f_i, f_i1a, f_i1b, f_i2a, f_i2b, f_i3a, f_i3b, f_i4a, f_i4b, f_i5a, f_i5b, f_i6a, f_i6b, f_i7a, f_i7b, f_i8a, f_i8b, f_iM, f_iM1, f_iM2, f_iM3, f_iM

4, f_iM5, f_iM6, f_iM7, f_iM8, f_im
 eas, f_imeas1, f_imeas2, f_imeas3,
 f_imeas4, f_imeas5, f_imeas6, f_ime
 as7, f_imeas8, f_n_SS, f_pG_SS, f_p
 H_SS, f_SI, f_TrtMeas, f_TrtMeas1,
 f_TrtMeas2, f_TrtMeas3, f_TrtMeas4,
 f_TrtMeas5, f_TrtMeas6, f_Trt_SS,
 f_VrtMeas, f_VrtMeas1, f_VrtMeas2,
 f_VrtMeas3, f_VrtMeas4, f_VrtMeas5,
 f_VrtMeas6, f_Vrt_SS, f_XiAUT, f_X
 iOHO, f_XiPAO, ISS_fiOHO, ISS_fiPAO
 , ISS_fiPAOBM, ISS_meas, ISS_meas1,
 ISS_meas2, ISS_meas3, ISS_meas4, I
 SS_meas5, ISS_meas6, ISS_meas7, ISS
 meas8, ISS_meas8x5, ISS_Xioi, ISS_
 Xioin, ISS_Xioini, ISS_Xioinila, IS
 S_Xioinilb, ISS_Xioini2a, ISS_Xioin
 i2b, ISS_Xioini3a, ISS_Xioini3b, IS
 S_Xioini4a, ISS_Xioini4b, ISS_Xioin
 i5a, ISS_Xioini5b, ISS_Xioini6a, IS
 S_Xioini6b, ISS_Xioini7a, ISS_Xioin
 i7b, ISS_Xioini8a, ISS_Xioini8b, IS
 S_Xioini_SS, ISS_Xioini_SS1a, ISS_X
 ioini_SS1b, ISS_Xioini_SS2a, ISS_Xi
 oini_SS2b, ISS_Xioini_SS3a, ISS_Xio
 ini_SS3b, ISS_Xioini_SS4a, ISS_Xioi
 ni_SS4b, ISS_Xioini_SS5a, ISS_Xioin
 i_SS5b, ISS_Xioini_SS6a, ISS_Xioini
 SS6b, ISS_Xioini_SS7a, ISS_Xioini
 SS7b, ISS_Xioini_SS8a, ISS_Xioini_S
 S8b, ISS_Xoi, i_NBM, i_NSf, i_NSi,
 i_NXi, i_NXs, i_PBM, i_Psf, i_PSi,
 i_PXi, i_PXs, i_TSSBM, i_TSSXi, i_T
 SSXs, K_ALK, K_ALKAUT, K_ALKPRE, K_
 AOHO, K_APAO, K_F, K_fe, K_h, K_h20
 , K_IPP, K_La, K_Max, K_NH4AUT, K_N
 H4OHO, K_NH4PAO, K_NO3, K_O2, K_P,
 K_PHA, K_PP, k_PRE, K_PS, k_RED, K_
 X, K_X20, mue_AUT, mue_AUT20, mue_H
 , mue_H20, mue_PAO, mue_PAO20, mVSS
 , Nnt_SS, OUR_AUT, OUR_c, OUR_c1a,
 OUR_c1b, OUR_c2a, OUR_c2b, OUR_c3a,
 OUR_c3b, OUR_c4a, OUR_c4b, OUR_c5a
 , OUR_c5b, OUR_c6a, OUR_c6b, OUR_c7
 a, OUR_c7b, OUR_c8a, OUR_c8b, O_c_S
 S, O_G_SS, OUR_H, OUR_H1a, OUR_H1b,
 OUR_H2a, OUR_H2b, OUR_H3a, OUR_H3b
 , OUR_H4a, OUR_H4b, OUR_H5a, OUR_H5
 b, OUR_H6a, OUR_H6b, OUR_H7a, OUR_H
 7b, OUR_H8a, OUR_H8b, OUR_HSA, OUR_
 HSF, O_H_SS, OUR_Meas, OUR_meas, OU
 R_Meas1, OUR_meas1, OUR_Meas2, OUR_
 meas2, OUR_Meas3, OUR_meas3, OUR_Me
 as4, OUR_meas4, OUR_Meas5, OUR_meas
 5, OUR_Meas6, OUR_meas6, OUR_Meas7,
 OUR_Meas8, OUR_Meas8x5, O_n_SS, OU
 R_P, OUR_P1a, OUR_P1b, OUR_P2a, OUR
 P2b, OUR_P3a, OUR_P3b, OUR_P4a, OU
 R_P4b, OUR_P5a, OUR_P5b, OUR_P6a, O
 UR_P6b, OUR_P7a, OUR_P7b, OUR_P8a,
 OUR_P8b, OUR_PAO, OUR_PP, OUR_t, OU

R_t1a, OUR_t1b, OUR_t2a, OUR_t2b, O
 UR_t3a, OUR_t3b, OUR_t4a, OUR_t4b,
 OUR_t5a, OUR_t5b, OUR_t6a, OUR_t6b,
 OUR_t7a, OUR_t7b, OUR_t8a, OUR_t8b
 , O_T_SS, Pst_G_SS, Pst_H_SS, Pst_S
 S, q_fe, q_fe20, q_fe20a, q_fe20b,
 q_PHA, q_PHA20, q_PP, q_PP20, q_PP2
 0a, q_PP20b, R_hn, R_hn1a, R_hn1b,
 R_hn2a, R_hn2b, R_hn3a, R_hn3b, R_h
 n4a, R_hn4b, R_hn5a, R_hn5b, R_hn6a
 , R_hn6b, R_hn7a, R_hn7b, R_hn8a, R
 _hn8b, R_s, R_s1a, R_s1b, R_s2a, R_
 s2b, R_s3a, R_s3b, R_s4a, R_s4b, R_
 s5a, R_s5b, R_s6a, R_s6b, R_s7a, R_
 s7b, R_s8a, R_s8b, S_A, S_Aini, S_A
 inila, S_Ainilb, S_Aini2a, S_Aini2b
 , S_Aini3a, S_Aini3b, S_Aini4a, S_A
 ini4b, S_Aini5a, S_Aini5b, S_Aini6a
 , S_Aini6b, S_Aini7a, S_Aini7b, S_A
 ini8a, S_Aini8b, S_F, S_Fini, S_Fin
 ila, S_Finilb, S_Fini2a, S_Fini2b,
 S_Fini3a, S_Fini3b, S_Fini4a, S_Fin
 i4b, S_Fini5a, S_Fini5b, S_Fini6a,
 S_Fini6b, S_Fini7a, S_Fini7b, S_Fin
 i8a, S_Fini8b, S_I, S_Iini, S_Iinil
 a, S_Iinilb, S_Iini2a, S_Iini2b, S_
 Iini3a, S_Iini3b, S_Iini4a, S_Iini4
 b, S_Iini5a, S_Iini5b, S_Iini6a, S_
 Iini6b, S_Iini7a, S_Iini7b, S_Iini8
 a, S_Iini8b, S_N2, S_N2ini, S_N2ini
 1a, S_N2inilb, S_N2ini2a, S_N2ini2b
 , S_N2ini3a, S_N2ini3b, S_N2ini4a,
 S_N2ini4b, S_N2ini5a, S_N2ini5b, S_
 N2ini6a, S_N2ini6b, S_N2ini7a, S_N2
 ini7b, S_N2ini8a, S_N2ini8b, S_NH4,
 S_NH4ini, S_NH4inila, S_NH4inilb,
 S_NH4ini2a, S_NH4ini2b, S_NH4ini3a,
 S_NH4ini3b, S_NH4ini4a, S_NH4ini4b
 , S_NH4ini5a, S_NH4ini5b, S_NH4ini6
 a, S_NH4ini6b, S_NH4ini7a, S_NH4ini
 7b, S_NH4ini8a, S_NH4ini8b, S_NH4mea
 s, S_NH4meas1, S_NH4meas2, S_NH4mea
 s3, S_NH4meas4, S_NH4meas5, S_NH4mea
 s6, S_NH4meas7, S_NH4meas8, S_NO3
 , S_NO3ini, S_NO3inila, S_NO3inilb,
 S_NO3ini2a, S_NO3ini2b, S_NO3ini3a
 , S_NO3ini3b, S_NO3ini4a, S_NO3ini4
 b, S_NO3ini5a, S_NO3ini5b, S_NO3ini
 6a, S_NO3ini6b, S_NO3ini7a, S_NO3in
 i7b, S_NO3ini8a, S_NO3ini8b, S_NO3mea
 s, S_NO3meas1, S_NO3meas2, S_NO3mea
 s3, S_NO3meas4, S_NO3meas5, S_NO3mea
 s6, S_NO3meas7, S_NO3meas8, S_NO
 3meas8x5, S_O2, S_O2aer, S_O2sat, S_
 PO4, S_PO4ini, S_PO4inila, S_PO4in
 ilb, S_PO4ini2a, S_PO4ini2b, S_PO4i
 ni3a, S_PO4ini3b, S_PO4ini4a, S_PO4
 ini4b, S_PO4ini5a, S_PO4ini5b, S_PO
 4ini6a, S_PO4ini6b, S_PO4ini7a, S_P
 O4ini7b, S_PO4ini8a, S_PO4ini8b, S_
 PO4meas, S_PO4meas1, S_PO4meas2, S_

P04meas3, S_P04meas4, S_P04meas5, S_P04meas6, S_P04meas7, S_P04meas8, S_P04meas8x5, S_Ptmeas, S_Ptmeas5, S_Ptmeas6, S_Ptmeas7, S_Ptmeas8, T, t, the_bAUT, the_bH, the_bPAO, the_bPHA, the_bPP, the_Kh, the_KX, the_mueAUT, the_mueH, the_muePAO, the_qfe, the_qPHA, the_qPP, TKN, TKN_meas, TKN_meas1, TKN_meas2, TKN_meas3, TKN_meas4, TKN_meas5, TKN_meas6, TKN_meas7, TKN_meas8, TKN_meas8x5, TSS_fi, TSS_ISS, TSS_meas, TSS_meas1, TSS_meas2, TSS_meas3, TSS_meas4, TSS_meas5, TSS_meas6, TSS_meas7, TSS_meas8, TSS_meas8x5, TSS_RedMeas, TSS_RedMeas1, TSS_RedMeas2, TSS_RedMeas3, TSS_RedMeas4, TSS_RedMeas5, TSS_RedMeas6, VSS, VSS_meas, VSS_meas1, VSS_meas2, VSS_meas3, VSS_meas4, VSS_meas5, VSS_meas6, VSS_meas7, VSS_meas8, VSS_meas8x5, VSS_RedMeas, VSS_RedMeas1, VSS_RedMeas2, VSS_RedMeas3, VSS_RedMeas4, VSS_RedMeas5, VSS_RedMeas6, X_AUT, X_AUTini, X_AUTini1a, X_AUTini1b, X_AUTini2a, X_AUTini2b, X_AUTini3a, X_AUTini3b, X_AUTini4a, X_AUTini4b, X_AUTini5a, X_AUTini5b, X_AUTini6a, X_AUTini6b, X_AUTini7a, X_AUTini7b, X_AUTini8a, X_AUTini8b, X_eGt_SS, X_eHt_SS, X_et_SS, X_Gt_SS, X_H, X_Hini, X_Hini1a, X_Hini1b, X_Hini2a, X_Hini2b, X_Hini3a, X_Hini3b, X_Hini4a, X_Hini4b, X_Hini5a, X_Hini5b, X_Hini6a, X_Hini6b, X_Hini7a, X_Hini7b, X_Hini8a, X_Hini8b, X_Ht_SS, X_I, X_Iini, X_Iini1a, X_Iini1b, X_Iini2a, X_Iini2b, X_Iini3a, X_Iini3b, X_Iini4a, X_Iini4b, X_Iini5a, X_Iini5b, X_Iini6a, X_Iini6b, X_Iini7a, X_Iini7b, X_Iini8a, X_Iini8b, X_PAO, X_PAOini, X_PAOini1a, X_PAOini1b, X_PAOini2a, X_PAOini2b, X_PAOini3a, X_PAOini3b, X_PAOini4a, X_PAOini4b, X_PAOini5a, X_PAOini5b, X_PAOini6a, X_PAOini6b, X_PAOini7a, X_PAOini7b, X_PAOini8a, X_PAOini8b, X_PHA, X_PHAini, X_PHAini1a, X_PHAini1b, X_PHAini2a, X_PHAini2b, X_PHAini3a, X_PHAini3b, X_PHAini4a, X_PHAini4b, X_PHAini5a, X_PHAini5b, X_PHAini6a, X_PHAini6b, X_PHAini7a, X_PHAini7b, X_PHAini8a, X_PHAini8b, X_PP, X_PPini, X_PPini1a, X_PPini1b, X_PPini2a, X_PPini2b, X_PPini3a, X_PPini3b, X_PPini4a, X_PPini4b, X_PPini5a, X_PPini5b, X_PPini6a, X_PPini6b, X_PPini7a, X_PPini7b, X_PPini8a, X_PPini8b, X_S, X_Sini, X_Sinila, X_Sini1b, X_Sini2a, X_Sini2b, X_Sini3a, X_Sini3b, X_Sini4a, X_Sini4b, X_Sini5a

, X_Sini5b, X_Sini6a, X_Sini6b, X_Sini7a, X_Sini7b, X_Sini8a, X_Sini8b
 , X_Ti_SS, X_Tt_SS, X_Vi_SS, X_Vt_SS, Y_AUT, Y_H, Y_H_SS, Y_PAO, Y_PAO_SS, Y_PHA, Y_PO4
 Active Processes: Aeration, AerobicHydrolysis, AeroGrowthS_A, AeroGrowthS_F, AeroGrowthX_PAO, AnaerobicHydrolysis, AnoxicGrowthS_A, AnoxicGrowthS_F, AnoxicHydrolysis, Fermentation, GrowthX_AUT, LysisX_AUT, LysisX_H, LysisX_PAO, LysisX_PHA, LysisX_PP, StorageX_PHA, StorageX_PP

Initial Conditions:

Variable(Zone) : Initial Condition
 S_I(Bulk Volume) : S_Ini
 S_NH4(Bulk Volume) : S_NH4ini
 X_AUT(Bulk Volume) : X_AUTini
 X_H(Bulk Volume) : X_Hini
 X_I(Bulk Volume) : X_Ini
 X_PAO(Bulk Volume) : X_PAOini
 X_S(Bulk Volume) : X_Sini
 S_A(Bulk Volume) : S_Aini
 S_NO3(Bulk Volume) : S_NO3ini
 S_PO4(Bulk Volume) : S_PO4ini
 X_PHA(Bulk Volume) : X_PHAini
 X_PP(Bulk Volume) : X_PPini
 S_F(Bulk Volume) : S_Fini
 S_N2(Bulk Volume) : S_N2ini
 ISS_Xioi(Bulk Volume) : ISS_Xioini

Inflow: 0

Loadings:

Volume: 5

Accuracies:

Rel. Acc. Q: 0.001
 Abs. Acc. Q: 0.001
 Rel. Acc. V: 0.001
 Abs. Acc. V: 0.001

Definitions of Calculations

calc01: Description:
 Calculation Number: 1
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 25000
 Status: active for simulation
 inactive for sensitivity analysis

calc02: Description:
 Calculation Number: 2
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001

Num. Steps: 25000
 Status: active for simulation
 inactive for sensitivity analysis

 calc03: Description:
 Calculation Number: 3
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 25000
 Status: active for simulation
 inactive for sensitivity analysis

 calc04: Description:
 Calculation Number: 4
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 25000
 Status: active for simulation
 inactive for sensitivity analysis

 calc05: Description:
 Calculation Number: 5
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 25000
 Status: active for simulation
 inactive for sensitivity analysis

 calc06: Description:
 Calculation Number: 6
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 25000
 Status: active for simulation
 inactive for sensitivity analysis

 calc07: Description:
 Calculation Number: 7
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 25000
 Status: active for simulation
 inactive for sensitivity analysis

 calc08: Description:
 Calculation Number: 8
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 25000
 Status: active for simulation
 inactive for sensitivity analysis

 calc11: Description:
 Calculation Number: 11
 Initial Time: 0

Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 25000
 Status: active for simulation
 inactive for sensitivity analysis

calc12: Description:
 Calculation Number: 12
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 25000
 Status: active for simulation
 inactive for sensitivity analysis

calc13: Description:
 Calculation Number: 13
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 25000
 Status: active for simulation
 inactive for sensitivity analysis

calc14: Description:
 Calculation Number: 14
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 25000
 Status: active for simulation
 inactive for sensitivity analysis

calc15: Description:
 Calculation Number: 15
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 25000
 Status: active for simulation
 inactive for sensitivity analysis

calc16: Description:
 Calculation Number: 16
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 25000
 Status: active for simulation
 inactive for sensitivity analysis

calc17: Description:
 Calculation Number: 17
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 25000
 Status: active for simulation
 inactive for sensitivity analysis

calc18: Description:

Calculation Number: 18
 Initial Time: 0
 Initial State: given, made consistent
 Step Size: 0.001
 Num. Steps: 25000
 Status: active for simulation
 inactive for sensitivity analysis

Plot Definitions

Biomass_a: Description: Biomass
 Abscissa: Time
 Title: (a) Concentrations of ANO, OHO and
 PAO for BT-3 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: Biomass conc (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : X_AUT [3, Reactor, Bulk Volume, 0]
 Value : X_AUT [6, Reactor, Bulk Volume, 0]
 Value : X_H [3, Reactor, Bulk Volume, 0]
 Value : X_H [6, Reactor, Bulk Volume, 0]
 Value : X_PAO [3, Reactor, Bulk Volume, 0]
 Value : X_PAO [6, Reactor, Bulk Volume, 0]

Biomass_b: Description: Biomass
 Abscissa: Time
 Title: (b) Concentrations of ANO, OHO and
 PAO for BT-3 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: Biomass conc (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : X_AUT [13, Reactor, Bulk Volume, 0]
 Value : X_AUT [16, Reactor, Bulk Volume, 0]
 Value : X_H [13, Reactor, Bulk Volume, 0]
 Value : X_H [16, Reactor, Bulk Volume, 0]
 Value : X_PAO [13, Reactor, Bulk Volume, 0]
 Value : X_PAO [16, Reactor, Bulk Volume, 0]

COD_flg: Description: Filtered COD
 Abscissa: Time
 Title: (a) Measured and simulated filtered
 -COD for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: Filtered COD (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : CODf [1, Reactor, Bulk Volume, 0]
 Value : CODf [2, Reactor, Bulk Volume, 0]
 Value : CODf [3, Reactor, Bulk Volume, 0]
 Value : CODf_m1 [1, Reactor, Bulk Volume, 0]
 Value : CODf_m2 [2, Reactor, Bulk Volume, 0]
 Value : CODf_m3 [3, Reactor, Bulk Volume, 0]

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COD_f1b:      Description:      Filtered COD
              Abscissa:        Time
              Title:           Measured and simulated filtered-COD
                               for BT-1, BT-2 and BT-3
              Abscissa Label:   Retention time (d)
              Ordinate Label:   Filtered COD (mg/l)
              Curves:
                Type : Variable [CalcNum,Comp.,Zone,Time/Space]
                Value : CODf [11,Reactor,Bulk Volume,0]
                Value : CODf [12,Reactor,Bulk Volume,0]
                Value : CODf [13,Reactor,Bulk Volume,0]
                Value : CODf_m1 [1,Reactor,Bulk Volume,0]
                Value : CODf_m2 [2,Reactor,Bulk Volume,0]
                Value : CODf_m3 [3,Reactor,Bulk Volume,0]
-----
COD_f2a:      Description:      Filtered COD
              Abscissa:        Time
              Title:           (a) Measured and simulated filtered
                               -COD for BT-4, BT-5 and BT-6
              Abscissa Label:   Retention time (d)
              Ordinate Label:   Filtered COD (mg/l)
              Curves:
                Type : Variable [CalcNum,Comp.,Zone,Time/Space]
                Value : CODf [4,Reactor,Bulk Volume,0]
                Value : CODf [5,Reactor,Bulk Volume,0]
                Value : CODf [6,Reactor,Bulk Volume,0]
                Value : CODf_m4 [4,Reactor,Bulk Volume,0]
                Value : CODf_m5 [5,Reactor,Bulk Volume,0]
                Value : CODf_m6 [6,Reactor,Bulk Volume,0]
-----
COD_f2b:      Description:      Filtered COD
              Abscissa:        Time
              Title:           Measured and simulated filtered-COD
                               for BT-4, BT-5 and BT-6
              Abscissa Label:   Retention time (d)
              Ordinate Label:   Filtered COD (mg/l)
              Curves:
                Type : Variable [CalcNum,Comp.,Zone,Time/Space]
                Value : CODf [14,Reactor,Bulk Volume,0]
                Value : CODf [15,Reactor,Bulk Volume,0]
                Value : CODf [16,Reactor,Bulk Volume,0]
                Value : CODf_m4 [4,Reactor,Bulk Volume,0]
                Value : CODf_m5 [5,Reactor,Bulk Volume,0]
                Value : CODf_m6 [6,Reactor,Bulk Volume,0]
-----
COD_t1a:      Description:      Total COD
              Abscissa:        Time
              Title:           (a) Measured and simulated total-CO
                               D for BT-1, BT-2 and BT-3
              Abscissa Label:   Retention time (d)
              Ordinate Label:   Total COD (mg/l)
              Curves:
                Type : Variable [CalcNum,Comp.,Zone,Time/Space]
                Value : CODt [1,Reactor,Bulk Volume,0]
                Value : CODt [2,Reactor,Bulk Volume,0]
                Value : CODt [3,Reactor,Bulk Volume,0]
                Value : CODt_m1 [1,Reactor,Bulk Volume,0]
                Value : CODt_m2 [2,Reactor,Bulk Volume,0]
                Value : CODt_m3 [3,Reactor,Bulk Volume,0]
-----
COD_t1b:      Description:      Total COD

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Abscissa: Time
 Title: (b) Measured and simulated total-COD for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: Total COD (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : CODt [11, Reactor, Bulk Volume, 0]
 Value : CODt [12, Reactor, Bulk Volume, 0]
 Value : CODt [13, Reactor, Bulk Volume, 0]
 Value : CODt_m1 [1, Reactor, Bulk Volume, 0]
 Value : CODt_m2 [2, Reactor, Bulk Volume, 0]
 Value : CODt_m3 [3, Reactor, Bulk Volume, 0]

COD_t2a: Description: Total COD
 Abscissa: Time
 Title: (a) Measured and simulated total-COD for BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: Total COD (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : CODt [4, Reactor, Bulk Volume, 0]
 Value : CODt [5, Reactor, Bulk Volume, 0]
 Value : CODt [6, Reactor, Bulk Volume, 0]
 Value : CODt_m4 [4, Reactor, Bulk Volume, 0]
 Value : CODt_m5 [5, Reactor, Bulk Volume, 0]
 Value : CODt_m6 [6, Reactor, Bulk Volume, 0]

COD_t2b: Description: Total COD
 Abscissa: Time
 Title: (b) Measured and simulated total-COD for BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: Total COD (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : CODt [14, Reactor, Bulk Volume, 0]
 Value : CODt [15, Reactor, Bulk Volume, 0]
 Value : CODt [16, Reactor, Bulk Volume, 0]
 Value : CODt_m4 [4, Reactor, Bulk Volume, 0]
 Value : CODt_m5 [5, Reactor, Bulk Volume, 0]
 Value : CODt_m6 [6, Reactor, Bulk Volume, 0]

COD_tDa: Description: Total COD (Dilution check)
 Abscissa: Time
 Title: Measured and simulated total-COD for BT-7 and BT-8
 Abscissa Label: Retention time (d)
 Ordinate Label: Total COD (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : CODt [7, Reactor, Bulk Volume, 0]
 Value : CODt [8, Reactor, Bulk Volume, 0]
 Value : CODt_m7 [8, Reactor, Bulk Volume, 0]
 Value : CODt_m8 [8, Reactor, Bulk Volume, 0]

COD_tDb: Description: Total COD (Dilution check)
 Abscissa: Time
 Title: Measured and simulated total-COD for BT-7 and BT-8

Abscissa Label: Retention time (d)
 Ordinate Label: Total COD (mg/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : CODt [17,Reactor,Bulk Volume,0]
 Value : CODt [18,Reactor,Bulk Volume,0]
 Value : CODt_m7 [8,Reactor,Bulk Volume,0]
 Value : CODt_m8 [8,Reactor,Bulk Volume,0]

deltaTSS1a: Description: TSS reduction (change of TSS)
 Abscissa: Time
 Title: (a) Measured and simulated TSS reduction (change of TSS) for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: TSS Reduction (mgTSS/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : deltaTSSt_SS [1,Reactor,Bulk Volume,0]
 Value : deltaTSSt_SS [2,Reactor,Bulk Volume,0]
 Value : deltaTSSt_SS [3,Reactor,Bulk Volume,0]
 Value : TSS_RedMeas1 [1,Reactor,Bulk Volume,0]
 Value : TSS_RedMeas2 [2,Reactor,Bulk Volume,0]
 Value : TSS_RedMeas3 [3,Reactor,Bulk Volume,0]

deltaTSS2a: Description: TSS Reduction (delta TSS)
 Abscissa: Time
 Title: (a) Measured and simulated TSS Reduction (delta TSS) for BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: TSS Reduction (mgTSS/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : deltaTSSt_SS [4,Reactor,Bulk Volume,0]
 Value : deltaTSSt_SS [5,Reactor,Bulk Volume,0]
 Value : deltaTSSt_SS [6,Reactor,Bulk Volume,0]
 Value : TSS_RedMeas4 [4,Reactor,Bulk Volume,0]
 Value : TSS_RedMeas5 [5,Reactor,Bulk Volume,0]
 Value : TSS_RedMeas6 [6,Reactor,Bulk Volume,0]

deltaVSS1a: Description: VSS reduction (change of VSS)
 Abscissa: Time
 Title: (a) Measured and simulated VSS reduction (change of VSS) for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: VSS Reduction (mgCOD/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : deltaVSSt_SS [1,Reactor,Bulk Volume,0]
 Value : deltaVSSt_SS [2,Reactor,Bulk Volume,0]
 Value : deltaVSSt_SS [3,Reactor,Bulk Volume,0]
 Value : VSS_RedMeas1 [1,Reactor,Bulk Volume,0]
 Value : VSS_RedMeas2 [2,Reactor,Bulk Volume,0]
 Value : VSS_RedMeas3 [3,Reactor,Bulk Volume,0]

deltaVSS2a: Description: VSS Reduction (delta VSS)
 Abscissa: Time
 Title: (a) Measured and simulated VSS Reduction (delta VSS) for BT-4, BT-5 and

d BT-6

Abscissa Label: Retention time (d)
 Ordinate Label: VSS Reduction (mgCOD/l)
 Curves:

Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : deltaVSSSt_SS [4, Reactor, Bulk Volume, 0]
 Value : deltaVSSSt_SS [5, Reactor, Bulk Volume, 0]
 Value : deltaVSSSt_SS [6, Reactor, Bulk Volume, 0]
 Value : VSS_RedMeas4 [4, Reactor, Bulk Volume, 0]
 Value : VSS_RedMeas5 [5, Reactor, Bulk Volume, 0]
 Value : VSS_RedMeas6 [6, Reactor, Bulk Volume, 0]

DOa: Description: Dissolved oxygen concentration (mg/l)
 Abscissa: Time
 Title: (a) Simulated DO concentration for BT-1 to BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: DO (mgO/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : S_O2 [1, Reactor, Bulk Volume, 0]
 Value : S_O2 [2, Reactor, Bulk Volume, 0]
 Value : S_O2 [3, Reactor, Bulk Volume, 0]
 Value : S_O2 [4, Reactor, Bulk Volume, 0]
 Value : S_O2 [5, Reactor, Bulk Volume, 0]
 Value : S_O2 [6, Reactor, Bulk Volume, 0]

DOb: Description: Dissolved oxygen concentration (mg/l)
 Abscissa: Time
 Title: (b) Simulated DO concentration for BT-1 to BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: DO (mgO/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : S_O2 [11, Reactor, Bulk Volume, 0]
 Value : S_O2 [12, Reactor, Bulk Volume, 0]
 Value : S_O2 [13, Reactor, Bulk Volume, 0]
 Value : S_O2 [14, Reactor, Bulk Volume, 0]
 Value : S_O2 [15, Reactor, Bulk Volume, 0]
 Value : S_O2 [16, Reactor, Bulk Volume, 0]

fcv1a: Description: COD/VSS ratio
 Abscissa: Time
 Title: Measured and simulated COD/VSS ratio for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: COD/VSS ratio (mgCOD/mgVSS)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : f_cv [1, Reactor, Bulk Volume, 0]
 Value : f_cv [2, Reactor, Bulk Volume, 0]
 Value : f_cv [3, Reactor, Bulk Volume, 0]
 Value : f_cvml [1, Reactor, Bulk Volume, 0]
 Value : f_cvm2 [2, Reactor, Bulk Volume, 0]
 Value : f_cvm3 [3, Reactor, Bulk Volume, 0]

fcv1b: Description: COD/VSS ratio
 Abscissa: Time

Title: Measured and simulated COD/VSS ratio
o for BT-1, BT-2 and BT-3

Abscissa Label: Retention time (d)

Ordinate Label: COD/VSS ratio (mgCOD/mgVSS)

Curves:

Type : Variable [CalcNum,Comp.,Zone,Time/Space]

Value : f_cv [11,Reactor,Bulk Volume,0]

Value : f_cv [12,Reactor,Bulk Volume,0]

Value : f_cv [13,Reactor,Bulk Volume,0]

Value : f_cvm1 [1,Reactor,Bulk Volume,0]

Value : f_cvm2 [2,Reactor,Bulk Volume,0]

Value : f_cvm3 [3,Reactor,Bulk Volume,0]

fcv2a: Description: COD/VSS ratio

Abscissa: Time

Title: Measured and simulated COD/VSS ratio
o for BT-4, BT-5 and BT-6

Abscissa Label: Retention time (d)

Ordinate Label: COD/VSS ratio (mgCOD/mgVSS)

Curves:

Type : Variable [CalcNum,Comp.,Zone,Time/Space]

Value : f_cv [4,Reactor,Bulk Volume,0]

Value : f_cv [5,Reactor,Bulk Volume,0]

Value : f_cv [6,Reactor,Bulk Volume,0]

Value : f_cvm4 [4,Reactor,Bulk Volume,0]

Value : f_cvm5 [5,Reactor,Bulk Volume,0]

Value : f_cvm6 [6,Reactor,Bulk Volume,0]

fcv2b: Description: COD/VSS ratio

Abscissa: Time

Title: Measured and simulated COD/VSS ratio
o for BT-4, BT-5 and BT-6

Abscissa Label: Retention time (d)

Ordinate Label: COD/VSS ratio (mgCOD/mgVSS)

Curves:

Type : Variable [CalcNum,Comp.,Zone,Time/Space]

Value : f_cv [14,Reactor,Bulk Volume,0]

Value : f_cv [15,Reactor,Bulk Volume,0]

Value : f_cv [16,Reactor,Bulk Volume,0]

Value : f_cvm4 [4,Reactor,Bulk Volume,0]

Value : f_cvm5 [5,Reactor,Bulk Volume,0]

Value : f_cvm6 [6,Reactor,Bulk Volume,0]

fcv_Da: Description: COD/VSS ratio (Dilution check)

Abscissa: Time

Title: Measured and simulated COD/VSS ratio
o for BT-7 and BT-8

Abscissa Label: Retention time (d)

Ordinate Label: COD/VSS ratio (mgCOD/mgVSS)

Curves:

Type : Variable [CalcNum,Comp.,Zone,Time/Space]

Value : f_cv [7,Reactor,Bulk Volume,0]

Value : f_cv [8,Reactor,Bulk Volume,0]

Value : f_cvm7 [7,Reactor,Bulk Volume,0]

Value : f_cvm8 [8,Reactor,Bulk Volume,0]

fcv_Db: Description: COD/VSS ratio (Dilution check)

Abscissa: Time

Title: Measured and simulated COD/VSS ratio
o for BT-7 and BT-8

Abscissa Label: Retention time (d)

Ordinate Label: COD/VSS ratio (mgCOD/mgVSS)

Curves:

Type : Variable [CalcNum, Comp., Zone, Time/Space]

Value : f_cv [17, Reactor, Bulk Volume, 0]

Value : f_cv [18, Reactor, Bulk Volume, 0]

Value : f_cvm7 [7, Reactor, Bulk Volume, 0]

Value : f_cvm8 [8, Reactor, Bulk Volume, 0]

fila: Description: VSS/TSS ratio
 Abscissa: Time
 Title: Measured and simulated VSS/TSS ratio for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: VSS/TSS ratio (mgVSS/mgTSS)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : f_i [1, Reactor, Bulk Volume, 0]
 Value : f_i [2, Reactor, Bulk Volume, 0]
 Value : f_i [3, Reactor, Bulk Volume, 0]
 Value : f_imeas1 [1, Reactor, Bulk Volume, 0]
 Value : f_imeas2 [2, Reactor, Bulk Volume, 0]
 Value : f_imeas3 [3, Reactor, Bulk Volume, 0]

filb: Description: VSS/TSS ratio
 Abscissa: Time
 Title: Measured and simulated VSS/TSS ratio for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: VSS/TSS ratio (mgVSS/mgTSS)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : f_i [11, Reactor, Bulk Volume, 0]
 Value : f_i [12, Reactor, Bulk Volume, 0]
 Value : f_i [13, Reactor, Bulk Volume, 0]
 Value : f_imeas1 [1, Reactor, Bulk Volume, 0]
 Value : f_imeas2 [2, Reactor, Bulk Volume, 0]
 Value : f_imeas3 [3, Reactor, Bulk Volume, 0]

fi2a: Description: VSS/TSS ratio
 Abscissa: Time
 Title: Measured and simulated VSS/TSS ratio for BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: VSS/TSS ratio (mgVSS/mgTSS)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : f_i [4, Reactor, Bulk Volume, 0]
 Value : f_i [5, Reactor, Bulk Volume, 0]
 Value : f_i [6, Reactor, Bulk Volume, 0]
 Value : f_imeas4 [4, Reactor, Bulk Volume, 0]
 Value : f_imeas5 [5, Reactor, Bulk Volume, 0]
 Value : f_imeas6 [6, Reactor, Bulk Volume, 0]

fi2b: Description: VSS/TSS ratio
 Abscissa: Time
 Title: Measured and simulated VSS/TSS ratio for BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: VSS/TSS ratio (mgVSS/mgTSS)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]

Value : f_i [14,Reactor,Bulk Volume,0]
 Value : f_i [15,Reactor,Bulk Volume,0]
 Value : f_i [16,Reactor,Bulk Volume,0]
 Value : f_imeas4 [4,Reactor,Bulk Volume,0]
 Value : f_imeas5 [5,Reactor,Bulk Volume,0]
 Value : f_imeas6 [6,Reactor,Bulk Volume,0]

fi_Da: Description: VSS/TSS ratio (Dilution check)
 Abscissa: Time
 Title: Measured and simulated VSS/TSS ratio for BT-7 and BT-8
 Abscissa Label: Retention time (d)
 Ordinate Label: VSS/TSS ratio (mgVSS/mgTSS)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : f_i [7,Reactor,Bulk Volume,0]
 Value : f_i [8,Reactor,Bulk Volume,0]
 Value : f_imeas7 [7,Reactor,Bulk Volume,0]
 Value : f_imeas8 [8,Reactor,Bulk Volume,0]

fi_Db: Description: VSS/TSS ratio (Dilution check)
 Abscissa: Time
 Title: Measured and simulated VSS/TSS ratio for BT-7 and BT-8
 Abscissa Label: Retention time (d)
 Ordinate Label: VSS/TSS ratio (mgVSS/mgTSS)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : f_i [17,Reactor,Bulk Volume,0]
 Value : f_i [18,Reactor,Bulk Volume,0]
 Value : f_imeas7 [7,Reactor,Bulk Volume,0]
 Value : f_imeas8 [8,Reactor,Bulk Volume,0]

f_Trt1a: Description: Fraction of TSS removed (%)
 Abscissa: Time
 Title: Measured and simulated fractions of TSS removed for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: Fraction of TSS removed (%)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : f_Trt_SS [1,Reactor,Bulk Volume,0]
 Value : f_Trt_SS [2,Reactor,Bulk Volume,0]
 Value : f_Trt_SS [3,Reactor,Bulk Volume,0]
 Value : f_TrtMeas1 [1,Reactor,Bulk Volume,0]
 Value : f_TrtMeas2 [2,Reactor,Bulk Volume,0]
 Value : f_TrtMeas3 [3,Reactor,Bulk Volume,0]

f_Trt2a: Description: Fraction of TSS removed (%)
 Abscissa: Time
 Title: Measured and simulated fraction of TSS removed (%) for BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: Fraction of TSS removed (%)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : f_Trt_SS [4,Reactor,Bulk Volume,0]
 Value : f_Trt_SS [5,Reactor,Bulk Volume,0]
 Value : f_Trt_SS [6,Reactor,Bulk Volume,0]

Value : f_TrtMeas4 [4, Reactor, Bulk Volume, 0]
 Value : f_TrtMeas5 [5, Reactor, Bulk Volume, 0]
 Value : f_TrtMeas6 [6, Reactor, Bulk Volume, 0]

f_Vrt1a: Description: Fraction of VSS removed (%)
 Abscissa: Time
 Title: Measured and simulated fractions of
 VSS removed for BT-1, BT-2 and BT
 -3
 Abscissa Label: Retention time (d)
 Ordinate Label: Fraction of VSS removed (%)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : f_Vrt_SS [1, Reactor, Bulk Volume, 0]
 Value : f_Vrt_SS [2, Reactor, Bulk Volume, 0]
 Value : f_Vrt_SS [3, Reactor, Bulk Volume, 0]
 Value : f_VrtMeas1 [1, Reactor, Bulk Volume, 0]
 Value : f_VrtMeas2 [2, Reactor, Bulk Volume, 0]
 Value : f_VrtMeas3 [3, Reactor, Bulk Volume, 0]

f_Vrt2a: Description: Fraction of VSS removed (%)
 Abscissa: Time
 Title: Measured and simulated fraction of
 VSS removed (%) for BT-4, BT-5 and
 BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: Fraction of VSS removed (%)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : f_Vrt_SS [4, Reactor, Bulk Volume, 0]
 Value : f_Vrt_SS [5, Reactor, Bulk Volume, 0]
 Value : f_Vrt_SS [6, Reactor, Bulk Volume, 0]
 Value : f_VrtMeas4 [4, Reactor, Bulk Volume, 0]
 Value : f_VrtMeas5 [5, Reactor, Bulk Volume, 0]
 Value : f_VrtMeas6 [6, Reactor, Bulk Volume, 0]

ISS1a: Description: ISS
 Abscissa: Time
 Title: (a) Measured and simulated ISS for
 BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: ISS (mgISS/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : ISS_Xoi [2, Reactor, Bulk Volume, 0]
 Value : ISS_Xoi [3, Reactor, Bulk Volume, 0]
 Value : ISS_meas2 [2, Reactor, Bulk Volume, 0]
 Value : ISS_meas3 [3, Reactor, Bulk Volume, 0]

ISS1b: Description: ISS
 Abscissa: Time
 Title: Measured and simulated ISS for BT-1
 , BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: ISS (mgISS/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : ISS_Xoi [12, Reactor, Bulk Volume, 0]
 Value : ISS_Xoi [13, Reactor, Bulk Volume, 0]
 Value : ISS_meas2 [2, Reactor, Bulk Volume, 0]
 Value : ISS_meas3 [3, Reactor, Bulk Volume, 0]

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Abscissa Label: Retention time (d)
 Ordinate Label: Nitrate (mg/l)

Curves:

Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : Nnt_SS [3, Reactor, Bulk Volume, 0]
 Value : Nnt_SS [4, Reactor, Bulk Volume, 0]
 Value : Nnt_SS [5, Reactor, Bulk Volume, 0]
 Value : Nnt_SS [6, Reactor, Bulk Volume, 0]
 Value : S_NO3meas3 [3, Reactor, Bulk Volume, 0]
 Value : S_NO3meas4 [4, Reactor, Bulk Volume, 0]
 Value : S_NO3meas5 [5, Reactor, Bulk Volume, 0]
 Value : S_NO3meas6 [6, Reactor, Bulk Volume, 0]

Nnt_SSb: Description: Nitrate (SSM)
 Abscissa: Time
 Title: (b) Nitrate computed with SSM and measured for BT-3, BT-4, BT-5 and BT-6

Abscissa Label: Retention time (d)
 Ordinate Label: Nitrate (mg/l)

Curves:

Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : Nnt_SS [13, Reactor, Bulk Volume, 0]
 Value : Nnt_SS [14, Reactor, Bulk Volume, 0]
 Value : Nnt_SS [15, Reactor, Bulk Volume, 0]
 Value : Nnt_SS [16, Reactor, Bulk Volume, 0]
 Value : S_NO3meas3 [3, Reactor, Bulk Volume, 0]
 Value : S_NO3meas4 [4, Reactor, Bulk Volume, 0]
 Value : S_NO3meas5 [5, Reactor, Bulk Volume, 0]
 Value : S_NO3meas6 [6, Reactor, Bulk Volume, 0]

OUR1a: Description: OUR
 Abscissa: Time
 Title: Measured and simulated OUR for BT-1, BT-2 and BT-3

Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)

Curves:

Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : OUR_t [1, Reactor, Bulk Volume, 0]
 Value : OUR_t [2, Reactor, Bulk Volume, 0]
 Value : OUR_t [3, Reactor, Bulk Volume, 0]
 Value : OUR_Meas1 [1, Reactor, Bulk Volume, 0]
 Value : OUR_Meas2 [2, Reactor, Bulk Volume, 0]
 Value : OUR_Meas3 [3, Reactor, Bulk Volume, 0]

OUR1b: Description: OUR
 Abscissa: Time
 Title: Measured and simulated OUR for BT-1, BT-2 and BT-3

Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)

Curves:

Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : OUR_t [11, Reactor, Bulk Volume, 0]
 Value : OUR_t [12, Reactor, Bulk Volume, 0]
 Value : OUR_t [13, Reactor, Bulk Volume, 0]
 Value : OUR_Meas1 [1, Reactor, Bulk Volume, 0]
 Value : OUR_Meas2 [2, Reactor, Bulk Volume, 0]
 Value : OUR_Meas3 [3, Reactor, Bulk Volume, 0]

OUR2a: Description: OUR
 Abscissa: Time
 Title: (a) Measured and simulated OUR for
 BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : OUR_t [4, Reactor, Bulk Volume, 0]
 Value : OUR_t [5, Reactor, Bulk Volume, 0]
 Value : OUR_t [6, Reactor, Bulk Volume, 0]
 Value : OUR_Meas4 [4, Reactor, Bulk Volume, 0]
 Value : OUR_Meas5 [5, Reactor, Bulk Volume, 0]
 Value : OUR_Meas6 [6, Reactor, Bulk Volume, 0]

OUR2b: Description: OUR
 Abscissa: Time
 Title: (b) Measured and simulated OUR for
 BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : OUR_t [14, Reactor, Bulk Volume, 0]
 Value : OUR_t [15, Reactor, Bulk Volume, 0]
 Value : OUR_t [16, Reactor, Bulk Volume, 0]
 Value : OUR_Meas4 [4, Reactor, Bulk Volume, 0]
 Value : OUR_Meas5 [5, Reactor, Bulk Volume, 0]
 Value : OUR_Meas6 [6, Reactor, Bulk Volume, 0]

OUR_1a: Description: OUR for BT-1
 Abscissa: Time
 Title: Measured total-OUR and simulated co
 mponents of OUR for BT-1
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : OUR_Meas1 [1, Reactor, Bulk Volume, 0]
 Value : OUR_t [1, Reactor, Bulk Volume, 0]
 Value : OUR_H [1, Reactor, Bulk Volume, 0]
 Value : OUR_AUT [1, Reactor, Bulk Volume, 0]
 Value : OUR_P [1, Reactor, Bulk Volume, 0]

OUR_1b: Description: OUR for BT-1
 Abscissa: Time
 Title: Measured total-OUR and simulated co
 mponents of OUR for BT-1
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : OUR_Meas1 [1, Reactor, Bulk Volume, 0]
 Value : OUR_t [11, Reactor, Bulk Volume, 0]
 Value : OUR_H [11, Reactor, Bulk Volume, 0]
 Value : OUR_AUT [11, Reactor, Bulk Volume, 0]
 Value : OUR_P [11, Reactor, Bulk Volume, 0]

OUR_2a: Description: OUR for BT-2
 Abscissa: Time

Title: Measured total-OUR and simulated components of OUR for BT-2
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : OUR_Meas2 [2,Reactor,Bulk Volume,0]
 Value : OUR_t [2,Reactor,Bulk Volume,0]
 Value : OUR_H [2,Reactor,Bulk Volume,0]
 Value : OUR_AUT [2,Reactor,Bulk Volume,0]
 Value : OUR_P [2,Reactor,Bulk Volume,0]

OUR_2b: Description: OUR for BT-2
 Abscissa: Time
 Title: Measured total-OUR and simulated components of OUR for BT-2
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : OUR_Meas2 [2,Reactor,Bulk Volume,0]
 Value : OUR_t [12,Reactor,Bulk Volume,0]
 Value : OUR_H [12,Reactor,Bulk Volume,0]
 Value : OUR_AUT [12,Reactor,Bulk Volume,0]
 Value : OUR_P [12,Reactor,Bulk Volume,0]

OUR_3a: Description: OUR for BT-3
 Abscissa: Time
 Title: Measured total-OUR and simulated components of OUR for BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : OUR_Meas3 [3,Reactor,Bulk Volume,0]
 Value : OUR_t [3,Reactor,Bulk Volume,0]
 Value : OUR_H [3,Reactor,Bulk Volume,0]
 Value : OUR_AUT [3,Reactor,Bulk Volume,0]
 Value : OUR_P [3,Reactor,Bulk Volume,0]

OUR_3b: Description: OUR for BT-3
 Abscissa: Time
 Title: Measured total-OUR and simulated components of OUR for BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : OUR_Meas3 [3,Reactor,Bulk Volume,0]
 Value : OUR_t [13,Reactor,Bulk Volume,0]
 Value : OUR_H [13,Reactor,Bulk Volume,0]
 Value : OUR_AUT [13,Reactor,Bulk Volume,0]
 Value : OUR_P [13,Reactor,Bulk Volume,0]

OUR_4a: Description: OUR for BT-4
 Abscissa: Time
 Title: Measured total-OUR and simulated components of OUR for BT-4
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:

Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : OUR_Meas4 [4,Reactor,Bulk Volume,0]
 Value : OUR_t [4,Reactor,Bulk Volume,0]
 Value : OUR_H [4,Reactor,Bulk Volume,0]
 Value : OUR_AUT [4,Reactor,Bulk Volume,0]
 Value : OUR_P [4,Reactor,Bulk Volume,0]

OUR_4b: Description: OUR for BT-4
 Abscissa: Time
 Title: Measured total-OUR and simulated components of OUR for BT-4
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : OUR_Meas4 [4,Reactor,Bulk Volume,0]
 Value : OUR_t [14,Reactor,Bulk Volume,0]
 Value : OUR_H [14,Reactor,Bulk Volume,0]
 Value : OUR_AUT [14,Reactor,Bulk Volume,0]
 Value : OUR_P [14,Reactor,Bulk Volume,0]

OUR_5a: Description: OUR for BT-5
 Abscissa: Time
 Title: Measured total-OUR and simulated components of OUR for BT-5
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : OUR_Meas5 [5,Reactor,Bulk Volume,0]
 Value : OUR_t [5,Reactor,Bulk Volume,0]
 Value : OUR_H [5,Reactor,Bulk Volume,0]
 Value : OUR_AUT [5,Reactor,Bulk Volume,0]
 Value : OUR_P [5,Reactor,Bulk Volume,0]

OUR_5b: Description: OUR for BT-5
 Abscissa: Time
 Title: Measured total-OUR and simulated components of OUR for BT-5
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : OUR_Meas5 [5,Reactor,Bulk Volume,0]
 Value : OUR_t [15,Reactor,Bulk Volume,0]
 Value : OUR_H [15,Reactor,Bulk Volume,0]
 Value : OUR_AUT [15,Reactor,Bulk Volume,0]
 Value : OUR_P [15,Reactor,Bulk Volume,0]

OUR_6a: Description: OUR for BT-6
 Abscissa: Time
 Title: Measured total-OUR and simulated components of OUR for BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : OUR_Meas6 [6,Reactor,Bulk Volume,0]
 Value : OUR_t [6,Reactor,Bulk Volume,0]
 Value : OUR_H [6,Reactor,Bulk Volume,0]
 Value : OUR_AUT [6,Reactor,Bulk Volume,0]

Value : OUR_P [6,Reactor,Bulk Volume,0]

OUR_6b: Description: OUR for BT-6
 Abscissa: Time
 Title: Measured total-OUR and simulated components of OUR for BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : OUR_Meas6 [6,Reactor,Bulk Volume,0]
 Value : OUR_t [16,Reactor,Bulk Volume,0]
 Value : OUR_H [16,Reactor,Bulk Volume,0]
 Value : OUR_AUT [16,Reactor,Bulk Volume,0]
 Value : OUR_P [16,Reactor,Bulk Volume,0]

OUR_7a: Description: OUR for BT-7
 Abscissa: Time
 Title: Measured total-OUR and simulated components of OUR for BT-7
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : OUR_Meas7 [7,Reactor,Bulk Volume,0]
 Value : OUR_t [7,Reactor,Bulk Volume,0]
 Value : OUR_H [7,Reactor,Bulk Volume,0]
 Value : OUR_AUT [7,Reactor,Bulk Volume,0]
 Value : OUR_P [7,Reactor,Bulk Volume,0]

OUR_7b: Description: OUR for BT-7
 Abscissa: Time
 Title: Measured total-OUR and simulated components of OUR for BT-7
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : OUR_Meas7 [7,Reactor,Bulk Volume,0]
 Value : OUR_t [17,Reactor,Bulk Volume,0]
 Value : OUR_H [17,Reactor,Bulk Volume,0]
 Value : OUR_AUT [17,Reactor,Bulk Volume,0]
 Value : OUR_P [17,Reactor,Bulk Volume,0]

OUR_8a: Description: OUR for BT-8
 Abscissa: Time
 Title: Measured total-OUR and simulated components of OUR for BT-8
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : OUR_Meas8 [8,Reactor,Bulk Volume,0]
 Value : OUR_t [8,Reactor,Bulk Volume,0]
 Value : OUR_H [8,Reactor,Bulk Volume,0]
 Value : OUR_AUT [8,Reactor,Bulk Volume,0]
 Value : OUR_P [8,Reactor,Bulk Volume,0]

OUR_8b: Description: OUR for BT-8
 Abscissa: Time
 Title: Measured total-OUR and simulated components of OUR for BT-8

Components of OUR for BT-8
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:

Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : OUR_Meas8 [8, Reactor, Bulk Volume, 0]
 Value : OUR_t [18, Reactor, Bulk Volume, 0]
 Value : OUR_H [18, Reactor, Bulk Volume, 0]
 Value : OUR_AUT [18, Reactor, Bulk Volume, 0]
 Value : OUR_P [18, Reactor, Bulk Volume, 0]

OUR_ASM_SSMi: Description: OUR
 Abscissa: Time
 Title: Comparison of simulated OURs with AS
 M-2 and SSM (for BT-1 and BT-2)
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : OUR_t [1, Reactor, Bulk Volume, 0]
 Value : OUR_t [2, Reactor, Bulk Volume, 0]
 Value : O_T_SS [1, Reactor, Bulk Volume, 0]
 Value : O_T_SS [2, Reactor, Bulk Volume, 0]

OUR_ASM_SSMii: Description: OUR
 Abscissa: Time
 Title: Comparison of simulated OURs with AS
 M-2 and SSM (for BT-3 and BT-4)
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : OUR_t [3, Reactor, Bulk Volume, 0]
 Value : OUR_t [4, Reactor, Bulk Volume, 0]
 Value : O_T_SS [3, Reactor, Bulk Volume, 0]
 Value : O_T_SS [4, Reactor, Bulk Volume, 0]

OUR_ASM_SSMiii: Description: OUR
 Abscissa: Time
 Title: Comparison of simulated OURs with AS
 M-2 and SSM (for BT-5 and BT-6)
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : OUR_t [5, Reactor, Bulk Volume, 0]
 Value : OUR_t [6, Reactor, Bulk Volume, 0]
 Value : O_T_SS [5, Reactor, Bulk Volume, 0]
 Value : O_T_SS [6, Reactor, Bulk Volume, 0]

OUR_Da: Description: OUR (Dilution check)
 Abscissa: Time
 Title: (a) Measured and simulated OUR for
 BT-7 and BT-8
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : OUR_t [7, Reactor, Bulk Volume, 0]
 Value : OUR_t [8, Reactor, Bulk Volume, 0]
 Value : OUR_Meas7 [7, Reactor, Bulk Volume, 0]

Value : OUR_Meas8 [8,Reactor,Bulk Volume,0]

OUR_Db: Description: OUR (Dilution check)
 Abscissa: Time
 Title: (b) Measured and simulated OUR for
 BT-7 and BT-8
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : OUR_t [17,Reactor,Bulk Volume,0]
 Value : OUR_t [18,Reactor,Bulk Volume,0]
 Value : OUR_Meas7 [7,Reactor,Bulk Volume,0]
 Value : OUR_Meas8 [8,Reactor,Bulk Volume,0]

O_T1a: Description: OUR (SSM)
 Abscissa: Time
 Title: (a) OUR computed with SSM and measu
 red for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : O_T_SS [1,Reactor,Bulk Volume,0]
 Value : O_T_SS [2,Reactor,Bulk Volume,0]
 Value : O_T_SS [3,Reactor,Bulk Volume,0]
 Value : OUR_Meas1 [1,Reactor,Bulk Volume,0]
 Value : OUR_Meas2 [2,Reactor,Bulk Volume,0]
 Value : OUR_Meas3 [3,Reactor,Bulk Volume,0]

O_T1b: Description: OUR (SSM)
 Abscissa: Time
 Title: (b) OUR computed with SSM and measu
 red for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : O_T_SS [11,Reactor,Bulk Volume,0]
 Value : O_T_SS [12,Reactor,Bulk Volume,0]
 Value : O_T_SS [13,Reactor,Bulk Volume,0]
 Value : OUR_Meas1 [1,Reactor,Bulk Volume,0]
 Value : OUR_Meas2 [2,Reactor,Bulk Volume,0]
 Value : OUR_Meas3 [3,Reactor,Bulk Volume,0]

O_T2a: Description: OUR (SSM)
 Abscissa: Time
 Title: (a) OUR computed with SSM and measu
 red for BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : O_T_SS [4,Reactor,Bulk Volume,0]
 Value : O_T_SS [5,Reactor,Bulk Volume,0]
 Value : O_T_SS [6,Reactor,Bulk Volume,0]
 Value : O_T_SS [8,Reactor,Bulk Volume,0]
 Value : OUR_Meas4 [4,Reactor,Bulk Volume,0]
 Value : OUR_Meas5 [5,Reactor,Bulk Volume,0]
 Value : OUR_Meas6 [6,Reactor,Bulk Volume,0]
 Value : OUR_Meas8 [8,Reactor,Bulk Volume,0]

O_T2b: Description: OUR (SSM)
 Abscissa: Time
 Title: (b) OUR computed with SSM and measured for BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: OUR (mg/l/h)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : O_T_SS [14, Reactor, Bulk Volume, 0]
 Value : O_T_SS [15, Reactor, Bulk Volume, 0]
 Value : O_T_SS [16, Reactor, Bulk Volume, 0]
 Value : OUR_Meas4 [4, Reactor, Bulk Volume, 0]
 Value : OUR_Meas5 [5, Reactor, Bulk Volume, 0]
 Value : OUR_Meas6 [6, Reactor, Bulk Volume, 0]

PsT_SS1a: Description: Orthophosphate concentration (SSM)
 Abscissa: Time
 Title: (a) Orthophosphate computed with SSM and measured for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: Orthophosphate (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : PsT_SS [1, Reactor, Bulk Volume, 0]
 Value : PsT_SS [2, Reactor, Bulk Volume, 0]
 Value : PsT_SS [3, Reactor, Bulk Volume, 0]
 Value : S_PO4meas1 [1, Reactor, Bulk Volume, 0]
 Value : S_PO4meas2 [2, Reactor, Bulk Volume, 0]
 Value : S_PO4meas3 [3, Reactor, Bulk Volume, 0]

PsT_SS1b: Description: Orthophosphate concentration (SSM)
 Abscissa: Time
 Title: (b) Orthophosphate computed with SSM and measured for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: Orthophosphate (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : PsT_SS [11, Reactor, Bulk Volume, 0]
 Value : PsT_SS [12, Reactor, Bulk Volume, 0]
 Value : PsT_SS [13, Reactor, Bulk Volume, 0]
 Value : S_PO4meas1 [1, Reactor, Bulk Volume, 0]
 Value : S_PO4meas2 [2, Reactor, Bulk Volume, 0]
 Value : S_PO4meas3 [3, Reactor, Bulk Volume, 0]

PsT_SS2a: Description: Phosphate (SSM)
 Abscissa: Time
 Title: (a) Orthophosphate computed with SSM and measured for BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: Orthophosphate (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : PsT_SS [4, Reactor, Bulk Volume, 0]
 Value : PsT_SS [5, Reactor, Bulk Volume, 0]
 Value : PsT_SS [6, Reactor, Bulk Volume, 0]
 Value : S_PO4meas4 [4, Reactor, Bulk Volume, 0]

Value : S_PO4meas5 [5,Reactor,Bulk Volume,0]
 Value : S_PO4meas6 [6,Reactor,Bulk Volume,0]

PsT_SS2b: Description: Phosphate (SSM)
 Abscissa: Time
 Title: (b) Orthophosphate computed with SS
 M and measured for BT-4, BT-5 and B
 T-6
 Abscissa Label: Retention time (d)
 Ordinate Label: Orthophosphate (mg/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : PsT_SS [14,Reactor,Bulk Volume,0]
 Value : PsT_SS [15,Reactor,Bulk Volume,0]
 Value : PsT_SS [16,Reactor,Bulk Volume,0]
 Value : S_PO4meas4 [4,Reactor,Bulk Volume,0]
 Value : S_PO4meas5 [5,Reactor,Bulk Volume,0]
 Value : S_PO4meas6 [6,Reactor,Bulk Volume,0]

S_NH4_1a: Description: FSA
 Abscissa: Time
 Title: (a) Measured and simulated FSA for
 BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: FSA (mg/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_NH4 [1,Reactor,Bulk Volume,0]
 Value : S_NH4 [2,Reactor,Bulk Volume,0]
 Value : S_NH4 [3,Reactor,Bulk Volume,0]
 Value : S_NH4meas1 [1,Reactor,Bulk Volume,0]
 Value : S_NH4meas2 [2,Reactor,Bulk Volume,0]
 Value : S_NH4meas3 [3,Reactor,Bulk Volume,0]

S_NH4_1b: Description: FSA
 Abscissa: Time
 Title: (b) Measured and simulated FSA for
 BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: FSA (mg/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_NH4 [11,Reactor,Bulk Volume,0]
 Value : S_NH4 [12,Reactor,Bulk Volume,0]
 Value : S_NH4 [13,Reactor,Bulk Volume,0]
 Value : S_NH4meas1 [1,Reactor,Bulk Volume,0]
 Value : S_NH4meas2 [2,Reactor,Bulk Volume,0]
 Value : S_NH4meas3 [3,Reactor,Bulk Volume,0]

S_NH4_2a: Description: FSA
 Abscissa: Time
 Title: (a) Measured and simulated FSA for
 BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: FSA (mg/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_NH4 [4,Reactor,Bulk Volume,0]
 Value : S_NH4 [5,Reactor,Bulk Volume,0]
 Value : S_NH4 [6,Reactor,Bulk Volume,0]
 Value : S_NH4meas4 [4,Reactor,Bulk Volume,0]

Value : S_NH4meas5 [5,Reactor,Bulk Volume,0]

Value : S_NH4meas6 [6,Reactor,Bulk Volume,0]

S_NH4_2b: Description: FSA
 Abscissa: Time
 Title: (b) Measured and simulated FSA for
 BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: FSA (mg/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_NH4 [14,Reactor,Bulk Volume,0]
 Value : S_NH4 [15,Reactor,Bulk Volume,0]
 Value : S_NH4 [16,Reactor,Bulk Volume,0]
 Value : S_NH4meas4 [4,Reactor,Bulk Volume,0]
 Value : S_NH4meas5 [5,Reactor,Bulk Volume,0]
 Value : S_NH4meas6 [6,Reactor,Bulk Volume,0]

S_NO3a: Description: Nitrate
 Abscissa: Time
 Title: (a) Measured and simulated Nitrate
 for BT-3, BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: Nitrate (mg/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_NO3 [3,Reactor,Bulk Volume,0]
 Value : S_NO3 [4,Reactor,Bulk Volume,0]
 Value : S_NO3 [5,Reactor,Bulk Volume,0]
 Value : S_NO3 [6,Reactor,Bulk Volume,0]
 Value : S_NO3meas3 [3,Reactor,Bulk Volume,0]
 Value : S_NO3meas4 [4,Reactor,Bulk Volume,0]
 Value : S_NO3meas5 [5,Reactor,Bulk Volume,0]
 Value : S_NO3meas6 [6,Reactor,Bulk Volume,0]

S_NO3b: Description: Nitrate
 Abscissa: Time
 Title: (b) Measured and simulated Nitrate
 for BT-3, BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: Nitrate (mg/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_NO3 [13,Reactor,Bulk Volume,0]
 Value : S_NO3 [14,Reactor,Bulk Volume,0]
 Value : S_NO3 [15,Reactor,Bulk Volume,0]
 Value : S_NO3 [16,Reactor,Bulk Volume,0]
 Value : S_NO3meas3 [3,Reactor,Bulk Volume,0]
 Value : S_NO3meas4 [4,Reactor,Bulk Volume,0]
 Value : S_NO3meas5 [5,Reactor,Bulk Volume,0]
 Value : S_NO3meas6 [6,Reactor,Bulk Volume,0]

S_NO3_ASM_SSMi: Description: Nitrate
 Abscissa: Time
 Title: Comparison of simulated nitrate with
 ASM2 and SSM (for BT-3 and BT-4)
 Abscissa Label: Retention time (d)
 Ordinate Label: Nitrate (mg/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_NO3 [3,Reactor,Bulk Volume,0]

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Value : S_NO3 [4,Reactor,Bulk Volume,0]
 Value : Nnt_SS [3,Reactor,Bulk Volume,0]
 Value : Nnt_SS [4,Reactor,Bulk Volume,0]

S_NO3_ASM_SSMii:

Description: Nitrate
 Abscissa: Time
 Title: Comparison of simulated nitrate with
 ASM2 and SSM (for BT-5 and BT-6)
 Abscissa Label: Retention time (d)
 Ordinate Label: Nitrate (mg/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_NO3 [5,Reactor,Bulk Volume,0]
 Value : S_NO3 [6,Reactor,Bulk Volume,0]
 Value : Nnt_SS [5,Reactor,Bulk Volume,0]
 Value : Nnt_SS [6,Reactor,Bulk Volume,0]

S_NO3_Da:

Description: Nitrate (Dilution check)
 Abscissa: Time
 Title: (a) Measured and simulated Nitrate
 for BT-7 and BT-8
 Abscissa Label: Retention time (d)
 Ordinate Label: Nitrate (mg/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_NO3 [7,Reactor,Bulk Volume,0]
 Value : S_NO3 [8,Reactor,Bulk Volume,0]
 Value : S_NO3meas7 [7,Reactor,Bulk Volume,0]
 Value : S_NO3meas8 [8,Reactor,Bulk Volume,0]

S_NO3_Db:

Description: Nitrate (Dilution check)
 Abscissa: Time
 Title: (b) Measured and simulated Nitrate
 for BT-7 and BT-8
 Abscissa Label: Retention time (d)
 Ordinate Label: Nitrate (mg/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_NO3 [17,Reactor,Bulk Volume,0]
 Value : S_NO3 [18,Reactor,Bulk Volume,0]
 Value : S_NO3meas7 [7,Reactor,Bulk Volume,0]
 Value : S_NO3meas8 [8,Reactor,Bulk Volume,0]

S_PO4_1a:

Description: Orthophosphate concentration
 Abscissa: Time
 Title: (a) Measured and simulated orthophosphate for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: Orthophosphate (mg/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : S_PO4 [1,Reactor,Bulk Volume,0]
 Value : S_PO4 [2,Reactor,Bulk Volume,0]
 Value : S_PO4 [3,Reactor,Bulk Volume,0]
 Value : S_PO4meas1 [1,Reactor,Bulk Volume,0]
 Value : S_PO4meas2 [2,Reactor,Bulk Volume,0]
 Value : S_PO4meas3 [3,Reactor,Bulk Volume,0]

S_PO4_1b:

Description: Orthophosphate concentration
 Abscissa: Time

Title: (b) Measured and simulated orthophosphate for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: Orthophosphate (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : S_PO4 [11, Reactor, Bulk Volume, 0]
 Value : S_PO4 [12, Reactor, Bulk Volume, 0]
 Value : S_PO4 [13, Reactor, Bulk Volume, 0]
 Value : S_PO4meas1 [1, Reactor, Bulk Volume, 0]
 Value : S_PO4meas2 [2, Reactor, Bulk Volume, 0]
 Value : S_PO4meas3 [3, Reactor, Bulk Volume, 0]

S_PO4_2a: Description: Phosphate
 Abscissa: Time
 Title: (a) Measured and simulated orthophosphate for BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: Orthophosphate (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : S_PO4 [4, Reactor, Bulk Volume, 0]
 Value : S_PO4 [5, Reactor, Bulk Volume, 0]
 Value : S_PO4 [6, Reactor, Bulk Volume, 0]
 Value : S_PO4meas4 [4, Reactor, Bulk Volume, 0]
 Value : S_PO4meas5 [5, Reactor, Bulk Volume, 0]
 Value : S_PO4meas6 [6, Reactor, Bulk Volume, 0]

S_PO4_2b: Description: Phosphate
 Abscissa: Time
 Title: (b) Measured and simulated orthophosphate for BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: Orthophosphate (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : S_PO4 [14, Reactor, Bulk Volume, 0]
 Value : S_PO4 [15, Reactor, Bulk Volume, 0]
 Value : S_PO4 [16, Reactor, Bulk Volume, 0]
 Value : S_PO4meas4 [4, Reactor, Bulk Volume, 0]
 Value : S_PO4meas5 [5, Reactor, Bulk Volume, 0]
 Value : S_PO4meas6 [6, Reactor, Bulk Volume, 0]

S_PO4_ASM_SSMi: Description: Orthophosphate concentration
 Abscissa: Time
 Title: Comparisons of simulated OP with AS M2 and SSM for BT-1 and BT-2
 Abscissa Label: Retention time (d)
 Ordinate Label: Orthophosphate (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : S_PO4 [1, Reactor, Bulk Volume, 0]
 Value : S_PO4 [2, Reactor, Bulk Volume, 0]
 Value : PsT_SS [1, Reactor, Bulk Volume, 0]
 Value : PsT_SS [2, Reactor, Bulk Volume, 0]

S_PO4_ASM_SSMii: Description: Phosphate
 Abscissa: Time
 Title: Comparisons of simulated OP with AS M2 and SSM for BT-3 and BT-4

Abscissa Label: Retention time (d)
 Ordinate Label: Orthophosphate (mg/l)
 Curves:

Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : S_PO4 [3, Reactor, Bulk Volume, 0]
 Value : S_PO4 [4, Reactor, Bulk Volume, 0]
 Value : PsT_SS [3, Reactor, Bulk Volume, 0]
 Value : PsT_SS [4, Reactor, Bulk Volume, 0]

S_PO4_ASM_SSMiii:

Description: Phosphate
 Abscissa: Time
 Title: Comparisons of simulated OP with AS
 M2 and SSM for BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: Orthophosphate (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : S_PO4 [5, Reactor, Bulk Volume, 0]
 Value : S_PO4 [6, Reactor, Bulk Volume, 0]
 Value : PsT_SS [5, Reactor, Bulk Volume, 0]
 Value : PsT_SS [6, Reactor, Bulk Volume, 0]

S_PO4_Da: Description: Phosphate (Dilution check)
 Abscissa: Time
 Title: (a) Measured and simulated orthophosphate for BT-7 and BT-8
 Abscissa Label: Retention time (d)
 Ordinate Label: Orthophosphate (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : S_PO4 [7, Reactor, Bulk Volume, 0]
 Value : S_PO4 [8, Reactor, Bulk Volume, 0]
 Value : S_PO4meas7 [7, Reactor, Bulk Volume, 0]
 Value : S_PO4meas8 [8, Reactor, Bulk Volume, 0]

S_PO4_Db: Description: Phosphate (Dilution check)
 Abscissa: Time
 Title: (b) Measured and simulated orthophosphate for BT-7 and BT-8
 Abscissa Label: Retention time (d)
 Ordinate Label: Orthophosphate (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : S_PO4 [17, Reactor, Bulk Volume, 0]
 Value : S_PO4 [18, Reactor, Bulk Volume, 0]
 Value : S_PO4meas7 [7, Reactor, Bulk Volume, 0]
 Value : S_PO4meas8 [8, Reactor, Bulk Volume, 0]

TKNa: Description: TKN
 Abscissa: Time
 Title: (a) Measured and simulated TKN for
 BT-3, BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: TKN (mg/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : TKN [3, Reactor, Bulk Volume, 0]
 Value : TKN [4, Reactor, Bulk Volume, 0]
 Value : TKN [5, Reactor, Bulk Volume, 0]
 Value : TKN [6, Reactor, Bulk Volume, 0]

Value : TKN_meas3 [3,Reactor,Bulk Volume,0]
 Value : TKN_meas4 [4,Reactor,Bulk Volume,0]
 Value : TKN_meas5 [5,Reactor,Bulk Volume,0]
 Value : TKN_meas6 [6,Reactor,Bulk Volume,0]

TKNb: Description: TKN
 Abscissa: Time
 Title: (b) Measured and simulated TKN for
 BT-3, BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: TKN (mg/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : TKN [13,Reactor,Bulk Volume,0]
 Value : TKN [14,Reactor,Bulk Volume,0]
 Value : TKN [15,Reactor,Bulk Volume,0]
 Value : TKN [16,Reactor,Bulk Volume,0]
 Value : TKN_meas3 [3,Reactor,Bulk Volume,0]
 Value : TKN_meas4 [4,Reactor,Bulk Volume,0]
 Value : TKN_meas5 [5,Reactor,Bulk Volume,0]
 Value : TKN_meas6 [6,Reactor,Bulk Volume,0]

TKN_Da: Description: TKN
 Abscissa: Time
 Title: (a) Measured and simulated TKN for
 BT-7 and BT-8
 Abscissa Label: Retention time (d)
 Ordinate Label: TKN (mg/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : TKN [7,Reactor,Bulk Volume,0]
 Value : TKN [8,Reactor,Bulk Volume,0]
 Value : TKN_meas7 [7,Reactor,Bulk Volume,0]
 Value : TKN_meas8 [8,Reactor,Bulk Volume,0]

TKN_Db: Description: TKN
 Abscissa: Time
 Title: (b) Measured and simulated TKN for
 BT-7 and BT-8
 Abscissa Label: Retention time (d)
 Ordinate Label: TKN (mg/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : TKN [17,Reactor,Bulk Volume,0]
 Value : TKN [18,Reactor,Bulk Volume,0]
 Value : TKN_meas7 [7,Reactor,Bulk Volume,0]
 Value : TKN_meas8 [8,Reactor,Bulk Volume,0]

TSS_ASM_SSMi: Description: TSS
 Abscissa: Time
 Title: (a) Comparison of simulated TSS wit
 h ASM2 and SSM (BT-1 and BT-2)
 Abscissa Label: Retention time (d)
 Ordinate Label: TSS (mgTSS/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : TSS_ISS [1,Reactor,Bulk Volume,0]
 Value : TSS_ISS [2,Reactor,Bulk Volume,0]
 Value : X_Tt_SS [1,Reactor,Bulk Volume,0]
 Value : X_Tt_SS [2,Reactor,Bulk Volume,0]

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TSS_ASM_SSMii: Description:      TSS
                   Abscissa:      Time
                   Title:          Comparison of simulated TSS with AS
                                   M2 and SSM (for BT-3 and BT-4)
                   Abscissa Label: Retention time (d)
                   Ordinate Label: TSS (mgTSS/l)
                   Curves:
                       Type : Variable [CalcNum, Comp., Zone, Time/Space]
                       Value : TSS_ISS [3, Reactor, Bulk Volume, 0]
                       Value : TSS_ISS [4, Reactor, Bulk Volume, 0]
                       Value : X_Tt_SS [3, Reactor, Bulk Volume, 0]
                       Value : X_Tt_SS [4, Reactor, Bulk Volume, 0]
-----
TSS_ASM_SSMiii: Description:      TSS
                   Abscissa:      Time
                   Title:          Comparison of simulated TSS with AS
                                   M2 and SSM (for BT-5 and BT-6)
                   Abscissa Label: Retention time (d)
                   Ordinate Label: TSS (mgTSS/l)
                   Curves:
                       Type : Variable [CalcNum, Comp., Zone, Time/Space]
                       Value : TSS_ISS [5, Reactor, Bulk Volume, 0]
                       Value : TSS_ISS [6, Reactor, Bulk Volume, 0]
                       Value : X_Tt_SS [5, Reactor, Bulk Volume, 0]
                       Value : X_Tt_SS [6, Reactor, Bulk Volume, 0]
-----
TSS_fila:         Description:      TSS calculated using fi
                   Abscissa:      Time
                   Title:          (a) Measured and simulated TSS (com
                                   puted with VSS/TSS ratio from VSS)
                                   for BT-1, BT-2 and BT-3
                   Abscissa Label: Retention time (d)
                   Ordinate Label: TSS (mgTSS/l)
                   Curves:
                       Type : Variable [CalcNum, Comp., Zone, Time/Space]
                       Value : TSS_fi [1, Reactor, Bulk Volume, 0]
                       Value : TSS_fi [2, Reactor, Bulk Volume, 0]
                       Value : TSS_fi [3, Reactor, Bulk Volume, 0]
                       Value : TSS_meas1 [1, Reactor, Bulk Volume, 0]
                       Value : TSS_meas2 [2, Reactor, Bulk Volume, 0]
                       Value : TSS_meas3 [3, Reactor, Bulk Volume, 0]
-----
TSS_filb:         Description:      TSS calculated using fi
                   Abscissa:      Time
                   Title:          (b) Measured and simulated TSS (com
                                   puted with VSS/TSS ratio from VSS)
                                   for BT-1, BT-2 and BT-3
                   Abscissa Label: Retention time (d)
                   Ordinate Label: TSS (mgTSS/l)
                   Curves:
                       Type : Variable [CalcNum, Comp., Zone, Time/Space]
                       Value : TSS_fi [11, Reactor, Bulk Volume, 0]
                       Value : TSS_fi [12, Reactor, Bulk Volume, 0]
                       Value : TSS_fi [13, Reactor, Bulk Volume, 0]
                       Value : TSS_meas1 [1, Reactor, Bulk Volume, 0]
                       Value : TSS_meas2 [2, Reactor, Bulk Volume, 0]
                       Value : TSS_meas3 [3, Reactor, Bulk Volume, 0]
-----
TSS_fi2a:         Description:      TSS calculated using fi
                   Abscissa:      Time
                   Title:          (a) Measured and simulated TSS (com

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puted with VSS/TSS ratio from VSS)
for BT-4, BT-5 and BT-6

Abscissa Label: Retention time (d)
Ordinate Label: TSS (mgTSS/l)
Curves:
Type : Variable [CalcNum, Comp., Zone, Time/Space]
Value : TSS_fi [4, Reactor, Bulk Volume, 0]
Value : TSS_fi [5, Reactor, Bulk Volume, 0]
Value : TSS_fi [6, Reactor, Bulk Volume, 0]
Value : TSS_meas4 [4, Reactor, Bulk Volume, 0]
Value : TSS_meas5 [5, Reactor, Bulk Volume, 0]
Value : TSS_meas6 [6, Reactor, Bulk Volume, 0]

TSS_fi2b: Description: TSS calculated using fi
Abscissa: Time
Title: (b) Measured and simulated TSS (computed with VSS/TSS ratio from VSS) for BT-4, BT-5 and BT-6
Abscissa Label: Retention time (d)
Ordinate Label: TSS (mgTSS/l)
Curves:
Type : Variable [CalcNum, Comp., Zone, Time/Space]
Value : TSS_fi [14, Reactor, Bulk Volume, 0]
Value : TSS_fi [15, Reactor, Bulk Volume, 0]
Value : TSS_fi [16, Reactor, Bulk Volume, 0]
Value : TSS_meas4 [4, Reactor, Bulk Volume, 0]
Value : TSS_meas5 [5, Reactor, Bulk Volume, 0]
Value : TSS_meas6 [6, Reactor, Bulk Volume, 0]

TSS_ISS1a: Description: TSS calculated using ISS
Abscissa: Time
Title: (a) Measured and simulated TSS (computed with ISS approach) for BT-1, BT-2 and BT-3
Abscissa Label: Retention time (d)
Ordinate Label: TSS (mgTSS/l)
Curves:
Type : Variable [CalcNum, Comp., Zone, Time/Space]
Value : TSS_ISS [1, Reactor, Bulk Volume, 0]
Value : TSS_ISS [2, Reactor, Bulk Volume, 0]
Value : TSS_ISS [3, Reactor, Bulk Volume, 0]
Value : TSS_meas1 [1, Reactor, Bulk Volume, 0]
Value : TSS_meas2 [2, Reactor, Bulk Volume, 0]
Value : TSS_meas3 [3, Reactor, Bulk Volume, 0]

TSS_ISS1b: Description: TSS calculated using ISS
Abscissa: Time
Title: (b) Measured and simulated TSS (computed with ISS approach) for BT-1, BT-2 and BT-3
Abscissa Label: Retention time (d)
Ordinate Label: TSS (mgTSS/l)
Curves:
Type : Variable [CalcNum, Comp., Zone, Time/Space]
Value : TSS_ISS [11, Reactor, Bulk Volume, 0]
Value : TSS_ISS [12, Reactor, Bulk Volume, 0]
Value : TSS_ISS [13, Reactor, Bulk Volume, 0]
Value : TSS_meas1 [1, Reactor, Bulk Volume, 0]
Value : TSS_meas2 [2, Reactor, Bulk Volume, 0]
Value : TSS_meas3 [3, Reactor, Bulk Volume, 0]

```

TSS_ISS2a:  Description:      TSS calculated using ISS
            Abscissa:        Time
            Title:           (a) Measured and simulated TSS (com
                               puted with ISS approach) for BT-4,
                               BT-5 and BT-6
            Abscissa Label:   Retention time (d)
            Ordinate Label:   TSS (mgTSS/l)
            Curves:
                Type : Variable [CalcNum,Comp.,Zone,Time/Space]
                Value : TSS_ISS [4,Reactor,Bulk Volume,0]
                Value : TSS_ISS [5,Reactor,Bulk Volume,0]
                Value : TSS_ISS [6,Reactor,Bulk Volume,0]
                Value : TSS_meas4 [4,Reactor,Bulk Volume,0]
                Value : TSS_meas5 [5,Reactor,Bulk Volume,0]
                Value : TSS_meas6 [6,Reactor,Bulk Volume,0]
-----
TSS_ISS2b:  Description:      TSS calculated using ISS
            Abscissa:        Time
            Title:           (b) Measured and simulated TSS (com
                               puted with ISS approach) for BT-4,
                               BT-5 and BT-6
            Abscissa Label:   Retention time (d)
            Ordinate Label:   TSS (mgTSS/l)
            Curves:
                Type : Variable [CalcNum,Comp.,Zone,Time/Space]
                Value : TSS_ISS [14,Reactor,Bulk Volume,0]
                Value : TSS_ISS [15,Reactor,Bulk Volume,0]
                Value : TSS_ISS [16,Reactor,Bulk Volume,0]
                Value : TSS_meas4 [4,Reactor,Bulk Volume,0]
                Value : TSS_meas5 [5,Reactor,Bulk Volume,0]
                Value : TSS_meas6 [6,Reactor,Bulk Volume,0]
-----
TSS_ISS_Da: Description:      TSS calculated using ISS (Dilution
                               check)
            Abscissa:        Time
            Title:           (a) Measured and simulated TSS (com
                               puted with ISS approach) for BT-7 a
                               nd BT-8
            Abscissa Label:   Retention time (d)
            Ordinate Label:   TSS (mgTSS/l)
            Curves:
                Type : Variable [CalcNum,Comp.,Zone,Time/Space]
                Value : TSS_ISS [7,Reactor,Bulk Volume,0]
                Value : TSS_ISS [8,Reactor,Bulk Volume,0]
                Value : TSS_meas7 [7,Reactor,Bulk Volume,0]
                Value : TSS_meas8 [8,Reactor,Bulk Volume,0]
-----
TSS_ISS_Db: Description:      TSS calculated using ISS (Dilution
                               check)
            Abscissa:        Time
            Title:           (b) Measured and simulated TSS (com
                               puted with ISS approach) for BT-7 a
                               nd BT-8
            Abscissa Label:   Retention time (d)
            Ordinate Label:   TSS (mgTSS/l)
            Curves:
                Type : Variable [CalcNum,Comp.,Zone,Time/Space]
                Value : TSS_ISS [17,Reactor,Bulk Volume,0]
                Value : TSS_ISS [18,Reactor,Bulk Volume,0]
                Value : TSS_meas7 [7,Reactor,Bulk Volume,0]
                Value : TSS_meas8 [8,Reactor,Bulk Volume,0]

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T_P:	Description:	Total Phosphorus
	Abscissa:	Time
	Title:	Measured total phosphate for BT-5, BT-6, BT-7 and BT-8
	Abscissa Label:	Retention time (d)
	Ordinate Label:	Total-P (mg/l)
	Curves:	
		Type : Variable [CalcNum,Comp.,Zone,Time/Space]
		Value : S_Ptmeas5 [5,Reactor,Bulk Volume,0]
		Value : S_Ptmeas6 [6,Reactor,Bulk Volume,0]
		Value : S_Ptmeas7 [7,Reactor,Bulk Volume,0]
		Value : S_Ptmeas8 [8,Reactor,Bulk Volume,0]

VSS1a:	Description:	VSS
	Abscissa:	Time
	Title:	(a) Measured and simulated VSS for BT-1, BT-2 and BT-3
	Abscissa Label:	Retention time (d)
	Ordinate Label:	VSS (mgCOD/l)
	Curves:	
		Type : Variable [CalcNum,Comp.,Zone,Time/Space]
		Value : mVSS [1,Reactor,Bulk Volume,0]
		Value : mVSS [2,Reactor,Bulk Volume,0]
		Value : mVSS [3,Reactor,Bulk Volume,0]
		Value : VSS_meas1 [1,Reactor,Bulk Volume,0]
		Value : VSS_meas2 [2,Reactor,Bulk Volume,0]
		Value : VSS_meas3 [3,Reactor,Bulk Volume,0]

VSS1b:	Description:	VSS
	Abscissa:	Time
	Title:	(b) Measured and simulated VSS for BT-1, BT-2 and BT-3
	Abscissa Label:	Retention time (d)
	Ordinate Label:	VSS (mgCOD/l)
	Curves:	
		Type : Variable [CalcNum,Comp.,Zone,Time/Space]
		Value : mVSS [11,Reactor,Bulk Volume,0]
		Value : mVSS [12,Reactor,Bulk Volume,0]
		Value : mVSS [13,Reactor,Bulk Volume,0]
		Value : VSS_meas1 [1,Reactor,Bulk Volume,0]
		Value : VSS_meas2 [2,Reactor,Bulk Volume,0]
		Value : VSS_meas3 [3,Reactor,Bulk Volume,0]

VSS2a:	Description:	VSS
	Abscissa:	Time
	Title:	(a) Measured and simulated VSS for BT-4, BT-5 and BT-6
	Abscissa Label:	Retention time (d)
	Ordinate Label:	VSS (mgCOD/l)
	Curves:	
		Type : Variable [CalcNum,Comp.,Zone,Time/Space]
		Value : mVSS [4,Reactor,Bulk Volume,0]
		Value : mVSS [5,Reactor,Bulk Volume,0]
		Value : mVSS [6,Reactor,Bulk Volume,0]
		Value : VSS_meas4 [4,Reactor,Bulk Volume,0]
		Value : VSS_meas5 [5,Reactor,Bulk Volume,0]
		Value : VSS_meas6 [6,Reactor,Bulk Volume,0]

VSS2b:	Description:	VSS
	Abscissa:	Time

Title: (b) Measured and simulated VSS for
BT-4, BT-5 and BT-6
Abscissa Label: Retention time (d)
Ordinate Label: VSS (mgCOD/l)
Curves:
Type : Variable [CalcNum, Comp., Zone, Time/Space]
Value : mVSS [14, Reactor, Bulk Volume, 0]
Value : mVSS [15, Reactor, Bulk Volume, 0]
Value : mVSS [16, Reactor, Bulk Volume, 0]
Value : VSS_meas4 [4, Reactor, Bulk Volume, 0]
Value : VSS_meas5 [5, Reactor, Bulk Volume, 0]
Value : VSS_meas6 [6, Reactor, Bulk Volume, 0]

VSS_ASM_SSMi: Description: VSS
Abscissa: Time
Title: Comparison of simulated VSS with AS
M2 and SSM (for BT-1 and BT-2)
Abscissa Label: Retention time (d)
Ordinate Label: VSS (mgCOD/l)
Curves:
Type : Variable [CalcNum, Comp., Zone, Time/Space]
Value : mVSS [1, Reactor, Bulk Volume, 0]
Value : mVSS [2, Reactor, Bulk Volume, 0]
Value : X_Vt_SS [1, Reactor, Bulk Volume, 0]
Value : X_Vt_SS [2, Reactor, Bulk Volume, 0]

VSS_ASM_SSMii: Description: VSS
Abscissa: Time
Title: Comparison of simulated VSS with AS
M2 and SSM (for BT-3 and BT-4)
Abscissa Label: Retention time (d)
Ordinate Label: VSS (mgCOD/l)
Curves:
Type : Variable [CalcNum, Comp., Zone, Time/Space]
Value : mVSS [3, Reactor, Bulk Volume, 0]
Value : mVSS [4, Reactor, Bulk Volume, 0]
Value : X_Vt_SS [3, Reactor, Bulk Volume, 0]
Value : X_Vt_SS [4, Reactor, Bulk Volume, 0]

VSS_ASM_SSMiii: Description: VSS
Abscissa: Time
Title: Comparison of simulated VSS with AS
M2 and SSM (for BT-5 and BT-6)
Abscissa Label: Retention time (d)
Ordinate Label: VSS (mgCOD/l)
Curves:
Type : Variable [CalcNum, Comp., Zone, Time/Space]
Value : mVSS [5, Reactor, Bulk Volume, 0]
Value : mVSS [6, Reactor, Bulk Volume, 0]
Value : X_Vt_SS [5, Reactor, Bulk Volume, 0]
Value : X_Vt_SS [6, Reactor, Bulk Volume, 0]

VSS_Da: Description: VSS (Dilution check)
Abscissa: Time
Title: (a) Measured and simulated VSS for
BT-7 and BT-8
Abscissa Label: Retention time (d)
Ordinate Label: VSS (mgCOD/l)
Curves:
Type : Variable [CalcNum, Comp., Zone, Time/Space]
Value : mVSS [7, Reactor, Bulk Volume, 0]

Value : mVSS [8,Reactor,Bulk Volume,0]
 Value : VSS_meas7 [7,Reactor,Bulk Volume,0]
 Value : VSS_meas8 [8,Reactor,Bulk Volume,0]

VSS_Db: Description: VSS (Dilution check)
 Abscissa: Time
 Title: (a) Measured and simulated VSS for
 BT-7 and BT-8
 Abscissa Label: Retention time (d)
 Ordinate Label: VSS (mgCOD/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : mVSS [17,Reactor,Bulk Volume,0]
 Value : mVSS [18,Reactor,Bulk Volume,0]
 Value : VSS_meas7 [7,Reactor,Bulk Volume,0]
 Value : VSS_meas8 [8,Reactor,Bulk Volume,0]

XTt1a: Description: TSS (SSM)
 Abscissa: Time
 Title: (a) TSS computed with SSM and measu
 red for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: TSS (mgTSS/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : X_Tt_SS [1,Reactor,Bulk Volume,0]
 Value : X_Tt_SS [2,Reactor,Bulk Volume,0]
 Value : X_Tt_SS [3,Reactor,Bulk Volume,0]
 Value : TSS_meas1 [1,Reactor,Bulk Volume,0]
 Value : TSS_meas2 [2,Reactor,Bulk Volume,0]
 Value : TSS_meas3 [3,Reactor,Bulk Volume,0]

XTt1b: Description: TSS (SSM)
 Abscissa: Time
 Title: (b) TSS computed with SSM and measu
 red for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: TSS (mgTSS/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : X_Tt_SS [11,Reactor,Bulk Volume,0]
 Value : X_Tt_SS [12,Reactor,Bulk Volume,0]
 Value : X_Tt_SS [13,Reactor,Bulk Volume,0]
 Value : TSS_meas1 [1,Reactor,Bulk Volume,0]
 Value : TSS_meas2 [2,Reactor,Bulk Volume,0]
 Value : TSS_meas3 [3,Reactor,Bulk Volume,0]

XTt2a: Description: TSS (SSM)
 Abscissa: Time
 Title: (a) TSS computed with SSM and measu
 red for BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: TSS (mgTSS/l)
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : X_Tt_SS [4,Reactor,Bulk Volume,0]
 Value : X_Tt_SS [5,Reactor,Bulk Volume,0]
 Value : X_Tt_SS [6,Reactor,Bulk Volume,0]
 Value : TSS_meas4 [4,Reactor,Bulk Volume,0]
 Value : TSS_meas5 [5,Reactor,Bulk Volume,0]
 Value : TSS_meas6 [6,Reactor,Bulk Volume,0]

Xt2b: Description: TSS (SSM)
 Abscissa: Time
 Title: (b) TSS computed with SSM and measured for BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: TSS (mgTSS/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : X_Tt_SS [14, Reactor, Bulk Volume, 0]
 Value : X_Tt_SS [15, Reactor, Bulk Volume, 0]
 Value : X_Tt_SS [16, Reactor, Bulk Volume, 0]
 Value : TSS_meas4 [4, Reactor, Bulk Volume, 0]
 Value : TSS_meas5 [5, Reactor, Bulk Volume, 0]
 Value : TSS_meas6 [6, Reactor, Bulk Volume, 0]

Xvt1a: Description: VSS (SSM)
 Abscissa: Time
 Title: (a) VSS computed with SSM and measured for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: VSS (mgCOD/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : X_Vt_SS [1, Reactor, Bulk Volume, 0]
 Value : X_Vt_SS [2, Reactor, Bulk Volume, 0]
 Value : X_Vt_SS [3, Reactor, Bulk Volume, 0]
 Value : VSS_meas1 [1, Reactor, Bulk Volume, 0]
 Value : VSS_meas2 [2, Reactor, Bulk Volume, 0]
 Value : VSS_meas3 [3, Reactor, Bulk Volume, 0]

Xvt1b: Description: VSS (SS)
 Abscissa: Time
 Title: (b) VSS computed with SSM and measured for BT-1, BT-2 and BT-3
 Abscissa Label: Retention time (d)
 Ordinate Label: VSS (mgCOD/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : X_Vt_SS [11, Reactor, Bulk Volume, 0]
 Value : X_Vt_SS [12, Reactor, Bulk Volume, 0]
 Value : X_Vt_SS [13, Reactor, Bulk Volume, 0]
 Value : VSS_meas1 [1, Reactor, Bulk Volume, 0]
 Value : VSS_meas2 [2, Reactor, Bulk Volume, 0]
 Value : VSS_meas3 [3, Reactor, Bulk Volume, 0]

Xvt2a: Description: VSS (SSM)
 Abscissa: Time
 Title: (a) VSS computed with SSM and measured for BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: VSS (mgCOD/l)
 Curves:
 Type : Variable [CalcNum, Comp., Zone, Time/Space]
 Value : X_Vt_SS [4, Reactor, Bulk Volume, 0]
 Value : X_Vt_SS [5, Reactor, Bulk Volume, 0]
 Value : X_Vt_SS [6, Reactor, Bulk Volume, 0]
 Value : VSS_meas4 [4, Reactor, Bulk Volume, 0]
 Value : VSS_meas5 [5, Reactor, Bulk Volume, 0]
 Value : VSS_meas6 [6, Reactor, Bulk Volume, 0]

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Xvt2b: Description: VSS (SSM)
 Abscissa: Time
 Title: (b) VSS computed with SSM and measur
 ed for BT-4, BT-5 and BT-6
 Abscissa Label: Retention time (d)
 Ordinate Label: VSS (mgCOD/l)
 Curves:

 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : X_Vt_SS [14,Reactor,Bulk Volume,0]
 Value : X_Vt_SS [15,Reactor,Bulk Volume,0]
 Value : X_Vt_SS [16,Reactor,Bulk Volume,0]
 Value : VSS_meas4 [4,Reactor,Bulk Volume,0]
 Value : VSS_meas5 [5,Reactor,Bulk Volume,0]
 Value : VSS_meas6 [6,Reactor,Bulk Volume,0]

 Calculation Parameters

Numerical Parameters: Maximum Int. Step Size: 1
 Maximum Integrat. Order: 5
 Number of Codiagonals: 1000
 Maximum Number of Steps: 1000

 Fit Method: secant
 Max. Number of Iterat.: 100
