

A new Schematic representation of ASM models for concepts comparison

A new schematic representation of the model processes is proposed to facilitate model concept comparison in a systematic and transparent way. For each process type, the standard processes that use the same modelling concept are represented on a single figure, and the standard processes that are different in terms of modelling concept are represented on separate figures. Different concepts are given different numbers (concept 1, concept 2...), whereas variations within the same concept are pointed out using letters (concept 1a, 1b...). The process is represented as a reaction with consumed components on the left of the figure and produced components on the right. Figure I shows the symbols used for the schematic representation:

- Models that consider the process are given by a letter (a to g).
- The electron acceptor condition of the process is indicated by a square (Ox: aerobic; Ax: anoxic; An: anaerobic), close to the corresponding model name.
- The included state variables are represented through both a shape and a background: the shape indicates whether the variable is particulate or colloidal, soluble or refers to an organism and internal storage, and the background indicates its composition in terms of ThOD (theoretical oxygen demand) (C), nitrogen (N) or phosphorus (P). The state variable name is indicated inside the shape, using the standardised notation from Corominas *et al.* (2010).
- The electron acceptor consumed in the process is represented by a square. For instance, depending on its usage, nitrate can be represented by a circle-square (electron acceptor) or by a circle only (substrate).

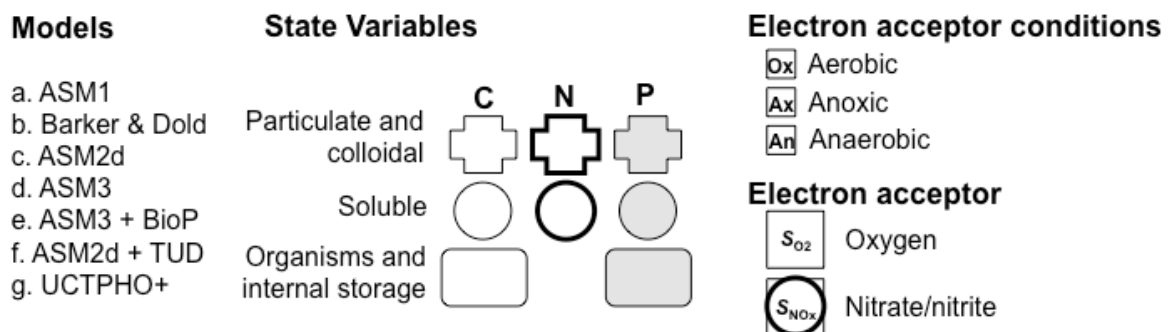


Figure I. Symbols used for the schematic representation

To simplify the graphs, alkalinity and total suspended solids are not represented. Only important stoichiometric coefficients (especially yields) are specified, as others can be calculated through conservation of ThOD, nitrogen and phosphorus (Hauduc et al. 2010).

In this process representation, the consumed and produced components of the reaction are linked by black arrows. In case state variables are not considered by all models or under all conditions, the models or conditions concerned are specified on the arrow.

The kinetic expression for the rate of reaction is also part of the concept and is therefore represented. This is also done in a condensed way by a standardised compact notation. Table I illustrates the different symbols used to keep the expression readable.

Table I. Symbols used for kinetic expressions: examples

Description	Notation	Symbol
Kinetic coefficients: maximum specific growth rate	μ_{OHO}	μ_{OHO}
Concentration of S_{NOx}	S_{NOx}	S_{NOx}
Monod function with S_{B} as substrate	$\frac{S_{\text{B}}}{K_{\text{SB}} + S_{\text{B}}}$	$M(S_{\text{B}})$
Inhibition Monod function with S_{NOx} as electron acceptor	$\frac{K_{\text{NOx}}}{K_{\text{NOx}} + S_{\text{NOx}}}$	$\text{IM}(S_{\text{NOx}})$
Monod function with S_{PO4} as substrate, only used in models considering phosphorus removal	$\frac{S_{\text{PO4}}}{K_{\text{PO4}} + S_{\text{PO4}}}$	$\langle M(S_{\text{PO4}}) \rangle$
Electron acceptor conditions (ex: OHO growth) (aerobic or anoxic conditions)		$\left\langle \frac{M(S_{\text{O2}})}{\eta_{\mu\text{OHO},\text{Ax}}} M(S_{\text{NOx}}) \cdot \text{IM}(S_{\text{O2x}}) \right\rangle$

N.B.: The symbol $\langle \rangle$ is used to indicate optional or alternative terms, one or none of the lines apply for the given condition.

The saturation functions and inhibition functions, which have the form of a Monod expression, are expressed $M()$ or $\text{IM}()$, with the component concerned in parenthesis. The symbol $\langle \rangle$ is used to indicate optional or alternative terms depending on the model or the environmental condition (see Table I for examples).

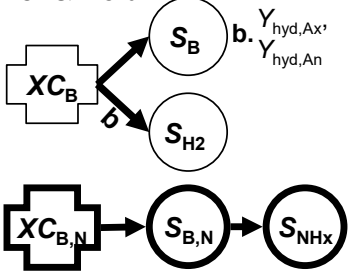
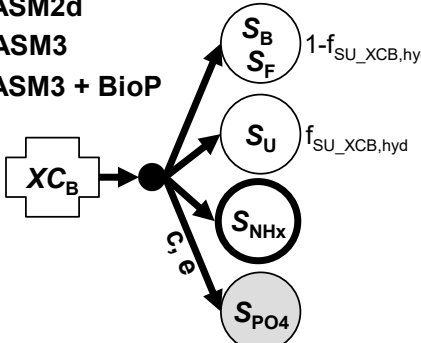
Nine standard processes have been identified and are listed below. These "standard processes" involve mechanisms that only differ by the environmental conditions under which they take place. For instance, aerobic and anoxic OHO growth processes are combined as one OHO standard growth process. This work is limited to biological processes, and therefore

chemical phosphorus precipitation is not discussed. Besides, as OHO- and ANO-related processes of ASM2d+TUD are exactly the same as ASM2d, ASM2d+TUD will be studied only for BioP-related processes.

The nine standard processes considered are:

- Hydrolysis of particulate substrate: Table II
- Fermentation: Table III
- OHO growth: Table IV
- ANO growth: Table V
- OHO & ANO decay: Table VI
- PHA storage: Table VII
- PolyP storage: Table VIII
- PAO growth: Table IX
- PAO decay: Table X and Table XI (PAO storage pools release/consumption)

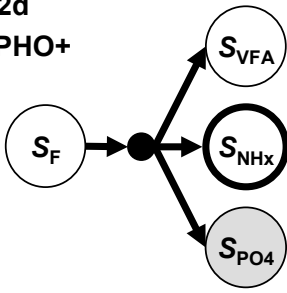
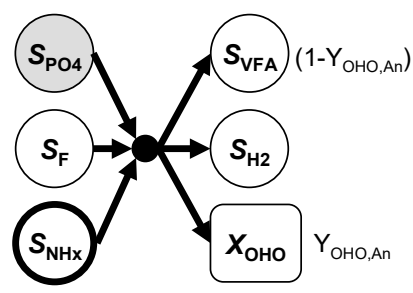
Table II. Hydrolysis of particulate substrate

Concept 1a: One step hydrolysis with organic N and C considered separately	Concept 1b: One step hydrolysis with N and P linked to organic matter
<div data-bbox="193 331 276 365">Ox</div> <div data-bbox="193 365 276 398">Ax</div> <div data-bbox="193 398 276 432">An</div> <p>a. ASM1</p> <p>b. Barker & Dold</p>  <p>b. $\gamma_{hyd,Ax}$, $\gamma_{hyd,An}$</p>	<div data-bbox="756 320 839 353">Ox</div> <div data-bbox="756 353 839 387">Ax</div> <div data-bbox="756 387 839 421">An</div> <p>c. ASM2d</p> <p>d. ASM3</p> <p>e. ASM3 + BioP</p>  <p>$1-f_{SU_XCB,hyd}$</p> <p>$f_{SU_XCB,hyd}$</p> <p>c, e</p>
<p>Organics:</p> <p>a: $q_{XCB_SB,hyd} \cdot M\left(\frac{XC_B}{X_{OHO}}\right) \cdot \left\langle \frac{M(S_{O_2})}{\eta_{qhyd,Ax} \cdot M(S_{NOx}) \cdot IM(S_{O_2})} \right\rangle \cdot X_{OHO}$</p> <p>b, c: $q_{XCB_SB,hyd} \cdot M\left(\frac{XC_B}{X_{OHO}}\right) \cdot \left\langle \frac{M(S_{O_2})}{\eta_{qhyd,Ax} \cdot M(S_{NOx}) \cdot IM(S_{O_2})} \right\rangle \cdot X_{OHO}$</p> <p>d, e: $q_{XCB_SB,hyd} \cdot M\left(\frac{XC_B}{X_{OHO}}\right) \cdot X_{OHO}$</p> <p>Particulate nitrogen hydrolysis:</p> <p>a, b: $q_{XCB_SB,hyd} \cdot M\left(\frac{XC_{B,N}}{X_{OHO}}\right) \cdot \left\langle \frac{M(S_{O_2})}{\eta_{qhyd,Ax} \cdot M(S_{NOx}) \cdot IM(S_{O_2})} \right\rangle \cdot X_{OHO}$</p> <p>Ammonification:</p> <p>a: $q_{am} \cdot S_{B,N} \cdot X_{OHO}$</p> <p>b: $q_{am} \cdot S_{B,N} \cdot (X_{OHO} + X_{PAO})$</p>	

N.B.: in UCTPHO+, hydrolysis is considered simultaneously with growth. ASM2d+TUD is identical to ASM2d.

The symbol $\langle \rangle$ is used to indicate optional or alternative terms, one or none of the lines should be chosen.

Table III. Fermentation process

Concept 1: Transformation	Concept 2: Anaerobic growth process
<div data-bbox="252 1556 300 1590">An</div> <p>c. ASM2d</p> <div data-bbox="252 1590 300 1624">An</div> <p>g. UCTPHO+</p>  <p>c: $q_{SF_VFA,Max} \cdot M(S_F) \cdot IM(S_{O_2}) \cdot IM(S_{NOx}) \cdot X_{OHO}$</p> <p>g: $q_{SF_VFA,Max} \cdot S_F \cdot IM(S_{O_2}) \cdot IM(S_{NOx}) \cdot X_{OHO}$</p>	<div data-bbox="798 1556 845 1590">An</div> <p>b. Barker & Dold</p>  <p>$(1-Y_{OHO,An}) \cdot Y_{fe}$</p> <p>$Y_{OHO,An}$</p> <p>$q_{SF_VFA,Max} \cdot M(S_F) \cdot M(S_{NHx}) \cdot M(S_{PO4}) \cdot IM(S_{O_2}) \cdot IM(S_{NOx}) \cdot X_{OHO}$</p>

N.B.: ASM2d+TUD is identical to ASM2d.

Table IV. OHO growth process concepts

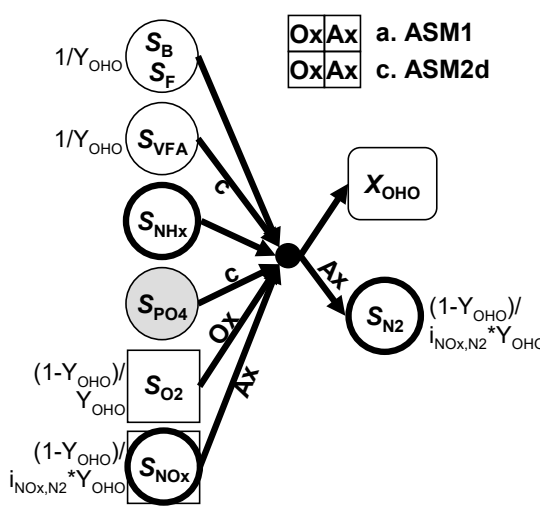
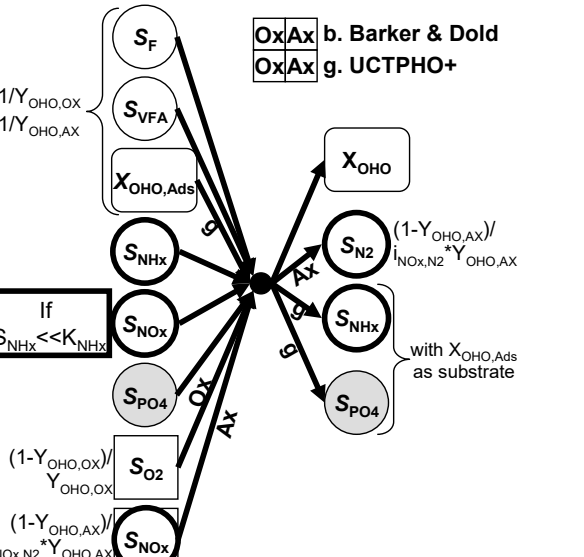
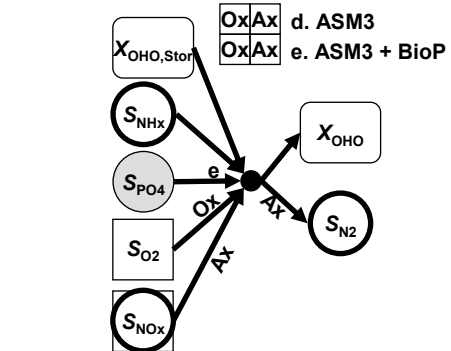
Concept 1: direct growth	Concept 2: storage - growth
<p>Concept 1a: S_{NHx} as only nitrogen source</p>  <p> $\begin{matrix} \text{Ox} & \text{Ax} \\ \text{Ox} & \text{Ax} \end{matrix}$ a. ASM1 $\begin{matrix} \text{Ox} & \text{Ax} \\ \text{Ox} & \text{Ax} \end{matrix}$ c. ASM2d </p>	<p>Concept 1b: S_{NHx} or S_{NOx} as nitrogen source</p> <p>Adsorption</p> <p>$\begin{matrix} \text{Ox} & \text{Ax} & \text{An} \\ \text{Ox} & \text{Ax} & \text{An} \end{matrix}$ g. UCTPHO+ $XC_B \rightarrow X_{OHO,Ads}$</p> <p>Growth</p>  <p> $\begin{matrix} \text{Ox} & \text{Ax} \\ \text{Ox} & \text{Ax} \end{matrix}$ b. Barker & Dold $\begin{matrix} \text{Ox} & \text{Ax} \\ \text{Ox} & \text{Ax} \end{matrix}$ g. UCTPHO+ </p> <p>If $S_{NHx} \ll K_{NHx}$</p>
<p>Adsorption: $q_{XC_B_Ads} \cdot XC_B \left(f_{Ads_OHO,Max} - \frac{X_{Ads}}{X_{OHO}} \right) \cdot X_{OHO}$</p> <p>Growth: With S_{Sub} the considered substrate (S_B, S_F or S_{VFA})</p> $\left\langle \mu_{OHO,Max} \left[\frac{M(S_{Sub}) \cdot S_{Sub}}{\sum_i S_{Sub,i}} \right] \right\rangle \cdot \left\langle \eta_{\mu_{OHO,Ax}} M(S_{NOx}) \cdot IM(S_{O2x}) \right\rangle \cdot \left\langle M(S_{PO4}) \right\rangle \cdot \left\langle \frac{M(S_{NHx})}{M(S_{NOx}) \cdot IM(S_{NHx})} \right\rangle \cdot X_{OHO}$ $\left\langle \mu_{Ads_OHO,Max} \left[M \left(\frac{X_{Ads}}{X_{OHO}} \right) \frac{S_{Sub}}{\sum_i S_{Sub,i}} \right] \right\rangle \cdot \left\langle \eta_{\mu_{OHO,Ax}} M(S_{NOx}) \cdot IM(S_{O2x}) \right\rangle \cdot \left\langle M(S_{PO4}) \right\rangle \cdot \left\langle \frac{M(S_{NHx})}{M(S_{NOx}) \cdot IM(S_{NHx})} \right\rangle \cdot X_{OHO}$	<p>Storage:</p> $q_{SB_Stor} \cdot M(S_B) \cdot \left\langle \eta_{\mu_{OHO,Ax}} \frac{M(S_{O2x})}{M(S_{NOx}) \cdot IM(S_{O2x})} \right\rangle \cdot X_{OHO}$ <p>Growth:</p> $\mu_{OHO,Max} \cdot M \left(\frac{X_{OHO,Stor}}{X_{OHO}} \right) \cdot \left\langle \eta_{\mu_{OHO,Ax}} \frac{M(S_{O2x})}{M(S_{NOx}) \cdot IM(S_{O2x})} \right\rangle \cdot \left\langle M(S_{PO4}) \right\rangle \cdot M(S_{NHx}) \cdot X_{OHO}$
<p>Concept 2: storage - growth</p> <p>Storage</p> <p>Growth</p>  <p> $\begin{matrix} \text{Ox} & \text{Ax} \\ \text{Ox} & \text{Ax} \end{matrix}$ d. ASM3 $\begin{matrix} \text{Ox} & \text{Ax} \\ \text{Ox} & \text{Ax} \end{matrix}$ e. ASM3 + BioP </p>	

Table V. ANO growth process

Ox	a. ASM1	
Ox	b. Barker & Dold	
Ox	c. ASM2d	
Ox	d. ASM3	
Ox	e. ASM3 + BioP	
Ox	f. ASM2d + TUD $(i_{COD_NOx} \cdot Y_{ANO}) / Y_{ANO}$	
Ox	g. UCTPHO+	
$\mu_{ANO,Max} \cdot M(S_{NHx}) \cdot \langle M(S_{PO4}) \rangle \cdot M(S_{O2}) \cdot X_{ANO}$		

Table VI. OHO and ANO decay process concepts

Concept 1: Death-Regeneration concept	Concept 2: Endogenous respiration concept
<p>Concept 1a: nutrients considered separately from substrate</p> <p>Ox Ax An a. ASM1 Ox Ax An b. Barker & Dold</p> <p>Concept 1b: nutrients linked to substrate</p> <p>Ox Ax An c. ASM2d Ox Ax An g. UCTPHO+</p> <p>Heterotrophs:</p> $b_{OHO} \cdot X_{OHO}$ <p>Autotrophs:</p> $b_{ANO} \cdot X_{ANO}$	<p>Ox Ax d. ASM3 Ox Ax e. ASM3 + BioP</p> <p>Storage lysis (OHOs only)</p> <p>Ox Ax d. ASM3 Ox Ax e. ASM3 + BioP</p> <p>Heterotrophs:</p> $\left\langle \frac{m_{OHO,Ox} \cdot M(S_{O2})}{m_{OHO,Ax} \cdot M(S_{NOx}) \cdot IM(S_{O2})} \right\rangle \cdot X_{OHO}$ <p>Storage lysis (OHOs only)</p> $\left\langle \frac{m_{Stor,Ox} \cdot M(S_{O2})}{m_{Stor,Ax} \cdot M(S_{NOx}) \cdot IM(S_{O2})} \right\rangle \cdot X_{OHO,Stor}$ <p>Autotrophs:</p> $\left\langle \frac{m_{ANO,Ox} \cdot M(S_{O2})}{m_{ANO,Ax} \cdot M(S_{NOx}) \cdot IM(S_{O2})} \right\rangle \cdot X_{ANO}$

N.B.: ASM2d+TUD is identical to ASM2d.

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Table VII. PHA storage process concept

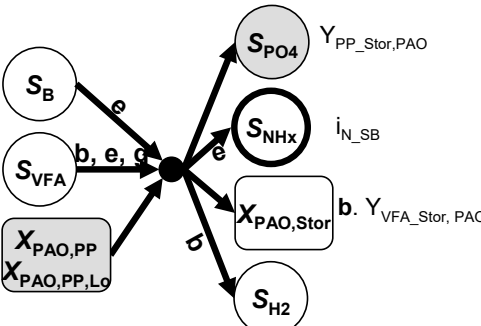
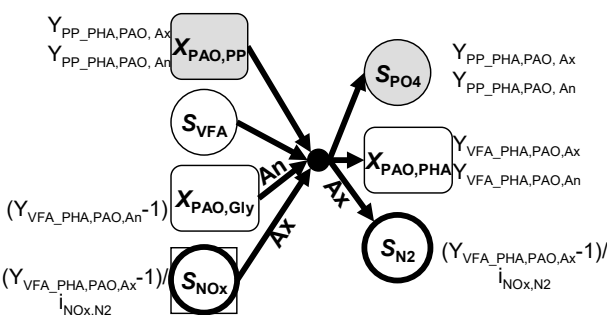
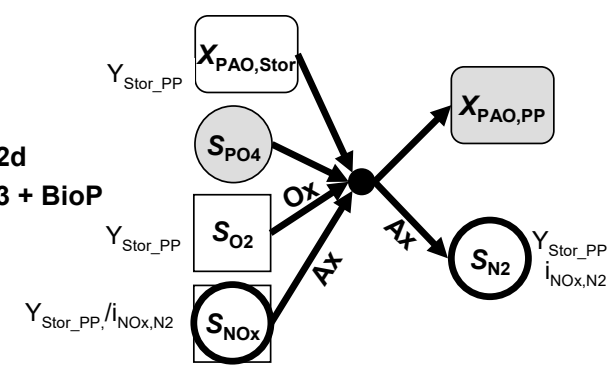
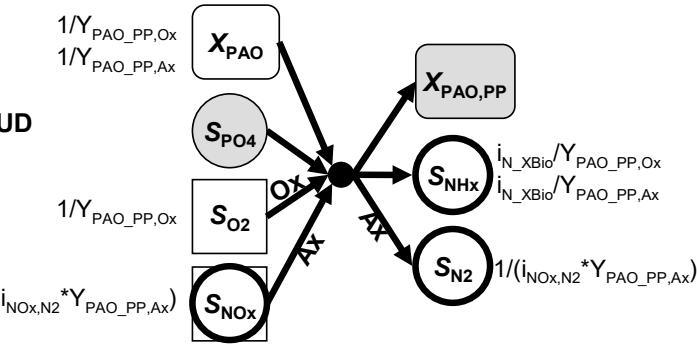
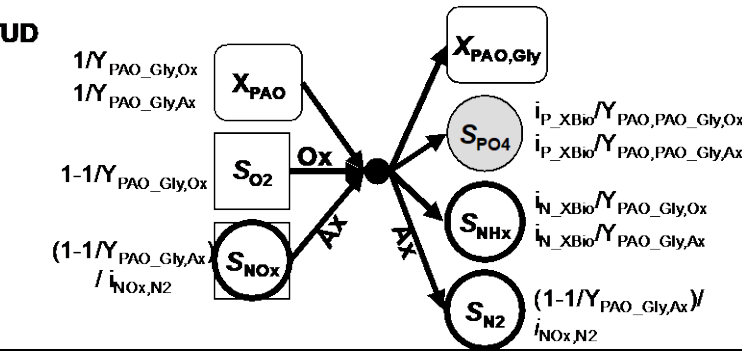
Concept 1: Energy from polyP, reducing power neglected	Concept 2: Energy from polyP, reducing power from glycogen														
<div><table><tr><td>Ox</td><td>Ax</td><td>An</td></tr><tr><td>Ox</td><td>Ax</td><td>An</td></tr><tr><td>Ox</td><td>Ax</td><td>An</td></tr><tr><td>Ox</td><td>Ax</td><td>An</td></tr></table><div><div>b. Barker & Dold</div><div>c. ASM2d</div><div>e. ASM3 + BioP</div><div>g. UCTPHO+</div></div></div> <div></div>	Ox	Ax	An	Ox	Ax	An	Ox	Ax	An	Ox	Ax	An	<div><table><tr><td>Ax</td><td>An</td></tr></table><div>f. ASM2d + TUD</div></div> <div></div>	Ax	An
Ox	Ax	An													
Ox	Ax	An													
Ox	Ax	An													
Ox	Ax	An													
Ax	An														
<div><div>b, g: $q_{PAO,VFA_Stor} \cdot M(S_{VFA}) \cdot M(X_{PAO,PP}) \cdot X_{PAO}$</div><div>c, e:</div><div>$q_{PAO,VFA_Stor} \cdot \left\langle \frac{M(S_{VFA})}{M(S_B)} \right\rangle \cdot M(X_{PAO,PP} / X_{PAO}) \cdot X_{PAO}$</div></div>	<div>$\left\langle \frac{q_{PAO,VFA_PHA_An} \cdot IM(S_{O_2}) \cdot IM(S_{NOx}) \cdot M(X_{PAO,Gly})}{q_{PAO,VFA_PHA_Ax} \cdot IM(S_{O_2}) \cdot M(S_{NOx})} \right\rangle \cdot M(S_{VFA}) \cdot M(X_{PAO,PP}) \cdot X_{PAO}$</div>														

Table VIII. PolyP storage process concept

Concept 1: Uncoupled processes	Concept 2: Coupled processes (metabolic model)
<p>c. ASM2d e. ASM3 + BioP</p> 	<p>PP storage: f. ASM2d + TUD</p>  <p>Glycogen storage: f. ASM2d + TUD</p> 
$q_{PAO,PO4_PP} \cdot \left\langle \frac{M(S_{O_2})}{\eta_{qPAO,Ax} \cdot IM(S_{O_2}) \cdot M(S_{NOx})} \right\rangle \cdot M(S_{PO4}) \cdot M(X_{PAO,PHA}) \cdot M(f_{PP_PAO,Max} - X_{PAO,PP} / X_{PAO}) \cdot X_{PAO}$	<p>PP storage: $q_{PAO,PO4_PP} \cdot \left\langle \frac{M(S_{O_2})}{\eta_{qPAO,Ax} \cdot IM(S_{O_2}) \cdot M(S_{NOx})} \right\rangle \cdot [X_{PAO} / X_{PAO,PP}] \cdot M(S_{PO4}) \cdot M(X_{PAO,PHA}) \cdot M(f_{PP_PAO,Max} - X_{PAO,PP} / X_{PAO}) \cdot X_{PAO}$</p> <p>Glycogen storage: $q_{Gly} \cdot \left\langle \frac{M(S_{O_2})}{\eta_{qPAO,Ax} \cdot IM(S_{O_2}) \cdot M(S_{NOx})} \right\rangle \cdot [X_{PAO,PHA} / X_{PAO,Gly}] \cdot M(X_{PAO,PHA}) \cdot M(f_{Gly_PAO,Max} - X_{PAO,Gly} / X_{PAO}) \cdot X_{PAO}$</p>

NB: PolyP storage in the Barker & Dold and UCTPHO+ models are considered simultaneously with growth.

The symbol $\langle \rangle$ is used to indicate optional or alternative terms, one or none of the lines should be chosen.

Table IX. PAO growth

Concept 1: PAO growth	Concept 2: Simultaneous growth and polyP storage																
<p>Concept 1a: Two polyP storage pools</p> <p>Concept 1b: Single polyP storage pools</p> <p>Concept 1c: ASM2d</p> <p>Concept 1d: ASM3 + BioP</p> <p>Concept 1e: ASM2d + TUD</p> <table border="1"> <thead> <tr> <th></th><th>A</th><th>B</th><th>C</th></tr> </thead> <tbody> <tr> <td>c.</td><td>$1/Y_{Stor_PAO}$</td><td>$1-1/Y_{Stor_PAO}$</td><td>1</td></tr> <tr> <td>e.</td><td>$1/Y_{Stor_PAO,Ox}$ $1/Y_{Stor_PAO,Ax}$</td><td>$1-1/Y_{Stor_PAO,Ox}$ $1-1/(i_{NOx,N2} * Y_{Stor_PAO,Ax})$</td><td>1</td></tr> <tr> <td>f.</td><td>1</td><td>$1-1/Y_{Stor_PAO,Ox}$ $1-1/(i_{NOx,N2} * Y_{Stor_PAO,Ax})$</td><td>$1/Y_{Stor_PAO,Ox}$ $1/Y_{Stor_PAO,Ax}$</td></tr> </tbody> </table>		A	B	C	c.	$1/Y_{Stor_PAO}$	$1-1/Y_{Stor_PAO}$	1	e.	$1/Y_{Stor_PAO,Ox}$ $1/Y_{Stor_PAO,Ax}$	$1-1/Y_{Stor_PAO,Ox}$ $1-1/(i_{NOx,N2} * Y_{Stor_PAO,Ax})$	1	f.	1	$1-1/Y_{Stor_PAO,Ox}$ $1-1/(i_{NOx,N2} * Y_{Stor_PAO,Ax})$	$1/Y_{Stor_PAO,Ox}$ $1/Y_{Stor_PAO,Ax}$	<p>Concept 2a: Two polyP storage pools</p> <p>Concept 2b: Single polyP storage pools</p> <p>Concept 2c: UCTPHO+</p> <p>Concept 2d: UCTPHO+</p> <p>Concept 2e: UCTPHO+</p> <p>Concept 2f: UCTPHO+</p> <p>Concept 2g: UCTPHO+</p> <p>Concept 2h: UCTPHO+</p> <p>Concept 2i: UCTPHO+</p> <p>Concept 2j: UCTPHO+</p> <p>Concept 2k: UCTPHO+</p> <p>Concept 2l: UCTPHO+</p> <p>Concept 2m: UCTPHO+</p> <p>Concept 2n: UCTPHO+</p> <p>Concept 2o: UCTPHO+</p> <p>Concept 2p: UCTPHO+</p> <p>Concept 2q: UCTPHO+</p> <p>Concept 2r: UCTPHO+</p> <p>Concept 2s: UCTPHO+</p> <p>Concept 2t: UCTPHO+</p> <p>Concept 2u: UCTPHO+</p> <p>Concept 2v: UCTPHO+</p> <p>Concept 2w: UCTPHO+</p> <p>Concept 2x: UCTPHO+</p> <p>Concept 2y: UCTPHO+</p> <p>Concept 2z: UCTPHO+</p> <p>Concept 2aa: UCTPHO+</p> <p>Concept 2ab: UCTPHO+</p> <p>Concept 2ac: UCTPHO+</p> <p>Concept 2ad: UCTPHO+</p> <p>Concept 2ae: UCTPHO+</p> <p>Concept 2af: UCTPHO+</p> <p>Concept 2ag: UCTPHO+</p> <p>Concept 2ah: UCTPHO+</p> <p>Concept 2ai: UCTPHO+</p> <p>Concept 2aj: UCTPHO+</p> <p>Concept 2ak: UCTPHO+</p> <p>Concept 2al: UCTPHO+</p> <p>Concept 2am: UCTPHO+</p> <p>Concept 2an: UCTPHO+</p> <p>Concept 2ao: UCTPHO+</p> <p>Concept 2ap: UCTPHO+</p> <p>Concept 2aq: UCTPHO+</p> <p>Concept 2ar: UCTPHO+</p> <p>Concept 2as: UCTPHO+</p> <p>Concept 2at: UCTPHO+</p> <p>Concept 2au: UCTPHO+</p> <p>Concept 2av: UCTPHO+</p> <p>Concept 2aw: UCTPHO+</p> <p>Concept 2ax: UCTPHO+</p> <p>Concept 2ay: UCTPHO+</p> <p>Concept 2az: UCTPHO+</p> <p>Concept 2ba: UCTPHO+</p> <p>Concept 2bb: UCTPHO+</p> <p>Concept 2bc: UCTPHO+</p> <p>Concept 2bd: UCTPHO+</p> <p>Concept 2be: UCTPHO+</p> <p>Concept 2bf: UCTPHO+</p> <p>Concept 2bg: UCTPHO+</p> <p>Concept 2bh: UCTPHO+</p> <p>Concept 2bi: UCTPHO+</p> <p>Concept 2bj: UCTPHO+</p> <p>Concept 2bk: UCTPHO+</p> <p>Concept 2bl: UCTPHO+</p> <p>Concept 2bm: UCTPHO+</p> <p>Concept 2bn: UCTPHO+</p> <p>Concept 2bo: UCTPHO+</p> <p>Concept 2bp: UCTPHO+</p> <p>Concept 2bq: UCTPHO+</p> <p>Concept 2br: UCTPHO+</p> <p>Concept 2bs: UCTPHO+</p> <p>Concept 2bt: UCTPHO+</p> <p>Concept 2bu: UCTPHO+</p> <p>Concept 2bv: UCTPHO+</p> <p>Concept 2bv: UCTPHO+</p> <p>Concept 2bw: UCTPHO+</p> <p>Concept 2bx: UCTPHO+</p> <p>Concept 2by: UCTPHO+</p> <p>Concept 2bz: UCTPHO+</p> <p>Concept 2ca: UCTPHO+</p> <p>Concept 2cb: UCTPHO+</p> <p>Concept 2cc: UCTPHO+</p> <p>Concept 2cd: UCTPHO+</p> <p>Concept 2ce: UCTPHO+</p> <p>Concept 2cf: UCTPHO+</p> <p>Concept 2cg: UCTPHO+</p> <p>Concept 2ch: UCTPHO+</p> <p>Concept 2ci: UCTPHO+</p> <p>Concept 2cj: UCTPHO+</p> <p>Concept 2ck: UCTPHO+</p> <p>Concept 2cl: UCTPHO+</p> <p>Concept 2cm: UCTPHO+</p> <p>Concept 2cn: UCTPHO+</p> <p>Concept 2co: UCTPHO+</p> <p>Concept 2cp: UCTPHO+</p> <p>Concept 2cq: UCTPHO+</p> <p>Concept 2cr: UCTPHO+</p> <p>Concept 2cs: UCTPHO+</p> <p>Concept 2ct: UCTPHO+</p> <p>Concept 2cu: UCTPHO+</p> <p>Concept 2cv: UCTPHO+</p> <p>Concept 2cw: UCTPHO+</p> <p>Concept 2cx: UCTPHO+</p> <p>Concept 2cy: UCTPHO+</p>
	A	B	C														
c.	$1/Y_{Stor_PAO}$	$1-1/Y_{Stor_PAO}$	1														
e.	$1/Y_{Stor_PAO,Ox}$ $1/Y_{Stor_PAO,Ax}$	$1-1/Y_{Stor_PAO,Ox}$ $1-1/(i_{NOx,N2} * Y_{Stor_PAO,Ax})$	1														
f.	1	$1-1/Y_{Stor_PAO,Ox}$ $1-1/(i_{NOx,N2} * Y_{Stor_PAO,Ax})$	$1/Y_{Stor_PAO,Ox}$ $1/Y_{Stor_PAO,Ax}$														

Table X: PAO decay process concepts

Concept 1: Death-regeneration concept	Concept 2: Endogenous respiration
<div data-bbox="188 678 592 1048"> <p>c. ASM2d</p> <p>O_x, A_x, A_n</p> </div>	<div data-bbox="651 315 1430 1420"> <p>b. Barker & Dold</p> <p>e. ASM3 + BioP</p> <p>f. ASM2d + TUD</p> <p>g. UCTPHO+</p> <p>O_x, A_x, A_n</p> <p>$A_x: (1 - \eta_{\mu PAO})^* (1 - f_{XU_PAO,lys} - f_{SU_PAO,lys})$</p> <p>$A_n: 1 - f_{XU_PAO,lys} - f_{SU_PAO,lys}$</p> <p>$f_{XU_PAO,lys}$</p> <p>$f_{SU_PAO,lys}$</p> <p>$A_n: 1 - f_{SU_PAO,lys}$</p> <p>$f_{SU_PAO,lys} \cdot i_{N_SU}$</p> <p>$A_n: (1 - f_{SU_PAO,lys}) \cdot i_{N_SU}$</p> <p>b. $O_x: 1 - f_{XU_PAO,lys} - f_{SU_PAO,lys}$</p> <p>$A_x: (1 - f_{XU_PAO,lys} - f_{SU_PAO,lys}) / i_{NOx,N2}$</p> <p>e. $O_x: 1 - f_{XU_PAO,lys}$</p> <p>$A_x: (1 - f_{XU_PAO,lys}) / i_{NOx,N2}$</p> <p>f. $O_x: 1$</p> <p>$A_x: 1 / i_{NOx,N2}$</p> <p>g. $O_x: 1 - f_{XU_PAO,lys} - f_{SU_PAO,lys}$</p> <p>$A_x: \eta_{\mu PAO} \cdot (1 - f_{XU_PAO,lys} - f_{SU_PAO,lys}) / i_{NOx,N2}$</p> <p>Maintenance:</p> <p>b. Barker & Dold</p> <p>f. ASM2d + TUD</p> <p>g. UCTPHO+</p> <p>$X_{PAO_PP} / X_{PAO_PP,Lo} \rightarrow S_{PO4}$</p> </div>
$b_{PAO} \cdot X_{PAO}$	<div data-bbox="592 1420 1430 1984"> <p>Decay:</p> <p>b, g: $m_{PAO} \cdot \left\langle \frac{M(S_{O2})}{IM(S_{O2}) \cdot M(S_{NOx})} \right\rangle \cdot X_{PAO}$</p> <p>e: $m_{PAO} \cdot \left\langle \frac{M(S_{O2})}{\eta_{mPAO} \cdot IM(S_{O2}) \cdot M(S_{NOx})} \right\rangle \cdot X_{PAO}$</p> <p>f: $\left\langle \frac{m_{PAO,Ox} \cdot M(S_{O2})}{m_{PAO,Ax} \cdot IM(S_{O2}) \cdot M(S_{NOx})} \right\rangle \cdot X_{PAO}$</p> <p>Maintenance:</p> <p>b: $b_{PP_PO4} \cdot IM(S_{O2}) \cdot M(X_{PAO,PP,Lo}) \cdot X_{PAO}$</p> <p>f: $m_{PAO,A_n} \cdot IM(S_{O2}) \cdot IM(S_{NOx}) \cdot M(X_{PAO,PP}) \cdot X_{PAO}$</p> <p>g: $b_{PP_PO4} \cdot \left\langle \frac{(1 - \eta_{\mu PAO}) \cdot IM(S_{O2}) \cdot M(S_{NOx})}{IM(S_{O2}) \cdot IM(S_{NOx})} \right\rangle \cdot M(X_{PAO,PP}) \cdot X_{PAO}$</p> </div>

Table XI: PAO storage pools release/consumption during lysis

Concept 1: Stored compounds are released	Concept 2: Stored compounds are consumed
<p>PolyP lysis:</p> <div><div><div><div>Ox</div><div>Ax</div><div>An</div></div><div><div>b. Barker & Dold</div><div>c. ASM2d</div><div>e. ASM3 + BioP</div><div>g. UCTPHO+</div></div></div><div><div><div><div>X_{PAO_PP} /</div><div>X_{PAO_PP,Lo}</div></div><div><div></div><div>b</div></div><div><div>S_{PO4}</div><div>S_{PO4}</div></div></div></div><p>PHA lysis:</p><div><div><div><div>Ox</div><div>Ax</div><div>An</div></div><div><div>g. UCTPHO+</div></div></div><div><div><div><div>X_{PAO_Stor}</div><div></div></div><div><div></div><div></div></div><div><div>XC_B</div></div></div></div><div><div><div><div>Ox</div><div>Ax</div><div>An</div></div><div><div>b. Barker & Dold</div><div>c. ASM2d</div></div></div><div><div><div><div>X_{PAO_Stor}</div><div></div></div><div><div></div><div></div></div><div><div>S_{VFA}</div></div></div></div></div></div></div>	<div><div><div><div>Ox</div><div>Ax</div><div>An</div></div><div><div>e. ASM3 + BioP</div></div></div><div><div><div><div>X_{PAO_Stor}</div><div></div></div><div><div>1</div><div>S_{O2}</div><div>1/i_{NOx,N2}</div><div>S_{NOx}</div></div><div><div><div>Ox</div><div>Ax</div></div><div><div></div><div></div></div><div><div>S_{N2}</div><div>1/i_{NOx,N2}</div></div></div></div></div></div>
<p>PolyP lysis:</p> <p>b, g:</p> $m_{PAO} \cdot \left\langle \frac{M(S_{O_2})}{IM(S_{O_2}) \cdot M(S_{NOx})} \right\rangle \cdot \left\langle \frac{X_{PAO,PP,Lo} / X_{PAO}}{X_{PAO,PP,Hi} / X_{PAO}} \right\rangle \cdot X_{PAO}$ <p>c: $b_{PP_PAO} \cdot X_{PAO,PP}$</p> <p>e: $b_{PP_PAO} \cdot \left\langle \frac{M(S_{O_2})}{\eta_{bPP_PAO} \cdot IM(S_{O_2}) \cdot M(S_{NOx})} \right\rangle \cdot X_{PAO,PP}$</p> <p>PHA lysis:</p> <p>b: $m_{PAO} \cdot \left\langle \frac{M(S_{O_2})}{IM(S_{O_2}) \cdot M(S_{NOx})} \right\rangle \cdot \frac{X_{PAO,Stor}}{X_{PAO}} \cdot X_{PAO}$</p> <p>c: $b_{Stor_PAO} \cdot X_{PAO,Stor}$</p> <p>g:</p> $m_{PAO} \cdot \left\langle \frac{M(S_{O_2})}{IM(S_{O_2}) \cdot M(S_{NOx})} \right\rangle \cdot M(S_{NHx}) \cdot M(S_{PO4}) \cdot \frac{X_{PAO,Stor}}{X_{PAO}} \cdot X_{PAO}$	$m_{PAO,Stor} \cdot \left\langle \frac{M(S_{O_2})}{\eta_{mPAO,Stor} \cdot IM(S_{O_2}) \cdot M(S_{NOx})} \right\rangle \cdot X_{PAO,Stor}$