

# Mass balance-based plant-wide wastewater treatment plant models – Part 3: Biodegradability of activated sludge organics under anaerobic conditions

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## Abstract

From an experimental and theoretical investigation of the continuity of activated sludge organic (COD), inorganic and N compounds along the link between the fully aerobic or N removal activated sludge (AS) and anaerobic digestion unit operations, it was found that the unbiodegradable particulate organics originating from the influent wastewater and generated by the activated sludge endogenous process, as determined from the response of the activated sludge system, are also unbiodegradable under anaerobic digestion conditions. This means that the activated sludge biodegradable organics that can be anaerobically digested can be calculated from the active fraction of the waste activated sludge with the well-established stoichiometric and kinetic constants in steady state and dynamic simulation models. This research shows that the mass balance-based steady state activated sludge, aerobic digestion and anaerobic digestion models provide internally consistent and externally compatible elements that can be coupled to produce plant-wide steady state and dynamic simulation WWTP models.

**Keywords:** wastewater treatment, activated sludge, biodegradability, anaerobic digestion, model validation

## List of abbreviations

AD	anaerobic digestion
ADMI	Anaerobic Digestion Model No. 1
AerD	aerobic digestion
Alk	alkalinity with respect to the $H_2CO_3^*$ reference species
ADWF	average dry weather flow
AS	activated sludge
ASM1,2,3	Activated Sludge Models No. 1, 2 or 3
BEPR	biological excess phosphorus removal
BNR	biological nutrient removal
C	carbon
°C	degrees Centigrade
Ca	calcium
COD	chemical oxygen demand
d	day
Eq	equation
FSA	free and saline ammonia
H	hydrogen
ISS	inert suspended solids
K	potassium
ℓ	litres
Mg	magnesium
N	nitrogen
ND	nitrifying - denitrifying
NDBEPR	nitrifying - denitrifying biological excess phosphorus removal
O	oxygen
OHO	ordinary heterotrophic organism
OP	ortho-phosphorus

OrgN	organic nitrogen
OTR	oxygen transfer rate
OUR	oxygen utilisation rate, subscripts c, n and t denote carbonaceous, nitrification and total
P	phosphorus
PAO	phosphorus accumulating organism
pH	negative log of the hydrogen ion activity
PS	primary sludge
PST	primary settling tank
Q	flow
R	hydraulic retention time or sludge age for anaerobic digester
RBCOD	readily biodegradable COD
SBCOD	slowly biodegradable COD
SOUR	specific oxygen utilisation rate (mgO/(gVSS.d). Subscripts c, n and t denote carbonaceous, nitrification and total.
SS	settleable solids
TKN	total Kjeldahl nitrogen
TP	total phosphorus
TSS	total suspended solids
V	volume
VFA	volatile fatty acids
VSS	volatile suspended solids
VS	volatile solids
WAS	waste activated sludge
WW	wastewater
WWTP	wastewater treatment plant

## List of symbols

$b_{rT}$ , $b'_{rT}$	OHO endogenous respiration and death rates (/d). Additional subscripts T and 20 denote rates at T and 20°C
$f_{av}$ , $f_{at}$	OHO fraction of AS with respect to VSS and TSS. Additional subscripts i or e denote aerobic digester influent or effluent.

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