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

GA Ekama*, SW Sötemann and MC Wentzel
Water Research Group, Department of Civil Engineering, University of Cape Town, Rondebosch 7701, Cape, South Africa

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
ADM1 Anaerobic Digestion Model No. 1
AerD aerobic digestion
Alk alkalinity with respect to the H\textsubscript{2}CO\textsubscript{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
\ell 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
\( b_{\text{H}} \) \( b'_{\text{H}} \) OHO endogenous respiration and death rates (/d). Additional subscripts T and 20 denote rates at T and 20°C
\( f_{\text{av}} \) \( f_{\text{at}} \) OHO fraction of AS with respect to VSS and TSS. Additional subscripts i or e denote aerobic digester influent or effluent.

* To whom all correspondence should be addressed.
\( \text{+2721 650 2588; fax: +27 21 689 7471;} \)
e-mail: ekama@ebe.uct.ac.za

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