

Mass balance-based plant-wide wastewater treatment plant models – Part 4: Aerobic digestion of primary and waste activated sludges

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Abstract

From a theoretical investigation of the continuity of wastewater organic (COD) and N compounds along the links connecting the primary settling tank (PST), fully aerobic or N removal activated sludge (AS) treating raw and settled wastewater and aerobic digestion unit operations, it was found that the PS characteristics, viz. the biodegradable and unbiodegradable soluble and particulate COD and N concentrations, need to be calculated from mass balances around the PST so that the organic and N concentrations conform to continuity principles. Also, it can be accepted that the influent wastewater (fixed) inorganic suspended solids (ISS) concentration is conserved through the primary settling tank, activated sludge, aerobic digestion systems. However, the measured ISS flux at different stages through a series of wastewater treatment plant (WWTP) unit operations is not equal to the influent ISS flux because the OHO biomass contributes to the ISS flux by differing amounts depending on the active fraction of the VSS solids at that stage. The steady state activated sludge and aerobic digestion models, both modified to include the inorganic suspended solids (ISS) and the latter to include aerobic digestion of primary sludge, yielded virtually identical results as Activated Sludge Model No 1 (ASM1), also modified to include the ISS. This research shows that the mass balance-based steady state activated sludge and aerobic digestion models, modified to include the ISS compound, can be coupled to produce a plant-wide WWTP model for aerobic stabilisation of sludge that can be used for design and operation and checking of simulation model results.

Keywords: wastewater treatment, primary sludge, waste activated sludge, aerobic digestion, model validation

List of abbreviations

AD	anaerobic digestion	O	oxygen
ADM1	Anaerobic Digestion Model No. 1	OHO	ordinary heterotrophic organism
AerD	aerobic digestion	OP	ortho-phosphorus
Alk	alkalinity with respect to the $H_2CO_3^*$ reference species	OrgN	organic nitrogen
ADWF	average dry weather flow	OTR	oxygen transfer rate
AS	activated sludge	OUR	oxygen utilisation rate, subscripts c, n and t denote carbonaceous, nitrification and total
ASM1,2,3	Activated Sludge Models No. 1, 2 or 3	P	phosphorus
BEPR	biological excess phosphorus removal	PAO	phosphorus accumulating organism
BNR	biological nutrient removal	pH	negative log of the hydrogen ion activity
C	carbon	PS	primary sludge
°C	degrees Centigrade	PST	primary settling tank
Ca	calcium	Q	flow
COD	chemical oxygen demand	R	hydraulic retention time or sludge age for anaerobic digester
d	day	RBCOD	readily biodegradable COD
Eq	equation	SBCOD	slowly biodegradable COD
FSA	free and saline ammonia	SOUR	specific oxygen utilisation rate (mgO/(gVSS.d). Subscripts c, n and t denote carbonaceous, nitrification and total.
H	hydrogen	SS	settleable solids
ISS	inert suspended solids	TKN	total Kjeldahl nitrogen
K	potassium	TP	total phosphorus
ℓ	litres	TSS	total suspended solids
Mg	magnesium	V	volume
N	nitrogen	VFA	volatile fatty acids
ND	nitrifying - denitrifying	VSS	volatile suspended solids
NDBEPR	nitrifying - denitrifying biological excess phosphorus removal	VS	volatile solids
		WAS	waste activated sludge
		WW	wastewater
		WWTP	wastewater treatment plant

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