

The use of simultaneous chemical precipitation in modified activated sludge systems exhibiting biological excess phosphate removal

Part 7: Application of the IAWQ model

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Abstract

The IAWQ Activated Sludge Model (ASM) No. 2 is a kinetic-based model and incorporates two simple processes for chemical precipitation and redissolution that are readily integrated with biological processes for carbon, nitrogen and phosphorus removal. This model was applied to experimental data collected as part of this study from parallel pilot-scale 3-stage Phoredox systems with and without simultaneous dosing of chemical precipitant. The precipitants tested were alum, ferric chloride and ferrous-ferric chloride. The model was calibrated to the control unit (without precipitant addition) in order to match effluent phosphate (P) predictions (and hence P removal) as closely as possible. The same calibration was then applied to modelling the test unit (with precipitant addition). It was found that the default model input stoichiometry for the precipitation reaction (ideal 1:1 molar ratio of metal ion (Me) to P) was suitable for ferric chloride addition at a 20 d sludge age, but did not accurately reflect the test system behaviour for all experimental periods. A lower stoichiometry (0.60 to 0.75) was required for alum at a 20 d sludge age, and for a blend of predominantly ferrous chloride at a 10 d sludge age. The input stoichiometry was further decreased under P-limiting conditions. A simple approach to, and possible reasons for, the manipulation of the model stoichiometry are discussed in the light of observed stoichiometry from system P removal and fractionation data collected as part of this study. Furthermore, an alternative approach based on manipulation of the precipitation (and hence redissolution) kinetic constant is suggested and evaluated using available experimental data. Model predictions and observed data in respect of polyphosphate (polyP) and suspended solids are also compared and discussed. It is concluded that the ASM No. 2 model provides a useful basis for modelling simultaneous P precipitation, provided certain minor modifications are made. Further investigation into the kinetics of the precipitation process(es) is recommended, particularly in relation to the effect of system sludge age. The model lends itself to further enhancement by incorporating additional physico-chemical processes.

Nomenclature

D	Delta, meaning "difference in" or "change in" (e.g. DP_{rem})	Me	General symbol for metal trivalent ions
m_{AUT}	Maximum specific growth rate of the autotrophs (nitrifiers), d^{-1}	MeOH	Metal hydroxide e.g. $Fe(OH)_3$
AE1 or 2	Aerobic zone or reactor (1 st or 2 nd)	MeP	Metal phosphate or metal hydroxy phosphate (depends on stoichiometry)
BEPR	Biological excess P removal	orthoP	Orthophosphate
COD	Chemical oxygen demand	O_t	Oxygen uptake rate (in $mg/[l-h]$)
C_{TKN} or N _{ti}	Influent TKN concentration	P	Phosphate
C_{TP} or P _{ti}	Influent total P concentration	PHA	Polyhydroxy-alkanoate (organic storage products of PAOs)
f_{ac}	Fraction of RBCOD which is acetate (i.e. $S_A/(S_A + S_F)$)	polyP	Polyphosphate
f_{bs}	Fraction of (influent) biodegradable COD which is readily biodegradable	P_{rem}	Total P concentration removed
f_{up}	Fraction of (influent) total COD which is unbiodegradable particulate COD (X_p)	RBCOD	Readily biodegradable soluble COD in the influent
f_{us}	Fraction of (influent) total COD which is unbiodegradable soluble COD (S_p)	rem	Removal/removed
IAWQ	International Association on Water Quality (now International Water Association, IWA)	S_A	Fermentation products as acetate concentration (together with S_F makes up the RBCOD)
I_{NSI}	N content of unbiodegradable soluble COD (S_p)	SD	Sample standard deviation
ISS	Inorganic suspended solids	S_F	Fermentable substrate concentration (RBCOD which can be converted to acetate)
k_{PRE}	Kinetic (rate) constant for precipitation in IAWQ model	S_1	Soluble unbiodegradable COD concentration
k_{DIS}	Kinetic (rate) constant for redissolution in IAWQ model	S_{NH4}	Soluble ammonia concentration
		S_{NO3}	Soluble nitrate concentration
		S_{PO4}	Soluble orthoP concentration
		S_{TCOD} or S_{ti}	Influent (total) COD concentration
		S_{TKN}	Soluble TKN concentration
		TKN	Total Kjeldahl nitrogen
		Total P	Total phosphate concentration
		TSS	Total suspended solids
		VSS	Volatile suspended solids
		WWW	Wastewater works

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Received 14 November 2000.