Integrated biological, chemical and physical processes kinetic modelling Part 1 – Anoxic-aerobic C and N removal in the activated sludge system

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Abstract

The biological kinetic Activated Sludge Model No. 1 (ASM1, Henze et al., 1987; Dold et al., 1991) for carbon (C) and nitrogen (N) removal is integrated with the mixed weak acid/base model of Musvoto et al. (1997, 2000a,b,c) to extend application of ASM1 to situations where an estimate for pH is important. Because chemical precipitation is generally not significant when treating municipal wastewaters for C and N removal, only gas and liquid phase processes were considered for this integrated model. The biological processes in ASM1 were modified to take into account the effect of the interaction of the weak acid/base species of the ammonia, carbonate and phosphate systems and pH on heterotrophic and autotrophic organism behaviour, which includes generation and utilisation CO_2 in metabolism, use of specific weak acid/base species for organism growth and generation and utilisation of H^+. With these modifications, simulations with the model were compared with those of ASM1 and experimental data in the literature; a good correlation was obtained. However, these comparisons are only a preliminary validation, because, despite their inclusion, the weak acid/bases and pH do not have a significant effect on the biological processes in the cases considered (i.e. well buffered wastewater). A difficulty in calibrating this model is selection of the k_{LA} value for the aeration system, which affects the pH in the anoxic and aerobic reactors through CO_2 gas exchange. Aerobic reactor outflows from two full-scale wastewater treatment plants with fine bubble aeration systems were found to be around 20% supersaturated with CO_2. The performance of a ND activated sludge system with low influent alkalinity is evaluated.

Keywords: Activated sludge, weak acid/base chemistry, integrated modelling, N removal

Abbreviations

ACP	Amorphous calcium phosphate
ADL	Anaerobic digester liquor
Alk	Alkalinity
ANO	Autotrophic nitrifier organism
AS	Activated sludge
ASim	A computer simulation programme for NDBEPR systems (Gujer, 1998)
ASM1 &2d	Activated Sludge Models No. 1 and 2d
ATP	Adenosine triphosphate
BA	Biological activated sludge processes name prefix
BEPR	Biological excess phosphorus removal
C	Carbon
CED	Chemical equilibrium dissociation
CIP	Chemical ion pairing
COD	Chemical oxygen demand
CP	Chemical/physical
CPB	Chemical/physical/biological
DO	Dissolved oxygen
IWA	International Water Association
IAWPRC	International Association for Water Pollution Research and Control (former IWA)
N	Nitrogen
ND	Nitrification/Denitrification
OHO	Ordinary heterotrophic organism
OUR	Oxygen utilisation rate
P	Phosphorus
pH	-ve log of the hydrogen ion (H^+) activity
PGE	Physical gas exchange
PMP	Physical mineral precipitation
RBCOD	Readily biodegradable COD
SBCOD	Slowly biodegradable COD
SBR	Sequencing batch reactor
SCFA	Short chain fatty acid
T	Temperature
TDS	Total dissolved solids
TKN	Total Kjeldahl nitrogen
TN	Total inorganic nitrogen (FSA+nitrate+nitrite)
TOC	Total organic carbon
UCTOLD	A computer simulation programme for ND AS systems (see Dold et al., 1991)
UCTPHO	A computer simulation programme for NDBEPR AS systems (see Wentzel et al., 1992 and Dold et al., 1991)
VSS	Volatile suspended solids
W	Watts

Symbols

b	Endogenous respiration/death rate of organisms. Subscripts A and H denote rates for ANOs and OHOs respectively
C_T	Total inorganic carbon
D_{LCO2}, D_{LO2}	Liquid phase molecular diffusion coefficient for CO_2 and O_2
f_E	Endogenous residue fraction of biomass
$f_{ZE,P}$	P content of endogenous residue fraction of OHOs
$f_{ZB,N}$	N content of the OHOs

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Received 11 January 2005; accepted in revised form 25 April 2005.