Filamentous organism bulking in nutrient removal activated sludge systems

Paper 10: Metabolic behaviour of heterotrophic facultative aerobic organisms under aerated/unaerated conditions

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Abstract

A model is outlined for the major biochemical respiratory mechanisms of a conceptualised heterotrophic facultative organism (representing the heterotrophic facultative mass of activated sludge) subjected to four different sets of conditions: steady-state aerobic, steady-state anoxic, steady-state aerobic changed to anoxic, and steady-state anoxic/anaerobic changed to aerobic. Proposals and implications of the model regarding changes between these conditions are tested experimentally and verified with special aerobic batch tests on sludges from IAND, 2RND, MUCT, continuous aerobic, and continuous anoxic systems fed municipal sewage.

List of symbols

BT	=	batch test
COD	=	chemical oxygen demand
cs	=	cysteine
cyt	=	cytochrome
DBT	=	denitrification batch test
DO	=	dissolved oxygen
e^-	=	electron
ETP	=	electron transport pathway
FAD	=	flavin adenine dinucleotide - oxidised
$FADH_2$	=	flavin adenine dinucleotide - reduced
FeS	=	iron sulphide
FMN	=	flavin mononucleotide
hs	=	histidene
IAND	=	intermittently aerated nitrification-denitrification
MLE	=	modified Ludzack-Ettinger
MUCT	=	modified University of Cape Town
NAD^+	=	nicotinamide adenine dinucleotide - oxidised
NADH	=	nicotinamide adenine dinucleotide - reduced
NO	=	nitric oxide
NO_2^-	=	nitrite
NO_3^-	=	nitrate
N_2	=	dinitrogen
N_2O	=	nitrous oxide
OUR	=	oxygen utilisation rate
RBCOD	=	readily biodegradable COD
SBCOD	=	slowly biodegradable COD
TCA	=	tricarboxylic acid
$\hat{\mu}_i$	=	nitrifier specific growth rate
$\hat{\mu}_m$	=	nitrifier maximum specific growth rate
2RND	=	two-reactor nitrification-denitrifcation

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Section I
A conceptual biochemical model

Introduction

In the nutrient removal activated sludge sewage treatment system, the microbial population is subjected to cycles of aerated and unaerated conditions. It can be assumed that the main portion of the microbial population that develops under such conditions will be the facultative heterotrophic organisms, which have a capacity for substrate utilisation under both aerated and unaerated conditions. Casey et al. (1999) presented a review of the biochemical respiratory pathways and mechanisms operative in heterotrophic facultative organisms under a variety of environmental conditions. The review established that a general similarity exists in biochemical pathway organisation between different facultative heterotrophic organism species. In a mixed culture such as activated sludge, these individual species are likely to give rise to a conjoined response which retains features commonly present in pure cultures but which may not be entirely representative of the response of any single species. In order to model the macroscopic behaviour of activated sludge it is necessary to conceptualise this conjoined response as that of a single surrogate heterotrophic facultative organism. It is the intention in this paper to develop a model for the respiratory biochemical mechanisms operative in such a conceptualised surrogate organism under aerated and unaerated conditions (and in changes between them), the biochemical mechanisms being based on those of individual species in pure culture.

Method for modelling aerobic and anoxic respiration by the conceptualised facultative heterotrophic organism

For the purposes of this model, the complexes which mediate proton and electron transport in the ETP and their arrangement about the cytoplasmic membrane can be conceptualised as illustrated in Fig. 2 of Casey et al. (1999). This ETP is a modification of that proposed by Ferguson (1982) for the facultative organism *Paracoccus* (*Pa.*) *denitrificans*, and incorporates the reduction of nitric oxide at nitric oxide reductase as an obligatory step. As