Filamentous organism bulking in nutrient removal activated sludge systems

Paper 8: The effect of nitrate and nitrite

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Abstract

The presence of nitrate (NO_3^-) and nitrite (NO_2^-) has a significant effect on the proliferation of low F/M filamentous organisms in nitrogen (N) and nutrient (N and phosphorus-P) removal activated sludge systems. In experiments in which the concentrations of NO_3^- and NO_2^- were manipulated in the 2nd anoxic reactor of a modified University of Cape Town (MUCT) nutrient removal system, either by addition of ammonium to the influent or by dosing NO_3^- or NO_2^- to the 2nd anoxic reactor, the extent of low F/M filamentous organism proliferation could be controlled, as measured by the diluted sludge volume index (DSVI). With a sufficiently high TKN/COD ratio (> 0.10 mgN/mgCOD) in the influent, or by dosing NO_3^- and NO_2^- at a level at which the denitrification potential of the anoxic zone was exceeded by the NO_3^- or NO_2^- load, the DSVI increased from values less than 100 mℓ/g to values greater than 150 mℓ/g in periods of between 3 and 5 sludge ages. It could not be determined which of NO_3^- or NO_2^- had the most significant effect on filament proliferation. While the stimulatory effect of the NO_3^- or NO_2^- passing into the aerobic zone on low F/M filamentous organism proliferation was positively identified, the mechanism by which this effect operated could not be established.

List of symbols

AA	=	anoxic-aerobic filament classification group
AVSS	=	active volatile suspended solids
COD	=	chemical oxygen demand
DSVI	=	diluted sludge volume index
F/M	=	food to micro-organism ratio
$f_{av,OHO}$)	=	the theoretical fraction of the VSS that is ordinary heterotrophic organisms (OHO)
$f_{S,up}$	=	wastewater unbiodegradable particulate COD fraction
IAND	=	intermittently aerated nitrification-denitrification
K_2 , K'_2	=	second (slow) rate of denitrification, in $mgNO_3^-$-N/(mgAVSS·d) in the primary anoxic reactor utilising SBCOD in ND and NDBEPR systems respectively
MLSS	=	mixed liquor suspended solids
MLVSS	=	mixed liquor volatile suspended solids
MUCT	=	modified University of Cape Town
ND	=	nitrification-denitrification
NDBEPR	=	nitrification-denitrification biological excess phosphorus removal
RBCOD	=	readily biodegradable COD
SBCOD	=	slowly biodegradable COD
TKN	=	total Kjeldahl nitrogen
VSS	=	volatile suspended solids
MLE	=	modified Ludzack-Ettinger

Introduction

From observations on the experimental investigation into various factors proposed as possibly being associated with low F/M filamentous organism bulking (Lakay et al., 1999), it was concluded that the exposure of sludge to alternating anoxic and aerobic conditions, combined with the presence of NO_3^- and/or NO_2^-, played a significant role in proliferation of these organisms. This conclusion was drawn from observations that experimental changes which resulted in significant increases and decreases in sludge settleability were accompanied by significant increases and decreases in the concentration of NO_3^- and NO_2^-, either in the anoxic zone or in the effluent. The reasons for this association were not clear. To determine more precisely the relationship between low F/M filament proliferation and the NO_3^-/NO_2^- concentration, experiments were conducted in which the NO_3^-/NO_2^- concentration in the system was manipulated by increasing the influent TKN/COD ratio by addition of ammonium (NH_4^+) to the influent (in the form of an ammonium chloride solution); and direct addition of NO_3^- and/or NO_2^- to the anoxic reactor of the system by drip feeding a concentrated solution of sodium nitrate or sodium nitrite directly to the anoxic reactor.

Preliminary tests

Effect of changes in influent TKN/COD ratio on low F/M filament proliferation

The effect on low F/M filament proliferation of changes in the TKN/COD ratio through the addition of ammonium to the influent was examined at laboratory-scale in two MUCT systems (referred to as MUCT1 and MUCT2), the design and operating parameters of which are given in Table 1.

Initially, the two systems had the same operating conditions, including the same anaerobic, anoxic and aerobic mass fractions, i.e. anaerobic:anoxic:aerobic; 3:10½: 6½ [*Note: The anoxic mass fractions (50 to 65%) employed in the N&P removal (MUCT) systems in these experiments are considerably larger than would be employed in practice. This is to ensure complete anoxic denitrification even for high TKN/COD ratios (0.12 mgN/mgCOD) encountered from time to time with the sewage batches fed to the*

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