

Filamentous organism bulking in nutrient removal activated sludge systems. Paper 6: Review, evaluation and consolidation of results

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Abstract

The finding that the selector effect did not control bulking by low food to micro-organism ratio (F/M) filaments, concluded this research direction that was considered to hold promise for controlling low F/M filament proliferation, and placed this research back into an exploratory phase. In this paper, the information collected so far in the research programme is *evaluated* together with that published in the literature, in order to delineate new research directions aimed at solving the low F/M filament bulking problem. In the conclusions, a framework is established that provided guidance for the subsequent research.

List of symbols

COD	=	chemical oxygen demand
d	=	day
DO	=	dissolved oxygen (mg O/l)
DSVI	=	diluted sludge volume index
F/M	=	food to micro-organism ratio
h	=	hour
K_s	=	half saturation coefficient (mgCOD/l)
min	=	minute
MUCT	=	modified UCT
N	=	nitrogen
P	=	phosphorus
RBCOD	=	readily biodegradable COD
SBCOD	=	slowly biodegradable COD
TSS	=	total suspended solids
UCT	=	University of Cape Town
VFA	=	volatile fatty acids
μ_H	=	maximum specific growth rate of heterotrophs (/d)
um	=	micro (10^{-6}) meter

Introduction

In the experimental research programme two approaches to bulking control in N and N & P removal systems were adopted: non-specific and specific. The non-specific control approach was evaluated because this approach is a useful emergency/temporary control measure, which can be quickly implemented and has a rapid effect. By following the procedure set out by Jenkins et al. (1984), chlorination was found to be successful for controlling the low F/M filament types 0092, *Microthrix parvicella* and type 0914 (Lakay et al., 1988). The DSVI was reduced from 230 ml/g to 48 ml/g over a period of 19 d and the biological N & P removal were not significantly adversely affected even at fairly high chlorine dosage rates [8 g Cl/(kg TSS-d)].

While successful, the problem with non-specific control methods is that they treat temporarily the symptoms of bulking but do not constitute a permanent cure - after dosing ceases the filaments inexorably regrow. With specific bulking control, the

causes for the proliferation of the filaments are sought. By eliminating these through waste-water characteristic or system modification, the bulking problems caused by specific filamentous organism types are cured permanently.

Surveys of South African N and N & P removal plants indicated that the six most frequently dominant filaments are 0092, 0675,0041, *M. parvicella*, 0914 and 1851 (Blackbeard et al., 1986; 1988). Four of these six filaments sort into the low F/M (or long sludge age) group of filaments. Interestingly although frequently dominant in laboratory-scale systems (Gabb et al., 1989) *Sphaerotilus natans* was not, and *Thiothrix* only rarely, identified as a dominant filament in South African full-scale plants.

Specific bulking control

The promoted specific bulking control method for low F/M filaments is system configuration modification so as to incorporate alternating or sequential feed-starve conditions into the system such as intermittent (batch) feeding; multi-reactor or plug flow conditions; or completely mixed systems including selector reactors (Jenkins et al., 1984). In the literature, it has been hypothesised that the mechanism whereby these systems apparently effect control over the low F/M filaments is that under high readily biodegradable COD (RBCOD) concentrations the floe formers have, or develop, a higher rate of RBCOD utilisation than the filamentous organisms and hence preferentially remove available RBCOD from the filamentous organisms. A sludge in which a high RBCOD uptake rate has been stimulated, is said to have acquired a "selector effect". This mechanism for controlling the low F/M filaments, and the systems in which they develop was investigated and described in Still et al. (1996); Ekama et al. (1996); and Gabb et al. (1996a; b). In this paper the conclusions and implications that emerged from this work are summarised and compared with other research conducted elsewhere.

1 Selector effect is stimulated under alternating feed-starve conditions under aerobic or anoxic conditions

The alternating feed-starve conditions imposed by intermittent feeding (once daily) to completely mixed reactor systems (batch fed), either fully aerobic or anoxic-aerobic; and aerobic selector reactors incorporated in continuously fed completely mixed systems,

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