A review of the potential application of non-specific activated sludge bulking control

J van Leeuwen
Division of Water Utilisation, Dept. of Chemical and Environmental Engineering, University of Pretoria, Pretoria 0002, South Africa

Abstract

Filamentous bulking occurs in most biological nutrient removal activated sludge plants. The sludge mass becomes extremely voluminous, difficult to settle and has poor thickening and dewaterability properties. An analysis of the situation in six typical South African nutrient removal plants indicated that the cost of additional settling capacity, to accommodate the bulking sludge, amounts to 1,5 c/m^3 of sewage treated in 1991 replacement amortisation cost terms. The additional retention period in the secondary settlers promotes phosphate release and denitrification with subsequent sludge floating and carry-over into the effluent. The larger waste sludge volumes and poor dewaterability result in an additional cost of 0,9 to 3,7 c/m^3 in 1991 terms. Oxidants are effective as a non-specific bulking control measure and obviate the need for additional settling and sludge thickening and dewatering capacity. Chlorination will add about 5 cm/m^3 to the cost of sewage treatment, but also affects nutrient removal detrimentally. Hydrogen peroxide dosing will cost 10,5 c/m^3 of sewage treated and does not interfere with the nutrient removal processes. Ozonation costs about 3,3 c/m^3, does not disturb nutrient removal and can lead to an improvement in effluent quality. Since amortisation contributes the major fraction of ozonation costs, less than full utilisation of the capacity increases cost, e.g. if the equipment is only used 25% of the time, ozonation costs increase to 8,7 c/m^3 of sewage treated.

Introduction

Filamentous bulking is a problem in most biological nutrient removal activated sludge plants. According to a survey by Blackbeard et al. (1988), about three-quarters of these plants as operated in South Africa had diluted sludge volume indices (DSVI) > 150 ml/g. The total extended bacterial filament length in a gram of sludge can, under these circumstances, exceed 30 km (Lee et al., 1983). The filaments form weblike structures extending into the bulk liquid leading to a diffuse floc structure and bridging between the flocs (Ekama and Marais, 1984). The sludge mass becomes extremely voluminous and difficult to settle.

Sludge bulking can also have wider implications than difficult secondary settling. Low settleability may result in poor effluent quality due to a high solids carry-over from the secondary settlers. The high effluent solids can be ascribed to incomplete settling as well as anoxic conditions developing in the settler due to sludge accumulation. Denitrification occurs and the resulting nitrogen bubbles cause sludge particles to float. The poorly compacted sludge results in excessive waste sludge volumes usually with poor thickening properties with respect to gravity settling and dissolved air flotation (Bratby, 1977) and poor dewaterability in centrifuges and belt presses (Osborn et al., 1986).

Bulking is clearly a serious and costly problem and its prevention or amelioration is certainly worth investigating. Among the various possiblities, control of the growth of filamentous bacteria with chemicals, particularly the oxidants chlorine, hydrogen peroxide and ozone, looks feasible and attractive. This article is aimed at investigating the practical and cost implications of chemical bulking control.

Background

Bulking can be due to a variety of organisms, but in the case of biological nutrient removal plants bulking is mainly caused by 14 different filamentous bacteria (Eikelboom and Van Buÿsen, 1983). The five main filamentous bacteria dominating South African nutrient removal plants, according to a comprehensive survey by Blackbeard et al. (1988) are *Type 0092* - dominant in 82% of plants, *Type 0675, Type 0041, Microthrix parvicella* and *Type 0914.* The first four are classified by Jenkins et al. (1984) as typical in plants with a low food to micro-organism (F/M) ratio, while *0041* and *M. parvicella* are also associated with other nutrient deficiencies.

Blackbeard et al. (1988) suggest that *0914* should also be classified as a low F/M ratio organism. All these filaments are slow growers compared with floc-forming bacteria, but have the competitive edge under food or nutrient limiting conditions; probably due to their much larger surface to mass ratio through which they are more effectively able to absorb these substances essential for growth.

The growth of filamentous bacteria may, according to Lakay et al. (1988), be controlled by either:

- specific measures or
- non-specific measures.

Specific control measures are aimed at eliminating or circumventing the conditions which preferentially favour the growth of filaments. Chudoba et al. (1973) had some success with selector reactors ahead of the main plant where high F/M ratios ensure that floc-formers outgrow filaments. This approach is not practical in nutrient removal processes since selectors have no effect on bulking (Gabb et al., 1989). Some filaments, notably *M. parvicella* proliferate competitively under low dissolved oxygen concentrations and can be disadvantaged by increasing dissolved oxygen levels (Osborn et al., 1986; Barnard and Hoffmann, 1986). Some filaments, particularly *M. parvicella* and *Nocardia* concentrate in foam and actually cause the foam. Selective removal of foam (Jenkins et al., 1984; Hart, 1985; Pretorius and Laubscher, 1987) avoids foam build-up and could serve to keep the population of the particular filament at lower levels.

Non-specific bulking control involves the inhibition of the growth of filamentous organisms by the addition of chemicals, usually oxidants such as chlorine, hydrogen peroxide or ozone. It

Received 13 August 1991; accepted in revised form 2 December 1991.