Isolation and cultivation of filamentous bacteria implicated in activated sludge bulking

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Abstract

Filamentous bacteria have long been associated with activated sludge bulking and foaming and are known to be the main cause of this problem. Chemical control methods such as chlorination and the use of hydrogen peroxide have been, and still are, used to cure bulking and foaming but are only effective as interim measures. More detailed understanding of the physiology and biochemistry of filamentous bacteria is still required for effective long-term control of bulking and foaming. Isolation and cultivation of filamentous bacteria in pure culture have shown promise as methods to gaining better understanding of bulking and foaming. The aim of this project was, therefore, to assess different techniques for effective isolation and cultivation of filamentous bacteria in pure culture. Activated sludge samples from Durban and surrounding areas were screened microscopically to identify constituent filamentous bacterial populations. Samples with varieties of different filamentous bacteria were subjected to various floc break-up procedures (nonidet surfactant treatment, sonication and cellulase hydrolysis) in conjunction with physical separation (centrifugation) to separate filamentous bacteria from floc-forming bacteria. Both treated and untreated samples were serially diluted and plated onto a variety of different solid media, whereafter discrete bacterial colonies were isolated and screened microscopically for filamentous morphology. Cellulase hydrolysis proved unsuccessful for filament isolation while direct inoculation, nonidet pretreatment and sonication resulted in the isolation of five different filaments, one via sonication and two each via the other methods. The filaments were provisionally identified as Sphaerotilus natans, Microthrix parvicella, Type 1863, Type 0092 and Haliscomenobacter hydrossis.

Keywords:

Introduction

The activated sludge process has found vast application as an effective means of wastewater treatment. Due to public concern about environmental protection, and its (the public's) increasing exposure to pollution and subsequent consequences, an extensive re-evaluation of existing wastewater management concepts has come about (Orhon and Artan, 1994). The objective of the activated sludge process is to remove soluble and insoluble organics from the wastewater and to convert this material into a flocculent microbial suspension that settles well in a conventional gravity clarifier. As a general rule, the nature of the wastewater will dictate the preferred process modifications, primarily for the purpose of maintaining mixed liquor settling quality (Eckenfelder and Musterman, 1995). Basically, activated sludge comprises a microbiological enrichment culture consisting of a mixed, and largely uncontrolled, consortium of micro- and macro-organisms that remove wastewater inorganics and organics and transform them into environmentally acceptable forms (Richard, 1989).

It is important to maintain the growth of floc-forming bacteria on wastewater organics, which will settle under gravity in the final clarifier so as to obtain or sustain a clarified supernatant (final effluent) and a thickened return sludge. However, not all bacteria in the activated sludge process are floc-formers. Many different types of filamentous bacteria have been identified in activated sludge and play important roles in wastewater treatment. Filamentous bacteria directly affect sludge settling as they make provision for the rigid support network or backbone upon which

** +2731 204 2346; fax: +2731 204 2778; e-mail: GavinD@dit.ac.za Received 13 December 2002; accepted in revised form 29 August 2003. floc-forming bacteria can adhere and grow into suitable activated sludge flocs (Richard, 1989). Filamentous bacteria may be considered detrimental to wastewater treatment when they occur in excessive quantities (sludge bulking), but are just as important in the development of activated sludge flocs with proper settling and clarification properties (Gerardi et al., 1990). Filamentous microorganisms can also be good indicators of conditions prevailing in an activated sludge system on a microbiological level. The indications given by the filamentous bacteria could be of low dissolved oxygen (DO) (e.g. Sphaerotilus natans), low food-to-micro-organism (F/M) ratio (e.g. Microthrix parvicella, Type 0092), presence of septic waste (e.g. Thiothrix spp.), nutrient deficiency (e.g. Haliscomenobacter hydrossis) and low pH in the system (e.g. fungi) (Jenkins et al., 1986).

Since the introduction of continuous-flow reactors, sludge bulking has been one of the major problems affecting biological waste treatment (Slykes, 1989 as cited by Bitton, 1999). A bulking sludge may be defined as one which settles and compacts slowly due to proliferation of filamentous organisms and resultant interfloc bridging, which in turn produces sludge with a poor settling rate (Richard, 1989). Two toxicants, chlorine and hydrogen peroxide, have been used to selectively kill filamentous organisms and therefore alleviate symptoms of activated sludge bulking (Jenkins et al., 1986). Chlorination is however, a last resort in the control of bulking. It should only be contemplated when effluent from the bulking plant is likely to cause environmental damage to the receiving water. If used correctly it provides a rapid alleviation of bulking, but, if used incorrectly may completely inhibit all treatment (Horan, 1990). The formation of foams or scums, on the surface of activated sludge aeration basins and secondary clarifiers, has also been ascribed to the possible presence of undegraded surfactants in the aeration basin and the presence of large numbers

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