Operation of anaerobic digesters at increased solids concentrations

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Abstract

Conventional anaerobic digesters treating municipal sewage usually function with a hydraulic retention time of 30 to 60 d and at a total solids (TS) concentration of 1.5 to 3% (m/v). A cross-flow microfiltration unit was constructed at Northern Waste Water Treatment Works, Durban to concentrate sludge from a conventional anaerobic digester and to facilitate operation with a higher solids concentration. Semi-continuous digesters were, therefore, operated with a 30 d retention time and at an optimum temperature to investigate the efficacy of digesters supplied with concentrated digested sludge. The results showed that the rate of gas production from a digester supplied with 3.8% (m/v) TS was higher than the control (2% (m/v) TS) and a digester supplied with 3% (m/v) TS. Increased total solids concentrations (4.7% (m/v)), however, effected slightly lower gas production rates than the digester with 3.8% (m/v) TS. The volatile solids concentrations of all four digesters were similar, indicating neither favourable nor unfavourable effects from increased solids concentrations. The digesters operated at total solids concentrations 3.8% (m/v) TS produced higher concentrations of volatile acids than the control. The alkalinity concentrations (ca. 4 000 mg.1-[1]) were similar for all four digesters.

Introduction

For waste stabilisation, the anaerobic digestion process has several advantages over aerobic treatment. These include a significantly lower operating cost and sludge production rate per kilogram of organics oxidised, the potential for chemical energy production through methane and the generation of a sludge which is relatively odour-free and easy to dewater. The process is, however, limited by a low bacterial growth rate which, until fairly recently, has restricted the use of the process for the treatment of low volume streams such as raw sewage sludge (Malina, 1992; Treffry-Goatley et al., 1986).

In anaerobic digestion the methanogens are the slowest growing population and are also the most significant group with regard to waste stabilisation (Song et al., 1992).The generation times for methanogens range from less than 2 d to more than 20 d at 35°C (Malina, 1992; Lettinga and Hulshof Pol, 1991). Solids retention time (SRT) is recognised as a key parameter for successful design and operation of an anaerobic digester because it most accurately expresses the relationship between the catabolic bacterial population and the operating conditions (Pfeffer, 1968; Parkin and Owen, 1986). Zhang and Noike (1991) showed that a decrease in the solids retention time in an acidogenic reactor resulted in the washout of the methanogens utilising acetic acid, formic acid and methanol while the population sizes of the hydrogenotrophs, such as the hydrogen-utilising methanogens, homoacetogens and sulphate-reducing bacteria increased rapidly, with no washout apparent.

The degree of waste stabilisation is a function of retention time, waste characteristics and operating conditions (Pfeffer, 1968; Parkin and Owen, 1986). The more time the sludge spends in the digester in the presence of active biomass, the greater the volatile solids destruction. The volatile solids content controls the rate and volume of gas production. In conventional anaerobic digesters, volatile solids conversion to gaseous products and solids retention time is controlled by the hydraulic retention time and typical hydraulic retention times are 15 to 20 d (Pfeffer, 1968; Malina, 1992; Ouyang and Lin, 1992). The design criteria for anaerobic digesters must, therefore, take the time-dependency factor of volatile solids destruction into consideration (Malina, 1992; Lettinga and Hulshoff Pol, 1991).

Therefore, the ability to thicken sludge becomes an important design and operating consideration since, in the absence of thickening, digester loadings are limited. With thickened sludge the high solids loading reduces the operating digester volume for a given retention time (Malina, 1992). It is possible to increase the solids retention times (mean cell retention time) by accumulating biomass within the reactor by means of settling/concentrating, attachment to solids or by recirculation. Therefore, these systems are designed to facilitate the retention of slow-growing micro-organisms (especially the methanogens) by ensuring that the mean solids residence time becomes much longer than the mean hydraulic residence time (Malina, 1992; Lettinga and Hulshof Pol, 1991; Ouyang and Lin, 1992). Such systems must also improve contact between the biomass and waste water to overcome problems of diffusion of substrates and products from the bulk liquid to the biofilms or granules, and enhance the activity of the biomass through adaptation and growth (Iza et al., 1991; Parkin and Owen, 1986).

The Renovexx cross-flow microfiltration (CFMF) process aims to improve anaerobic digestion by increasing the sludge concentration within the digester, thus effecting a higher biological solids retention time. This process should effect the retention of the active biomass which would otherwise be lost as a waste product (Bindoff et al., 1988). The Renovexx CFMF process operates by pumping slurry, tangentially, through a flexible woven fabric tube (25 mm dia.) under pressure, which causes the suspended matter to be deposited on the inside of the filter tube. The slurry permeates through the filter cake depositing more suspended matter and leaving a clear filtrate which is collected for additional processing. The concentrate is then recycled (Gosling and Brown, 1993; Pillay, 1991; Bindoff et al, 1988). This process operates on a high recycle and a low water recovery basis to produce a clear permeate, for return to the head of the works, and

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