Sludge granulation during anaerobic treatment of pre-hydrolysed domestic wastewater

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Abstract

The aim of this study was to examine sludge granulation during the anaerobic treatment of pre-hydrolysed municipal wastewater. The pretreated wastewater had a total chemical oxygen demand (CODt) of 432 ± 20 mg/l, a soluble COD (CODs) of 259 ± 8 mg/l, volatile fatty acids (VFA) of 101 ± 9 mg/l and suspended solids (SS) of 94 ± 12 mg/l. Prior to entering the digester, the influent was supplemented with sucrose, which increased the total and soluble COD by 300 mg/l. An upflow anaerobic sludge bed (UASB) digester was operated at different hydraulic retention times (HRT) ranging from 26.7 h to 2.2 h, while the organic load rate (OLR) ranged from 0.9 to 7.3 kgCOD/m^3·d. Sludge granulation was observed after day 150 of operation, at an HRT of 3.4 h, when small granules of less than 2 mm in size appeared. The granules had a weak structure and low density, with the specific methanogenic activity of the sludge being about 0.24 g CH_4-COD/gVSS·d. After granulation, the digester performance was 57% CODt removal and 76% CODs removal for steady state operation at an HRT of 3.4 h and an OLR of 5.6 kgCOD/m^3·d.

Nomenclature

COD:	Chemical oxygen demand ($_t$: total, $_s$: soluble).
HRT:	Hydraulic retention time
OLR:	Organic load rate
SS:	Suspended solids
VSS:	Volatile suspended solids
VFA:	Volatile fatty acids
CH_4-COD:	Methane expressed as COD
UASB:	Upflow anaerobic sludge bed (anaerobic digester)
HUSB:	Hydrolytic upflow sludge bed (anaerobic digester)
rCH_4:	Methane production rate

Introduction

Anaerobic digestion has become the most commonly used method for the treatment of medium- and high-strength effluents, due to the economy of the process and the low generation of surplus sludge. Different anaerobic technologies have been applied for the treatment of less concentrated effluents, such as domestic wastewater and some industrial effluents, providing good treatment efficiencies at low hydraulic retention times (Hickey et al., 1995). One of the digester designs used for anaerobic digestion is the UASB digester, because it achieves the best results in developing and maintaining a granular sludge.

Most of the studies concentrating on clarifying the granulation process were carried out with medium to high substrate concentrations and at mesophilic (30ºC to 38ºC) or thermophilic temperatures (Hulshoff Pol, 1989; Fang et al., 1994; Quarmby and Forster, 1995). Furthermore, treatment studies at ambient temperatures were carried out by using granular sludge as an inoculum, since there is a lack of available information on granulation in digesters treating diluted wastewater at ambient temperatures (Soto et al., 1997).

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Some low-strength wastewaters like domestic and municipal effluents contain significant amounts of both fats and SS, but complex carbohydrates and VFA are among the main organic constituents (Elefsiniotis and Oldham, 1994). Several factors, such as sludge flotation and inhibition due to the effect of fats and long-chain fatty acids, or the adsorption of finely dispersed colloidal matter on the surface of the sludge, may cause the granulation process to be difficult or the granular sludge to deteriorate (Sayed, 1987; Rinzema, 1988; Hawkes, 1995). In addition, low gradients of substrate concentration and reduced methanogenic activity at low temperatures could enhance the negative effects of these factors.

Given the contradictory results reported on the feasibility of sludge granulation treating these low-strength municipal wastewaters (Van der Last and Lettinga, 1992; Lettinga et al, 1993; Vieira et al., 1994; Ruiz et al., 1998), several granulation studies have been planned to be included as a part of a more extensive research project dealing with the anaerobic treatment of low-strength municipal wastewaters. A previous study by Soto et al (1997) reported the influence of temperature on the granulation process during the start-up of UASB digesters treating a dilute synthetic wastewater (500 mgCOD/l as sucrose) at mesophilic (30ºC) and psychrophilic (20ºC) temperatures. The results showed that the granulation process followed a similar pattern at both temperatures and complete granulation was achieved between 1 and 2 months after the start-up.

In this paper the results obtained during the start-up and granulation process in a laboratory-scale UASB digester treating a pre-hydrolysed domestic wastewater at ambient temperature (20ºC) supplemented with sucrose as a COD source (300 mg COD/l) in order to enhance granulation are reported.

Materials and methods

Anaerobic digester set-up and operation

The UASB digester was made of Plexiglas and had an active volume of 485 ml with an internal diameter of 35 mm, and a height of 420 mm. The digester was placed in a temperature-regulated