Lauter tun (brewery) waste in UASB systems - Feasibility, alkalinity requirements and pH control

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Abstract

Lauter tun (brewery) waste developed a pelletised sludge bed in a laboratory UASB reactor. Product formation along the line of flow in the bed was similar to that when treating a pure carbohydrate, apple juice waste. Virtually no H_2CO_3* alkalinity was present in the waste or generated by the process; the H_2CO_3* alkalinity required to buffer the minimum bed pH to 6,6 had to be supplied from an external source. On a flow-through UASB reactor with a base influent COD (COD_b) = 4 000 mg/l, the H_2CO_3* alkalinity requirement was 0,9 mg as $CaCO_3$ per mg COD_b. By imposing a recycle from the effluent to the influent, the H_2CO_3* alkalinity required per mg COD_b was reduced substantially. H_2CO_3* alkalinity (in the form of NaOH) was added to the recycle stream, not to the base influent flow. When added to the base influent flow the pH increased to 11 and, apparently, trace elements precipitated leading to partial failure of the process. When added to the recycle stream (recycle ratio 15:1) the pH downstream did not rise above 8,5 and the process operated satisfactorily. In a UASB system with a recycle, the H_2CO_3* alkalinity to be supplemented to maintain a near neutral minimum bed pH was assessed using the effluent H_2CO_3* alkalinity as reference parameter, not the influent H_2CO_3* alkalinity, to take into account any internally generated H_2CO_3* alkalinity. For a COD_b = 13 000 mg/l and a practical COD loading rate of 9 kg/(m^3 sludge bed-d), a recycle ratio as high as 22:1 reduced COD_b to an effective influent COD of 570 mg/l and did not significantly influence COD reduction (> 90 per cent) or effluent SCFA (about 50 *mg/l* as acetic acid).

Introduction

In reviewing parameters that influence anaerobic treatment systems, Moosbrugger et al. (1993a) noted that pH is one of the principal ones: for optimal treatment the reactor pH > 6,6. In anaerobic systems, "buffering agents" resist a decline in pH. In systems operating "normally", the carbonate weak acid/base is the dominant buffering agent; its buffering ("ability" to resist pH change) at any pH can be assessed via the parameter H_2CO_3* alkalinity (Loewenthal et al., 1989).

The H_2CO_3* alkalinity requirements to control the minimum reactor pH in upflow anaerobic sludge bed (UASB) systems differs for different types of substrates. Substrates can be divided into two basic categories:

- substrates that do not generate internal buffer and hence depend completely on buffer from an external source to control the minimum pH in the reactor; and
- substrates that generate internal buffer from, for example, influents containing proteins (deamination), sulphates (reduction to sulphides) and/or short-chain fatty acids (acetoclastic methanogenesis). These may cause that the anaerobic process becomes partially or completely independent of buffer from an external source for pH control.

This paper presents a study of the behaviour of a waste of the first category, i.e. a waste producing very little internal buffer, brewery lauter tun waste. In a further paper the behaviour of a waste in the second category will be presented.

In a brewery plant, there are a number of different waste streams generated from the bottling hall, cleaning of fermentation tanks, filter unit, wort kettle and lauter tun. Some of these waste streams, e.g. the wash water from the bottling hall, may contain substances inhibitory or toxic to anaerobic micro-organisms. In the particular brewery from which the waste batches were obtained, all the waste streams discharge to a central holding tank and from there, controlled discharge to a sewer. Of all the waste streams, that from the lauter tun contributes the main mass of COD generated in the brewing process. Lauter tun waste has a high carbohydrate content so that it has potential for treatment in a UASB system. Furthermore, in the particular brewery the lauter tun waste stream could be separated easily from the other waste streams, thereby avoiding the risk of interference from potentially inhibitory or toxic chemicals. Accordingly, the lauter tun waste stream was selected for study. The study was subdivided into two parts:

- Feasibility study of the treatment of this waste in a laboratory-scale UASB system, to ascertain formation of a pelletised sludge bed and to study the product formation pattern along the line of flow of the reactor.
- Investigation into the effects of recycling on system performance and mass of H_2CO_3* alkalinity required to maintain a near neutral minimum pH in the lower part of the sludge bed.

Feasibility study

Experimental set-up

A laboratory-scale UASB reactor was constructed from a transparent perspex cylinder of 94 mm diameter, 900 mm high, with a conically shaped inlet at the bottom and a solid/liquid/gas separator at the top, total reactor volume ca. 6,5 *I* (Fig. 1). The substrate was fed by means of a constant speed multi-channel peristaltic pump, the feed rate being controlled by an on/off timer. Gas collection was by means of a hollow inverted cone: Rising gas bubbles are deflected into the cone by a deflector collar around the inside wall of the reactor below the cone; liquid effluent discharges via an annular space between the gas collection cone and the reactor wall, to enter a small liquid/solid separator (1 000 *mi);* clarified liquid flows over a launder into the collection vessel while solids settle out and return into the reactor by gravity. Ten sample ports were installed evenly spaced up the

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