Two-phase anaerobic digestion of three different dairy effluents using a hybrid bioreactor

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Abstract

The South African dairy industry is a major water user and as a result has to reconsider current effluent treatment and disposal methods. The effluents from three dairy factories (cheese, fresh milk and milk powder/butter factories) were analysed and the chemical oxygen demand (COD), pH and effluent volumes were found to be highly variable over short time intervals during the daily production cycles. The pH was found to vary between 2.2 and 11.8 units and the COD values ranged from 800 to 15 000 *mg-l-'* over a period of 2 h. The average COD of the effluents emerging from the three factories varied between 1 908 and 5 340 *mg-l-*[1]. Significant differences were also found in the composition of the effluents from the three factories.

In this study, a mesophilic laboratory-scale hybrid bioreactor was used in conjunction with a pre-acidification step to treat the three dairy factory effluents. It was clear from the data obtained on the cheese, fresh milk and milk powder/butter waste waters that dairy effluents are suitable for treatment by means of the anaerobic digestion process and the use of a hybrid anaerobic bioreactor can be seen as a viable treatment option. The COD values of the three pre-digested dairy waste waters were reduced by between 91% and 97% at organic loading rates of between 0.97 and 2.82 kg COD m.3.d-[1] and subsequent methane yields varied from 0.287 to 0.359 m^3 CH_4-kg-[1]$COD_{removed}$(73 and 91% of the theoretical maximum yield) during anaerobic digestion. The pH values of all the digester effluents were >7.5 units. The data clearly indicated that anaerobic treatment of the different dairy effluents was successful and that this particular type of bioreactor would be suitable for the anaerobic treatment of dairy effluents. An important consequence of the data from this study is that a two-phase set-up will be required to protect the methanogens in the bioreactor from prohibitively low pH values and high VFA concentrations produced during the acidogenic phase. The two-phase system will allow pH control in the acidogenic phase should it be needed in a full-scale or pilot-scale treatment plant.

Introduction

Water is South Africa's most limiting natural resource and the dairy industry is considered to be a major water user. The Water Research Commission (1989) estimated the total annual water usage of the South African dairy industry to be 4.5 million m^3. Generally, between 75 and 95% of this "process water" is discharged as effluent. In order to contribute to water conservation in South Africa, the dairy industry has to seriously reconsider present effluent treatment and disposal methods and an efficient and cost-effective effluent treatment technology has to be developed.

In a recent survey (Strydom et al., 1993), it was reported that South African dairies were experiencing effluent-related problems. It was also found that dairies generally dispose of their effluents either to municipal sewage treatment works, or by means of irrigation onto pastures. Thus, dairy factories either run the risk of causing surface- or groundwater pollution, or they incur high financial costs for disposing of their effluents to nearby municipal sewage treatment works.

Anaerobic digestion, as an effluent treatment option, offers several benefits to the dairy industry (Anon., 1990; Strydom et al., 1995). Furthermore, successful treatment of dairy effluents not only offers pollution control in the short term, but can also serve as the starting point for the longer term development of a total water reuse biotechnology.

Since an anaerobic digester using a hybrid design was successfully used for the treatment of a synthetic dairy effluent (Strydom et al., 1995), the aim of this study was to evaluate the hybrid digester as an option for the treatment of waste waters from a cheese, fresh milk, and a milk powder/butter factory.

Materials and methods

Dairy factories

Cheesefactory

This factory handles up to 1601 of milk per day for the production of various hard cheeses, notably Gouda, Edam and Cheddar. The whey produced is evaporated and transported by tanker to other factories for spray drying. The general factory effluent consists of diluted products and wash water as well as the initial rinse water from the silos and tankers. Presently, the final effluent is irrigated onto approximately 45 ha of pasture.

Fresh milk factory

This factory produces mainly pasteurised milk, fruit juice blends, yoghurt and cottage cheese, and processes about 2301 of milk per day. The cottage cheese whey is included in the general factory effluent. The effluent passes through a fat trap before being discharged into the local municipal sewage treatment works.

Milk powder/butter factory

The milk powder/butter factory produces up to 40 t of butter per day. Roller-dried milk powder and buttermilk are also produced

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Received 27 June 1996; accepted in revised form 23 September 1996.