Influence of higher organic loading rates on the efficiency of an anaerobic hybrid digester while treating landfill leachate

C Myburg and TJ Britz*
Department of Microbiology, University of the Orange Free State, PO Box 339, Bloemfontein 9300, South Africa

Abstract

An anaerobic hybrid laboratory-scale digester was used to evaluate the treatment efficiency when using high strength landfill leachate at organic loading rates (OLR) of more than 20 kg COD m-3.d-'. The digester was operated at mesophilic temperatures and the hydraulic retention kept constant at 1,0 d. It was found that the digester can be used successfully to treat landfill leachate at higher OLRs and should be able to withstand loading shocks within specific values. The data showed that at an OLR of >24 kg C0D m^3 d-', a total COD removal of 88% can be obtained with a CH_4 yield of 0,237 m^3kg-' COD removed. At an OLR of 26,05 kg COD m'-d-^{1} the hybrid digester could reduce the COD of the leachate by 95% and more than 80% at a loading rate of 29,0 kg COD m-'-d-^{1}. The methane content of the biogas varied between 64% and 74%. Total methane yields per COD removed ranged between 0,215 and 0,230 m^3kg-' COD at OLRs of 26,05 and 29,0 kg m-^{3}d-' respectively. The poor propionic acid removal of 68% at COD concentrations of 29,0 kg COD m-3-d-' appeared to be an indication of digester overloading and impending digester failure.

Introduction

Landfill-site dumping is one of the oldest and most common methods of municipal waste disposal and dates back as far as 6 000 to 3 000 BC. Since it appears to be financially and technically the most viable solution, landfilling is likely to remain the commonest method to treat municipal waste. Landfills are really just large bioreactors that generate 2 types of products, leachate and biogas, from aerobic and anaerobic refuse catabolism.

The most important aspect that must be taken into consideration is the capacity of landfills to generate leachate and particular attention must be paid to the protection of surface and ground waters. Leachate is water which has percolated through emplaced refuse, carrying with it soluble compounds and transportable organic and inorganic materials as well as bacteria and viruses. These pollute soil and ground water and decrease their value for man and beast. Various field observations indicate that even small municipal landfills may impact ground water (Bagchi, 1987). South Africa, a semi-arid country with limited water resources, cannot afford to lose water by unnecessary pollution. In many parts of the United States no new natural-attenuation landfills are permitted, so as to prevent ground-water pollution. Since many of the newly constructed landfills are sealed at the bottom, especially in Germany, Italy and the UK, leachate becomes an even greater problem and must be removed for treatment by physical-chemical or biological methods (Stegmann, 1983).

The collection and treatment of leachate are now recognised as 2 of the greatest problems associated with the operation of landfi II sites. Anaerobic digestion is a promising possibility for the treatment of landfill leachate (Henry et al., 1987). Britz et al. (1990) found that a hybrid digester could reduce the chemical oxygen demand (COD) of leachate by 82% at a loading rate of 18,65 kg COD m-'d-^{1}.

The objective of this study was to evaluate the treatment efficiency of an anaerobic hybrid digester, when using a COD concentration of more than 20 kg COD m-'d-^{1}.

* To whom all correspondence should be addressed.
Received 9 February 1993; accepted in revised form 22 April 1993.

Materials and methods

Anaerobic digester

A laboratory-scale upflow anaerobic digester (hybrid) with a working volume of 5l was used in the study. The digester combined a fixed-film (an inert porous polyethylene foam fitted to the inside wall) and an upflow sludge blanket (Fig. 1). The leachate substrate was introduced continuously via a horizontal inlet at the base of the digester. Biogas exited at the top via a gas-solids separator and gas production was determined by means of an electronic gas-measuring system. The biogas volumes were corrected for standard temperature and pressure (STP) conditions. An operational temperature of 35°C was used and regulated by means of a heating tape

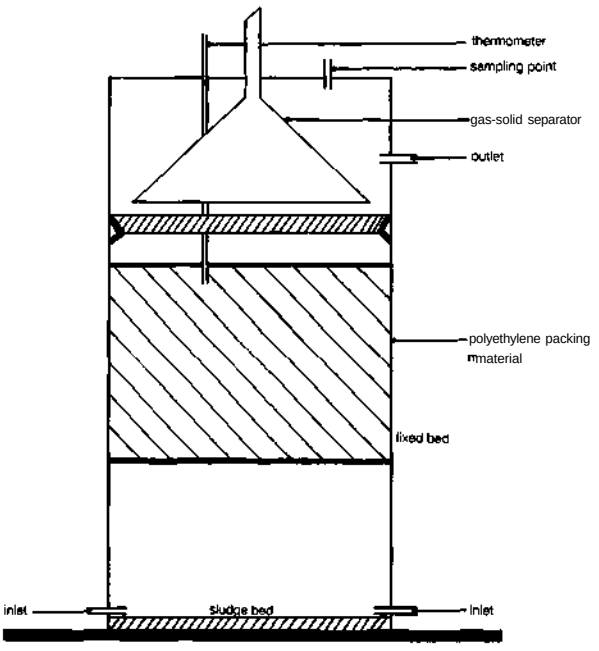

Figure 1
Laboratory-scale anaerobic hybrid digester