Hydrogen production from the organic fraction of municipal solid waste in anaerobic thermophilic acidogenesis: Influence of organic loading rate and microbial content of the solid waste

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HIGHLIGHTS

- We studied the hydrogen production from municipal solid waste.
- Different operating conditions were assayed in this study.
- Increasing organic loading rates resulted in an increase in hydrogen production.
- It is possible to treat solid waste within an optimal range for a liquid substrate.
- Microbial concentration in the reactor is influenced by the microbial content of the waste.

ABSTRACT

Hydrogen production (HP) from the organic fraction of municipal solid waste (OFMSW) under thermophilic acidogenic conditions was studied. The effect of nine different organic loading rates (OLRs) (from 9 to 220 g TVS/l/d) and hydraulic retention times (HRTs) (from 10 d to 0.25 d) was investigated. Normally, butyrate was the main acid product. The biogas produced was methane- and sulfide-free at all tested OLR. Increasing the OLR resulted in an increase in both the quantity and quality of hydrogen production, except at the maximum OLR tested (220 g TVS/l/d). The maximum hydrogen content was 57% (v/v) at an OLR of 110 g TVS/l/d (HRT = 0.5 d). HP was in the range of 0.1–5.7 l H2/l/d. The results have clearly shown that the increase in OLR was directly correlated with HP and microbial activity. The bacterial concentration inside the reactor is strongly influenced by the content of microorganisms in the OFMSW.

1. Introduction

The generation and management of waste is a serious environmental problem for modern societies. However, properly managed wastes become resources that contribute to savings in raw materials, conservation of natural resources and climate, and sustainable development. Hydrogen is currently considered one of the major energy carriers of the near future because it is clean, recyclable and efficient and can be used to generate electricity at the same time as not contributing to greenhouse-gas production. Several authors have studied its production by means of biological processes (Kapdan and Kargi, 2006; Valdez-Vazquez et al., 2005, 2006), including anaerobic acidification of MSW (Shin et al., 2004; Shin and Youn, 2005). A basic description of the anaerobic acidogenesis process includes three steps. In the first step (hydrolysis), complex organic polymers are hydrolyzed into simpler soluble organic compounds. Acidogenesis and acetogenesis are the second and third steps, respectively, and produce volatile fatty acids (VFA), H2, CO2 and other intermediates.

Acidogenesis of municipal solid waste (MSW) needs short HRTs and low pH to prevent the growth of hydrogen consumers as methanogens. Several authors have suggested that the optimal pH for enhanced hydrolytic and acidogenic bacteria activity ranges between 5 and 6 (Verrier et al., 1987). To date, the lowest HRT for acidogenic of MSW is 1.2 d (Ueno et al., 2007), operating under continuous mode and thermophilic conditions and inoculating the acidogenic reactor with seed microflora. Furthermore, thermophilic conditions have been reported to have an inhibitory effect on methanogenesis (Ueno et al., 1996, 2007).

H2 production from MSW is also influenced by the composition of the waste. Changes in waste composition can be produced by several factors, including climate, collection frequency and seasonal practices (Tchobanoglous et al., 1997). Some reports have