

Biogas generation in landfills

Equilibria, rates & yields

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Abstract:

Landfilling in "cells" has become more common in recent years. Different waste streams are guided to different cells, among which the biocell is a landfill designed for biogas production.

In this thesis, the dependence of biogas generation on waste composition was investigated. Six 8,000 m³ test cells, with contents ranging from mainly commercial waste to pure domestic waste and equipped with gas extraction systems and bottom liners, were monitored for seven years.

Great emphasis was given to the characterization of conversion process and governing mechanism in the topics of bioenergetics, kinetics and capacities.

A thermodynamic model, in which the oxidations of volatile fatty acids (VFA) ($2 < 7$) and hydrogenotrophic methanogenesis were assumed to equilibrate at a certain lower limit for energy conversation (DG_{min}), explained the relative distribution of VFA's observed in situ. DG_{min} ranged between -11 to -15 kJ/reaction and decreased with increasing levels of undissociated acetic acid, indicating the reduction of proton gradients over cytoplasmic membranes.

Comparisons of methane production rates and internal conditions observed during a two-year period demonstrated that high biogas rates corresponded with low VFA levels.

Rates obtained in test cells with mainly commercial waste were 13 - 19 Nm³ CH₄/dry tonne, yr, whereas VFA levels ranged between 10 and 24 gO₂/l. Corresponding values in domestic waste and food-rich waste fraction were 10 - 14 Nm³ CH₄/dry tonne, yr and 18 - 77 gO₂/l, respectively. This demonstrate that substrate inhibition of acetotrophic methanogenesis is one of the most important factors governing the rate of biogas generation, a notion supported by the findings from the thermodynamic model, and that the shift from acidogenic to methanogenic condition is not a discrete one, but rather a continuous transition.

To explain the discrepancies between theoretical methane potentials and quantified yields (in this study found to be 150 - 200 and 40 - 70 Nm³/dry tonne, respectively), the possible nutritional limitation was investigated. Pools and emissions of chemical oxygen demand, N, P and K were quantified. Biomass pools were estimated from methane yields, growth yield coefficients, and bacterial mineral contents.

However, results from commercial waste test cells showed that assimilation of P exceeded the refuse content, which suggests the turn over of microbial biomass and questions the notion of nutritional limitations.

In sum, the results showed that advantages of a reduced content of readily biodegradable material, achieved by guidance of pretreatment, encompass several aspects of the performance.

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