

ABSTRAK

Penelitian ini dilakukan untuk mengevaluasi padatan berpori sebagai media imobilisasi dalam peruraian anaerobik dengan dua tahap eksperimen. Tahapan pertama bertujuan melakukan evaluasi jenis media imobilisasi bakteri, yaitu media imobilisasi berbasis zeolit, karbon, dan campuran zeolit-karbon. Tahapan ini dilakukan dengan substrat ideal berupa *effluent* digester aktif. Media imobilisasi dimasukkan ke dalam digester sebanyak 90 g/mL (5 g/g *Volatile Solid*) dan dilakukan perbandingan dengan digester tanpa media imobilisasi.

Dari eksperimen pertama diketahui bahwa dengan penambahan media imobilisasi, produksi biogas per hari lebih stabil dibandingkan dengan digester tanpa media. Namun, total volume biogas tertinggi selama 39 hari diberikan oleh digester tanpa media imobilisasi, diduga karena penambahan media imobilisasi bakteri menyebabkan ketidakseimbangan C/N ratio dalam substrat yang sudah ideal. Perbandingan antarjenis media imobilisasi menunjukkan zeolit merupakan media imobilisasi terbaik karena memberikan stabilitas *Volatile Fatty Acid*, serta volume kumulatif metana dan kelimpahan relatif *Bacteria* dan *Archaea* paling tinggi dibandingkan dengan jenis media imobilisasi yang lain.

Tahapan kedua bertujuan menentukan jumlah optimum media imobilisasi bakteri untuk peruraian limbah cair yang memiliki efek inhibisi terhadap bakteri anaerobik, yaitu *stillage* yang diencerkan hingga 10.000 mg SCOD/L. Eksperimen dijalankan selama 30 hari dengan variasi rasio media imobilisasi bakteri berbasis zeolit terhadap cairan 20; 45; dan 120 g/g SCOD. Penambahan media imobilisasi berbasis zeolit hingga 45 g/g SCOD memberikan peningkatan volume biogas dan metana, tetapi peningkatan jumlah hingga 120 g/g SCOD menurunkan volume biogas dan metana. Elektroforegram gel agarosa memberikan kesimpulan bahwa variasi jumlah media imobilisasi berbasis zeolit 120 g/g SCOD lebih berpengaruh terhadap kelimpahan relatif *Bacteria* dibandingkan *Archaea*. Analisis kuantitatif dengan model matematis menunjukkan penambahan media imobilisasi berbasis zeolit memberikan pengaruh signifikan terhadap laju penurunan produksi metana. Disimpulkan bahwa kadar fenol dalam *stillage* yang diencerkan hingga 10.000 mg SCOD/L belum menyebabkan inhibisi sehingga penambahan media imobilisasi belum memperlihatkan peningkatan signifikan. Walaupun data yang diperoleh dalam penelitian ini belum mencukupi untuk melakukan optimasi proses secara komprehensif, penelitian ini telah menghasilkan model matematis yang sesuai untuk analisis kuantitatif eksperimen sejenis.

Kata kunci: biogas, imobilisasi, karbon, *stillage*, zeolit.

ABSTRACT

This work studied porous media for anaerobic bacteria immobilization in two sets of experiment. The first experiment evaluated three types of immobilization media, i.e. zeolite-based, carbon-based, and zeolite-carbon based media. Ninety grams per mL (5 g/g Volatile Solid) of immobilization media were added to the digester. The digesters with media were compared to control digester that did not contain any immobilization media.

The first experiment showed that the addition of immobilization media increased the stability of daily biogas production. However, the highest cumulative volume of biogas produced per VS for 39 days was given by control digester. This might be caused by the possibility that immobilization media changed the C/N ratio of the substrate which had already been in ideal composition. Zeolite-based immobilization medium was considered as the best media because it maintained Volatile Fatty Acid stability, and resulted in highest amount of biogas, methane content, and relative abundance of Bacteria and Archaea to be compared to other media.

Optimum dose of zeolite-based media was determined in second experiment, using diluted stillage containing 10,000 mg SCOD/L. Experiment was conducted for 30 days, varied doses of zeolite-based media added, e.g. 20, 45, and 120 g/g SCOD. Zeolite-based media dosed up to 45 g/g SCOD gave highest volume of biogas and methane, but the addition of zeolite-based media up to 120 g/g SCOD reduced digester performance. Agarose gel electrophoresis showed that zeolite-based media enhanced the relative abundance of Bacteria more than Archaea. Quantitative analysis using mathematical model was done and showed that addition of zeolite-based media had significant effect on rate of methane production. It is concluded that the inhibitory phenol in diluted stillage containing 10,000 mg SCOD/L have not caused inhibition yet, therefore the effect of zeolite-based media was not noticeable. Although the data obtained in this research have not been sufficient yet to conduct a comprehensive process optimization, this work has developed a mathematical model suitable for quantitative analysis of anaerobic digestion with similar case.

Keywords: Biogas, immobilization, carbon, stillage, zeolite