RINGKASAN

Studi Optimasi Penggunaan Biochar pada *Anaerobic Digestion* Kotoran Sapi terhadap Kualitas Biogas
Karya tulis ilmiah berupa tesis, 19 Juni 2026

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Optimisation of Biochar Addition in Anaerobic Digestion of Cow Manure to Improve Biogas Quality

xix + 77 halaman, 9 tabel, 29 gambar, dan 3 lampiran

Kebutuhan energi alternatif yang ramah lingkungan semakin meningkat seiring keterbatasan sumber daya fosil dan meningkatnya dampak negatif terhadap lingkungan. Salah satu solusi yang berpotensi dikembangkan adalah produksi biogas melalui proses *anaerobic digestion* (AD) limbah organik, seperti kotoran sapi. Proses AD tidak hanya menghasilkan energi terbarukan, tetapi juga berperan dalam pengelolaan limbah dan pengurangan emisi gas rumah kaca. Namun demikian, efektivitas proses AD masih sering terkendala oleh rendahnya stabilitas sistem, akumulasi senyawa penghambat seperti asam lemak volatil (VFA) dan amonia, serta lambatnya pertumbuhan mikroorganisme metanogenik. Penelitian ini bertujuan untuk meningkatkan efektivitas proses AD dengan melakukan penambahan biochar. Biochar merupakan material kaya karbon hasil pirolisis biomassa yang memiliki luas permukaan tinggi, porositas, dan gugus fungsi aktif, sehingga berpotensi menyediakan media tumbuh mikroba, menyerap senyawa penghambat, menstabilkan pH, serta meningkatkan efisiensi transfer elektron antar mikroorganisme. Biochar yang digunakan berasal dari sekam padi dan cangkang kelapa sawit dengan variasi dosis 5, 10, dan 15 g/L. Pemilihan kedua bahan tersebut didasarkan pada ketersediaannya yang melimpah di Indonesia serta karakteristik alkalinitas dan struktur pori yang mendukung proses AD. Karakteristik bahan baku dianalisis melalui pengujian COD, nitrogen total, TSS, dan VSS. Karakteristik biochar dianalisis menggunakan SEM–EDX dan BET, sedangkan komposisi biogas dianalisis menggunakan GC. Hasil penelitian menunjukkan bahwa kotoran sapi memiliki potensi tinggi sebagai substrat biogas dengan nilai COD sebesar 53.333 mg/L dan rasio VSS/TSS sebesar 94,32%. Analisis SEM–EDX menunjukkan bahwa biochar cangkang kelapa sawit didominasi oleh kandungan karbon tinggi yang berpotensi mempercepat fase start-up metanogenesis, sedangkan biochar sekam padi kaya akan silika yang berperan dalam stabilisasi pH dan adsorpsi senyawa inhibitor. Analisis BET menunjukkan bahwa biochar sekam padi memiliki luas permukaan dan volume pori yang lebih besar dibandingkan biochar cangkang kelapa sawit. Penambahan biochar meningkatkan fraksi metana dan mempercepat pembentukan kondisi anaerob. Biochar cangkang kelapa sawit menghasilkan kandungan CH_4 maksimum sebesar 68,08% pada hari ke-15 pada dosis 5 g/L, sedangkan biochar sekam padi menunjukkan kestabilan terbaik dengan kandungan CH_4 maksimum sebesar 68,65% pada hari ke-20 pada dosis 15 g/L.

Kata kunci: biochar, *anaerobic digestion*, kotoran sapi, sekam padi, cangkang kelapa sawit
Kepustakaan: 76 (2019-2026)

SUMMARY

Optimisation of Biochar Addition in Anaerobic Digestion of Cow Manure to Improve Biogas Quality
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xix + 77 pages, 9 tables, 29 pictures, dan 3 attachments

The demand for environmentally friendly alternative energy continues to increase due to the limited availability of fossil fuel resources and the growing negative environmental impacts associated with their use. One promising solution is the production of biogas through the anaerobic digestion (AD) of organic waste, such as cow manure. The AD process not only generates renewable energy but also contributes to waste management and the reduction of greenhouse gas emissions. However, the effectiveness of AD systems is often constrained by low process stability, the accumulation of inhibitory compounds such as volatile fatty acids (VFAs) and ammonia, and the slow growth of methanogenic microorganisms. This study aimed to improve the effectiveness of the AD process through biochar addition. Biochar is a carbon-rich material produced through biomass pyrolysis, characterized by a high surface area, porous structure, and active functional groups. These properties enable biochar to provide a suitable medium for microbial growth, adsorb inhibitory compounds, stabilize pH, and enhance electron transfer efficiency among microorganisms. The biochar used in this study was derived from rice husks and palm kernel shells at dosages of 5, 10, and 15 g/L. These materials were selected because of their abundant availability in Indonesia and their alkalinity and pore structure characteristics that support the AD process. Feedstock characteristics were analysed through COD, total nitrogen, TSS, and VSS tests. Biochar characteristics were evaluated using SEM–EDX and BET analyses, while biogas composition was analysed using gas chromatography (GC). The results showed that cow manure has high potential as a biogas substrate, with a COD value of 53,333 mg/L and a VSS/TSS ratio of 94.32%. SEM–EDX analysis revealed that palm kernel shell biochar was dominated by high carbon content, which potentially accelerated the methanogenic start-up phase, whereas rice husk biochar was rich in silica, contributing to pH stabilization and adsorption of inhibitory compounds. BET analysis indicated that rice husk biochar possessed a larger surface area and pore volume than palm kernel shell biochar. Biochar addition increased the methane fraction and accelerated the establishment of anaerobic conditions. Palm kernel shell biochar produced a maximum CH_4 content of 68.08% on day 15 at a dosage of 5 g/L, while rice husk biochar showed the best stability with a maximum CH_4 content of 68.65% on day 20 at a dosage of 15 g/L.

Keywords: biochar, anaerobic digestion, cow manure, rice husk, palm kernel shell
References: 76 (2019-2026)