ENHANCED BIOGAS PRODUCTION FROM ANAEROBIC CO-DIGESTION OF PALM OIL MILL EFFLUENT USING SOLAR-ASSISTED BIOREACTOR

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MASTER OF SCIENCE

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and, in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Anaerobik co-digestion (ACoD), teknologi hijau yang mampan, memberikan peluang yang luar biasa untuk penukaran tenaga dan kawalan pencemaran alam sekitar. Ini telah menjadi kaedah utama untuk mengolah sisa organik kerana faedah pengeluaran dan persekitarannya dari segi ekonomi dan ekonomi. Tempoh permulaan yang berpanjangan, reaksi lambat, dan metanogenesis sangat dihambat dalam proses ACoD yang menghalang peningkatan pengeluaran tenaga. Sebaliknya, oxidation by hydrogen peroxide (OHP) mempunyai kesan yang besar terhadap pemecahan biologi dan meningkatkan pengeluaran biogas dengan kaedah ACoD. Sekali lagi, kekurangan substrat nitrogen dan potensi penyangga telah dikenali sebagai penghalang untuk rawatan POME dalam proses ACoD. Objektif utama kajian ini adalah untuk menyelidiki potensi ACoD untuk rawatan palm oil mill effluent (POME) dengan cattle manure (CM) dalam solar-assisted bioreactor (SABr) untuk menghasilkan biogas yang dipertingkatkan. Akhirnya, kajian ini mengembangkan artificial neural network (ANN) model yang merupakan pendekatan pemodelan yang sesuai dan tidak rumit untuk aplikasi ACoD untuk meramalkan hasil pengeluaran biogas menggunakan data eksperimen. Kaedah Standard American Public Health Association (APHA) menganalisis pencirian sampel. Panel solar pertama kali mengubah sinaran suria menjadi elektrik, yang memanaskan campuran POME dan CM untuk mengekalkan suhu reaktor yang diperlukan (35°C). Tenaga yang dihasilkan dianalisis pada nisbah pencampuran 0:100, 25:75, 50:50, 75:25, dan 100:0 POME dan CM. Jumlah biogas dikumpulkan dalam beg gas dan isipadu biogas diukur dengan kaedah perpindahan air. Campuran dengan perkadaran POME dan CM yang sama menghasilkan jumlah maksimum biogas, iaitu, 1567.00 mL, sementara kandungan metana adalah 64.13%. Kesan OHP pada dos 1.00% dengan penambahan $FeCl_3$ 1 mM untuk reaksi Fenton pada POME pada pendedahan 30 min terhadap chemical oxygen demand (COD) dan penyingkiran total organic carbon (TOC) adalah 33.80% dan 28.31%. Peningkatan biodegradable dissolved organic carbon (BDOC) adalah 59% lebih banyak untuk POME pada dos OHP 1.00% dan dengan itu, BOD/COD juga ditingkatkan sehingga 0.72 untuk POME. Pengeluaran biogas dan biomethane dapat ditingkatkan hingga 46.00% dan 64.83% jika dirawat dengan 1.00% dos OHP. Komposisi metana juga ditingkatkan hingga 72.4% berbanding kawalan yang 64.13%. Hasil biogas ditunjukkan sebagai akibat ketoksikan NH_4^+. Untuk mengatur kesan ketoksikan ammonium bikarbonat pada sistem ACoD, kitaran dos antara 10 hingga 40 mg/L telah ditambah. Pengeluaran biogas kumulatif 2034.00 mL dijumpai dengan penambahan 10 mg/L ammonium bikarbonat dan 29.80% lebih tinggi daripada operasi ACoD kawalan. Di ANN, model rangkaian saraf umpan maju multi-lapis yang dicadangkan dapat meramalkan hasil pengeluaran biogas dari proses ACoD dengan ralat kuadrat rata untuk pengesahan 0.0562 dan nilai-R untuk pengesahan 0.97733. Pendekatan ini didapati berkesan, fleksibel dan serba boleh dalam mengatasi hubungan tidak linear menggunakan maklumat yang ada. Kesan ekonomi pembinaan loji biogas telah berjaya dianalisis dan diramalkan juga. Loji biogas yang dicadangkan nampaknya dapat dilaksanakan secara ekonomi kerana jangka masa pembayaran balik sekitar 3 tahun, kadar pulangan dalaman 23.62% dan nisbah faedah-kos 1.34 pelaburan dapat dicapai jika teknologi ini digunakan dalam skala besar. Oleh itu, secara keseluruhan kajian ini dapat membantu meminimumkan kesan buruk persekitaran POME dengan rawatan ACoD di masa depan dan menunjukkan bahawa penyelesaian lengkap untuk penggunaan SABr dalam penyatuan ciri-ciri yang berbeza untuk peningkatan pengeluaran biogas.

ABSTRACT

Anaerobic co-digestion (ACoD), a sustainable green technology, presents an outstanding opportunity for energy conversion and environmental pollution control. It has become a core method of treating organic wastes on account of its environmental and economic benefits of energy production. Prolonged start-up period, slow reactions, and methanogenesis are highly inhibited in the ACoD process which prevents enhancement in energy production. Instead, oxidization by hydrogen peroxide (OHP) had substantial impacts on biological break down and enhancing biogas production by ACoD methods. Again, lack of nitrogenous substrate and buffering potential has been known as an obstruction for the treatment of POME in the ACoD process. The key objective of this study was to investigate the potential of the ACoD for palm oil mill effluent (POME) treatment with cattle manure (CM) in a solar-assisted bioreactor (SABr) to produce enhanced biogas. Finally, this study developed the artificial neural network (ANN) model which is an appropriate and uncomplicated modeling approach for ACoD applications to predict the outcomes of biogas production using experimental data. Standard American Public Health Association (APHA) methods analyzed the characterization of the samples. The solar panel first converted solar radiation into electricity, which warmed up the POME and CM mixture to maintain the required reactor temperature (35°C). The produced energy was analyzed at 0:100, 25:75, 50:50, 75:25, and 100:0 mixing ratios of POME and CM. The total biogas amount was collected in a gas bag and biogas volume was measured by the water displacement method. The mixture with equal proportions of POME and CM produced the maximum amount of biogas, i.e., 1567.00 mL, while the methane content was 64.13%. The effect of OHP at 1.00% dose with 1 mM $FeCl_3$ addition for Fenton reaction on the POME at 30 min exposure on chemical oxygen demand (COD) and total organic carbon (TOC) removal was 33.80% and 28.31%. The improvement of biodegradable dissolved organic carbon (BDOC) was 59% more for POME at 1.00% OHP doses and thus, BOD/COD was also enhanced up to 0.72 for POME. Biogas and biomethane production can be enhanced up to 46.00% and 64.83% if treated by 1.00% OHP doses. The methane composition is also enhanced up to 72.4% compared to control which was 64.13%. Biogas yield was indicated as the consequence of NH_4^+ toxicity. To regulate the toxicity impact of the ammonium bicarbonate on the ACoD system, a cycle of dosing from 10 to 40 mg/L was supplemented. The cumulative biogas production of 2034.00 mL was found with the addition of 10 mg/L ammonium bicarbonate and 29.80% more which are higher than that of the control ACoD operation. In ANN, the proposed multi-layered feed-forward neural network model could predict the outcomes of biogas production from the ACoD process with a mean squared error for validation of 0.0562 and an R-value for validation of 0.97733. The approach was found to be effective, flexible and versatile in coping with the non-linear relationships using available information. The economic impact of constructing a biogas plant has been successfully analyzed and predicted as well. The proposed biogas plant seems to be economically feasible because an approximately 3-year payback period, internal rate of return of 23.62% and benefit-cost ratio of 1.34 on investment could be achieved if this technology is used on a large scale. So, overall this study may help in minimizing the adverse environmental effects of POME by ACoD treatment in the future and demonstrated that a complete solution to the application of SABr in the integration of different features for enhanced biogas production.

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