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Evaluation of Biogas Production Potential from Raw and Processed Agricultural Wastes

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Abstract

In this study, the evaluation of biogas production potential from 5 raw and processed agricultural wastes: soybean residues, papaya peels, sugarcane bagasses, rice straws and greater galangals were investigated. The experimental study was carried out into 2 parts. Firstly, the batch experiment was conducted in mesophilic conditions (30°C), at five different hydraulic retention times (HRT): 15 days, 20 days 25 days 30 days and 35 days. The results revealed that soybean residue generated the highest biogas yield of 560.47 ml. at the HRT of 25 days. Papaya peels produced the highest biogas yield of 404.24 ml. at the HRT of 15 days. Bagasse generated the highest biogas yield of 263.04 ml. at the HRT of 25 days. Straw and greater galangal showed a very low biogas yield under the studied conditions. Secondly, the continuous experiment was carried out under an optimal HRT of each feedstock using a digester of 200 liters between 60 days. The average biogas production rate of soybean residue, papaya peel, bagasse, straw and greater galangal was 63.01, 54.63, 16.28, 13.94 and 0.68 L/days, respectively. Finally, the methane yield of biogas produced from different feedstocks was analyzed using a gas chromatography. The results shown that biogas from soybean residue, papaya peel, bagasse, straw and greater galangal precedes the methane yield of 57.14%, 53.70%, 49.12%, 56.25% and 73.50%, respectively.

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Keywords: agricultural waste, biogas production, hydraulic retention time

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1. Introduction

Progressive depletion of world fossil resources, combined to increasing energy consumption as well as the negative environmental impacts of fossil fuel use, led to a shift toward alternative renewable resources of energy. Biogas could be a potential renewable source for heat and electricity as well as motor fuel for the foreseeable future,

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contributing significantly to sustainable development in terms of socioeconomic and environmental concerns [1]. Biogas is a mixture of different gases produced by the biological decomposition of organic matter in the absence of oxygen, called an anaerobic digestion process. It mainly consist of methane (CH_4), carbon dioxide (CO_2) and a trace amount of other gases such as hydrogen sulfide (H_2S), ammonia (NH_3), hydrogen (H_2), nitrogen (N_2) and carbon monoxide (CO). Biogas can be produced by anaerobically digesting several organic matters such as agricultural wastes, municipal wastes and industrial wastes.

Regarding agricultural crop wastes and residues, they are usually disposed into the land. Although their advantages as soil fertilizers and harvesting nutrients in feed crops, the accumulation of large amounts of agricultural wastes causes greenhouse gas and toxic gas emissions, leading to environmental impacts and public health problems. Therefore, the utilization of agricultural wastes as a bio-fuel source has become crucial in order to overcome the crisis energy problems as well as environmental damages. However, the main problem with anaerobic digestion of crop residues is that the most of the agricultural wastes are lignocellulosic with low nitrogen content. To improve the digestibility of these materials, several researches and technologies were recently investigated such as co-digestion with other manure wastes [2-4] and different pretreatment methods [5-7]. However, these technologies cannot be applied to convert agricultural wastes into biogas for small scale productions, especially households and small farms since their cost ineffective and their complication. To overcome this problem, the suitability between agricultural waste type and bio-fuel type are basically required in order to efficiently use the renewable source.

In this work, the evaluation of biogas production potential of raw and processed agricultural wastes was investigated, allowing suitable and effective utilization renewable sources of energy as well as sustainable application for households and small scale users. Experimental investigations were carried out in both laboratory scale and pilot scale. For the laboratory scale study, the effect of hydraulic retention time on the rate of biogas production was investigated in a batch digester system of 500 ml of capacity. For the pilot scale study, the stability of biogas production rate was studied in a continuous digester system of 200 L of capacity. Finally, the biogas composition was analyzed for assuring the possibility of utilization of raw and processed agricultural wastes studied in this work as an alternative renewable source of energy.

Nomenclature

HRT	Hydraulic retention time
V	Working volume of the digester
Q	Feedstock flowrate or organic loading rate

2. Materials and methods

2.1 Materials and feedstock

Five raw and processed agricultural wastes: soybean residues, papaya peels, sugarcane bagasses, rice straw and greater galangal were used in this studied. Soybean residues, papaya peels and sugarcane bagasses were daily collected from soybean milk shop, fruit shop and juice shop, respectively, located in the area of Pa-payom district of Phattalung, Thailand. Rice straws and greater galangals were obtained from a rural area of Songkhla, Thailand. The collected agricultural residue samples were chopped and then ground into small particles less than 5 mm in size. Fresh caw manure was collected from the caw farm of faculty of technology and community development, Thaksin University, Phattalung campus, Thailand. Such manure was chosen as it was well adapted to the types of wastes considered in this study. The inoculum was prepared by mixing caw manure and distilled water at the ratio of 1:1 (v/v).

2.2 Experimental procedures

In this work, the evaluation of biogas production potential of raw and processed agricultural wastes was investigated using batch digestion and continuous digestion processes. For the batch experiment, the effect of hydraulic retention times (HRT) on the biogas production rate was investigated. Five different HRT: 15, 20, 25, 30 and 35 days were carried out under mesophilic conditions (34 - 37°C). The digestion system consists of 500 ml