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Production of biogas from poultry litter mixed with the co-substrate cow dung

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Abstract

Poultry litter (a mixture of rice hulls, sawdust and chicken excreta of broilers) mixed with the co-substrate cow dung and poultry droppings was evaluated under anaerobic conditions for the production of biogas (methane). Four laboratory scale reactors, R1, R2, R3 and R4, were set up with different proportions of waste poultry litter, cow dung and poultry droppings and had a 6% total solid concentration. Digestion was carried out for 50 days at room temperature, $32 \pm 3\,^{\circ}C$. Volatile solid degradation and specific gas production in the four reactors was 46%, 51.99%, 51.96%, 43% and 0.263, 0.469, 0.419, 0.221 l/g, respectively, based on the volatile solid (VS) feed. The methane yields were 71%, 72.5%, 72.6% and 70%, respectively. The COD reductions were 46.1%, 50.76%, 48.23% and 45.12%, respectively. A kinetic analysis showed that the anaerobic digestion of poultry litter with a co-substrate followed first order kinetics. Among the experimental reactors, R2 (25% cow dung, 75% poultry litter) gave the optimum results: a VS reduction of 51.99%, a specific gas yield of 0.469 l/g and a methane yield of 72.5%.

Keywords: Poultry litter; Co-substrate; C/N ratio; Anaerobic digestion; Biogas

1. Introduction

Biogas is an environmental friendly and one of the most efficient and effective options for renewable energy among various other alternative sources [1]. Biogas is produced by the biomethanation process, and the effluent from the process is rich in essential nutrients that can be utilized as a very good fertilizer. Biomethanation is the degradation of organic materials by microorganisms in the absence of oxygen. It is a multi-step biological process in which organic carbon is converted mostly to carbon dioxide and methane [2]. Biogas can be produced from variety of substrates, such as animal manure, energy crops, industrial waste and so on. The typical reactions that occur in the anaerobic digestion process [1,3] are:

Acetogenic bacteria:

$$\text{Cellulose}\ C_6H_{12}O_6 \rightarrow\ 2CH_3COOH\ +\ 2CO_2 + 4H_2$$

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Methanogenic bacteria:

$$CH_3COOH \rightarrow CH_4 + CO_2,\ CO_2 + H_2 \rightarrow CH_4$$

Bangladesh is home to approximately 160 million people. Recently, poultry farms in Bangladesh have been rapidly expanding to meet the growing demand for meat and eggs. There are 123 million chickens [4] and approximately 50,000.00 poultry farms [5] in Bangladesh. It is estimated that approximately 1,560,000.00 metric tonnes of poultry manure is produced in Bangladesh each year. Including bedding material, wasted feed and feathers, the total poultry waste (litter) is much higher. Most of the waste materials are dumped into nearby sites, although a small portion of poultry waste is used for fish and crop production by farmers. Crude dumping of this waste is not only unattractive but also environmentally unsafe. Biogas production can be a sustainable solution to treat waste materials, and the cost of waste treatment using this process is low. Poultry waste, cow dung and other waste have been used for biogas production [1,6], but the efficiency of the gas production is low.

In this study, biomethanation of poultry litter was studied with the co-substrates cow dung and poultry droppings. A comparative analysis using different materials was performed on biogas production.

2. Materials and methods

2.1. Sample collection

The poultry litter and poultry droppings were collected from Joypara, Dohar, Dhaka. Cow dung was also used in various proportions as a co-substrate to maintain the C/N ratio.

2.2. Preparation of reactors

The anaerobic digestion process was studied in batch reactors to develop an appropriate technology for the production of biogas from the solid waste from poultry farms. A known amount of substrate containing a mixture of waste was transferred into a 2-litre, wide mouth glass bottle. All of the bottles were sealed with air tight rubber stoppers, and another bottle was filled with water to collect gas and was equipped with glass tubes for gas removal. Biogas produced by anaerobic digestion was collected by the water displacement method [7]. Four reactors were prepared using various proportions of poultry litter and other materials. Reactor R1 was set up using poultry litter alone. R2 was prepared using 75% poultry litter and 25% cow dung, R3 was 50% poultry litter and 50% cow dung and R4 was 70% poultry litter and 30% poultry droppings. A reactor is pictured in Fig. 1.

2.3. Sample analysis

The sample pH was measured with a digital pH metre (HANNA, HI 98204). The carbon and nitrogen content of the poultry litter, poultry droppings and cow dung were determined with a C–H–N elemental analyser. Total solids (TS) were determined by incubating a sample at 104 °C until no further weight change was evident, and volatile solids (VS) were measured by the loss on ignition of the dried sample at 550 °C. The composition of the gas was measured using an Orsat gas analyser. COD was determined by a chemical method, and the calorific value was determined in a bomb calorimeter. The total gas production was measured via the water displacement method at an interval of 24 h. The pH, VS reduction and COD reduction were measured every 10 days throughout the experiment. Each experiment was conducted at a temperature of $32 \pm 3^{\circ}$ C for 50 days.

3. Results and discussion

Various parameters of the raw materials are shown in Table 1. Table 1 shows that the C/N ratio of poultry litter is 7.5, which is quite low for optimum biogas generation [8], and it can be increased by mixing with cow dung

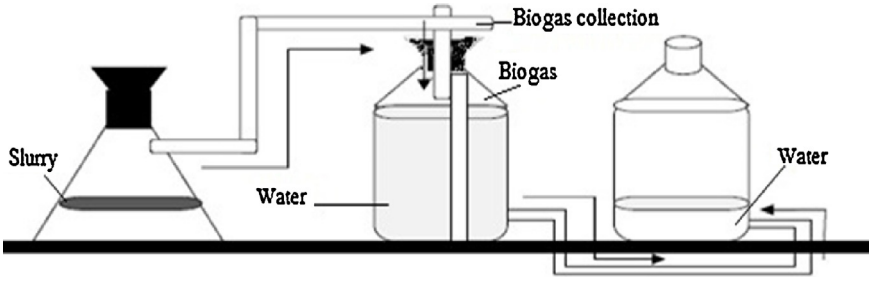

Fig. 1. Outline of the experimental setup for biogas generation.