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Biomethane Recovery from Fresh and Dry Water Hyacinth Anaerobic Co-Digestion with Pig Dung, Elephant Dung and Bat Dung with Different Alkali Pretreatments

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Abstract

Biomethane was produced from water hyacinth (*Eichhornia crassipes* (Mart.) Solms), an aquatic weed plant, comprising of cellulose, hemicellulose and lignin by using two steps of methods. The first was that fresh and dry water hyacinth in the length of 1 cm, were pretreated with 2 different alkali solutions; 2%(w/v) of NaOH and 10% (w/v) of Lime . The optimum condition was selected from 100, 120 and 140ºC for 4 hr at ratio of 1g $_{plant}$ per 15 ml of treatment solution. The yields of sugar from NaOH pretreatments were higher than lime conditions. The highest of sugar yield at 60 g $_{sugar}$ /g $_{substrate}$ was observed from 140ºC by using dry water hyacinth, whereas fresh hyacinth had yield at 36.7 g $_{sugar}$ /g $_{substrate}$. The second method was 12 sets of anaerobic co-digestions with 3 types of dung; pig dung, elephant dung and bat dung, and 2 types plants; fresh and dry hyacinth that pretreated by sodium hydroxide and calcium hydroxide. The mixtures of sugar solution and treated plant solid from both hyacinths were used as substrates by using 200 ml of waste water from sweet corn industrial as starter. The co-digestions were achieved at 1:1 ratio of dung and mixture solutions and at 37±2ºC under anaerobic condition for 45 days. The COD removal in rang of 51-69% were absorbed from all 12 conditions. The digestions from all lime treated plants showed higher methane concentration than NaOH treated plants. The lime treated fresh hyacinth had highest values of biochemical methane potential (BMP) and methane concentration were at 59.3% and 63.65 vol.%, respectively. They were equivalent to heating value at 12.58 MJ/m^3. The second was lime treated dry hyacinth that showed 32.4% BMP and 43.15 vol.% of methane, respectively.

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Keywords: *water hyacinth; alkali pretreatment; animal dungs; anaerobic co-digestion; biomethane*

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1. Introduction

In Thailand, the water hyacinth or *Eichhornia crassipes* (Mart.) Solms is commonly known as Phaktop Chawa. The water hyacinth makes the negative effects to ecosystem of wetland that the water hyacinth increases the rate of water evaporation which is higher than natural water resources without the spread of water hyacinth to 3-8 times. Now a day, the water hyacinth has been attempted to utilize on renewable energy production. The most efficiency of renewable production from water hyacinth is biogas production by conversion of complex materials as lignocelluloses into biomethane under anaerobic digestion. Biogas production requires lower energy input and lower initial cost of investigation [1]. The lignocelluloses are complex materials that can be found in the most natural plants. The water hyacinth consists of 23.31% of cellulose and 22.11 % of [2] whereas other plants such as palm oil contain 71.52% of cellulose, 9.89 % of hemicellulose and 19.92% of lignin [3]. These complex materials are converted into various sugars by pretreatment under alkali, acid or thermal condition, for examples. For the new opportunity, the agricultural lime which is natural strong base, can be used as alkali solution in the step of plant pretreatment. Its cost is lower than other chemical pretreatment solutions, especially sodium hydroxide, sulfuric acid and hydrochloric acid, for examples. However, on biogas production, the cow dung, pig dung, elephant dung and chicken dung were also normally used as co-materials on biogas productions. The biogas co-digestion between water hyacinth and cow dungs were produced methane concentration at 24% [4] whereas digestion of pig dung and rice straws produced 52.8–55.3% of methane [5]. These are meant that the different types of animal dungs affected on biogas production efficiency. By the way, the other dungs; elephant dungs and bat dungs can be found in specific area of Thailand, are possible used in co-digestion.

Therefore, the utilization of water hyacinth on biogas co-digestion was investigated by using 2 alkali solutions; sodium hydroxide and lime. The efficiency of biogas productions using different dungs; pig dung, elephant and bat dung were also determined.

2. Methodology

2.1 Water hyacinth collection and preparation

. Water hyacinths consists of leaves, straws and flowers were collected from fresh water pond in north of Thailand, Chiang Mai province (98°50’53.4” E). After collection, the plants were cleaned with tap water for 2 times to remove soils and other unwanted materials, and then continued with chopped into small pieces in size of 1 cm. The small pieces of water hyacinths were separated into 2 groups that were fresh and dry plants. For dry plants preparation of dry plants, the fresh small plants were dried at 100^{o}C for 3 hr to remove water contents in plant. Both fresh and dry water hyacinths were pre-treated under alkali conditions. These were 2 % (w/v) of NaOH solution and 2%(w/v) of lime solution. The ratio of water hyacinth sample (2 g) and alkali solution (30 ml) was at 1: 15. The plants were soaked in each alkali solution at room temperature for overnight (16-18h) and then were heated at 100 ^{o}C, 120 ^{o}C, and 140 ^{o}C by hot air oven for 4 hr. The treated water hyacinths were kept every hour for sugar determination by total phenol sulphuric method and Somogyi-Nelson method. Moreover, all pretreated plant samples were analyzed in terms of total sugar concentration by phenol-sulfuric acid method, pH, total solids, moisture, volatile solids and COD methods by closed reflux titrimetric method [6].

2.2 Animal *dungs collection and preparation*

All different dungs were collected in Chiang Mai, Thailand. Fresh pig dungs were collected from Maejo University’s farm, Maejo University whereas the fresh elephant dungs were supplied from Native Agricultural Community and Measa elephant camp. While, the bat dungs were bought from market. Before the production, all dungs were grinned, suspended in fresh natural water, and used immediately. All dungs were used immediately after grinding and suspending with fresh water.

2.3 Biogas reactor design and operation

The 12 sets of BMP biogas digestion were performed in 1 liter of glass reactor. The reactors were tidy closed with black rubbers to keep anaerobic condition. The production gases were kept in 500 ml of plastic cylinder. The replacements of gas into water were used for recovered and determined the amount of product gases. During the digestion, the reactors were put in water and controlled temperature of system by water heating controller. The soaking water was circulated by water pump.