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Biogas production from anaerobic co-digestion of cow manure with kitchen waste and Water Hyacinth

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ABSTRACT

The prime objective of this paper was to analyze and compare biogas production from various sources of waste material. The Renewable Energy Policy envisions that 5% of total energy production needs to be achieved by 2015 and 10% by 2020. This work focuses on the comparative study of the production of biogas through anaerobic co-digestion utilizing abandoned resources of biomass. Materials under study were Cow manure, Sewage Sludge, Kitchen Waste & Water Hyacinth. Experiments were conducted under mesophilic condition (37 °C) with 1.5 wt%NaOH to obtain the desirable pH. The loading ratio of each batch was maintained as 1:1 on both experiments. Kitchen Waste and Cow Manure showed promising results till about the 120th hour following plummeting production of biogas. Total production for 1 L batch of Water Hyacinth, Cow Manure & Sewage Sludge was 812 ml with 65%Methane, 14%CO and 21% other gases obtained after 800 h, while Kitchen Waste & Cow Manure provided 335 ml consisting of 60% Methane, 18%CO & 22%other gases within the same time frame. Results indicated that addition of Sewage Sludge with the widely used Cow Manure can lead to accelerated reaction, increased production and an improved methane content.

1. Introduction

The exploration of alternative energy sources is associated with several urgent issues including the energy independence, fluctuation of petroleum fuel costs, the threat of climate change and foreseen depletion of non-renewable fuel sources [1]. These resources are declining very fast in densely populated areas where people have no access to alternative modern energy sources [2]. There are renewable sources, including wood, plants, dung, falling water, geothermal sources, solar, tidal, the wind, and wave energy, as well as human and animal muscle-power. But each has its own economic, health, and environmental costs, benefits, and risks - factors that interact strongly with other governmental and global priorities. Choices must be made, but in the certain knowledge that choosing an energy strategy inevitably means choosing an environmental strategy [3]. Renewable energy is often thought of as the next great technology that will one day replace mankind's dependency on fossil fuels. Development of Renewable Energy is one of the important strategies adopted as part of Fuel Diversification Program in Bangladesh.

With a total population of 120 million and a density of 755 per square km, Bangladesh is one of the most densely populated countries in the world. 81 percent of the people are living in the rural zone and the remaining 19 percent in the urban areas [4]. As an agriculture based country, Bangladesh has embedded plenty of biomass which has been used for extracting energy – either through direct burning or from the production of biogas. Almost 80% of the population in our country is highly dependent on agriculture [5]. During winter seasons, huge amounts of vegetables are cultivated in our country which can be a potential source of Kitchen waste. Due to lack of efficient transportation and preservation, huge amounts of vegetables are wasted, which could be a source of biogas [6]. Due to urbanization, many solid wastes are generated and their effective disposal is a matter of concern. On the other hand, owing to its organic composition, these wastes have a great potential for biogas extraction. Although rural areas are a major source of Cow Manure for biogas production, there is also plenty of biomass in urban regions which can be effectively utilized.

The first Biogas plant was installed in Bangladesh at Bangladesh Agriculture University (BAU) in 1972. Bangladesh Council of

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Fig. 1. Raw materials (i) Cow Manure (ii) Sewage Sludge (iii) Kitchen Waste (iv) Water Hyacinth.

Scientific and Industrial Research and Integrated Rural Development Program (IFRD) established a floating dome biogas plant in 1976, which was very costly. To reduce the cost, they developed another floating type dome biogas plant in 1981. After conducting a research during 1990–91, fixed dome biogas model was considered more economical and durable compared to floating dome. From then onwards, fixed dome model began its journey throughout the country. The IFRD in collaboration with Dhaka City Corporation built an experimental Biogas Plant of 85 cubic meter digester volume in 1992 at Dholpur for the treatment of city garbage [7]. So far, the total number of biogas plants installed in Bangladesh is around 7000 [8].

Considering the scope of biogas production in Bangladesh, this work was conducted to investigate the production potentials of a combination of different sources of waste material. The principal goal of the research was to analyze the biogas production scenarios from these combinations and extract valuable information from inter-comparison.

2. Materials and methods

2.1. Benefits of selecting waste materials in consideration

2.1.1. Cow Manure

Open dumping of Cow manure can emit unpleasant odors, harmful air pollutants, and greenhouse gases; including ammonia, VOCs, hydrogen sulfide and particulate matter, many of which can cause health problems in humans [9]. Besides polluting the air, ammonia emissions from manure can contaminate ground water and lead to eutrophication of the soil [10]. Manure also emits methane and nitrous oxide, two potent greenhouse gases [11].

2.1.2. Sewage sludge

Sewage Sludge can negatively impact the environment and human health. However, it cannot be denied that treatment of Sludge is expensive. On the other hand, it is organizationally, technically, and economically very tough to prevent or strongly reduce the amount of municipal wastewater. Also, the presence of toxic pollutants in municipal wastewater cannot be avoided because a large part of these toxics originates from diffuse sources. The amount of nitrogen-containing components in the sludge is small compared to a number of these components present in wastewater. Anaerobic digestion is used to stabilize the sewage sludge and convert part of the volatile compounds into biogas. The biogas can be applied as an energy source either at the wastewater treatment plant itself or elsewhere [12].

2.1.3. Kitchen waste

Utilization of Kitchen Waste helps to reduce landfilling cost, energy cost, carbon emission and negative consequences of the current disposal system. It also improves public image. The effluents can be used as an organic fertilizer as well [13].

2.1.4. Water hyacinth

The biomass of water hyacinth is used rather than disposed of as a waste. Furthermore, the emission of landfill gas is avoided [14].

2.2. Sources of raw materials

Wet Cow Manure (CM) was collected from the village nearby our university campus and Sewage Sludge (SS) was collected from the sewage system of the university. Water Hyacinth (WH) was collected from the university Masjid Pond and only the stem of WH was used. Kitchen Waste (KW) was collected from different dormitories of Shahjalal University of Science & Technology (SUST) and Surma residential area, Sylhet, Bangladesh (see Fig. 1).

Fig. 2. Hopper for mashing.

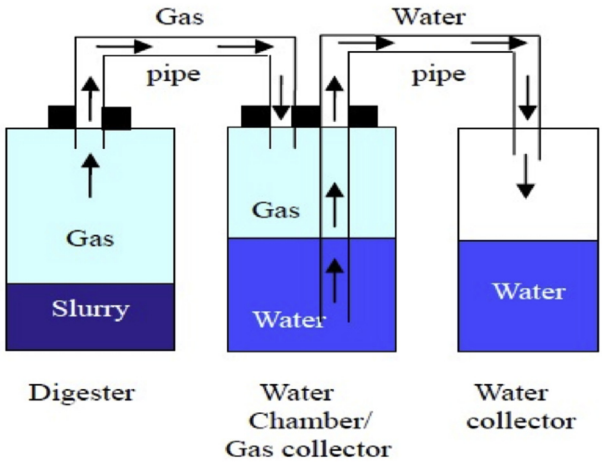

Fig. 3. Schematic diagram of the lab-scale experimental set-up [6].