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Effect Of CO Digestion Of Biogas.

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ABSTRACT

Due to high levels of organic macronutrients such as carbohydrates, proteins, and lipids, Kitchen Waste (KW) is considered an ideal substrate for anaerobic digestion (AD). AD is an efficient and sustainable technology, which provides the dual benefit of stabilizing organic waste and recovering energy from KW in the form of biogas.KW and Cow manure were collected and stored in a freezer at -20 °C.PH of the feedstock was maintained around 7-8 using buffer solution. The methane yields of feedstock were determined by laboratory-scale anaerobic batch tests. The tests were performed in 5 L reactors containing substrates of 10 & 20 g of Volatile Solids (NaOH). Reactor 1 will be operated with KW, CM, and the mixtures of KW and CM at a 10 g of VS, mixing ratio is 1:1, 4:3 and 2:1. Rector 2 will be operated with KW, CM, and the mixtures of KW and CM at a 20 g of VS, mixing ratio is 1:1, 4:3 and 2:1. The CM was pretreated by 1% sulfuric acid at a pH of 6.0 for 3 days. After acid pretreatment, the whole liquid was fed into the reactor for batch digestion. After inoculation, batch reactors will be isolated and sparged thoroughly to create an anaerobic condition. Samples were tested for biogas and ethanol production. To determine the characterization SEM and TGA analysis had done. The characteristics of relative density at 15.6 ℃, ethanol content percent by volume at 15.6 ℃, miscibility with water, alkalinity, acidity (as CH_3COOH) mg/L, residue on evaporation percent by mass, aldehyde content (as CH_3CHO) mg/L, copper, mg/kg, conductivity, μ/m, methyl alcohol, mg/L and appearance.

Keywords: biogas, cow manure, anaerobic digestion.

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INTRODUCTION

The remarkable improvement of people's living standard and the rapid development of the catering industry has significantly increased kitchen waste (KW) outputs in recent years. The Food and Agriculture Organization of the United Nations has reported that approximately 1.3 billion tons of KW were produced globally in 2013, which represents nearly one-third of the global food supply for human consumption.

In China alone, the Chinese Statistical Year Book reported that nearly 100 million tons of KW were produced in 2016, which highlights the magnitude of the global food waste crisis. KW is a high moisture content and high organic load waste, and thus easily spoils even at room temperature. Therefore, an increase in KW is not only a serious resource and food security problem, but also leads to severe environmental pollution, causing odors, toxic gases, and groundwater contamination if handled improperly.

Due to its high levels of organic macronutrients such as carbohydrates, proteins, and lipids, KW is considered an ideal substrate for anaerobic digestion (AD). AD is an efficient and sustainable technology, which provides the dual benefit of stabilizing organic waste and recovering energy from KW in the form of biogas. However, AD is a complex bioprocess, whereby a complex community of microorganisms belonging to different functional groups degrade various organic compounds to produce methane.

Among the microorganisms involved in AD, methanogens, the only known methane-producing microorganisms, are critical and fragile contributors to the anaerobic digestion process, and are easily affected by various parameters such as pH, organic loading rate, temperature, carbon to nitrogen (C/N) ratio, trace elements, hydraulic retention time, salinity, and feedstock characteristics.

Anaerobic digestion is a multi-step biological process during which the organic carbon is converted to its most oxidized (CO_2) and most reduced (CH_4) state without the presence of air. The product of the process is biogas which is a mixture of methane and carbon dioxide, as well as trace gases such as hydrogen sulfide and hydrogen present in the typical composition of biogas.

The biogas production process is complex and sensitive since several groups of microorganisms are involved. The important processes in anaerobic digestion are hydrolysis, fermentation, acetogenesis, and methanogenesis, where hydrolysis is subject to the fermentation process, while acetogenesis and methanogenesis are linked. The hydrolysis step is an extra-cellular process where the hydrolytic and fermentative bacteria excrete enzymes to catalyze hydrolysis of complex organic materials into smaller units.

The hydrolyzed substrates are then utilized by fermentative bacteria. Fermentation products such as acetate, hydrogen and carbon dioxide can directly be used by methanogenic microorganisms producing methane and carbon dioxide, while other more reduced products such as alcohols and higher volatile fatty acids are further oxidized by acetogenic bacteria in syntrophic with the methanogens.

The feedstock to be utilized in a biogas-to-energy establishment/ plant is considered to constitute of a mixture of biomass input streams, mainly:

- Organic wastes (pig manure, sludge from wastewater treatment plants,etc.).
- Energy crops (sweet sorghum, miscanthus, rape, sunflower, etc.)
- Conventional crops (maize, wheat, sugar beet, etc.)
- Other organic feedstocks (e.g.glycerol, etc.)

MATERIALS AND METHODS

Feedstock Characteristics

The KW used in this study was collected from nearby restaurants and households. The KW consisted of fried vegetables, starches, rice, and meat, etc. It was shredded into a slurry state by a food grinder after the bones, chopsticks, plastic bags, and other inorganic residuals were removed. The cow manure (CM) was collected from the local farm in Coimbatore. A scraping system was used for manure collection, and the manure was then stacked in an open field. The prepared KW and CM were stored in a freezer at -20 °C for later uses. The characteristics of KW and CM will be studied. The sludge from a cow waste treatment will be used as the inoculums. PH of the feedstock was maintained around 7-8 using buffer solution.

Experimental setup

The methane yields of feedstock were determined by laboratory-scale anaerobic batch tests. The tests were performed in 5 L reactors containing substrates of 10 & 20 g of VS (NaOH). Reactor 1 will be operated with KW, CM, and the mixtures of KW and CM at a 10 g of VS, mixing ratio is 1:1, 4:3 and 2:1. Rector 2 will be operated with KW, CM, and the mixtures of KW and CM at a 20 g of VS, mixing ratio is 1:1, 4:3 and 2:1. The CM was pretreated by 1% sulfuric acid at a pH of 6.0 for 3 days. After acid pretreatment, the whole liquid was fed into reactor for batch digestion. After inoculation, batch reactors will be isolated and sparged thoroughly to create an anaerobic condition. Samples were tested for biogas and ethanol production. The daily biogas production was recorded by water displacement method, and the cumulative biogas volume and methane yield were calculated after correction at standard temperature and pressure (STP). Methane and carbon dioxide in the biogas were measured by gas chromatography. Biogas production was performed on 118mL dark bottles which were used as bioreactors. The inoculum from the 2L anaerobic digester working under mesophilic conditions was used. Gas sampling was conducted daily until the 11^{th} day. A gas pressure lock syringe was used to take a 200 mL sample from the bottle headspace for gas chromatograph (GC) analysis.

Characterization Technique

SEM is a method for high resolution surface imaging. The SEM uses electrons for imaging, much as light microscopy uses visible light. The advantages of SEM over light microscopy include greater magnification (up to 100,000X) and much greater depth of field. Different elements and surface topography emit different amounts of electrons; the varying amount of electrons are responsible for the contrast in the electron micrograph (picture) which is representative of surface topography and composition.

Thermogravimetric Analysis (TGA) is a thermal analysis technique involving the determination of the change in weight of a sample as a function of temperature and/or time of heating.

Weight loss information is useful in the characterization of materials, such as polymers, soils, or adhesives, and in problem solving. The instrument has an integral mass flow control, gas switching capability (nitrogen or air), and superb software which provides quality results for each analysis. The TGA can be used to determine polymer composition (organic and inorganic (filler) content), thermal stability, degree of hydration, and level of residual solvent or moisture.

TGA is performed either in an inert nitrogen environment or in an oxidative environment (air). In certain sample types, different mechanisms of degradation may be present in oxidative and inert environments. Thus, the number of degradation steps and the temperatures at which the steps occur can be studied in different environments.

RESULTS AND DISCUSSION

Characterization Studies

Maximum methanol obtained at optimum condition was characterized for TGA and SEM analysis.The loss of weight between 250 and 350℃ is associated with dehydration i.e. water molecules adsorbed on the sample surface as well as those bound within the inner cells are released. The second stage of thermal decomposition occurs in the temperature range between 350℃ and 450℃ with maximum weight loss occurring at 350-500 ℃ , which may be attributed to volatilization of hemicelluloses. During this stage, the chemical bonds of different bio polymers start breaking, with less thermally stable compounds decomposing first. The cellulose decomposition peak, which typically manifests itself in the temperature range of 500-600℃ probably, overlaps with that of hemicellulose. A similar profile for the ethanol has been reported by various authors, where hemicellulose thermally degrades faster than cellulose, with the latter breaking down between 250 and 407℃, or higher. A long tail of devolatilization was observed in duckweed at 420℃, which is due to loss of lignin content. This nevertheless is lesser than other lignocellulosic biomasses, which identifies duckweed as a potential feedstock for biogas production.

Biogas Production

Biogas production of 100g FC; mixture with 10g and 20g of VS

Total Biogas Production (ml) comparison for M1, M2 and M3 for FC 100g, 150g and 200g with 10g and 20g VS

FC 100g - 10gVS - M1 (35422.60) > M3 (35339.91) > M2 (30141.80) FC 100g - 20gVS - M1 (34714.15) > M3 (30633.11) > M2 (24934.71) FC 150g - 10gVS - M1 (37936.04) > M2 (36788.93) > M3 (31783.51) FC 150 g - 20gVS - M2 (42619.93) > M1 (38710.25) > M3 (36513.79) FC 200g - 10gVS - M1 (44869.35) > M3 (44375.54) > M2 (43085.71)

Figure -1 KW Kitchen Waste

Figure 2: Kitchen Waste after removing plastics and bones

Figure 3: Cow Manure

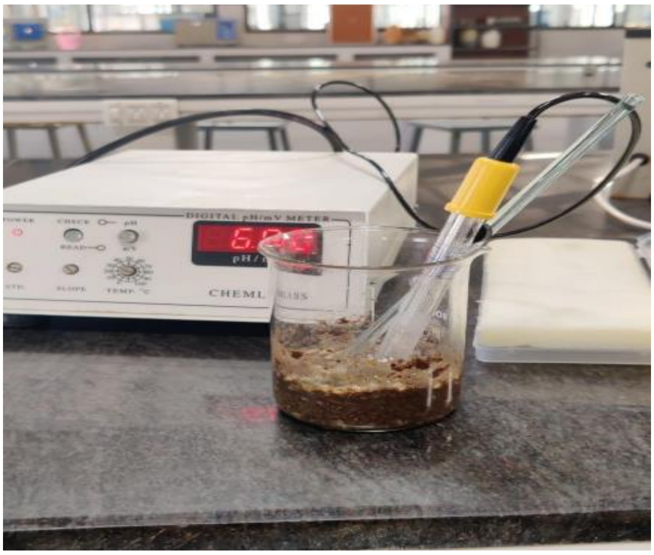

Figure 3: PH Measurement.

Figure 4: Lab Apparatus Setup

Figure 5: Inverted Burette for Biogas production measurement.

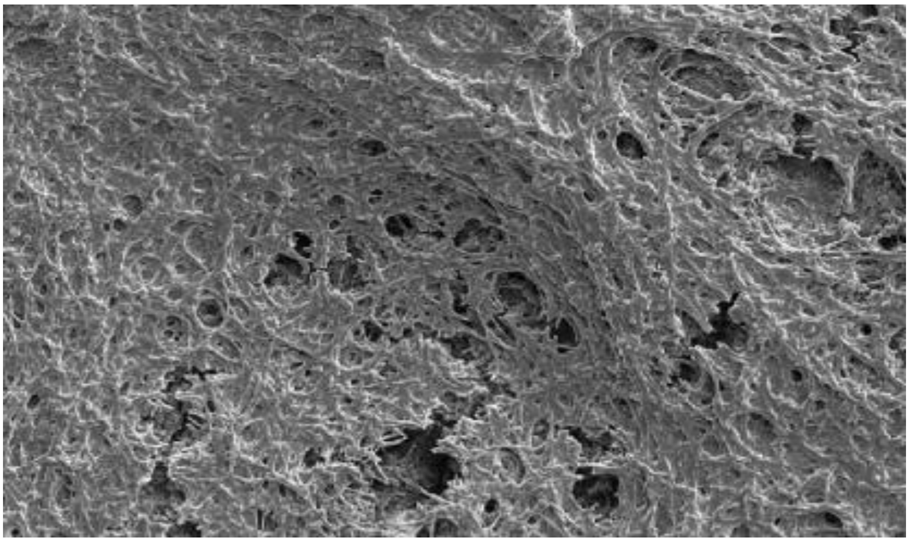

Figure 6: SEM analysis of obtained Ethanol from FC-200g at KW and CM; M2 at 10g VS

CONCLUSION

A process was proposed for utilizing KW and CM for biogas production from the perspective of industrial applications. From the experimental analysis it is understood that the maximum biogas was obtained as 44874.03 and 44869.35 at M-3 at FC-200g with 20g VS andM-1 at FC-200g with 10g VS respectively. At the same time maximum ethanol was obtained as 7841.19 and 7755.42 at M-2 at FC-200g with 10gand 10g VS respectively. SEM and TGA analysis was done for the maximum obtainment of ethanol. The co-digestion of KW and CM anaerobic processes showed good production potential of biogas and ethanol [1-10].

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