Production of Biogas from Cow Manure by Adding Various Additives

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***Abstract*- In today's world, the use of fossil fuels and the effect of greenhouse gases on environment is very serious problem. So, the research is driving into the production of renewable energy from various biodegradable wastes, organic resources etc. The energy demand is increasing day by day and majority of the energy is produced from the fossil fuels. Therefore, the need of the time is to switch from fossil fuels to renewable energy resources. So that from the various renewable energy resources, this paper focus from the production of biogas from cow manure by adding different additives. The production of biogas carried out through anaerobic digestion in two stages. In first stage, the batch production was conducted under mesophilic range (28-30 ^{o}C) by using cow manure and water slurry. In second stage, alfalfa powder, pongamia pinnata powder (karanj) and urea was added in slurry. The experiment was carried out by using self-made anaerobic digester having working volume of 1000 L. Cow dung and water were mixed at a ratio of 1:1. Daily measurement of biogas was checked by measuring its pressure using U-tube manometer. The result found that the pressure of biogas production in first stage was obtained 1.43 bar in 46 days and in second stage 2.67 bar in 32 days. Therefore, biogas production was increased and HRT was decreased using different additives compared to cow dung only.**

Keywords- Biogas production, Anaerobic digestion, Biogas plant, Cow dung, Additives, Hydraulic retention time

I. INTRODUCTION

In last few years, global energy demand is increasing day by day specially in developing countries like India. [1] As demand of energy is rising with rapid economic development, its availability is one of the serious problems for every country whilst fossil fuel energy resources decreasing due to its utilization. For those reasons, renewable and reliable energy is key factor to overcome the shortage of existing energy. [2] Biogas is sustainable renewable energy produced by anaerobic digestion process that will one day replace conventional resources like petrol, diesel, oil etc. Biogas can be produced from the different type of biomass such as animal wastes, municipal solid waste, agriculture waste, sewage waste, food and paper waste etc. [3] Biogas is composed of methane (CH_4), carbon dioxide (CO_2), and trace amount of hydrogen sulphide (H_2S), nitrogen (N_2), hydrogen (H_2), & ammonia. [4] The production of biogas is divided in four stages: hydrolysis, acidogenesis, acetogenesis and methanogenesis. [5] In first stage, organic polymers such as fats, carbohydrates and proteins are broken into fatty acids, simple sugar and amino acids respectively. In acidogenesis, the products of hydrolysis are converted into volatile fatty acid such as butyric acid, propionic acid and valeric acid, alcohol, CO_2, H_2 by acidogenesis bacteria. In acetogenesis, the products of acidogenesis are converted to acetic acid, H_2 and CO_2. In final stage, the products of acetogenesis is convert into CH_4 and CO_2 by methanogens bacteria. [6] The production rate of biogas depends on a several parameters such as temperature, pressure, pH, hydraulic retention time, nature of substrate, carbon/nitrogen ratio, microbes balance, digester size and volatile fatty acids. [7]

An investigation was carried out by Cunsheng Zhang et al. [8] to study anaerobic co-digestion of food waste and cow manure in 1 L glass digester in the ratio of 2, 3 and 4. The result obtained that optimum methane and biogas production was obtained at ratio of 2 because for optimum C/N ratio. Ningning Zhai et al. [9] investigated the effects of initial pH (6.0 to 8.0) for anaerobic co-digestion of kitchen waste and cow manure conducted in lab scale digester. The result obtained that, the range of pH value of 7.7-7.9 increased the rate of biogas production. Farzana Tasnim et al. [10] conducted experiment on anaerobic co-digestion of cow manure with kitchen waste and cow manure with sewage sludge and water hyacinth in 1 L batch digester with 1.5% NaOH added. The result obtained that cow manure with water hyacinth and sewage sludge was increased production and also methane content. Xiaojiao Wang et al. [11] investigated improving of methane yield by adjusting C/N ratio (15:1-35:1) for mixtures of dairy manure, chicken manure and wheat straw. The result found that optimum C/N ratio was found 25:1-30:1 because of stable pH. Usa Onthong et al. [12] conducted experiment on production of biogas from different raw and processed waste: soybean residues, papaya peels, sugarcane bagasses, rice straws and greater galangals into two parts. The batch experiment was conducted under different HRT and continuous experiment was carried out for 60 days. The result obtained that in continuous experiment, soybean residues produced highest production and in batch production its HRT of 25 days. Also, papaya peels produced high production rate in just 15 days. Gabriele Mancini et al. [13] investigated the effect of three different pre-treatment on

Fig 1. Additives (i) Alfalfa Powder (ii) Pongamia Pinnata Powder (iii) Urea (iv) Waste Decomposer

production of biogas from wheat straw. The result obtained that all pre-treatments were increased biogas production from 11 to 15%. Riggio et al. [14] investigated biogas production by anaerobic co-digestion of cow slurry, olive pomace and apple pulp. The result obtained that, mixture of 85% cow slurry, 15% olive pomace and 5% apple pulp gave a better yield. Natacha Phetyim et al. [15] conducted experiment on the effects of vegetable loading rate of 0.5 kg and 1.0 kg per week on biogas production and effect of production rate of different percentage of dog manure added in cattle manure at 10 and 20%. The result revealed that methane content increased with increased of dog manure and got low hydrogen sulphide compare to only cattle manure. A Haryanto et al. [16] conducted experiment on effect of urea addition on biogas production from the mixture of cow dung and rice straw in semi continuous flow digester. For that, urea was added in different quantity (0, 0.25, 0.65 and 1.30 g/L) in mixture of cow dung and rice straw at a ratio of 3:1. The result obtained that, urea addition of 0.25 g/L at C/N ratio of 27.3 gave higher biogas production.

The purpose of the research was to make an attempt to use alfalfa, pongamia pinnata (karanja) and urea as a co-substrate with cow manure for production of biogas within short HRT.

II. Materials And Methods

A. *Feedstock*

The fresh cow manure (CM) was collected from a local farm house, near dudhdhara dairy, Bholav, Bharuch. The visible straws present in CM were removed manually. Urea was collected from the Utran village, Surat and used as an external nitrogen source. Pongamia pinnata (PP) leaves were collected from our SVMIT college campus, Bharuch. The purpose for use of this leaves to increase C/N ratio. These leaves were dried for 2 days in sun light. Now, dry leaves were crushed manually and grinded in mixture machine. Alfalfa powder (AP) was collected from the Poonam greens, sankheda, Chhota Udaipur. Waste decomposer powder was purchased from the amazon and used for rapid decomposition of feedstock.

B. *Experimental setup and design*

In this study, experiments were conducted in small scale anaerobic batch digester under mesophilic range temperature (28-30 ^{o}C) for 45 days. The experiments were carried out in two stages. In first stage, cow manure was mixed with water at a ratio of 1:1 in 1000 L digester. Digester contained 300 L of total liquid (150 kg CM & 150 L water), remaining space used for gas collection and air tight sealing was done by using M-seal (epoxy compound), as shown in fig 2. In second stage, the alfalfa powder, pongamia pinnata powder & urea were added an amount of 5%, 5% and 1% respectively and also waste decomposer liquid was added in cow dung slurry, as shown in fig 1. Waste decomposer liquid was made by using 1 bottle of waste decomposer powder is to added in a plastic drum containing 200 litres water and 2 kg jaggery and mix it properly with a wooden stick for uniform distribution and cover the drum with paper or cardboard. Stir it to 5 day once or twice and after 5 days the solution of drum turns creamy and ready to use.

The volume of biogas produced in digester was measured by water displacement method in U-tube manometer in which volume of gas generated equals to expelled water in manometer. Biogas was generated in first digester is then enter into the second digester by opening wheel valve which is filled with water for elimination of CO_2 and H_2S from it. Both digesters were connected by means of U-PVC pipe. One end of pipe was inserted at top most portion of first digester and in other end of pipe, holes were made for proper contact of biogas with water which was inserted at slightly above the bottom of the digester.

C. *Analytical Methods*

The composition of biogas was depicted by using gas chromatography (GC) method from Saharsh EHS services. Gas sampling rubber bladder is used for filling of biogas for checking its different composition. Carbon-nitrogen (C/N) ratio of cow manure slurry with different additives was checked at Pollucon laboratories. The pH, total solids (TS) and volatile solids (VS) of cow manure, pongamia pinnata and alfalfa powder samples and also pH value of mixtures of these three samples without and with NaOH were measured at En-vision environmental services. To determining the percentage of total solid, a sample of certain weight was taken (W_1) and put in ceramic vessels and dried in an oven at 105^{o}C for one day until constant weight obtained. After this sample placed in desiccator for cooling and weighed the sample (W_2) for TS measurement. A part of this sample (W_3) was taken and burnt in furnace at 600^{o}C for 3 hours for volatile solids measurement.

Fig 2. Anaerobic digester set up

III. Results And Discussion

The value of CH_4, CO_2, H_2S and calorific value of biogas generated from cow manure was shown in table 1. The results of substrate characterization are shown in table 2. The C/N ratio and pH value is a very important parameter to take into account when investigating different feedstock and feedstock mixtures for anaerobic digestion. [11] From the table 2, it is shown that C/N ratio of mixture of three additives is 55.7 which is too high. Therefore, urea was used as an external nitrogen sources for reducing C/N ratio in optimum range. The pH value of three mixing additives was 6.12 which is below the optimum range of pH (6.5-8). So that, NaOH was used to increase the pH value and by adding NaOH, pH value become 7.10.

Fig 3. shown daily biogas production rate from cow manure with additives and without additives. The biogas pressure was obtained in U-tube manometer by using cow manure only is 1.43 bar in 46 days. Whilst using AP, PP, urea and waste decomposer in cow manure increased biogas production rate by obtained 2.67 bar pressure in just 32 days because of C/N ratio, pH value in optimum range compare to cow dung and faster bacteria production. The purpose for usage of this additives in this research work was that to faster production rate in short HRT and also it will be easily available at very low cost. Alfalfa powder available at just 90 Rs/kg, waste decomposer powder at just 20 Rs per bottle, urea is buying from the local suppliers and for pongamia pinnata, only labour cost included.

TABLE 1
Composition Of Biogas

Sr. No.	Parameters	Units	Results
1	CH_4	%w/w	53.80
2	CO_2	%w/w	39.20
3	H_2S	%w/w	0.35
4	Calorific Value	kcal/m^3	5130

TABLE 2
Chemical Characterization Of Substrates

Parameters	Cow Manure	Pongamia Pinnata	Alfalfa
pH	7.15	5.97	5.87
TS (g/kg)	157	720	530
TS (g/kg)	134	540	410
C/N (without urea)	55.7		
pH (without NaOH)	6.12		
pH (with NaOH)	7.10		

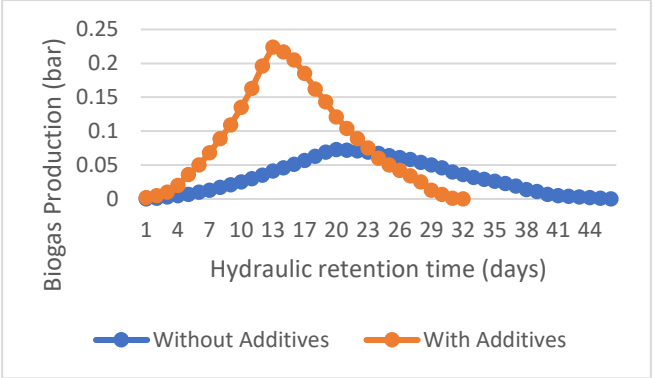

Fig 3. Daily biogas production rate from cow manure with and without additives

IV. Conclusion

The present study showed that co-digestion of AP and PP are promising for biogas co-substrate. Urea addition in slurry to maintain C/N ratio and waste decomposer was used for decompose of waste rapidly. Co-digestion of CM, AP and PP with urea and waste decomposer performed well than CM alone. CM alone gave 1.43 bar pressure in 46 days while different additives with CM gave 2.67 bar pressure in 32 days. The result concludes that, by using of different additives, HRT will be decreased and production rate will be increased by 43.75 % and 86.71 % respectively.

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