Optimized Biomethanization Of Grinded Organic Waste Using Catalyst

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Abstract. Research work was conducted to investigate the production of biogas using mesophilic anaerobic digestions. The organic waste utilized for bio gas appeared to produce less bio gas in the initial state up to 5 days due to temperature changes, then the gas production gradually increases. From the experimental set up, it was discovered that biogas generation was not uniform. Cow dung, food waste and agriculture wastes were used as organic waste for loading the anaerobic digester. Catalyst such as lime, hydrogen peroxide and silica gel were added to enhance the reaction. From above investigation, it is conceivable that the COD reduced gradually in the digester. Biogas production were fluctuating throughout the study period. The ideal measure of gas production in the range of 320 mg/l was obtained by adding hydrogen peroxide but for a period of 30 days experiment cumulative bio gas production measure is 4697 mg/l, which is achieved by adding lime as catalyst. Efficient bio methanation of grinded organic waste can be achieved by adding lime in most economical way.

1 Introduction

Biomass could be a scientific term for living matter, a lot of expressly, any organic matter that has been derived from plants as a results of the conversion method of photosynthetic [1] . basically, the use of biomass for energy is that the reversal of photosynthesis. In nature, all biomass ultimately decomposes to its elementary molecules with the discharge of heat [2]. throughout conversion processes like combustion, biomass releases its energy, typically within the type of heat, and therefore the carbon is re-oxidized to greenhouse gas to switch that that was absorbed whereas the plant was growing[3]. As a lot of economical bioenergy technologies square measure developed, fuel inputs are reduced; biomass and its by-products may be used as sources for fueling several energy needs[4]. The energy worth of biomass from plant matter originally comes from solar energy through the method referred to as photosynthesis[5]. According to the European Directive 2009/28/EC, the term biomass assigns "the biological origin and perishable fraction of products, waste and remnants from agriculture (including animal and vegetal substances), forestry and related industries including aquaculture and fisheries, as well as the biodegradable fraction of industrial and municipal waste[6]. Europe and Central Asia produced 392 million tons of waste in 2016,

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and about 31 percent of wastage is currently being recovered through composting and recycling. Biological conversion of wastes has been exhibited as one of the most advantageous and effective method of lower the pollution[7].

Bio waste is known to be containing pathogenic bacteria such as Salmonella and different microorganisms that may be a health risk for both people and animals[8] The bio security risk linked with using digested residue as fertilizer is hard to assess, but this risk cannot be unattended. It is of greatest importance that the treatment in the biogas plants (BGP) reduce the survival of pathogens. Temperature is the most important factor when considering the decrease of pathogens in BGP, but there are also other factors involved [9]. The potential health risk with digested residues from BGPs is partly dictated by the substrate that is treated in the plant. It is well known that bio wastes contain pathogenic bacteria [10]. They arise from tissues of diseased animals and people and from healthy carriers who excrete bacteria in faeces, urine, and exudates. Therefore, bio waste may contain pathogenic bacteria of various species such as Salmonella, Listeria, Escherichia coli, Campylobacter, Mycobacteria, Clostridia, and Yersinia[11].

Biogas can be transformed directly into electricity by using a fuel cell. However, this operation requires very clean gas and high-priced fuel cells. Therefore, this choice is still a situation for research and is not currently a practical option[12]. The changing of biogas to electric power by a generator set is much more practical. In contrast to natural gas, biogas is identified by a high knock resistance and hence can be used in ignition motors with high compression rates. In most economically run biogas power plants today, internal burning motor shave become the standard mechanization either as gas or diesel motors. There is mature, dependable high-quality automation available on the in international market [13]. The techno-logical difficulties with which portable biogas plants were opposes two decades ago have been resolved[14]. Different methods of desulphurization have been successfully accepted and combustion motors liberal to biogas that have proven their performance available in the market. Sufficient know-how for planning and constructing dependable biogas power plants is also available [15]. The electricity production element of a biogas power plant does not require much more know-how and effort for supporting than a normal generator set for fossil fuels with a well-working biogas fermentation process as an indispensable prerequisite[16]

Generally, two types of classifications of micro-organisms are involved for this mode of conversion. The first among them is the acid formers which changes macro molecules like carbohydrates, starches, proteins, cellulose, lipids etc to organic acids. In the third step these organic acids are changes in to acetate & eventually in the fourth step the acetate is transform to methane & carbon dioxide by a kind of organisms called methanogens[17]. Solid retention time for batch digestion is pretty high. Time is essential for first two steps is very high that absorbs most of the time[18]. Production of biogas can be enhanced by inclusion of trace elements that serve as micro nutrients for the anaerobic microorganisms. Supplementation of essential trace components has been appeared to maintain and stimulate the digestion process[19].

The useful effects of co-digestion are mostly related to a balanced usefulness of macro- and micronutrient are need by the microbial community, optimal moisture content, buffer capacity and dilution of inhibitory or dangerous compounds. Additionally, co-digestion may upgrade the process kinetics rather than the bioavailability of the feedstock. Regular the hydrolysis rates using bio-methane potential assays, and found that co-digestion expand hydrolysis rates when food waste and manure was co-digested differentiate to mono-digestion in BMP assays[20]. This investigation have been done to provide biogas from organic wastes with cow dung and also victimization silica gel, lime, hydrogen peroxide as a catalysts[21].

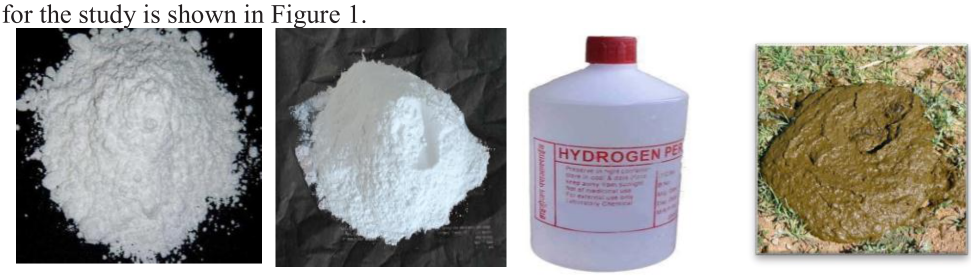
2. Materials and Methods

2.1 Raw Materials

Cow dung, food waste and agriculture waste and catalysts were used for this study. Fresh cow dung was collected from the Ananthasagar area, Telangana state. Whereas other organic waste were procured from local market in Warangal town. Organic waste collected is grinded into slurry in grinding machine. About 15 kg of grinded organic waste is with 1 kg of cow dung which is taken in digester for digestion process. Totally 4 anaerobic digesters were used. The digesters were loaded in batch wise and the temperature is maintained in the range of 27℃ to 30℃. The detention time of 30 days were provided for each of the reactor. The pH, temperature, COD and biogas generation were observed daily. In the three digesters to induce the anaerobic reaction catalyst such as lime, hydrogen peroxide and silica gel were added. It is always superior to have surplus catalyst than to have shortage because concentration of catalysts is proportional to the rate of catalyst One anaerobic digester is left without any catalyst as controlled digester to perform comparative study of mesophilic digestion process.

2.2 Catalyst

Catalyst speeds up reaction as distinct from a change in physical form, but is not absorbed by the reaction; hence a catalyst can be recuperated chemically unchanged at the end of the reaction it has been used to speed up, or catalyze. In this Bio methanation process three different catalyst such as lime, silica gel and hydrogen peroxide were used and the performance of the four reactors in terms of bio gas production were observed. Activation energy is reduced by the catalysts preventing higher rate of reaction and inducing mesophilic reaction, thereby increasing bio methanation process. Catalysts also optimize the performance of the bacteria responsible for waste digestion. Catalyst and organic matter used for the study is shown in Figure 1.



a. Lime b. Silica gel c. Hydrogen peroxide d. cow dung

Fig. 1. Catalysts and organic material used for the study

3. Experimental setup

Experiment was conducted by fabricating 4 prototype cylindrical digesters (20 liters capacity water cans) were taken, before adding catalyst, grinded organic waste of 15 litres along with 1kg of cow dung (seeding sludge) is added for quick decomposition. In each digester 15 liters of grinded organic waste along with seeding sludge is added and mixed thoroughly. After that the catalyst (lime, silica gel, hydrogen peroxide) of 0.5% of weight of organic slurry is added in three anaerobic digesters. Leveling tube is connected to digester tank to the measuring jar, to preventing the air & water leakage by using M-seal. The measuring jars are placed (inverted) in each plastic tub to conceal the gas as shown in Figure 2. At the time of inverting measuring jar the water is filled in measuring jar and tub for holding gas in measuring jar.

Fig. 2. Experimental set up

The downward displacement of water in each measuring cylinder was taken as a measure of the volume of biogas produced in each digester as shown in Figure 3, and the volume of daily biogas production in each digester was noted separately. The gas produced in anaerobic digester is collected through levelling tube to the measuring jar if the gas is accumulated the water level in measuring jar is decreases .so the production of gas calculated based on water displacement method.

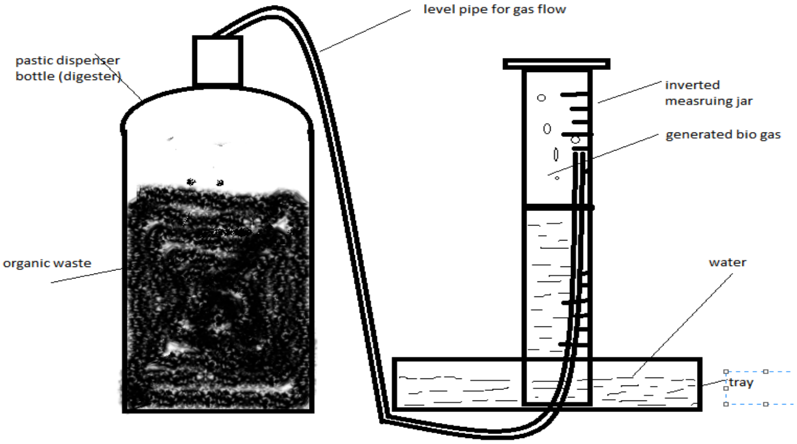


Fig. 3. Water displacement method

4. Kinetics of biogas production

4.1 Hydrolysis:

The hydrolysis In several cases, the biomass is formed from massive organic wastage. For the bacteria in anaerobic digesters to access the energy potential of the material, these chains first must be breake down into their smaller constituent pieces. These constituent pieces, or monomers, such as sugars, are preparedly available to other bacteria. The action of shattering these chains and diffusing the smaller molecules into solution is called hydrolysis. Therefore, hydrolysis of these high-molecular-weight polymeric element is the most necessary first step in anaerobic digestion as shown in Figure 4.

4.2 Acidogenesis:

The biological process of acedogenesis results are in the breakdown of the remaining components by the acidogenic (fermentative) bacteria. Here, VFA's are formed, along with ammonia, carbon dioxide, and hydrogen sulfide, as well as another byproducts. Performance of the bacteria responsible for waste digestion. Catalyst and organic matter used for the study is shown in Figure 1.

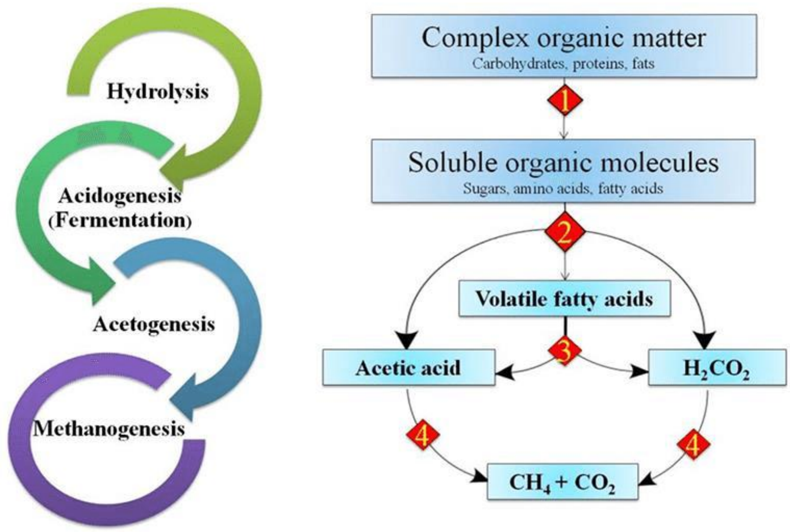


Fig. 4. Kinetics of biogas production

4.3 Acetogenesis:

In an anaerobic digestion the third phase is acetogenesis. Here, simple molecules generated through the acidogenesis phase are further digested by acetogens to generate largely acetic acid, as well as carbon dioxide and hydrogen.

4.4 Methanogenesis:

It is the terminal stage of anaerobic digestion is the biological process of methanogenesis. Here, methanogens use the intervene products of the preceding phases and change them into methane, carbon dioxide, and water. These elements form the majority of the biogas released from the system. The Methanogenesis is sensitive to both high and low pH and occurs between pH 6.5 and pH 8.

5. Result and Discussion

Animal manures have a high alkaline capacity, that changes them into useful substrates for anerobic digestion. Most especially, active microorganism might reinforce the degradation activity of waste as it has working substrate supply with an excellent capacity to produce biogas. Rapid biogas production began in the reactors treating ternary mixtures, even though it did not show any clear dependence on the substrate mixing ratio. In the microbiome level, numerous challenges may induce changes in bioreactor behavior, as it is setup by the physiological and biochemical interactions of microorganisms within the bioreactor. Former scientific reports refer ammonia being the principal reason of digester inhibition as it penetrates the bacterial cells causing by the proton imbalance, altering intercellular pH, and inhibiting specific enzyme responses. Thus, co-digestion with different waste is an efficient technique to avoid resurgence of NH3 and to balance the C/N ratio in the digester.

5.1 pH

The test investigation of pH on the bio gas creation by utilizing of grinded organic water, the pH was measured in the sample regularly for 30 days (without catalyst, silica gel, lime, hydrogen peroxide). The pH is less attained on sample without catalyst at the end of 30 days in the order of 7.4, and most extreme value of 7.9 was found to be in hydrogen peroxide is shown in Figure 5. It takes the primary spot in all other samples. Next to it, pH is elevated by the catalyst hydrogen peroxide and it gives the base pH level of 6.5 and most extreme value is was found to be 7.8. Catalyst silica gel observations found to be the base value of 6.4 and greatest value is 7.6.The last value is acquired by the organic waste (without including catalyst) it gives the base value of 6.6 and greatest value of 7.5. Finally, the bio gas production by using organic grinded waste water in the lime gives the optimum pH value.

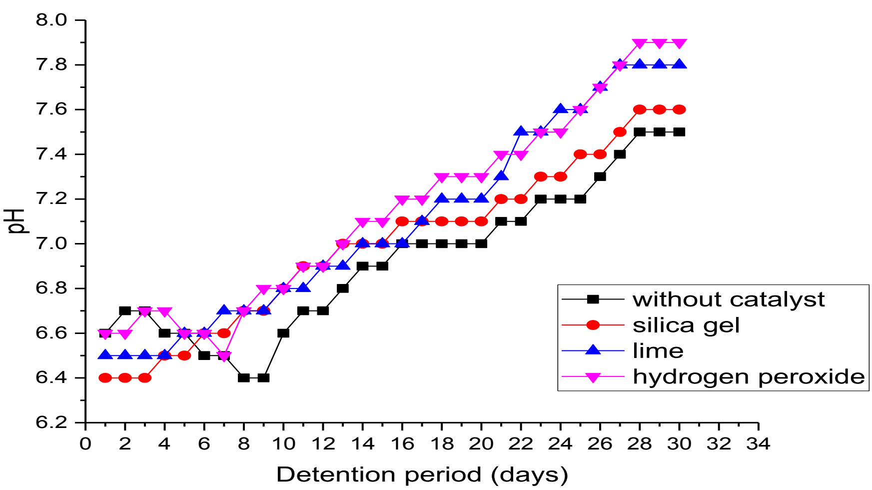


Fig. 5. pH variation in the anaerobic digester

5.2 CoD

Initially the COD of the organic grinded waste was varying from 470 mg/l to 700 mg/l . hydrogenesis reaction was started in the organic waste in the anaerobic reactor as shown in Figure 6. As the digestion proceeds the COD starts decreases in the samples. It gets stable after 20 days of digestion. The overall completion was low due to fast hydrolysis and the subsequent volatile fatty acids (VFAs) acidification that hold back the methanogenic reactions. Graph shows that COD reactions of samples with silica gel, hydrogen peroxide and without catalysts are slight difference and are in the same manner but comparing to all samples lime is decreased rapidly at the range of 150 mg/l in 24 days even though initially the values are high.

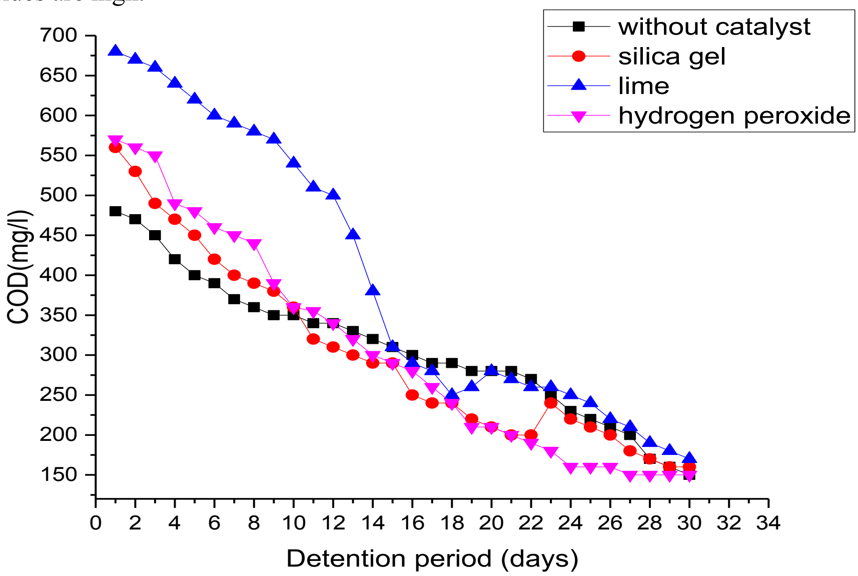


Fig. 6. COD variation in the anaerobic digester

5.3 Biogas Yield

From the Figure 7 shows that the bio gas yield upto 4 days is more i.e bio gas yield for the sample with 0.5% lime is more upto 4 days .and then next to lime ,the sample with silica gives next gas production and with hydrogen peroxide appearing 3rd place while comparing to normal sample without catalyst. After 20 days the bio gas production is gradually increasing with the additional factors like temperature, time etc. So finally, the bio gas is more with in production and speedy reaction with using catalyst.

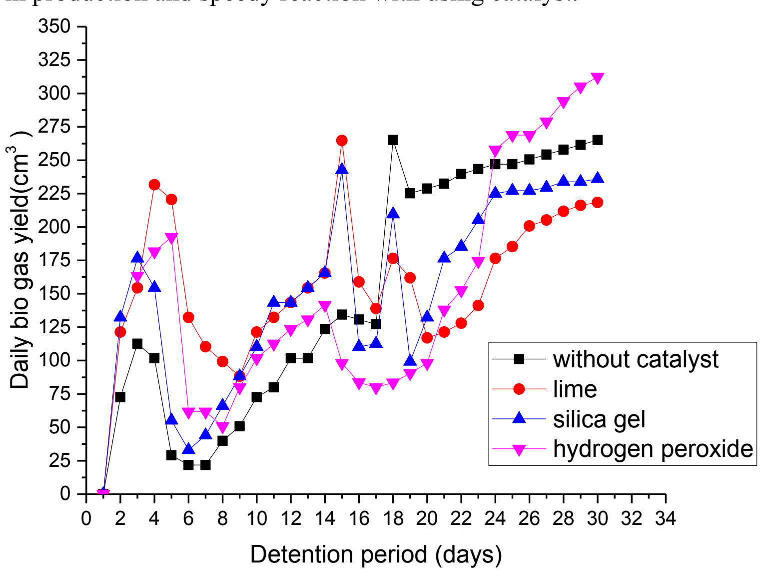


Fig. 7. Biogas production

The tests and results lime catalyst acting more in production and less in cost too. While utilizing organic waste for bio gas it is appeared that up to certain period. up to 5 days the results obtained in bio gas production is decreased due to temperature changes. after given preference that organic cow dung waste with lime producing more bio gas 4697.458 cm3. from the trial information, it was discovered that biogas generation was not uniform. From above investigation, one might say that by this structure it is conceivable to get the ideal measure of gas creation by utilizing a particular catalyst. Approximately lime cost is RS 5.2 as it is used in the study is about 0.5% less than the costs Rs 6.8.so bio gas production is more and reaction time is less within 30 days the gas yield is obtained about 4697.458cm3 in presence of lime as catalyst.

Table 1. Daily bio gas yield with and without catalysts.

Detention period(days)	**Daily bio Gas yield (cm^3)**			
	Without catalyst	**Lime 0.5 %**	**Silica gel 0.5 %**	**Hydrogen peroxide 0.5 %**
1	0	0	0	0
2	72.64	121.33	132.36	130 .752
3	112.59	154.42	176.48	163.44
4	101.69	231.63	154.42	181.6
5	29.1	220.6	55.15	192.5
6	21.8	132.36	33.09	61.7
7	21.8	110.3	44.12	61.7
8	39.95	99.27	66.18	50.85
9	50.85	88.24	88.24	79.90
10	72.64	121.33	110.3	101.70
11	79.9	132.36	143.39	112.60
12	101.70	143.4	143.39	123.49
13	101.70	154.42	154.42	130.75
14	123.5	165.45	165.45	141.65
15	134.38	264.72	242.66	98.06
16	130.75	158.83	110.3	83.56
17	127.12	138.98	112.56	79.9
18	265.14	176.48	209.57	83.5
19	225.18	161.92	99.27	90.5
20	228.82	116.92	132.36	98.06
21	232.45	121.33	176.48	138.016
22	239.71	127.95	185.30	152.544
23	243.34	141.18	205.16	174.336
24	246.98	176.48	225.01	257.872
25	246.98	185.30	227.22	268.768
26	250.61	200.75	227.22	268.768
27	254.24	205.16	229.42	278.937
28	257.87	211.78	233.84	294.192
29	261.50	216.19	233.84	305.088
30	265.14	218.39	236.04	312.352
Total bio gas	4540.06	4697.46	4553.24	4386.33

5. Conclusion

The performance and potential of biogas production in anaerobic digester is analyzed by utilizing lime, silica gel, hydrogen peroxide by feeding organic waste in the grinded form. The gas yield seems to be fluctuating though out the period of 30 days. At the initial stage catalyst lime increased the COD to about 700 mg/l and it reduced upto 150 mg/l in 24 days. High reduction of COD for all the samples were observed in 24 days Gradual increase or decrease of gas production is not observed. Initial gas production started after a day of degradation and gradually it reached the peak of about 220 mg/l in 4 days. At the 30 days of time interval, gas production was observed to be 320 mg/l. Catalyst hydrogen peroxide shows highest gas production. Approximately lime cost is Rs. 2 as it is used in the study is about 0.5% less than the costs of other catalysts such as silica gel is Rs. 84 and hydrogen peroxide is Rs. 15.2. Hence lime is suitable to be used as catalyst to increase the gas production in the anerobic digestor.

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