A Lab Scale Study on Anaerobic Digestion for Analyzing Energy Generation using Vegetable Waste

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Abstract- Vegetable wastes (Banana stem, Cabbage and Ladies finger) were an-aerobically digested in a fed-batch laboratory scale reactor at mesophilic conditions (35^{o}c). The Organic Loading Rate (OLR) was maintained at 2.25g/l.d with a Hydraulic Retention Time (HRT) of 30 days. The objective of this paper was to study the performance of the selected vegetable wastes in a single stage fed-batch anaerobic reactor for biogas production. The study is carried out during the year 2015-2016.

Keywords – Anaerobic digestion, Biogas, Ultimate methane yield.

I. Introduction

Global energy crisis has posed serious problems due to shortage of fossil fuels. Organization for Economic Co-operation and Development (OECD) has become increasingly aware of the problems which aimed at more efficient energy use and exploitation of energy sources. Bio mass seems one of the most valuable sources of energy because it is in principle renewable and to large extent the techniques for converting it to energy are known.

The reasons for increased use of anaerobic digestion include improvement of the reactor designs to reduce the energy cost and minimization of problems created by energy storages which have made those processes economically competitive with other techniques. Correspondence should be made with this author. Even though anaerobic digestion is an old and proven technology, process design for efficient energy production is not fully understood and research and development work is going on to improve efficiency, reliability and applicability using various biomass. Literature shows that many works have been carried out in India and abroad for production of biogas using farm wastes, sewage sludge, and municipal solid wastes (MSW) etc. It is clear from review that there are no common governing factors that indicate the suitability of any particular reactor design for a specific effluent.

By suitable modifications in the reactor designs and also by altering the influent physio-chemical characteristics, high rate digesters can be accomplished for the treatment of organic solid wastes.

Raw vegetables wastes are used to produce biogas by anaerobic digestion process from a long time because in principle, it has high energy potential and enormous quantity of vegetable wastes are dumped daily in municipal and urban areas which needs to be processed to minimize environ mental pollution. Anaerobic digestion is a biochemical process in which organic matter in absence of air (oxygen) is converted to a mixture of methane and carbon dioxide called biogas. In the technical point of view anaerobic digestion is a four step (1) process namely hydrolysis, acetogenesis, hydrogenesis and methanogenesis in which complex organic materials are converted to the end products of methane and carbon dioxide. In general two groups of micro -organisms are responsible for this conversion. The first group of organism is collectively termed as acid formers which convert large organic molecules such as proteins, starches, cellulose etc. into organic acids (step one and Step two). In step three the conversion of acids to acetate and finally, in step four, acetate is converted to methane and carbon dioxide by the help of a group of micro -organisms collectively termed methanogens. Solid retention time in anaerobic batch digestion is high (2). Time required for first two steps is very high with respect to other steps because hydrolysis and acid formations are taking places in these stages which consumes most of the time. These studies are aimed to produce biogas using dried vegetable wastes other than raw vegetable wastes with short retention time and compression of both. Optimum solid concentration and ultimate yields of biogas using dried and raw vegetable wastes have been presented.

Anaerobic digestion is the biological degradation by a complex microbial ecosystem of organic and occasionally inorganic substrates in the absence of an organic source. There are four metabolic stages involved in the production of methane using anaerobic digestion process. First, the particulate organic matters undergo hydrolysis by extra cellular enzymes to convert polymers into monomers. Then the soluble organic matter and the products of hydrolysis are converted into organic acids, alcohols, hydrogen and carbon dioxide by acidogenic bacteria. Thirdly, the acetogenic bacteria convert the products of acidiogens into acetic acid, hydrogen and carbon dioxide. Finally, methanogenic bacteria are responsible for methane production from acetogen products. The main advantage in using anaerobic digestion is the biogas production, which can be used for steam heating; cooking and generation of electricity. The effluent produced can be used as a biofertiliser or soil conditioner. Vegetable wastes generated largely in markets were disposed in municipal landfill or dumping sites. Bioconversion processes are suitable for wastes containing moisture content above 50% than the thermo- conversion processes. Vegetable wastes, due to high biodegradability nature and high moisture content (75 – 90%) seemed to be a good substrate for bio-energy recovery through anaerobic digestion process. A major limitation of anaerobic digestion of vegetable wastes is the rapid acidification due to the lower pH of wastes and the larger production of volatile fatty acids (VFA), which reduce the methanogenic activity of the reactor. Preliminary treatment is required to minimize organic loading rate, hence aerobic processes are not preferred for vegetable wastes. The rate limiting step in vegetable wastes is by methanogenesis rather than by hydrolysis because methanogenic bacteria take long mass doubling time of 3-4 days in anaerobic reactors.

II. MATERIALS AND METHODS

2.1 Collections of waste:–

Data collected from all the three sites are

i.) K R Market, Vijayawada
ii.) Municipal market, Guntur
iii.) Vegetable market, Tenali

S.NO	x1	x2	x3	x4	x5	x6	x7		Avrg
1	12700	12800	12720	12770	12730	12780	12750	89250	12750
2	11850	11950	11880	11920	11870	11930	11900	83300	11900
3	8450	8550	8430	8570	8420	8580	8500	59500	8500

Where x1, x2, x3, x4, x5, x6, x7 are the no. of days.

Total vegetable waste generated: 1. K R Market= 12750kgs 2. G M Market= 1190kgs 3. Tenali market= 8500kgs
Total average waste generated

location	total waste generated(kg)
vijayawada market	12750
guntur market	11900
tenali market	8500

B. Experimental setup :–

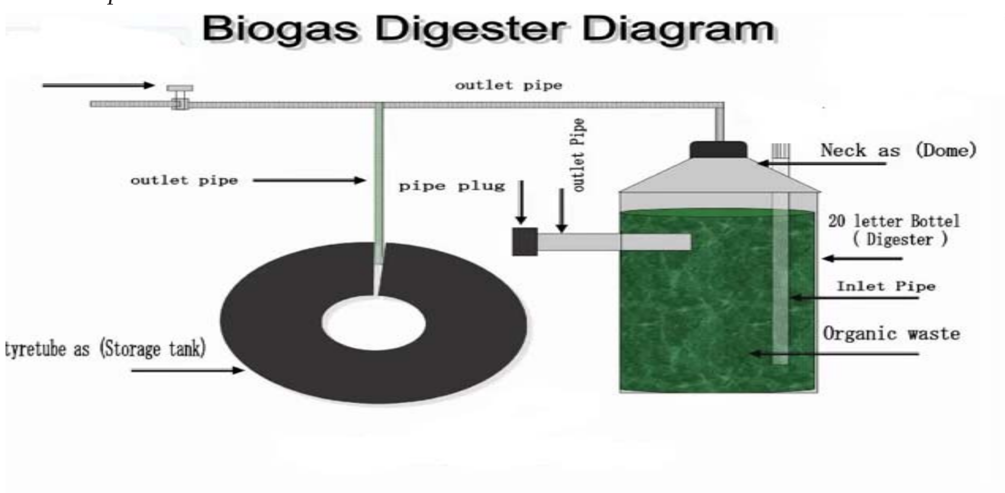


Fig: Experimental set up.

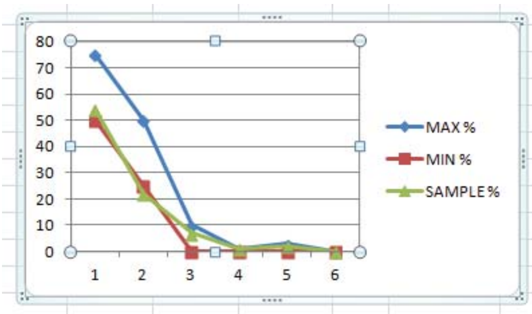
The performance of the reactors was evaluated by estimating destruction of total and volatile Solids and by monitoring daily gas production. Mean methane production rate were determined at different organic loading range. Predictive models for analyzing the performance of the batch reactor and for determining cumulative biogas production for a given organic loading have been developed.

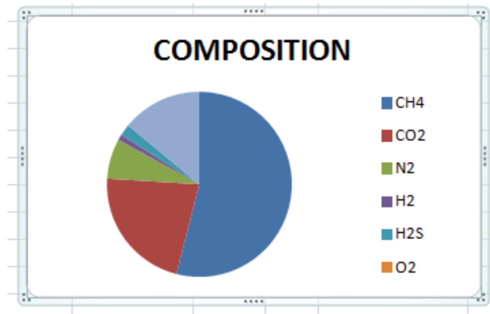
Organic compounds decompose under anaerobic condition to yield biogas. This work presents results of the study on biogas production from fruits and vegetables waste materials and their effect on plants when used as fertilizer (Using digested and undigested sludge). The results obtained shows that difference in the production of biogas to a large extent depends on the nature of the substrate. All the substrates used appeared to be good materials for biogas production and their spent slurries can be used as a source of plant nutrients.

In the present study the problems being faced by VMC are studied and various possible options for source reduction, recycling, disposal and creating wealth out of waste (WOW) are studied and their feasibility is evaluated.

III. Results and Discussions

3.1. Comparison of Biogas yield for samples with natural gas limits





1. Composition Analysis Report

Compound	Formula	%	Sample %
Methane	CH_4	50–75	54
Carbon dioxide	CO_2	25–50	22
Nitrogen	N_2	0–10	7
Hydrogen	H_2	0–1	1
Hydrogen sulphide	H_2S	0–3	2
Oxygen	O_2	0–0	0

2.Standard Properties Analysis

Properties	CH_4	CO_2	H_2	H_2S	NH_3	N_2	O_2
Molar percent [%]	54	22	1	2	0.05	7	0
Calorific value [MJ.m-3]	35.88	-	10.78	22.8	-	-	-
Normal density [kg m-3]	0.72	1.98	0.09	1.54	0.77	1.25	1.43
Molar Mass [g mol-1]	16.04	44.01	2.02	34.08	17.03	28.01	32.00

Table: Lab analysis report of the bio gas generated

Fig: Production of Bio gas from vegetable waste

Table 3.1: Amount of bio gas generated from the data collected

s.no	total waste generated(kg)	bio gas for (kg)	total gas generated(kg)	no. Of cylinders
1	12750	0.0852	1086.3	76.5
2	11900	0.0852	1013.88	71.4
3	8500	0.0852	724.2	51

Where 1, 2, 3 are Vijayawada, Guntur, Tenali municipal markets

Table 3.2: Total cost of 3 bio gas plants in three areas

s.no	Total waste (kgs)	tonnes	cost/ton(lcs)	total cost (lcs)
1	12750	12.75	25	318.75
2	11900	11.9	25	297.5
3	8500	8.5	25	212.5

IV.CONCLUSION

- From our research the following conclusions were made.
- The biogas is generated through bio digester is 1.704kgs. For1kg of waste ----- 0.852kgs of bio gas is generated, percentage of methane (CH4) is 54% , percentage of carbon di-oxide (CO2) is 22%, N2 is 7%, H2 is 1%, H_2S is 2%, percentage of O2 is 0%
- Hence we conclude with this statement stating that Bio gas from vegetable waste meets the demand of 1% of all the three site areas population.

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