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Generation of Biogas from Kitchen Waste -Experimental Analysis

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***ABSTRACT**: Biogas production requires anaerobic digestion. We should go for creating an Organic Processing Facility to create biogas which will be more cost effective, eco-friendly, cut down on landfill waste, generate a high-quality renewable fuel, and reduce carbon dioxide & methane emissions. The anaerobic digestion of kitchen waste produces biogas, a valuable energy resource. Anaerobic digestion is a microbial process for production of biogas, which consists of primarily methane (CH4) & carbon dioxide (CO2). Mixture of vegetable wastes was an-aerobically digested in a 20L capacity lab scale batch reactors. Biogas can be used as energy source and also for numerous purposes. But, any possible application requires knowledge & information about the composition and quantity of constituents in the biogas produced. The continuously-fed digester requires addition of sodium hydroxide (NaOH) to maintain the alkalinity and pH to 7. For this reactor we have prepared our Inoculum than we installed batch reactors, to which inoculum of previous cow dung slurry along with the kitchen waste was added to develop our own Inoculum. A combination of this mixed inoculum was used for biogas production at 37°C in laboratory (small scale) reactor (20L capacity). In our study, the production of biogas and methane is done from the starch-rich and sugary material and is determined at laboratory scale using the simple digesters.*

***KEYWORDS:** Biogas, digester, methane, inoculum.*

I. INTRODUCTION

One of the burning problems faced by the world today is management of all types of wastes and energy crisis. Rapid growth of population and uncontrolled and unmonitored urbanization has created serious problems of energy requirement and solid waste disposal. Vegetable market wastes contribute to a great amount of pollution; hence, there has been a strong need for appropriate vegetable waste management systems. [1] Vegetable wastes that comprise of high fraction of putrecible organic matter cause serious environmental and health risks. It is known that organic waste materials such as vegetables contain adequate quantity of nutrients essential for the growth and metabolism of anaerobic bacteria in biogas production. [2]India produces 150 million tones of fruits and vegetables and generates 50 million tones of wastes per annum8, Therefore it become necessary to develop appropriate waste treatment technology for vegetable wastes to minimize green house gas emission. [3] The process of digestion and production of biogas depends on the composition of feedstock and the fermentation products of the vegetable wastes. The main objective of this research is to employ anaerobic digestion process as a sustainable technology for digesting the vegetable wastes, produced in large amounts during harvesting, handling, transportation, storage, marketing and processing, and to provide the renewable source of energy as well as to reduce the potential green house gas emission. [4] The specific objectives are (i) to optimize the methane gas evolution from the vegetable waste. (ii) To get an understanding of the anaerobic digestion of the vegetable wastes under ambient temperature conditions by conducting a lab scale study and hence to investigate the biogas yield and the kinetics of anaerobic digestion of vegetable waste fed.

The techniques used for the conversion of organic materials to biogas have been in existence for many years. Methane generation has been applied to meeting the energy needs in rural areas. In the England, India, Taiwan, for example, methane generating units as well as plants using cow manure and municipal waste have been in operation for years. In United States there has been considerable interest in the process of anaerobic digestion as an approach to generating a safe clear fuel as well as source offertilizer [5'6]. The use of rural wastes for biogas generation, rather than directly used as fuel or fertilizer, offers several benefits such as, the production of energy resource that can be stored and used more efficiently, the production of stabilized residue (sludge) that retains the fertilizer value of original material and the saving of energy required to produce equivalent amount of nitrogen-containing fertilizer by synthetic process. Indirect benefits of biogas generation include the potential for partial sterilization of waste during formation with consequent reduction of the public health hazard of faecal pathogens and reduction of fungal and other plant pathogens from one year's crop residue to the next. [7] Biogas is a flammable gas produced when organic materials are fermented under anaerobic condition. It contains methane and carbon (IV) oxide with traces of hydrogen sulphide and water vapour. It burns with pale blue flame and has a calorific value of between 25.9-30J/m3 depending on the percentage of methane in the gas. The gas is called by several other names, such as: dung gas, marsh gas, gobar gas, sewage gas and swamp gas [8]. The rate of biogas production depends: the nature of the substrate, temperature, pH, loading rate, toxicity, stirring, nutrients, slurry concentration, digester construction and size, carbon to nitrogen ratio, retention time, alkalinity, initial feeding, total volatile acids, chemical oxygen demand (COD), total solid (Ts), volatile liquids etc. This paper presents results of the study on biogas production from fruits and vegetable wastes aimed and at comparing the quantity of biogas produced from the substrates. [9]

II. MATERIALS AND METHODS

1) SOURCES AND GENERATION OF FOOD WASTE:

Food waste which includes vegetables, fruits and other items is taken for studies. The treatment process of food waste products gives hazardous waste. The usage of chemicals is one of the main reasons for this. The manufacturing of food items is a process that must be accomplished by adhering to strict controls of both the local and Federal food regulatory agencies. The items of food that are manufactured are as varied as the people they serve. Common staples, exotic delicacies, snack foods and ethnic specialties are all food items that go through a controlled and precise manufacturing process with safety always at the forefront.

2) SAMPLE COLLECTION:

Samples for treatment of food waste about 15 kg of waste items collected are categorized as vegetables, fruits, rice, other food items and waste water which mixing together, forms semi solid state.

3) FOOD WASTE CHARACTERIZATION:

The study was conducted on a mixed food waste sample collected from leftovers at households. The wastes were ground in a kitchen grinder to reduce its particle size in the range of 0.2-1mm. The FW slurry concentration was 50% made after diluting with tap water and later fed to the reactor. The characteristics of FW used in the experiment were compared with literature and the comparison is shown in table 1.

Table I Characteristics of food waste

S.N.	**Parameter**	**This study**	**Zhang et al (2007)**
1	pH	4-7.1	7.57
2	COD(g/L)	5-25	-
3	TS (g/L)	80-110	309
4	TVS (g/L)	68- 93	263
5	Moisture content (%)	30-70	70

4) REACTORSET-UP:

A completely recycled anaerobic reactor made from cylindrical column of borosilicate glass with total volume of 20L was utilized in the study. The reactor column was blanketed with a woolen cloth to avoid entry of direct sunlight and escape of process heat. Reactor system for AD of FW with arrangement for feed, recirculation and biogas measurement is made by using 20 liter container (used for drinking water storage), Solid tape, M – seal, PVC pipe 0.5'' (length ~ 1 m), Rubber or plastic cape (to seal container), Funnel (for feed input), Cape 0.5" (to seal effluent pipe), Pipe (for gas output, I was used level pipe) (3-5 m), Bucket (15-20 litter) and Bottle – for gas collection (2-10 lit.)

Fig 3
Experimental setup

5) REACTOR OPERATION:

The FW slurry was fed to the reactor from the top by a one way funnel and the equal quantity of the reactor digestate was withdrawn for the physico chemical analysis. The complete recycle was done to obtain complete mixing/agitation of the reactor digestate. The feeding was done daily at 11AM. The controlled up flow pattern of FW slurry through the reactor renders stratification of the phases such as hydrolysis, acidogenesis and methanogenesis. Such a pattern of single phase reactor operation provides advantages of two phase reactor.

6) INOCULUM:

Cow dung slurry was used as a source of inoculum since rumen of cow contains anaerobic microbial population. The cow dung slurry was prepared by mixing water in 1:5 proportions and sieved to remove coarse particles. The cow dung slurry and the FW slurry were mixed in 1:1 proportion and the mix was poured in the reactor. The nitrogen gas was sparged through the reactor to remove the oxygen toxicity to anaerobes. The total solids (TS) concentration of the mix was 9000ml/L with volatile fraction of 86%. The reactor content was mixed thoroughly by 100% recirculation from the outlet (top) to the inlet (bottom) of the reactor with the help of the slurry pump.

7) ANAEROBIC DIGESTION TESTS

The biodegradability and biogas yield of food waste were determined at 37 °C using three batches anaerobic digestion tests with the total volume of each reactor 20 L. Anaerobic microbial sludge, used as inoculums for the anaerobic reactors. The laboratory models were filled with the 1.4 L of new sludge before every dosage of new food waste sample. The initial values of the each sludge were measured. The dosage of substrate was adjusted by VSS content to avoid overloading of reactors. Daily biogas production from each digester was measured by using biogas flow meter. Chemical analysis of COD, TSS, VSS, nutrient contents and pH values was performed at the beginning, during the test and at the end of each biodegradability test.

III. EXPERIMENTAL RESULT

Table 2 Biogas production in ml

SET NO/DAY	1^{ST} DAY	2^{ND} DAY	3^{RD} DAY	4^{TH} DAY	5^{TH} DAY	6^{TH} DAY	7^{TH} DAY	8^{TH} DAY	AVERAGE
SET1	30	35	20	10	-	40	25	10	23.75
SET2	80	150	120	50	-	60	90	115	89.37
SET3	85	75	58	35	-	20	70	100	60.02

From the result it has been seen that in set2 which contain kitchen waste produces more gas, compare to other two set. In set2 with kitchen waste produces average 250.69% more gas than set 1 (with 200gm cow dung) and 67.5% more gas than set 3 (with 400gm cow dung). Means kitchen waste produces more gas than cow dung as kitchen waste contains more nutrient than dung. So use of kitchen waste provide more efficient method of biogas production.

Table 3 pH and total solid concentration of setup

DAY	SET 1		SET 2		SET 3	
	PH	TS%	PH	TS %	PH	TS %
1	7.25	8	7.2	6	7.25	8
4	6.7	7.6	5.8	5.4	6.6	7.5
5	6.85	7.6	6.45	5.4	6.9	7.5
8	6.65	7	4.92	4.7	6.5	7

From results it has been seen that pH reduces as the process going on as the bacteria produces fatty acids. Here methanogens bacteria which utilize the fatty acids, is slow reaction compare to other so it is rate limiting step in reaction. In set2 which contains kitchen waste pH decreases highly means reaction is fast, means hydrolysis and acidogenesis reaction is fast as organism utilize the waste more speedily than dung. And total solid decreases more in set2.

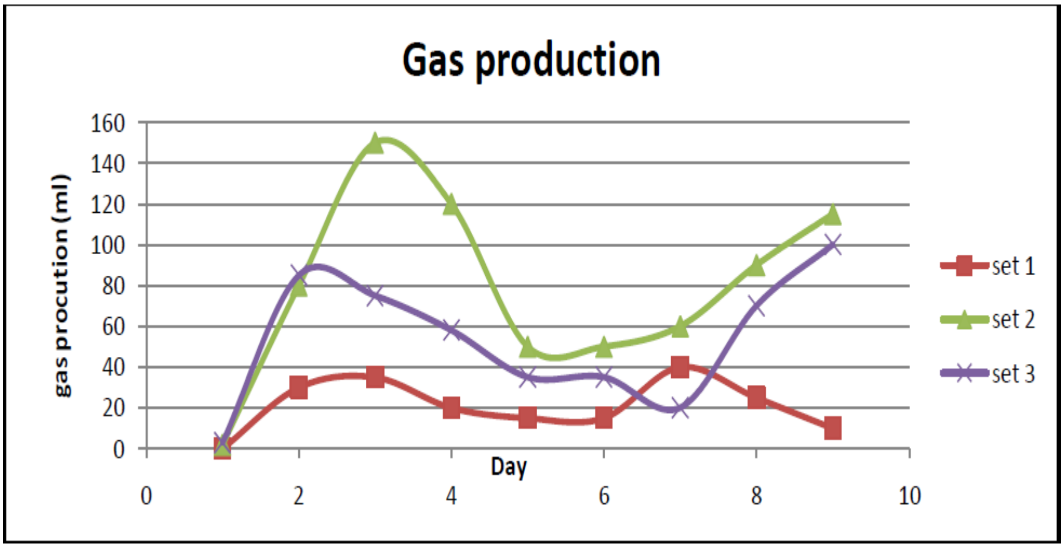

Fig. 2
Gas production V/s day for three sets

Graph Analysis- It can be seen from the graph that gas production increases first upto day 3 but then it starts decreasing as acid concentration increases in the bottles and pH decreases below 7 after 4-5 days water was added to dilute which increases the pH, gas production again starts increasing. Therefore,we can infer that acid concentration greatly affects the biogas production.

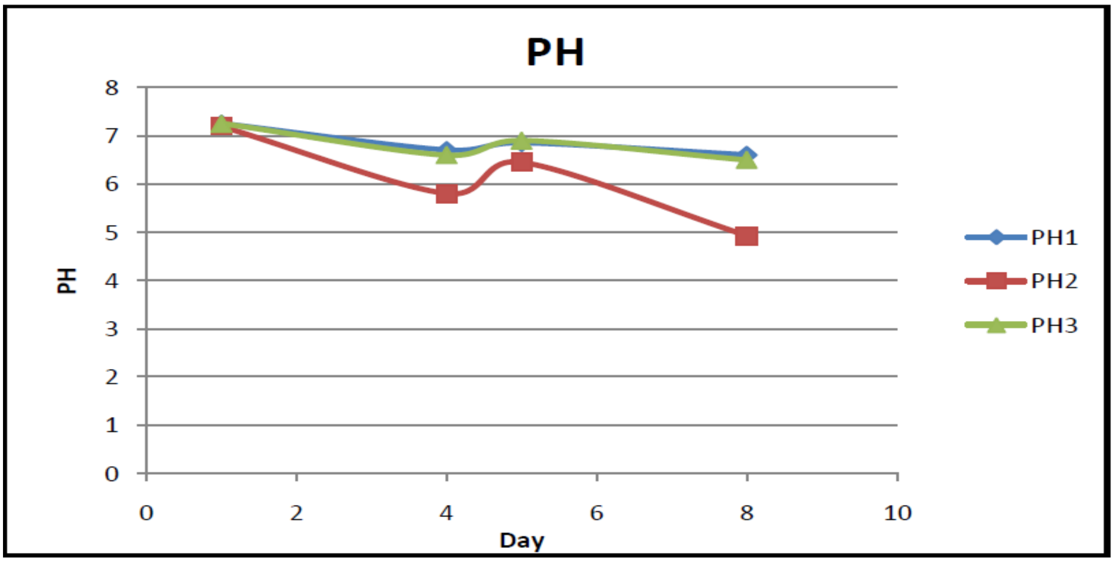

Fig.3
pH V/s day

GRAPH – This graph shows that first the ph is on higher side, as reaction inside the bottles continues it stars decreasing and after day 3 it becomes acidic. Then water added to dilute and thus pH increases.

IV. CONCLUSION

After the thorough study on the performance of reactor and evolution of acidogenic reactor, the following collusion have been reached, As a result of the treatment of food effluent using microorganisms, the useful bi product, bio-gas has been produced with a considerable rate of decrease in the values of COD, BOD, pH, acidity and alkalinity. Through the successful anaerobic processing inside the reactor in 90days food waste treatment, methanogen gradually converts the organic acids into the methane gas and carbon dioxide, which indicates that the waste has better anaerobic biodegradability. Thus achieves a waste of resource utilization. The results show that reactor can treat food waste with high contaminated load.

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