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A Comparative Study on Production of Bio Gas Using Green And Dried Vegetable Wastes By Anaerobic Batch Digestion Process.

[1,] DR. Chanchal Mondal, [2,] Prof. G.K.Biswas

[1, 2,] Department of Chemical Engineering, Jadavpur University, Kolkata, India

Abstract*-This paper shows a comparative study on production of bio gas from green vegetables wastes and dried vegetable wastes at different temperatures and concentrations by using two identical anaerobic bio digesters. The productions of biogas yield and ultimate methane yield have been compared for both the cases and optimizations of concentrations have been presented.*

Key words*- anaerobic digestion, biogas, ultimate methane yield.*

1. 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. Biomass 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 environmental 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.

2 Materials and Methods

2.1 Collections and preparations of samples. Wet vegetable wastes have been collected from local market and it has been separated in two parts. One part, labeled as sample (A) has been sun dried for two to three days and after sun drying the wastes are dried in an air oven for five to six hours at a temperature 100 to 105^0C. When the drying is completed, the dried sample is passed through standard size reduction equipments for a particular particle size. Another part, level sample (B) of wastes is passed in size reduction equipments for sizing and after size reduction the sample is kept in an Incubator at a temperature 5^0C.

2.2 Characterization of Samples

Both the samples have been characterized and the results have been tabulated as follows.

Samples	Moisture content (%)	Volatile Matter (%)	Calorific Value(cals/gam)	C:N:P
Sample(A)	14.61	58.82	2091.37	100:5:1
Sample(B)	68.23	4.59	2089.17	100:5:1

2.3 Methods

Two identical digesters as shown in figure 1 have been designed having each capacity of five liters with the provision of feed inlet opening, gas outlet nozzle and pressure measurement nozzle to carry out the experimental work. The digesters have been surrounded by water jackets to maintain constant temperature of the slurry inside the digesters. Each digester is fitted with stirrer and motor. The pressure and composition of gas have been measured using a U Tube Manometer and Gas Chromatograph (Model 8610, Made: Chemito).

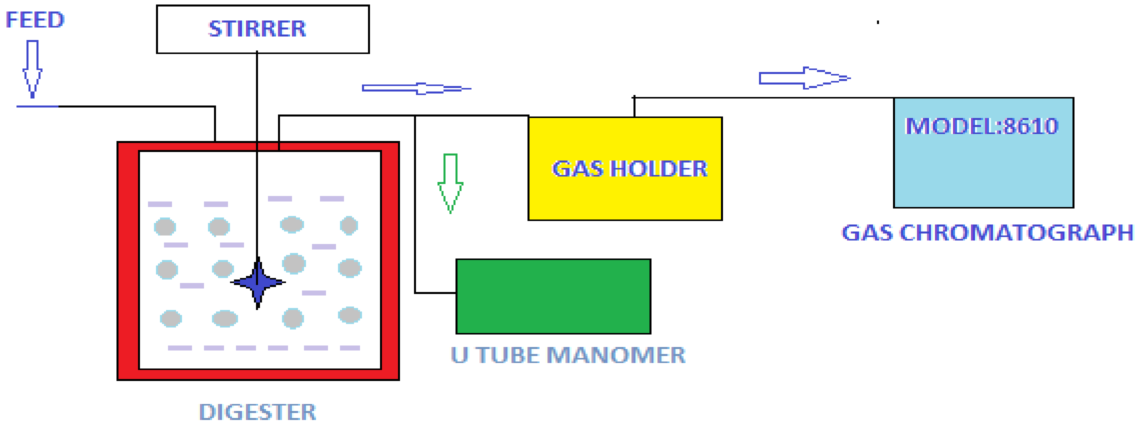

Fig: Experimental set up.

All experiments have been conducted preparing a mixture of water and either of sample A or B in a ratio that gives a final solid concentration of 4%, 5%, 6%, 7% and 8% at a temperatures of 20,28,and 38^0 C.

2.4. Limitations Caused by Experimental Conditions.

Because experimentation has been conducted in batch process we are not able to investigate the effect of kinetic parameters. In this work only the biogas production rate is measureable. Composition of slurry is measureable only once before and after experiment but not during experiment. Intermediate concentrations of substrate during different steps of reactions cannot be measured.

3. Results and Discussions

3.1. Comparison of Biogas yield for samples A &B:

Experimental values of biogas, methane and carbon dioxide (lit/kg D.M) have been plotted against retention times (day) for samples A and sample B at a temperatures of 20^0C, 28^0C and 38^0C maintaining constant pH =6.9 and constant slurry concentration (6% of solid in slurry) as shown in figure 2, 3&4. Figures shows maximum Biogas and methane yield were obtained at 11, 6 and 9 days for sample A whereas maximum biogas and methane yield are obtained at 19, 21 and 15 days for sample B.

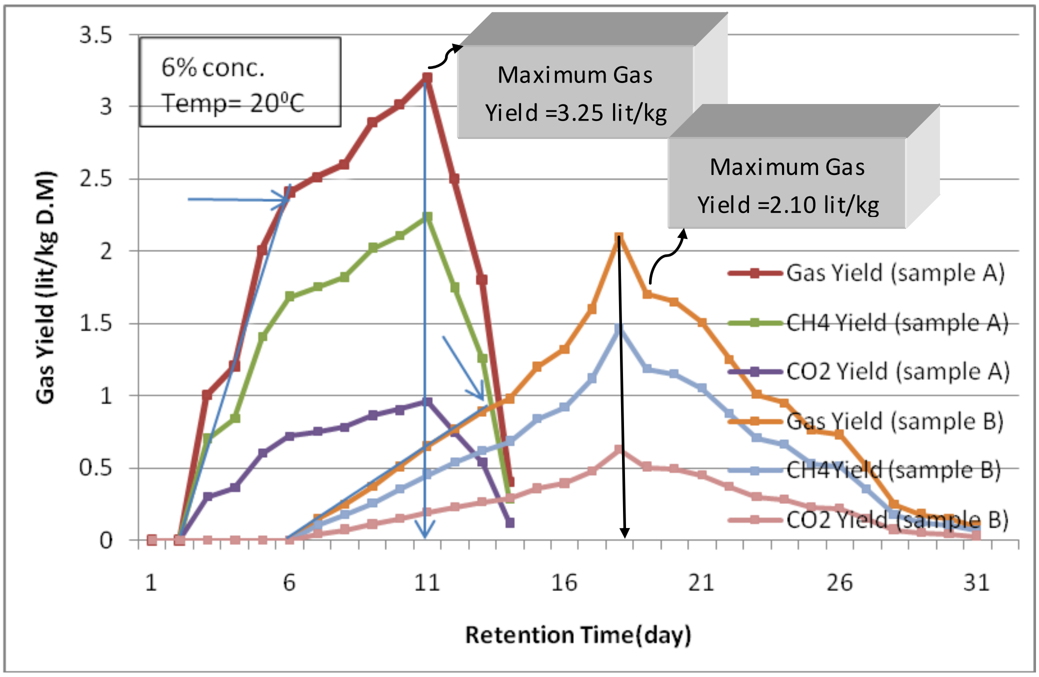

Fig 2: Variation of Biogas Yield of Samples A& B with Retention Time at 20^{0}C

It has been also clear from figures that gas yield followed linear nature within first few days of digestion then starts to show non linear behaviors' for both samples A and B. But for sample A slope of the lines is much more higher than that of sample B as a result yields of biogas for sample A tends to a maximum value within a very short period of time with respect to sample B at various temperatures. These trend of production of biogas at various temperatures as shown in fig. 5 can be clarified based on literature. Biodegradable volatile solids (BVS) are made up of soluble and insoluble organics. Soluble oraganics can be directly utilized whereas insoluble organics must be hydrolysed(3) first. Since Raw materials contain soluble organic & inorganic material solubility and diffusibity of organic solids from materials are more for sample A because the material is properly dried and grinded, though aditional energy is required for this purpose.

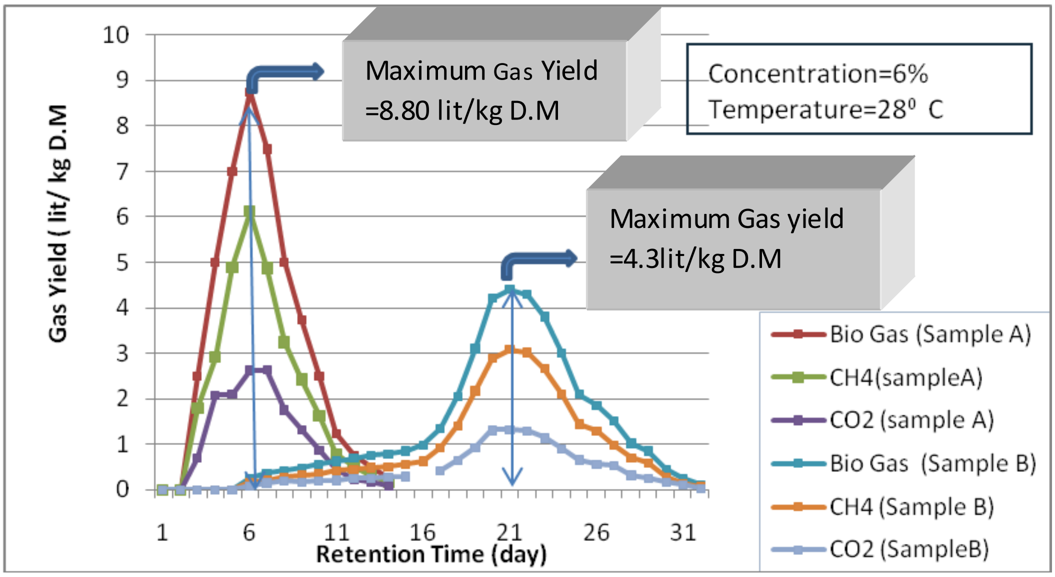

Fig 3: Variation of Biogas Yield of Samples A& B with Retention Time at 28 ^{0}C

Since sample A is properly grinded, more surface area or more active sites are created in which bacteria finds more attacking opportunity due to less biological stress than that of sample B. This may result solubility coefficient of organic material of sample A more than that of sample B which may reduce the solid retention time. It is also evident from the experimental results that the total production of biogas for sample A and sample B are nearly constant but retention time required to obtain this gas yield is completely different. Obviously, for sample A, it is much lower than that of sample B.

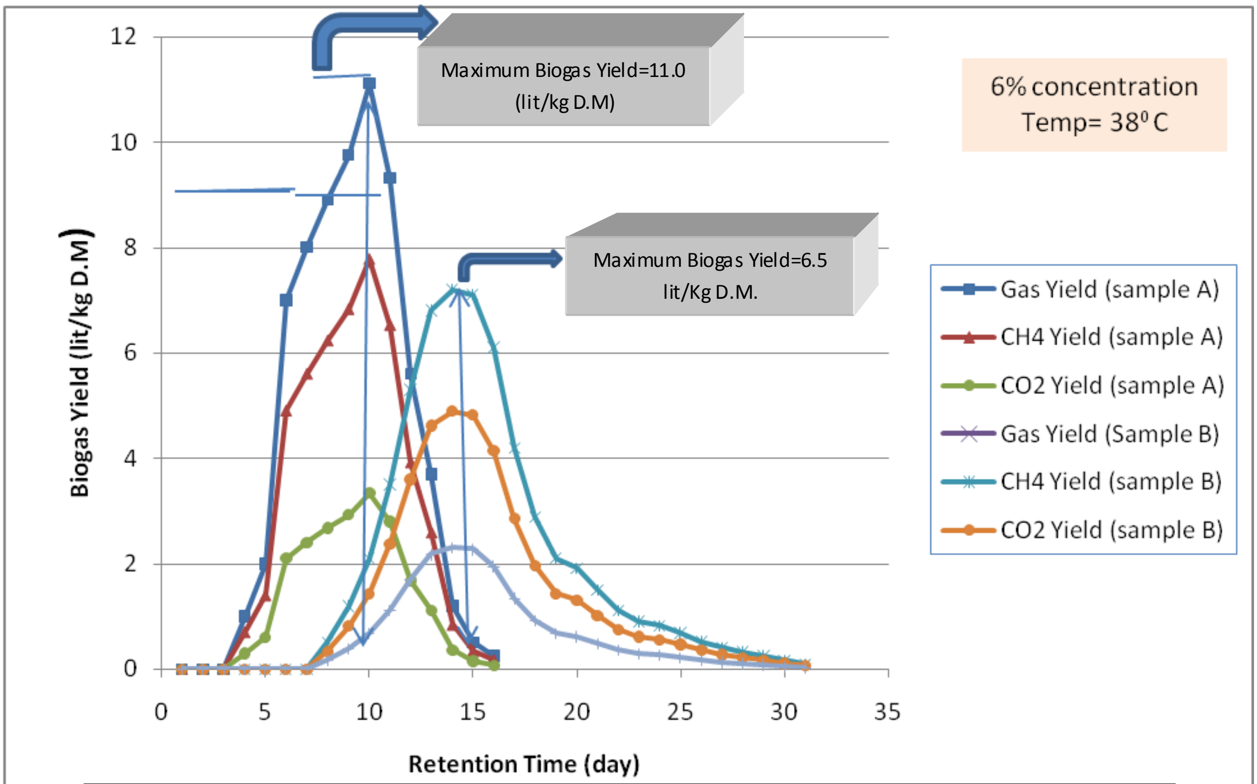

Fig 4: Variation of Biogas Yield of Samples A& B with Retention Time at 38^0C

3.2 Effect of temperature

Variation of biogas yield, methane yield has been plotted with temperature for sample A and for sample B as shown in fig. 5. Figure shows biogas as well as methane yield is increased as the temperature increased from 20^0C to 38^0C for both these cases. But the rate of increase in gas production is observed higher for sample A than that of sample B due to increase in growth rate of microorganisms with temperatures. The observed increase in methanogenic activity caused by increase in temperature varies from study to study (6, 7, 8). Furthermore, half saturation constant of acetate methanation has been reported both to increase and decrease at lower temperature (9, 10).

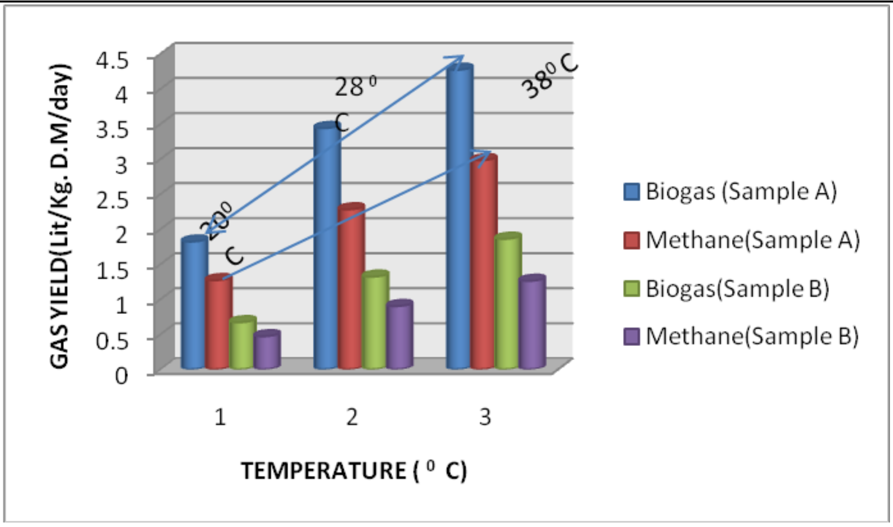

Fig 5: Variation of Biogas Yield of Samples A& B with Retention Time at different Temperatures

3.3 Evaluation of Optimum Concentration

Various experiments have been conducted using initial solid concentrations of 5%, 6%, 7% and 8% of solids in slurry for both the samples A & B at a temperature of 20^{0}C maintaining all other parameters be constant. Experimental results, as shown in fig. 6, indicates that initially productions of biogas increase as the concentration increases up to a certain concentration after which it starts to decrease for further rise in concentration. Same trends are also observed for both these samples A&B. Therefore, optimum concentration as judged from experimental output of solid in slurry of vegetable wastes are found 6% when the sample was dried (sample A)and 5.1% when the sample was raw in nature.

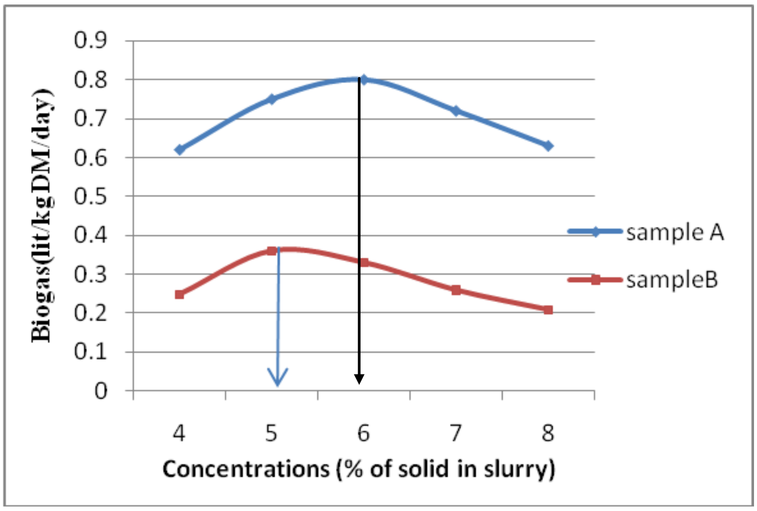

Fig. 6: Variation of Biogas Yield of Samples A & B with concentrations at 20^{0}C and one atmospheric pressure.

3.4 Estimation of Ultimate Methane Yield:

Cumulative biogas yields of sample A and sample B have been plotted against 1/retention time keeping all other parameters constant as shown in fig. 7. The figure shows linear relationship of biogas yield with 1/retention time which agrees well with literature prediction. Ultimate values of biogas yields (B_0) of the samples represent the biogas yield as residence time approaches infinity. B/B_0 is termed biodegradability constant, a similar constant as stated by Chen and Hashimoto (3, 4, 5). Ultimate biogas yield has been calculated from graph by extrapolating the lines where 1/retention time approaches zero and its value is nearly 100 lit/kg of D.M. for both these samples. It reveals that ultimate methane yield is process independent if the wastes get anaerobically digested for infinite retention time.

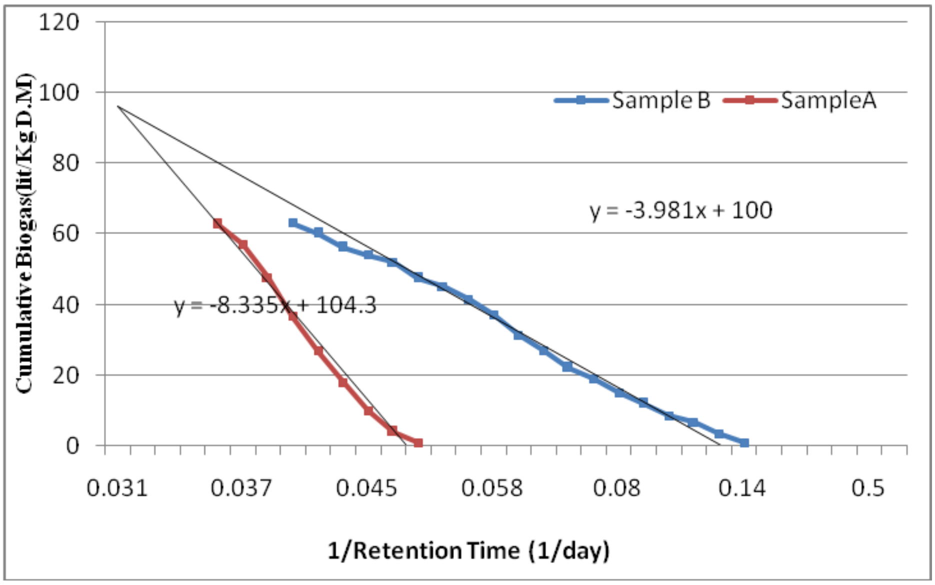

Fig. 7: Plots of Biogas Yields of Samples A & B with reciprocal of Retention time at constant Temperature.

4. Conclusions

Present study provides comparative information regarding fruitful utilization of dried grinded vegetable wastes and raw vegetable wastes by anaerobic digestion processes for the production of biogas. Study shows production of biogas as well as methane yield per day per kilogram of solid is much higher when dried grinded vegetable is used as feed rather than raw vegetable wastes for the production of biogas using anaerobic batch digester. This study will be helpful to produce biogas within very short period time. Maximization of concentrations of substrate for sample A and B have been done based on precise experimental results which will guide to get maximum possible yield during anaerobic batch digestion of vegetable wastes. On the other hand ultimate biogas yield and temperature dependency on production have been thoroughly investigated and results so found will take the key role in regards to influence of process parameters for getting maximum possible yield of biogas.

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