Comparative Study of Biogas Production from Municipal Solid Waste using Different Innoculum Concentration on Batch Anaerobic Digestion

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ABSTRACT---- ***In this study batch anaerobic digestion of municipal solid waste was carried out for 60 days at room temperature for two different inoculums (cowdung and sewage sludge) at varying inoculums concentration 10%, 20%, and 30%. The performance of reactors was evaluated by measuring the daily biogas production. Effect of organic solids concentration and digestion time on biogas yield was studied. The biogas yields at the end of the digestion from the reactors cow dung as inoculum were 337.365ml/gVS, 481.95ml/gVS and 567ml/gVS similarly sewage sludge as inoculum were 214.775ml/gVS, 321.198ml/gVS and 383.52ml/gVS respectively. About of 65.45%, 80.06%, 86.655%, 60.25%, 65, 89%,and 72,78% Volatile solid degradation were obtained during the loading in reactors.***

Keywords---- Anaerobic digestion, Volatile solid degradation, Municipal solid waste, biogas yield

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1. INTRODUCTION

Municipal solid waste (MSW) generation is significantly increasing in Indian urban areas and started creating enormous waste disposal problems in the recent past [1]. In India, MSW management is the duty of the local municipalities [2]. More than 90 percent of the municipal solid waste which generated in India is dumped in an unsatisfactory way, what creates environmental hazards to water, air and land [3], which creates the need of Systems for MSW management development capable to minimize the production of these and able to reduce the environmental impact and danger to the public health. Presently most of the developed countries. Waste minimization and energy generation is the recent emerging concepts. The conventional energy resources are declining now a days, hence a suitable substitute for conventional resources are being explored. Cities in Maharashtra typically produce municipal solid waste 0.4-0.5kg/person/day. Solid wastes can be used for production of biogas. Biogas comprises of 68% methane, 31% carbon dioxide, 1% nitrogen, it also forms a combustible mixture in range of 6% to 15% concentration in air. Anaerobic digestion is a known process to treat organic wastes. Resource recycling and energy saving systems for processing organic solid waste in urban areas need to be established. The anaerobic digestion is an attractive option for energy generation from the putrescible fraction of MSW as well as for reducing the disposal problem [4]. It has reduced environmental impact, especially with respect to the greenhouse effect and global warming.

Anaerobic digestion has been considered to be a promising energy saving and recovery process for the treatment of organic solid waste. Anaerobic digestion also has been suggested as an alternative method of removing the high concentration organic waste. Anaerobic digestion is a biological process wherein diverse group of microorganism convert the complex organic matter into simple and stable end products in the absence of oxygen [5]. This process is very attractive because it yields biogas, a mixture of methane and carbon dioxide which can be used as renewable energy resources. Several research groups have developed anaerobic digestion processes using different organic substrates [6]-[8].In this view, anaerobic digestion of solid waste is a process that is rapidly gaining momentum to new advances. The characteristics of the biogas produced depends upon the nature and type of the biomass or feed (wastes) used.

Anaerobic digestion technology has tremendous application in the future for sustainability of both environment and agriculture because it represents a feasible and effective waste-stabilization method to convert the undiluted solid bio-waste into renewable energy with nutrient rich organic fertilizer. However, the application of this process is limitedly practiced especially in developing countries due to the lack of appropriate treatment system configurations and mainly due to the longer time required for the bio stabilization of waste. Any kind of reactors design and operational criteria selection to be operated is depends upon the feedstock characteristics, financial aspects etc. This paper deals with the experimental study carried out by means of laboratory scale plant to generate biogas from the Municipal Solid

Waste .The objective of this study was to obtain the optimal conditions for biogas production from anaerobic digestion of municipal solid waste (MSW) using various inoculums from different sources like cow dunk slurry and sewage sludge. The substrates were treated anaerobically for biogas production and pH, alkalinity, and chemical oxygen demand were observed. The study of these parameters will help us to establish a biogas system with available substrate and utilize different types of available food waste for biogas production.

2. MATERIAL AND METHODS

2.1 Batch Reactors

The experiments were carried on batch Scale laboratory reactor (acrylic bottle) with total capacity of 20 L. The reactor was made of acrylic sheet with bottom sampling outlet. The bottles were closed by rubber stoppers equipped with glass tubes for gas removal and for adjusting the pH. The effective volume of the reactor was maintained at 13L.Biogas production from the reactors was monitored daily by water displacement method. The volume of water displaced from the bottle was equivalent to the volume of gas generated. The reactors were operated at room temperature.

2.2. Inoculum

The study had been carried out with the two different inoculums sources like Cow dung slurry, Sewage sludge. The percentage of inoculum for acidogenic fermentation of the organic wastes is approximately 10%, 20% and30% of the working volume of substrate. The inoculum was collected and kept at 4°C until used, which contains all the required microbes essential for anaerobic digestion process.

2.3. Feed stock preparation

Fresh organic MSW were used as feed to the bio rector. The organic MSW consists of food waste, fruit waste, vegetable waste from nearby vegetable market and house hold. The wastes were sorted and shredded, then mixed several times in laboratory and kept at 4°C until used. All reactors were loaded with raw feed stock and inoculated with Cow dung slurry and Sewage sludge each separately. Water was added to obtain the desired total solid concentration.

2.4. Experimental procedure

The study is programmed to evaluate the mesophilic digestion of MSW at three different initial inoculums concentrations and one control (without inoculum). The substrate concentration was expressed as weight of solids/total volume of solids plus water, assuming that the density of the solids is approximately equal to the density of water. Four reactors were operated at a volume of 20L and 13L effective volume at continuous condition with different inoculums concentrations of 10%, 20% and 30%of weight solids respectively. All the reactors were fed with municipal garbage, tap water and Cow dung slurry (inoculum), used as the starter in the reactors. Similarly for sewage sludge is an inoculum. Liquid samples were drawn from each reactor periodically and analysed for pH, volatile fatty acids, alkalinity chemical oxygen demand and ammonia nitrogen. The pH was measured every 2 days and it was maintained in the range of 6.8 to 7.3 using 6N-Sodium Hydroxide solution as which is the optimum range for methanogens growth. Daily biogas production was measured by water displacement method. The substrate was mixed once each day, at the time of the gas measurement, to maintain intimate contact between the microorganisms and the substrate. All the manipulations were conducted under sterile conditions and experiments were carried out in triplicate. Batch reactor used in this study is shown in Fig.1.

Fig.1 Batch Reactor – Optimization of Inoculum

2.5. Analytical methods

The parameters analysed for the characterization of substrates were as follows: Total Solids (TS), Volatile Solids (VS), pH, Volatile fatty acid (VFA), Total Organic Carbon (TOC).Following quantities were monitored during the digestion process: pH, VFA, alkalinity, Ammonia nitrogen (NH3-N), COD and production of biogas. All analytical determinations and gas production were estimated according to the procedures recommended in the Standard methods for examination of water and waste water [9].Gas production was measured at a fixed time each day by the water displacement method, with water prepared as specified in standard methods (APHA,1989).

2.6. Gas analysis

Gas samples were collected by gas sampling injector sand a sample of 100 *ll* was used for each run. The biogas composition (CH_4+CO_2) was determined using a Gas Chromatograph (NUCON 5700) equipped with a thermal conductivity detector and stainless steel column of length 6 ft, OD 1/4 in., ID 2 mm, Porapak Q 100having mesh range 80–100. The carrier gas used was $H_2$and the analysis was carried out at a carrier gas flow rate of 30 ml/min with the injector, column and detector temperatures maintained at 120, 90 and 120° _C, respectively. The gas quality was checked once a week.

3. RESULTS AND DISCUSSION

Substrate characteristics andInoculums characteristics

The characteristics of the substrate, inoculum Cow dung and sewage sludge were shown in the Table.1, 2 and 3. The experiments were done for 60days

Table.1 Characteristics of Chidambaram municipal solid waste

S.No.	Parameters	Value/weight fraction (%)
1.	Moisture (%)	80.5
2.	pH	5.13
3.	Total solids (%)	19.5
4.	Total volatile solids (%)*	90.3
5.	Ash content (%)*	12.55
6.	Total organic carbon (%)*	20.35
7.	Total nitrogen (%)*	1.03
8.	Chemical oxygen demand (ppm)	3952

*Indicates wt. % in total solids

Table.2 Characteristics of the inoculums (Cow dung)

S.No	Parameters	Value/weightfraction(%)
1.	Moisture (%)	91.40
2.	pH	6.64
3.	Total solids (%)	8.6
4.	Total volatile solids (%)*	88.29
5.	Ash content (%)*	11.23
6.	Total organic carbon (%)*	12.44
7.	Total nitrogen (%)*	0.85
8.	Chemical oxygen demand (ppm)	2419

*Indicates wt. % in total solids

Table.3 Characteristics of the inoculum (domestic sewage sludge)

S. No	Parameters	Value
1.	Moisture (%)	74.8
2.	pH	7.24
3.	Total solids (mg/L)	6.5
4.	Total volatile solids(mg/L)	73.3
5.	Ash content (%)	9.51
6.	Total organic carbon (%)	10.28
7.	Total nitrogen (%)	0.57
8.	Chemical oxygen demand (mg/L)	995

3.1. Optimization of Biogas Production

Degradation of substrate started slowly and proceeded without problems in the reactors maintained at room temperature it took about 6–8 days for initiation of biogas production. The cumulative biogas production at different inoculum concentration and total solids concentration was observed at room temperature.

3.2. Performance of batch reactorscow dungasinoculum

From Fig. 2 indicate the cumulative biogas production for 4(R_c, R_1, R_2, R_3) reactors. Were the biogas production was low in the beginning which was due to the log phase. The reactors Rc, R1, R2 andR3 were operated with inoclum concentration of 0%, 10%, 20% and 30% of the weight of substrate. Initially all reactors the pH value was reducing. So the production of biogas was reduced in the initial stages. So after adjusting the pH value in the optimum range by addition of 4MNaOH to the system, the production was increased. The maximum cumulative biogas production obtained for Rc was 173ml/gVS in 60th day. At the end of the 60 days total cumulative biogas for R1, R2 and R3 was obtained as 337.365ml/gVS, 481.95ml/gVS and 567ml/gVS respectively. The rates of biogas production differed significantly according to the organic loading. It can be observed from Fig. 2 that bulk of substrate degradation takes place up to a period of 60 days suggesting that the digesters should preferably be run at a digestion time close to 60 days for optimum energy yield. The methane content of the biogas generated from the reactors was in the range of 57–66% during the first 2–4 days of the digestion and remained in the range of 69–78% for the remaining period. The biogas generated from the reactors was in the range of 62–72%obtaned by M.S. Rao and S.P. Singh (2004).

The biogas production was decreased after 60days due to lack of amount of substrate. In an anaerobic system, the acetogenic bacteria convert organic matter to organic acids, possibly decreasing the pH, reducing the methane production rate and the overall anaerobic digestion process unless the acids were quickly consumed by the methanogens. pH in the range of 6.8 to 7.4 should be maintained in the anaerobic digestion process, which is the optimum range for methanogens growth. A decrease in pH was observed during the first few days of digestion due to the high volatile fatty acids formation; hence the pH was adjusted to 7 using 4MNaOH solution. The profile of pH was shown in the Fig. 4, 5.The pH was found to lie in the range of 6.8 to 7.3 during the entire period of the study.

3.3. Performance of batch reactors sewage sludge as inoculum

Fig. 3 show the cumulative biogas readings for 4(R_c,R_4,R_5,R_6) reactors. The reactors Rc, R4, R5 andR6 were operated with inoclum concentration of 0%,10%,20%,30% of the weight of substrate.. The cumulative biogas production obtained for Rc was 150ml/gVS in 60th day. At the end of the 60 days total cumulative biogas for R4, R5and R6 was obtained as 214.775ml/gVS, 321.198ml/gVS and 383.52ml/gVS respectively. The rates of biogas production differed significantly according to the inoculum and organic loading. It can be observed from Figs. 2 that bulk of substrate degradation takes place up to a period of 60 days suggesting that the digesters should preferably be run at a digestion time close to 60 days for optimum energy yield. The methane content of the biogas generated from the reactors was in the range of 47–56% during the first 3–7 days of the digestion and remained in the range of59–68% for the remaining period.

3.4. Comparative process efficiency

The summary of performance of batch reactors mentioning the characteristics of initial and digested substrate, it was observed that 51.69% of the total volatile matter converted in control reactor and that forR1, R2, R3,R4,R5 and R6 are 65.45%, 80.06%, 86.655%, 60.25%, 65,89% and 72,78% respectively. From the results, it was observed that maximum degradation was occurred for reactor R3. The rates of biogas production differed significantly according to inoculum concentration and the organic loading. It can be observed from that bulk of substrate degradation takes place up to a period of approximate 60 days.The methane yield % was more in the cow dung inoculum reactors was compared to sewage sludge reactor. Methane yield was based from % VS destruction for it offers better representation in the actual process performance [10].

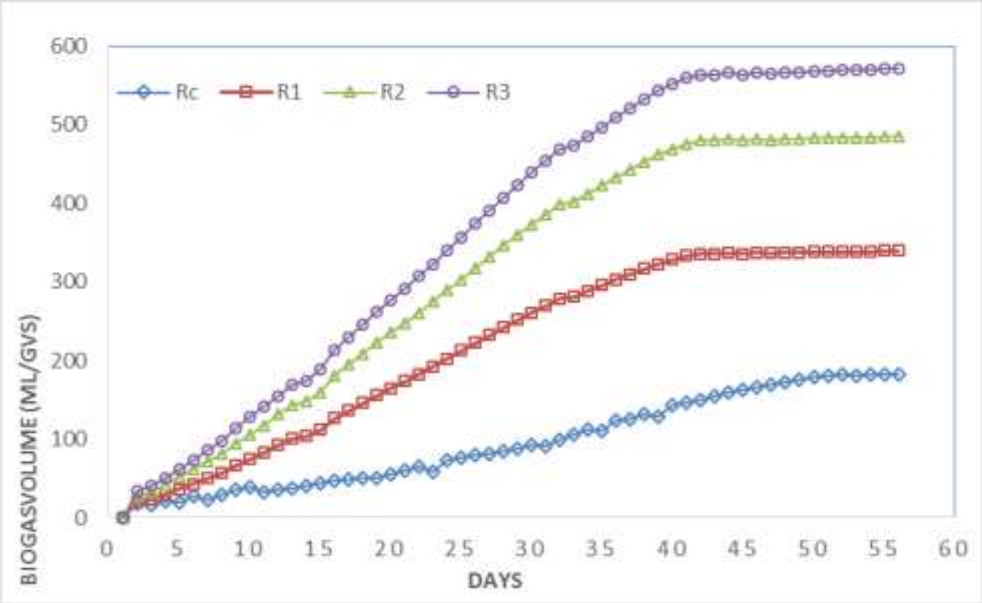

Fig.2 Cumulative Gas Production with Cow Dung as Inoculum

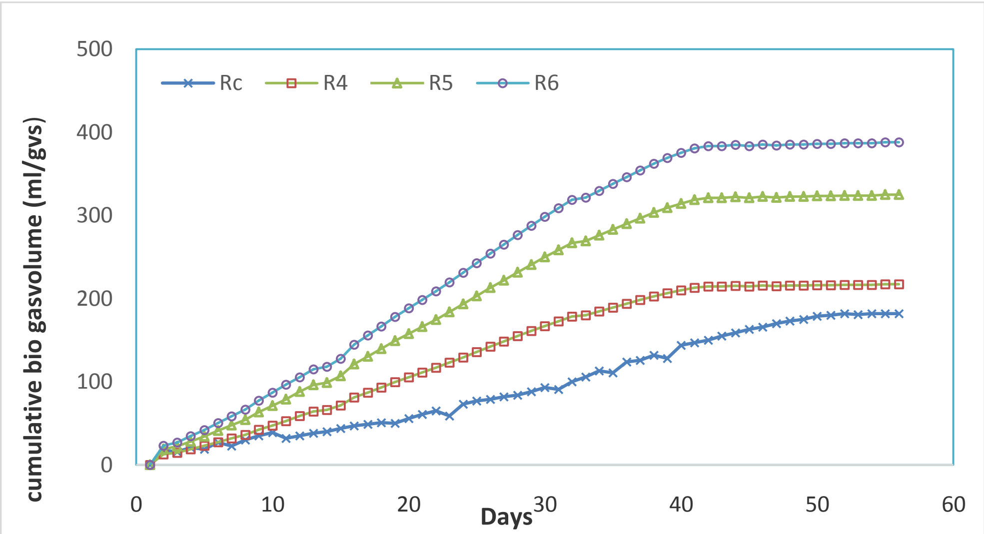

Fig.3 Cumulative Gas Production with Sewage sludge as Inoculum

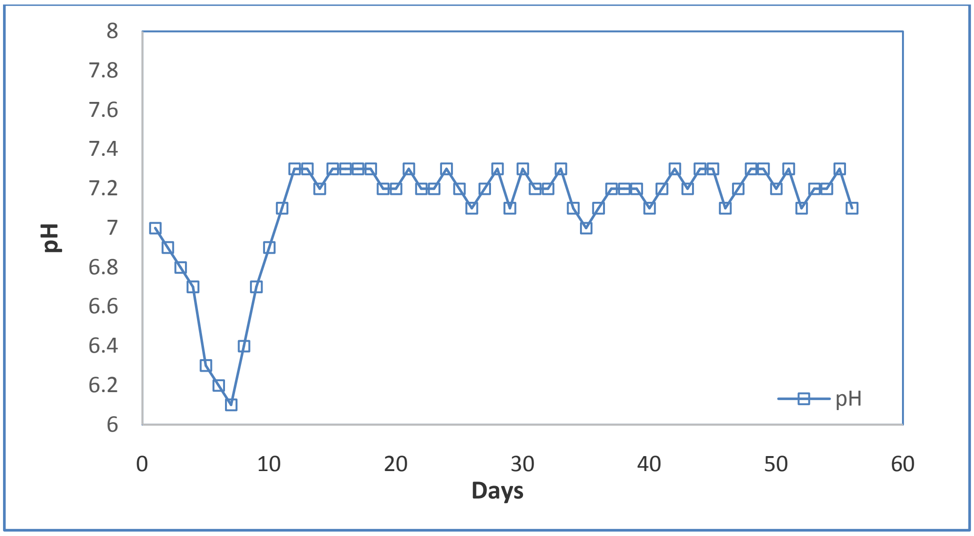

Fig. 4 Variation of pH for cow dung (30%) concentration

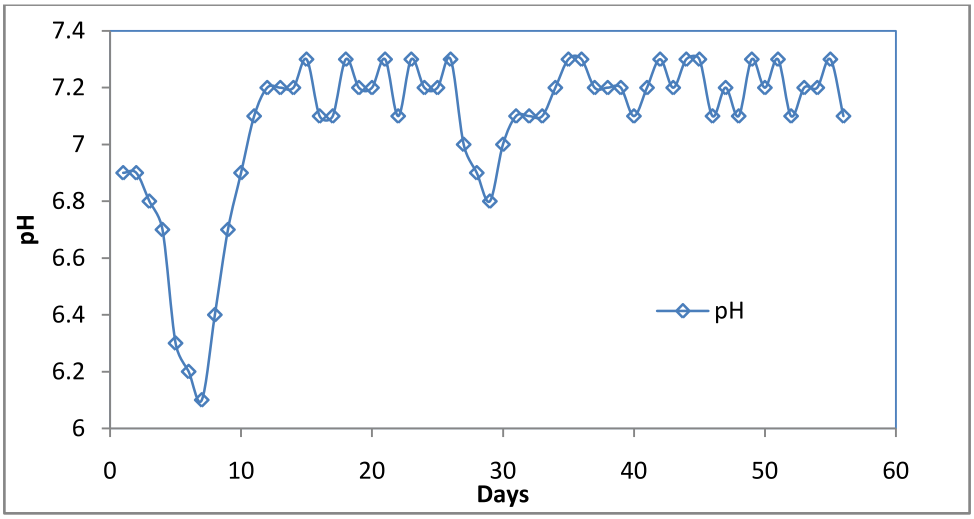

Fig. 5 Variation of pH for sewage sludge (30%) concentration

1. CONCLUSIONS

After studying the various parameters of all the different inoculum concentration substrates of municipal solid waste it was observed that the methane generation was lowest in Rc. Study revealed that the gas generation directly depends on the inoculum concentration and initial characteristics of the substrates. The results indicate that the cow dung slurry is the best inoculums source of methane generation due to its biodegradation capacity Biogas production from municipal solid wastes could be enhanced by adopting biotechnological applications. And further study could be carried by various pre-treatments of above substrates to gain maximum methane gas production. At the end of the 60days digestion about 567ml/gVS bio gas was produced. Volatile solid degradation of are 65.45%, 80.06%, 86.655%, 60.25%, 65,89% and 72,78% were obtained during the loading in reactor R1, R2 ,R3,R4,R5,and R6 respectively.

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