START UP FOR SOLID STATE ANAEROBIC FERMENTATION OF ORGANIC FRACTION OF MUNICIPAL WASTE AT MESOPHILIC CONDITION

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Abstract

The anaerobic digestion of municipal solid waste may be a method that has become a promising technology in waste management throughout the globe. Thus, the target of this study was to optimize the applications of anaerobic digestion to the treatment of municipal solid wastes. To attain this, the pilot scale experiment was conducted in inclined sort plug flow reactor. At first OFMSW was digestible in turn in start-up method to adapt the reactor. The reactor was operated in mesophilic condition (21° to 39°C). The start-up method was established over a amount of six weeks and therefore the highest volume of biogas production (193.17L/d) and gas composition (59.74%) was achieved at day twenty eight.

1. INTRODUCTION

Solid Waste Management could be a a part of public health and sanitation, and per the Indian Constitution, falls inside the range of the State list. Since this activity is non-exclusive, non-rivaled and essential, the responsibility for providing the service lies within the public domain. The activity being of a neighborhood nature is entrusted to the Urban native Bodies. The Urban Local Body undertakes the task of solid waste service delivery, with its own staff, equipment and funds. In a few cases, part of the said work is contracted out to private enterprises. There has been no major effort to make community awareness either regarding the doubtless perils because of poor waste management or the easy steps that each national will take that will facilitate in reducing waste generation and promote effective management of solid waste generated.

There are many renewable technologies for producing the energy from the solid wastes such as Anaerobic Digestion, Refuse Derived Fuel (RDF) etc. among them the conversion of wastes to energy by Anaerobic Digestion (AD) has become an interesting technology and many research works are going on all over the world. Since last twenty years, Anaerobic Treatment Technology had been in apply however those techniques were supported principally for treating waste matter sludge with low solid concentration. The Anaerobic Digestion of MSW could be a method that has become a serious focus of interest in waste management throughout the planet. During the last 20 years, considerable progress has been occurred in understanding the anaerobic process. The Anaerobic Digestion of Municipal Solid Waste could be a method that has become a promising technology in waste management throughout the planet. Thus, the objective of this study is to optimize the applications of Anaerobic Digestion to the treatment of Municipal Solid Wastes. To achieve this, the pilot scale experiment will be fabricated in inclined type plug flow reactor.

2. MATERIALS AND METHODS

Design of the digester

The digester was designed according to the organic loading rate and the hydraulic retention time. A single stage anaerobic digestion was operated at organic loading rates to optimize the biogas production and to investigate operational parameters. The digester was cylindrical wall container in order to maintain the room temperature inside the digester. For facilitating digestate disposal the digester was inclined at 30 degree and was also accommodated with piped outlet at bottom in order to prevent the intrusion of air inside the reactor during withdrawal. The total volume of the digester was approximately 200 L with working volume of 160L and the inside diameter of the cylindrical digester was 560 mm. The digester was also accommodated with other accessories such as heater for maintaining the room temperature 21 to 39°C wet gas meter to measure the biogas production. For the post treatment of the digestate, rectangular sand drying bed of size 56cm radius and 84 cm high was used. The leachate had been collected through drain pipe as shown in Figure3.2. The Figure 3.2 shows the detail design of pilot scale DCAD system along with the supporting equipments such as wet gas meter, pipe lines.

Figure 2.1 Experimental diagram of Anaerobic Digester

This section describes the results obtained during the pilot scale anaerobic digestion of MSW operating in mesophilic condition. The characteristics of the wastes stream are presented. The experiments were conducted in two phases i.e. start-up and continuous loading. The results of the BMP test are also illustrated to compare the performance of the system in terms of biogas production. The experiments were conducted with two different continuous loadings for constant retention time. The analyses and evaluation are described to examine the performance of several strategies particularly in pilot scale experiment to achieve the objectives of this study.

Feedstock preparation and analysis

The MSW used for this study was obtained as source-separated food waste from the organic waste. They were composition of municipal solid waste in vegetable, paper, plastics, cloth and others. they were shredded to small particles with average size of 10 mm organic fraction of municipal solid waste and homogenized to facilitate digestion. The sub-samples were dried and milled to the millimeter size and analyzed for moisture content (MC), total solids (TS) and volatile solids (VS) using standard methods (APHA, AWWA & WEF, 1998). The characteristics of the waste used in the experiment for lab-scale and pilot-scale systems are shown in Table 2.1.

Anaerobic sludge used as inoculum was collected from an anaerobic digester of wastewater treatment plant. The feedstock was prepared with the mixture of food wastes, fruit waste and boiled rice in order to obtain the desired loading rate and optimum C/N ratio.

Table 2.1 Characteristics of raw shredded solid waste and inoculums

PARAMETER	OFMSW	COWDUNG	ANAEROBIC SLUDGE	FEEDSTOCK
Density (kg/m^3)	500.0	1254	1100	1060
Moisture (%)	66.5	71.5	84.8	79.6
Solids (%)	79.25	55.63	2.5	20.4
Total solids (%)	19.2	8.5	12.5	20.41
Volatile solids (%)	92.3	90.3	40.3	86.6
COD	3876	2320	988	1596
pH	5.3	6.9	7.32	5.4
C/N ratio (organic matter)	22	19.2	21.32	23.54

3. RESULTS AND DISCUSSION

Reactor Start-Up

The reactor was initiated with the fresh waste of 56 kg which was 80% of the reactor volume. From the measurement the density of the waste was around 500 kg/m3. The total volume of the reactor was 200 L and the total weight of the waste fed including inoculums was 80 kg in which 30% of waste was inoculums. The reactor was operated in batch mode for 6 weeks for start-up process. The inoculum was comprised of cow dung anaerobic sludge. The ratio of these inoculums was 2:1 (Eliyan, 2007; Adhikari, 2006; Jean, 2005). Homogenization of fresh wastes with inoculums was done properly before feeding into the system. The composition of waste was 56 kg fresh solid wastes, 16 kg cow dung, 8 kg anaerobic sludge. To reactor start-up in the maintain the mesophilic temperature 21 to 39°C. The main feature of this system was to avoid the use of leachate for the mixing. The mixing was performed using agitator in inside the reactor.

a. Biogas generation and quality

Digestion during start-up ran for a total of 42 days, during that period start-up reached methanogenesis, characterized by high methane composition (59.74). Figure 3.1 and 3.2 indicates the daily and cumulative biogas production where the biogas production was high in the beginning which was due to the entrapped air inside the reactor and the waste itself because the methane composition during that period was almost zero. High biogas production and methane yield was obtained during circulation of the wastes inside the reactor. From figure 3.1 and 3.3, it is clear that the biogas production and methane composition was lower between 6 and 12 days. The proper mixing of feedstock using agitator in the start-up as methanogenic activities are increased in maximum in 28th day.

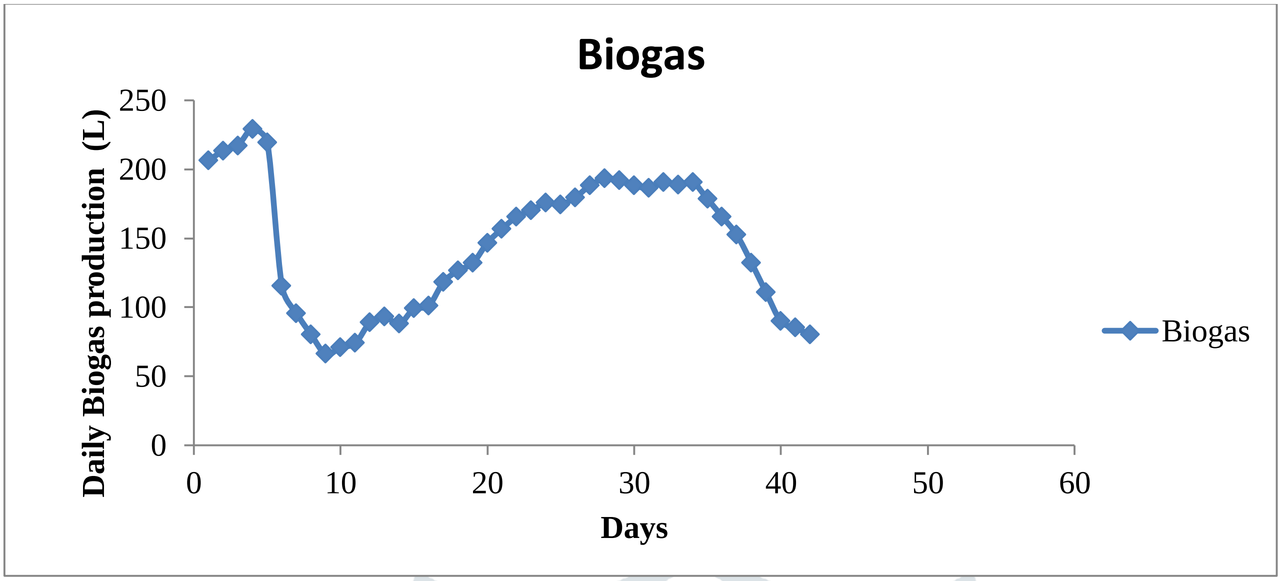

Figure 3.1 Daily biogas productions

The start-up period was attributed to the heterogeneity of the inoculum. The highest volume of biogas produced (193.27 L/d) was achieved at day 28 and the methane composition was reached to a maximum value of 59.74% (Figure 3.3) at the same day .

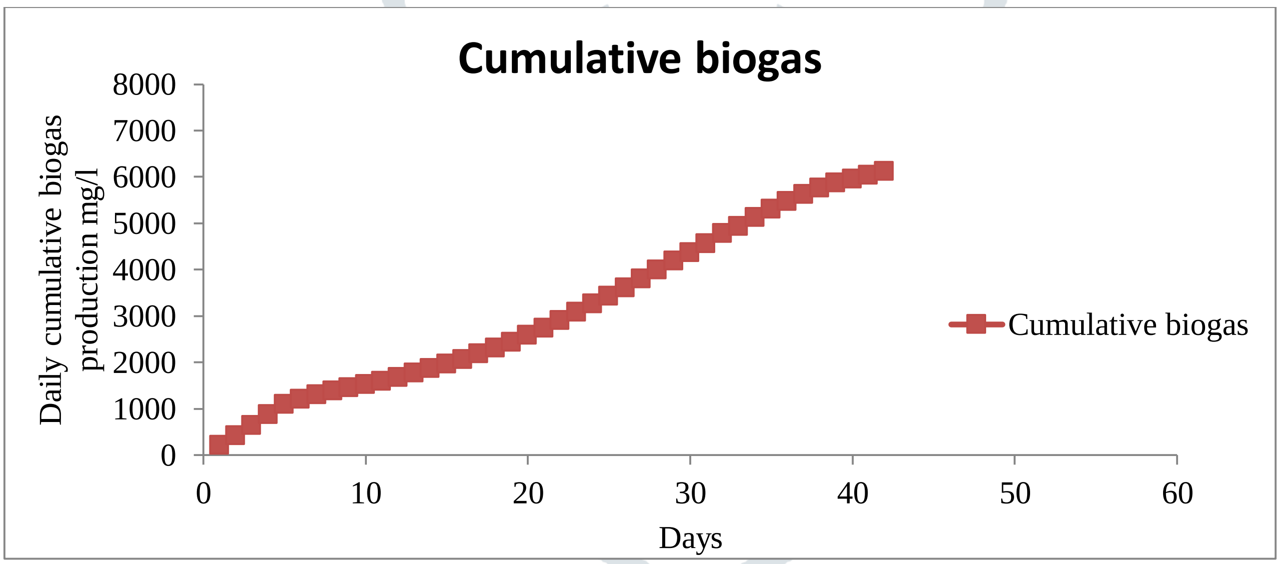

Figure 3.2 Daily cumulative biogas productions

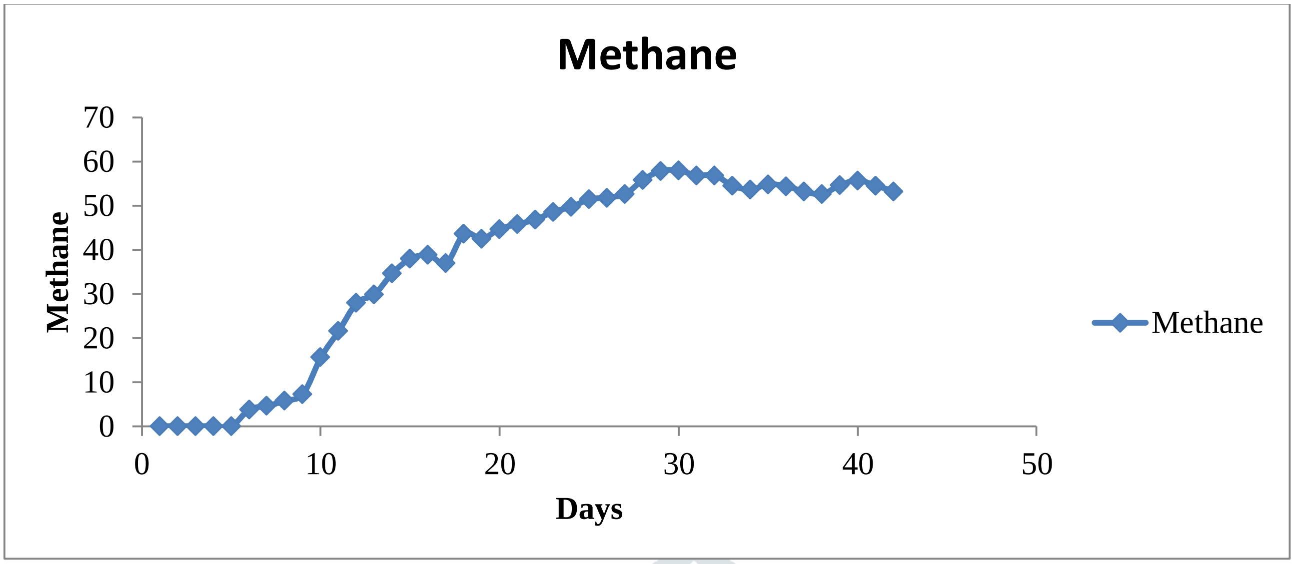

Figure 3.3 Daily methane productions

a.Leachate characteristics

The pH and alkalinity variation are shown in Figure 3.4 and 3.5 in which the pH was at a lower value below 7 during first 10 days. This was due to the formation of organic acids e.g. volatile fatty acid. The alkalinity was also found lower and reached to around 1500 mg/L as CaCO3. Due to lower alkalinity and pH, the methanogenic activity was not initialized and the composition of methane was below 50%. The pH of the leachate was monitored and an attempt was made to keep it above 6.5 by the addition of commercial NaOH. From day 10 to 30, the pH and alkalinity was almost found steady. Despite of steady pH and alkalinity, the biogas gas i.e. methane production was low during that period due to lack of mixing.

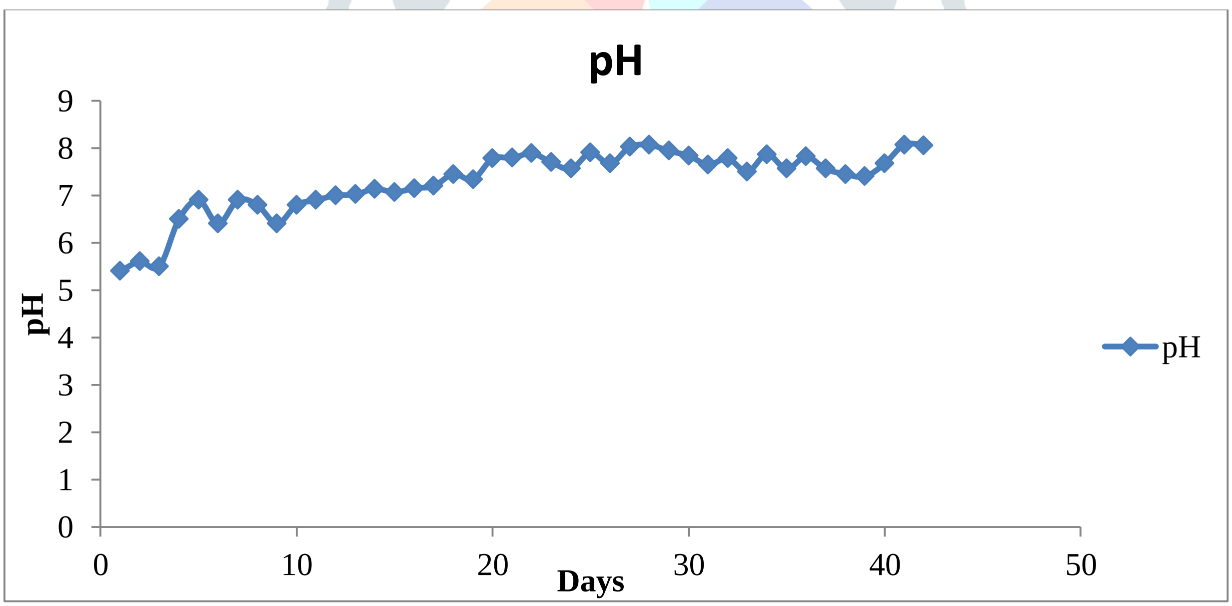

Figure 3.4 Daily pH variation

The pH reached above 7.5 but not exceeded 8.5 which are inhibiting condition for methanogenesis. During that period, the biogas production as well as methane composition was reached the maximum value of 193.17 L/d and 59.74 % respectively. Figure 3.5 shows the variation of volatile fatty acids (VFA) concentration during start-up period. The VFA generation within the starting was high because of higher acidogenesis and lower methanogenic activity. As the food waste consists of highly putrecible fraction, they were degraded quickly and the concentration of VFA was found elevated. The VFA production between days 1 to 30 was found around 3000 mg/L which was lower than inhibition concentration and the pH was also found between 6 to 7. After day 20 the VFA concentration was found decreased due to methanogenic activity in which the intermediate organic acids was started to convert into biogas such as methane and carbon dioxide. The VFA concentration reached around 1500 mg/L when day thirty.The pH dropped in the beginning, corresponding to the transient accumulation of volatile acids, but then increased as the VFAs were converted to methane.

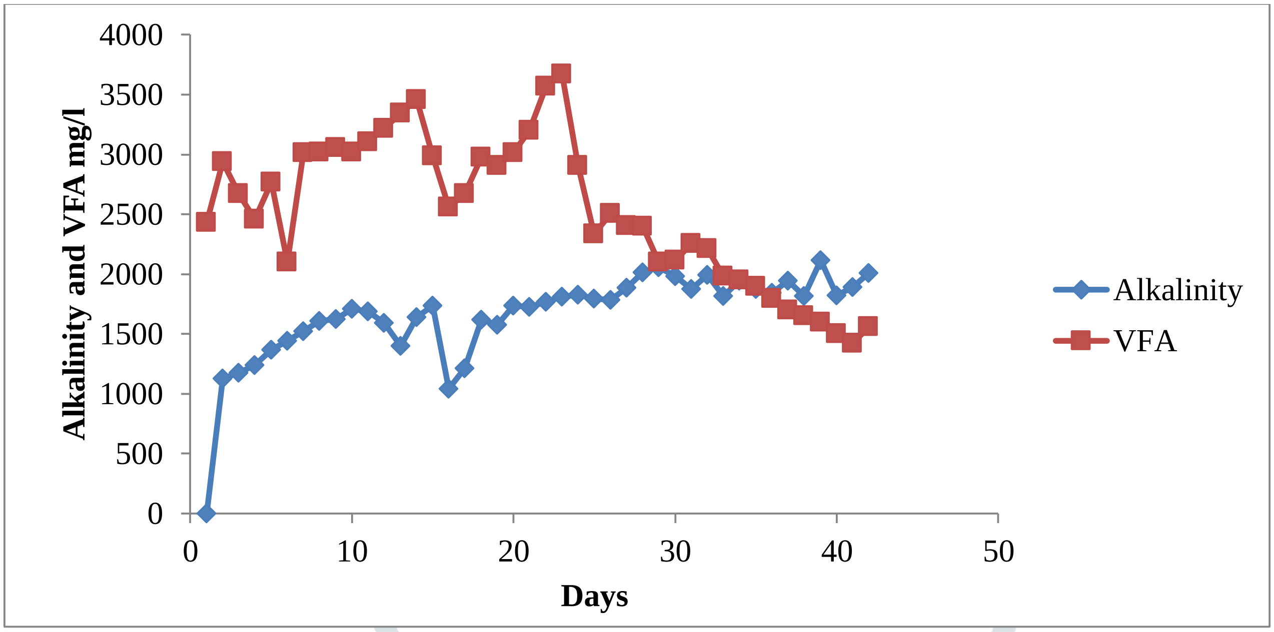

Figure 3.5 variation between alkalinity and VFA

The organic content of substrate was measured in terms of Chemical Oxygen Demand (COD). The Figure 3.6 depicts the variation of these parameters during start-up process. The significant increase in COD in leachate was observed in the beginning which was the sign of active hydrolyze phase. The COD of the leachate were found decreasing due to conversion of organic matter into biogas and the trend of COD with retention times were found similar so that can be used as a measure the parameter to estimate COD.

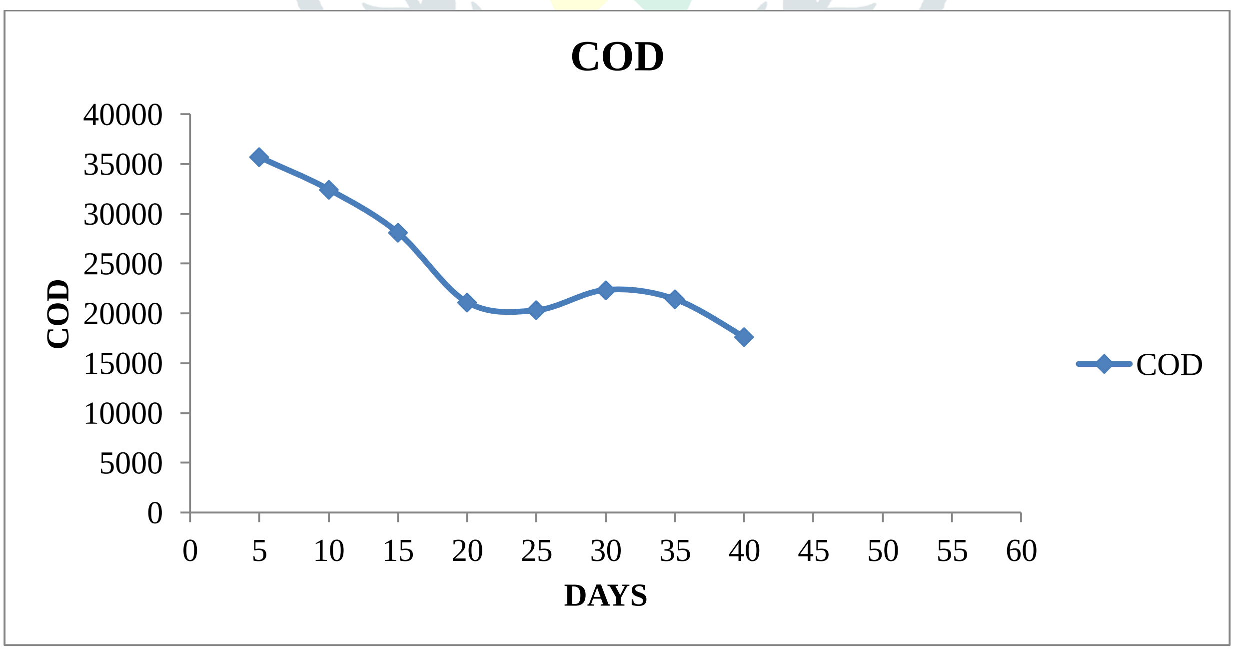

Figure 3.6 variation of COD

4. CONCLUSION

In this study, pilot scale anaerobic digestion of OFMSW was conducted. An inclined anaerobic reactor was designed and operated underneath continuous mode. An attempt to optimize the process was done by increasing the loading rate at constant retention time. From this investigation it is concluded that source sorted organic fraction of municipal solid wastes can be anaerobically digested, producing a biogas containing maximum 59.47% CH4 production in reactor start up at the 28 day . The rate of biogas production observed in the pilot scale digester declined with increasing influent volatile solids concentration and this decline was due to the limited ability of the digester to thoroughly mix the contents and thus avoid the production of scum layer. The mixing capability of the pilot scale digester far exceeded the mixing ability of commonly designed sludge digesters, indicating that new developments in digester mixing are needed for successful digestion of classified MSW.

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