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Kinetic Study of Anaerobic Process Producing Biogas from Poultry Waste Water

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Abstract: The Experimental work was carried out for the production of Biogas using poultry waste water. The Poultry waste was collected from farm near nagercoil at Kanyakumari District. We have designed a 20L Capacity of Anaerobic Reactor at normal room temperature. The Batch Operation was carried out using 20 L Capacity Digester tank. It was monitored for 36 days. We have checked the pH, TSS, COD for every 24hours in this system. The Production of biogas was measured by water displacement method and then Stored in an air pillow. The Methane Content was analyzed by gas chromatography test. Based on the experimental data kinetics has done by Line Weaver-Burk method, Eadie-Hofstee method, Hanes-Woolf method. This Kinetics was done for verification of designed equipment.
Keyword: Anaerobic Reactor, Poultry waste, Gas chromatography, pH, TSS, COD.

Introduction

Anaerobic digesters convert organic waste (agricultural and food waste, animal or human manure, and other organic waste), into energy (in the form of biogas or electricity). The benefits that the anaerobic digestion process provides are waste management, energy production, and fertilizer production [1]. Waste management is very important in both urban and rural settings. Most industrialized parts of the world already have waste management systems, though they often can be improved with regards to environmental impact. Rural areas often lack sanitation or reliable waste management systems, and this is a highly valuable service for health and environmental reasons [2]. Anaerobic digestion can provide energy to those who do not already have it, or can produce clean energy as an alternative to carbon-intensive energy production. Energy provided to those who do not already have it enables societies to accomplish more, and allows for a much higher quality of life [3]. Clean energy is gaining more importance as global energy consumption grows and humans have more of an impact on the global climate. The fertilizer by-product is another benefit that can add value to an anaerobic digestion system. Once a feedstock is consumed by the anaerobic digestion process, the leftover material can be used as a soil additive to enhance crop production [4]. In rural settings, this fertilizer is best used locally or on-site of the anaerobic digester. Biogas produced from anaerobic digestion often has high amounts of sulfur, which is what causes an uncomfortable smell. This is only very problematic if the intent is to use the biogas in a fuel cell, because the sulfur will poison the fuel cell [5].In our project we are going to produce biogas from poultry waste. Theoretical calculation has been made for the batch reactor and experimental work has been done for the batch reactor to study the various factor involving in the biogas production. Based on the experimental data kinetics has done by Line Weaver-Burk method, Eadie-Hofstee method, Hanes-Woolf method. This Kinetics has been done for verification of designed equipment [6].

Methods and materials

Raw material collection

The Poultry waste was collected from farms near nagercoil at Kanyakumari District. The raw material is diluted from ordinary tape water is in the ratio of (1:1).

Experimental setup for batch process

In this present study, Poultry waste water is taken as raw material and it's screened by the 100 mesh size and to remove the fibrous particles. The getting result of biogas yield from this organic waste after 8 days.The raw material is diluted from tape water is in the ratio of 1:1.The liquid form of poultry waste is sent through the reactor and the system was started up as batch to achieve an active acidifying culture by loading the substrates. The Working volume of the bioreactor was maintained at 20 lire and ran under uncontrolled pH. The pH is in the range of 6.5-7.5, which is without acid or base addition. Experiment was carried out at mesophilic temperature of 30-35.The Hydraulic Retention Time (HRT) was maintained at the six hours in the bioreactor. This process is called as stabilization processes. The volume of gas stored was calculated by water displacement method, in this method the Volume of gas is stored is equal to Volume of water outlet [7]. It means the amount of gas stored replaced the equal amount of water and the same is displaced. The flow sheet for batch process was given below(Figure 1).

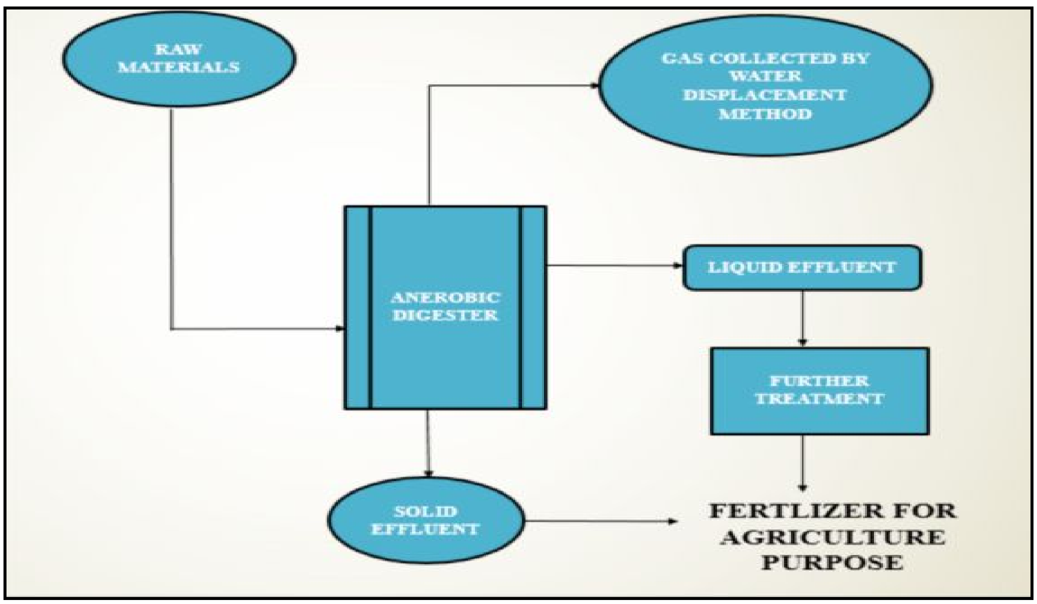

Figure 1. Flow Sheet for Batch Process

Results and discussion

The digestion performance of Poultry waste was investigated based on the results obtained from the process monitoring for: VS reduction, TS reduction, pH, acidity and biogas production with its methane content. Although, variations in reactor performance were observed in the period of digestion, the observed pH of 6.6 to 7.8 were primarily within the acceptable range for anaerobic digestion for the entire operation. This implies average buffering capacity of the mixed substrate.

Generally, degradation of substrate starts between day one today three before it commences the production of biogas in the batch operation. The batch operation results are given in Table 1. The Temperature Should be maintain at ambient temperature is in the 30-360C.

Table 1: Batch Process values

DAYS	pH (mg/L)	T^0C	COD (mg/L)	TSS (mg/L)	BIOGAS PRODUCTION (Lit)	YIELD FRACTION (Lit)
0	7.2	36	6000	20700	0	0
1	7.2	36	6000	20700	0.25	0.001158
2	7.2	36	6000	20000	0.62	0.00403
3	7.18	36	5900	19500	0.80	0.007736
4	7.15	36	5800	19000	1.22	0.013
5	7.13	36	5700	18500	1.86	0.022
6	7.11	36	5600	18200	2.41	0.035
7	7.1	36	5500	18000	3.0	0.047
8	7.06	36	5400	17800	3.74	0.064
9	7.02	36	5300	17500	4.37	0.0846
10	7	35	5200	17200	5.0	0.1077
11	6.94	35	5100	17000	5.5	0.133
12	6.9	35	5000	16800	6.2	0.1619
13	6.83	35	4900	16500	7.0	1.1944
14	6.77	35	4800	16400	7.6	0.229
15	6.7	35	4700	16000	8.2	0.2676
16	6.62	35	4600	15800	9.6	0.312
17	6.6	35	4500	15500	11.6	0.3658
18	6.5	35	4400	15200	14.0	0.4306
19	6,48	35	4300	15000	13.6	0.4936
20	6.45	35	4200	14800	13.0	0.553
21	6.4	35	4100	14000	12.4	0.6113
22	6.36	35	4000	13600	11.2	0.6632
23	6.3	34	3900	12800	10.1	0.710
24	6.24	34	3850	11900	8.8	0.75
25	6.2	33	3800	11000	8.2	0.788
26	6.18	33	3500	10900	7.1	0.8216
27	6.15	33	3350	10200	6.5	0.8517
28	6.1	33	3200	8900	6.1	0.88
29	5.9	32	3100	7800	5.4	0.90
30	5.88	32	3000	6300	4.2	0.9244
31	5.56	31	2600	5500	3.5	0.9407
32	5.43	30	2500	4500	3.0	0.9546
33	5.32	30	2200	3500	2.4	0.9657
34	5.28	29	2000	2700	2.0	0.974
35	5.22	28	1800	2000	1.4	0.9814
36	5	28	1500	1300	1.0	0.986

Gas production

The cumulative biogas production during the study period is shown in figure-6. It was observed that biogas production was actually slow at starting and the end of observation. This is predicted because biogas production rate in batch condition is directly equal to specific growth of Methanogenic bacteria [8]. During the first 5 days of observation, there was less biogas production and mainly due to the lag of microbial growth. Whereas, in the range of 8 to10 days of observation; biogas production increases substantially due to exponential growth of methanogens. Highest biogas production rate of 135ml was measured on day 10. The methane content of the biogas generated during the entire operation was on average 42.06%. The gas production rate in a batch process is given in Figure 2. This result implies that all the operation are most likely in balanced and stable operation.

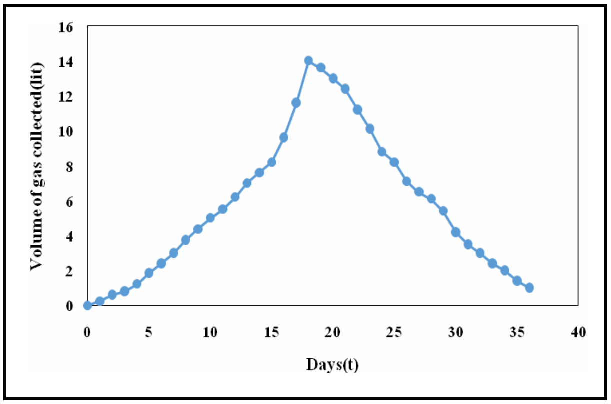

Figure 2.Gas production rate in Batch Process

Change of pH

The pattern of pH was typical of a digester operation under stable condition. A decrease in the processes pH was observed in the first few days of the digestion and this is due to high volatile fatty acid (VFA) formation [9]. The pH increased to its normal operating value after VFAs metabolism. The pH was observed to increase substantially with little variation on the commencement of the batch operation, leading to lower biogas yield [10]. This explains the observed ability of the operation to stabilize even with pH and with lower, but stable biogas production. At the day one pH Value is 7.2 similarly the pH Value is decrease day by day. Since in the Observation at the day of day 36 the pH Value is 5.2. But we maintained the pH is in the range of 6.5-7.5. It is the only range to Produce Biogas. The Graphical Representation of pH Values is as shown in the Figure 3.

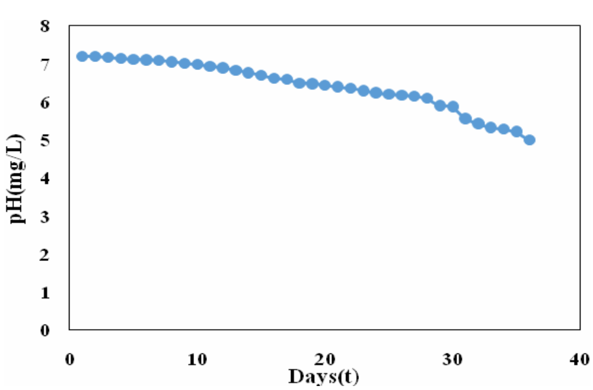

Figure 3.Effect of pH on Gas production

Biogas yield fraction

The Yield fraction of Biogas Production is during the study period is shown in Figure 4. It was observed that biogas production was actually slow at starting and the end of observation. This is predicted because biogas production rate in batch condition is directly equal to specific growth of Methanogenic bacteria [11]. During the first 12 days of observation, there was less biogas production and mainly due to lag of microbial growth. Whereas, in the range of 22-27 days of observation; biogas production increases substantially due to exponential growth of methanogens. Highest biogas yield fraction was measured on the day 36. Totally we have taken 36 days for their study period. The day by day biogas yield fraction of 36 days observation is as shown in the Figure 4. This result implies that all the operation are most likely in balanced and stable operation.

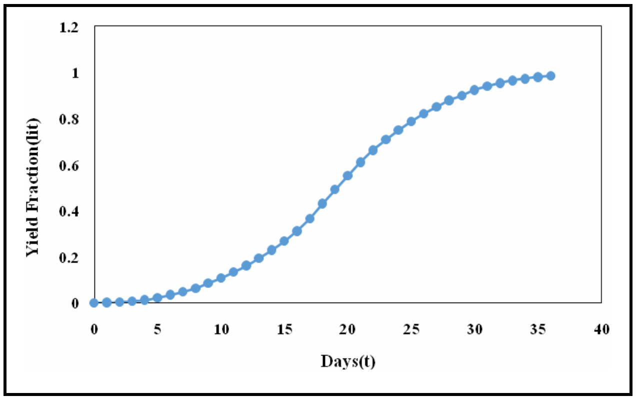

Figure4.Yield fraction of Batch Process

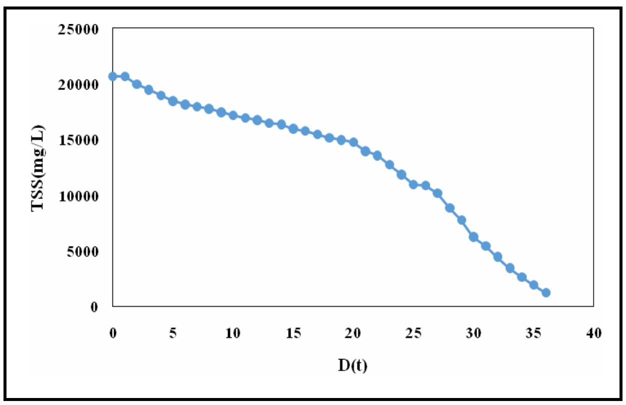

Figure 5. Total solid in bioreactor

Figure 5 shows the Time (days) Vs TSS profile of the bioreactor content during the experiment. TSS destruction is a vital aspect in evaluating anaerobic digestion performance. The most effective performance in terms of TS degradation was observed during batch digestion, probably through efficient hydrolysis in the acid phase [12]. The TS reduction is stably achieved during the operation.

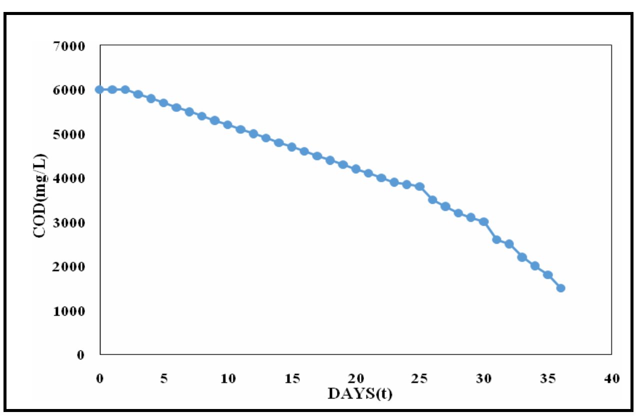

Figure 6. COD degradation in Batch Process

Figure 6 shows the Time (days) Vs COD profile of the bioreactor content during the experiment. COD destruction is a vital aspect in evaluating anaerobic digestion performance. The most effective performance in terms of COD degradation was observed during batch digestion, probably through efficient hydrolysis in the acid phase [13] [14]. The COD reduction is stably achieved during the operation.

SEM Analysis

The characterization of poultry waste sludge and the treated sludge was imaged using Scanning Electron microscope model Vega3 TESCAN with a view field of 267 µm before and 280 µm after, width of 13.30mm and range of 50 µm. Similarly the Scanning Electron microscope model Vega3 TESCAN with a View field of 7.5µm before and 80.5 µm after, width of 13.30 mm and range of 20 µm. The imaging was done to determine the morphological structure of the sludge and to view the bacterial growth on the surface of the sludge. The observation made from the 50µm, 20µm and 10µm SEM images Figure 7a and 7b , we can see that there is growth of bacterial layer on the sludge surface from initial and final sludge, hence we can say that the bacteria has anaerobically reduced the organic matter in the poultry wastewater and has grown by feeding on it [15] [16].

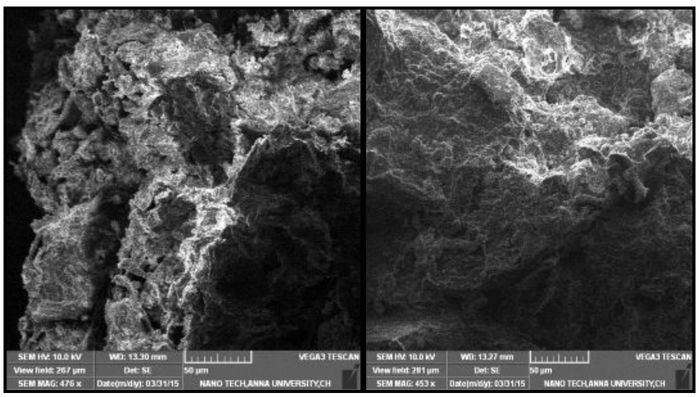

Figure 7 (a), shows the SEM image of poultry waste sludge, Figure (b), shows the growth of bacterial layers on the surface the sludge (50µm) after 36 days

Conclusion

This study investigated the effectiveness of Poultry waste for biogas production and presented the performance characteristics of the anaerobic digestion in batch operation. Under these conditions, In batch process the COD conversion is occur (6000-1500) and digestion reaches reduction with biogas of 12.4L biogas in 20L of Poultry waste water. The Kinetic Parameter of Line-weaver Burk Method, Eadie-Hofstee Method and Hanes-Woolf Method was studied. During the study period Line-weaver Burk method was not fit the experimental data and the other two methods is fitted the experimental data. Along these parameters the maximum growth rate is easily calculated. On Comparing the Eadie-Hofstee Method and Hanees-Woolf Method, The Eadie-Hofstee Method have provide better prediction than Hanees-Woolf Method with higher correlation value and generally lower deviation. The microbial growth rate of methanogenesis bacteria is to be estimated by the SEM analysis in Anna University. The Production of biogas is measured by water displacement method and it is Stored in an air pillow and the methane content is measured by gas chromatography test in Gandhi gram rural university. The by-product of bio gas Production is bio fertilizer. It is used to agriculture purpose as liquid and solid form fertilizer.

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