METHANE POTENTIAL OF COFFEE WASTE AND FOOD WASTE USING GAS CHROMATOGRAPHY

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Abstract - ***The purpose of the experiment was to study biochemical methane potential of two substrates namely coffeewaste left in coffee filter and food waste from hostel mess for bio-fuel production. Methane can be obtained from anaerobic decomposition of organic waste or energy crops and may turn out to be promising option for disposal of agro-waste. The anaerobic digestion of food waste and coffee waste produces biogas, a valuable energy resource Anaerobic digestion is a microbial process for production of biogas, which consist of Primarily methane (CH4) & carbon dioxide (CO2) and contains small amount of hydrogen sulphide (H2S) and ammonia(NH3), as well as trace amounts of other gases.The parameters analyzed were pH, TS/VS ratio, Alkalinity and VFA. The total gas produced was found by installing a simple liquid displacing system and the percentage of methane in the gas was found by gas chromatography.***

Keywords: Methane Potential, Coffee waste, Food Waste, Gas Chromatography

I.INTRODUCTION

The global growth in energy demand has induced active search for alternative energy sources. Renewable sources, such as biomass, have been under constant examination. A more efficient deployment of renewable energy sources will facilitate a reduction in greenhouse gas emissions and air pollution. Therefore, renewable energies offer an environmentally sound alternative to fossil fuels and account for a lesser contribution to climate change.

Analyses of the chemical composition of the biogas by gas chromatography has several advantages over other methods and has high resolving power and good speed of separation, and allows continuous monitoring of the effluent in the column, the exact quantitative measurement and repeatability and reproducibility analysis with automation of the analytical procedure and data processing

This study aimed at determining the concentration of methane in the biogasl waste sludge from the anaerobic treatment of wastewater from coffee waste and food waste using gas chromatography analysis. As already mentioned the quality of biogas varies depending on the physical-chemical characteristics of the effluent,and thus the interference of these factors on the concentration of biogas was evaluated.

Anaerobic digestion is a naturally occurring process of decomposition and decay, by which organic matter is broken down to its simpler chemicals components under anaerobic conditions. Anaerobic microorganisms digest the organic materials, in the absence of oxygen, to produce methane and carbon dioxide as end-products under ideal conditions. The biogas produced in AD-plant usually contains small amount of hydrogen sulphide (H2S) and ammonia(NH3), as well as trace amounts of other gases

The science underlying AD can be complex and the process is best understood if split into the three main stages: hydrolysis, acidogenesis and methanogenesis. During hydrolysis, the fermentative bacteria convert the insoluble complex organic matter, such as cellulose, into soluble molecules such as fatty acids, amino acids and sugars. The complex polymeric matter is hydrolyzed to monomers, e.g. cellulose to sugars or alcohols. The hydrolytic activity is of significant importance in wastes with high organic content and may become rate limiting. Chemicals can be added during this step in order to decrease the digestion time and provide a higher methane yield.

In the second stage, acetogenic bacteria, also known as acid formers, convert the products from the first stage into simple organic acids, carbon dioxide and hydrogen. The principal acids produced are acetic acid, butyric acid, propionic acid and ethanol. Finally, methane is produced during methanogenesis by bacteria called methane formers in two ways: by means of cleavage of two acetic acid molecules to generate carbon dioxide and methane, or by reduction of carbon dioxide with hydrogen. The acetate reaction is the primary producer of methane because of the limited amount of hydrogen available.

Anaerobic digestion is a biological process that stabilizes organic biomass while producing a methane-rich gas. Methane produced through anaerobic digestion is categorized as renewable energy. A number of different feedstocks consisting of degradable biomass can be employed in anaerobic digestion processes: i.e. municipal or industrial sludge, agricultural residues, like manure, forestry residues and energy crops or biosolids. These sources all represent stored chemical energy transformed from solar energy through photosynthesis. They can be degraded as substrates and co-substrates through anaerobic digestion processes, releasing methane.

The methane content of biogas is determined by the biochemical composition of the degradation substrate. Raw protein has the highest theoretical methane yield (70–71 vol%), 7 similarly, raw fat is characterised by a high theoretical methane yield (67–68 vol%). However, raw fat shows a significantly greater theoretical biogas yield than raw protein: 1200

It is important to note that some organic materials, such as lignin, remain effectively undigested, as of course do non-organic inclusions within the waste.
In this experiment, substrate used was the mixture of food waste and coffee waste mixed in ratio of 0:1, 1:0, 3:1, 1:1, 1:3and respectively. The substrate is tested in anaerobic reactor at the identical environmental conditions. The reactor was operated in batch mode. The production of biogas by the substrate is represented with the help of graph

The biochemical methane potential was studied in this experiment by allowing the substrate to digest anaerobically. The biogas generated was calculated.

The Objective of the experiment is to study biochemical methane potential of two substrates namely coffee waste left in coffee filter and food waste from hostel mess and also its combined effect.

II MATERIALS AND METHODS

2.1 Materials

2.1.1 Coffee Waste

Coffee waste from coffee filter is used as a asubstrate. Coffee is one of the most popular beverage in the world. . Lipid concentrations in coffee waste can reach more than 25% of its dry weight and have a good biogas production behavior, producing over 1 liter of CH_4/g-VS. The coffee grounds had a high level of lipids and low contents of hemicellulose, lignin, proteins and ash. The results indicated that the methane could be produced from coffee grounds, the reduction of volatile solids was 58 %, but system stability over the long term was a concern.the coffee grounds could contain constituents, e.g. caffeine, that have could have an effect on the degradation process and, hence, the production of methane.

2.1.2 Food waste

Food waste from hostel mess was used as substrate.It is important to know the composition of the kitchen waste in order to be able to predict both the bio-methanization potential and most efficient AD facility design. The bio-methanization potential of the waste depends on the concentration of four main components: proteins, lipids, carbohydrates, and cellulose. This is due to different bio-chemical characteristics of these components (Nerves et al. 2007) .The highest methane yields have systems with excess of lipids but with longest retention time. The methanization of the reactors with excess of cellulose and carbohydrates respectively. The lowest rates of the hydrolysis are with an excess of lipids and cellulose, indicating that when these components are in excess, a slower hydrolysis is induced (Nerves et al. 2007).

2.2 Methods

2.2.1 Experimental Setup

1 L glass bottle (fig. 1) was used as reactor (6 n.o’s). 500 ml of sludge was poured in to serum glass bottles and added 0.5 ml of ethanol, and nitrogen gas. Observed for gas production at 1 hour interval till the production of gas is same with respect to time.

The biogas production was measured by water displacement technique (a conical flask with stop cork and two pipes were connected in to it). One pipe was free and one end of one pipe was connected to syringe needle. The needle is inserted to reactor at each interval and collected the displaced water (the amount of gas produced is equal to the amount of water displaced).

We chose five different combinations of food and coffee waste as substrates.

- 100 % food waste
- 100 % coffee waste
- 25 % coffee waste, 75 % food waste

- 50 % both
- 75 % coffee waste, 25 % food waste
- blank

There was total of 6 reactors (one blank and five for different combination of substrates). Found the amount of substrates in gm to be added to each reactor using the total solids and volatile solids of sludge and substrates.

Fig 2.1 Reactor Setup

Fig 2.2 Water displacement setup
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2.3 Substrate and sludge characterisation

Total Solids (TS) Estimation:For total solids, a known amount of sample was transferred into a previously weighed crucible and dried at 105^{o}C for 24 hours. The increase in weight over that of the empty crucible represents the total solids.

Volatile Solids (VS) Estimation: For volatile solids estimation, the dried sample obtained after TS estimation was ignited in a muffle furnace at 550^{o}C for 2 hours. The weight lost on ignition represents the volatile solids.

Added substrates to each reactor and observed the gas production using water displacement method .The test was continued till no gas production.

Found alkalinity, pH and conductivity of substrate combinations and sludge substrate mix.

III. RESULTS AND DISCUSSIONS

Table3.1:Initial substrate and sludge characterestics

Parameter	Units	100% Food		100% Coffee		25% Food + 75% Coffee		50% Food + 50% Coffee		75% Food + 25% Coffee	
		Sludge +Substrate	Substrate	Sludge +Substrate	Substrate	Sludge +Substrate	Substrate	Sludge +Substrate	Substrate	Sludge +Substrate	Substrate
pH		6.7	3.84	8.01	5.61	7.18	4.8	6.71	5.16	6.6	4.05
Conductivity	mS/cm	4.4	6.08	5.22	2.48	4.26	2.6	3.92	4.85	4.1	6.73
Alkalinity	mg/l	3900	1700	3845	3750	3600	1600	3300	1800	4100	1700
Volatile Solids (VS)	%		94.28		99.38		92.15		96.44		95.66
Total Solids (TS)	%		29		49.72		45.32		67.3		39.58
VS/TS			0.94		0.99		0.97		0.57		0.78

3.2 Methane potential

The specific cumulative biogas production for each day measured is depicted in Table 4.4.2.TheGraphical representation of Biogas yield is depicted in figure 4.2.1.Experiment was carried out for 27 days under identical atmospheric conditions.

Table 3.2 Cumulative Gas Production for each day measured

No of Days	Production of Biogas mg/l					
	100% Food	100% Coffee	25% Food+ 75% Coffee	50% Food+ 50% Coffee	75% Food+ 25% Coffee	Blank
1	136.5	156	211	189.5	198	176.5
2	744	575	670	796	607.5	512
3	1458	240	0	226	363	0
4	1759	484	502	420	695	110
5	1315	455	425	360	445	88
6	855	192	161	128	125	0
7	389	155	102	46	101	0
8	486	330	120	265	195	85
9	286	454	368	40	90	46
10	381	830	349	223	139	68
11	120	225	135	190	100	0
12	241	585	118	55	43	0
13	456	605	230	59	92	0
14	177	318	101	114	0	0
15	71	160	54	0	100	0
16	0	170	0	0	0	0
17	130	230	94	0	65	0
18	95	255	0	131	0	0
19	0	275	0	0	72	0
20	0	220	160	0	0	0
21	106	200	42	0	10	0
22	0	221	76	0	0	0
23	115	272	0	0	0	0
24	0	72	0	0	0	0
25	0	79	130	230	180	0
26	0	0	0	0	0	0
27	117	129	0	0	0	171
Total	9437.5	7887	4048	3472.5	3620.5	1256.5

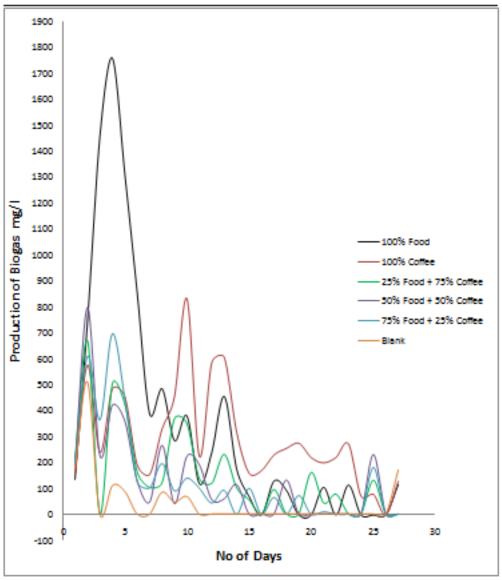

Fig 3.1 Graphical representation of Biogas Yeild

Biogas production of the substrate with 100% food waste was at peak during the initial days and decreased subsequently in remaining days.

Table 3.3 The percentage of methane and carbon dioxide was obtained by gaschromatography

Sr.No	Substrate	% of CH4	% of CO2
1	Food waste'	91.5	8.4
2	Coffee waste	89.2	10.1
3	25% Food waste + 75% Coffee waste	93.4	6.5
4	50% Coffee waste + 50% Food waste	90.9	9.04
5	75% Food waste + 25% Coffee waste	88.5	11.5
6	Blank	90.0	9

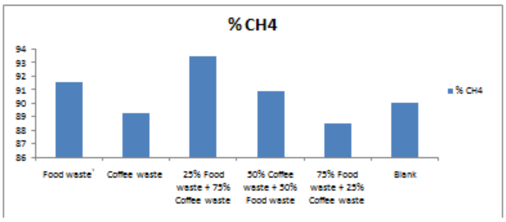

Fig 3.2 The percentage of methane

The biogas production was characterised by a high production rate in the first days of the experiment.Methane production is maximum for 100% food waste,but when it combine with 75% coffee waste,max biogass was produced.The minimum methane production was produced by the combination of 75% of food with 25% of coffee waste.methane produced by the coffee waste is 89%.The blank sample was also produces a methane range of about 90%.

IV.CONCLUSIONS

Generally, organic contents of food waste include sugar, protein, fat and cellulose, and they tend to have low total solids, high volatile solids, low C/N ratio and are easily degraded in anaerobic digester. Rapid hydrolysis of these feedstock may lead to acidification and consequent inhibition in methanogenesis. For this reason, the co-digestion of FW with other organic wastes, such as animal manure and crop residual straw, were considered. The codigestion of FW with other wastes in a single digester became increasingly popular, with the advantage of adjusting the C/N ratio, increasing the methane production yield, and improving the utilization efficiency.

Biogas production for the substrate with 100% food waste was at peak during the initial days and decreased subsequently in remaining days due to this rapid hydrolysis which lead to the formation to VFA's. Biogas production for the substrate with 100% coffee waste was at low during the initial days then increased in between and continuous to decrease subsequently. Coffee waste contains high carbon content (>58%) and low nitrogen (<2%).Also Lignin,polysaccharides, glucose and mannose are found in different proportions. This will help to adjustthe C/N ratio when added with food waste as a substrate for biogas production. The above obtained results suggested that the combination digestion was superior to single material fermentation.

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