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RESEARCH ARTICLE

PULPING OF ORGANIC-WASTE FOR USE AS A RAW MATERIAL FOR BIO-GAS GENERATION.

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Abstract

The growing aspects of renewable energy and environmental conditions, anaerobic digestion of biogas generation has pulled in extensive consideration inside of scientific researchers. The available organic-waste was collected from the streets of VIT institution is the alternative source for increasing the production rate in Biogas plant. This paper tries to prove the fact that instead of using direct raw material, the process of using pulp of the raw materials is more helpful for decomposition of the organic-waste in order to maximize the biogas production. The cow dung acts as inoculum and collected street waste as substrate for the study. The impact of physico-chemical characteristics carried out for cow dung, with and without making of pulp were analyzed in the CO2 research center in VIT University. The volume of biogas production was measured by using water displacement method for regular interval of time. Regular logging of the data has provided a basis for performance trend monitoring. The pH observations were experienced from 6-7.5 and treated substrate were characterized by a total solids(TS) content 87.9mg/g, volatile solids(VS) content 52.5mg/g. This nutrient level gives the faster hydrolysis and biogas production become higher with a less retention time to produce sufficient amount of biogas.

Introduction: -

The utilization of renewable energy is drastically expanding, alongside vitality security concerns, endeavors to relieve the environmental effect of conventional fuels, and changes in expectations for everyday comforts and renewable advances. Bioenergy is alternative source for the usage of advancing renewable energy options. Actually, bioenergy is assessed to be the fourth biggest vitality asset on the planet because of its renewable and broadly appropriate characteristics and its wealth. Forest waste assets, organic related waste, sewage and modern natural wastewater, municipal solid waste, live-stock and poultry disposed waste and biogas are real classifications for use. Biogas, which is by and larger production level to gas from anaerobic digestion plants, is a promising method for tending to worldwide vitality needs and giving different natural benefits. Biogas not just essentially diminishes the expenses of treating waste additionally has a moderately low feedstock cost. Likewise, biogas has a lower deal cost contrasted and diesel and petrol.

Biogas is produced from degradation process under anaerobic conditions whose application is quickly rising as a practical means for giving grater power supply. The aerobic digestion process cycle refers to a coordinated arrangement of a physiological procedure of microbial and energy digestion system, and in addition crude materials handling under particular conditions to create biogas which is made out of methane and carbon dioxide and follow gasses. The pretreatment of substrate before anaerobic digestion is viewed as a powerful technique to enhance biodegradability and biogas creation from lignocellulose materials by accelerating the hydrolysis process. Normal pretreatment techniques including physical, compound and natural might be utilized independently or as a part of mixes. Lignocellulose squanders for the most part incorporate harvest buildups and logging deposits with yield deposits making up the greater part. For China, more than 800 million metric huge amounts of waste that produced as a result of various agricultural operations is created every year. This waste can't be processed without any physical treatment because of unmanageable materials (cellulose, lignin and hemi-cellulose) that outcome in low biodegradation and it takes more time to digestion during the process of anaerobic digestion process. hence, additional aggregate measures are expected to begin the digestive process, for example, pulping of waste and inoculums.

Physical processing of waste was completed to separate the cell structure of biomass and to build the particular surface region. This gave the opportunity to the lytic activity of bacterial catalysts and reduce the viscosity level in digesters during the digestion process, which is especially vital for cellulosic substrates. By changing the characteristics of raw material, like expanding the surface area, grinding or dissolving lignin and hemicellulose, and decreasing the crystallinity of cellulose, pulping of a biomass more biodegradable and open to anaerobic microorganisms.

Lignocelluloses are fundamentally made out of sugars (cellulose and hemicelluloses), lignin, and incidental materials. but, the reduced crystalline structure where lignin physically secures the cellulose and hemicelluloses parts makes these materials more impervious to anaerobic assimilation. In the anaerobic digestion process, if a substrate is very much encased in lignin structures, the sort of degradation of the substrate gets to be vital. The structure is to be disturbed or disturbed as opposed to cut, since they are unmanageable to decompose under anaerobic conditions. Without any physical pretreatment of the raw material biogas production could turn out to be low with a long maintenance time required to generate adequate measure of biogas.

Methodology: -

Sample collection and preparation:

Fresh cow dung was collected from the Vellore farms in which the cows were fed with locally available resources. Cow dung samples were collected in a containers and preserved in a room temperature. After obtaining the samples, they were thoroughly mixed with tap water at the ratio 1:1, and then fibers were screened through a sieve (0.5cm x 0.5cm) mesh size in a container. From the container, single composite sample was taken out and shifted to the polythene bag and sealed air tight. Then the samples were stored for further analysis.

Experimental setup for cow dung:

Bioreactors used for the study, the experimental observations were conducted in two different biogas digesters having one 20 liters' slurry capacity and 10 liters' slurry capacity. The well designed bioreactors are kept above from the ground so that digester can receive the solar radiation. The one digester height 40cm, Liquid height and empty height 27cm,13cm and second digester height 20cm approximately. The schematic experimental setup for cow dung analysis as shown in figure-1. All valves were plugged with tightly rubber plug and made air tight with adhesive. The outlet valves were connected with long delivery tubes to pass the gas from the digester. These gas from the pipes are attached to the inverted water displacement setup as shown in a figure. The digesters were stirred manually in two times per day so that it will undergo anaerobic digestion. This field study has been done at Co2 Research center-VIT university Vellore.

Fig.1 Set up for the Cow dung.

Experimental setup for raw material(organic-waste): -

Preparation of Raw material: -

Samples of organic-wastes includes fallen (dried and wet) leaves, grass trimmings and small debris were collected from VIT University. The organic waste materials were collected in a polythene bags and it was grinded by using electrical grinder. The process of making pulp of the organic waste is acted as a substrate in Digester-1. The second set of organic waste is done on mechanical pretreatment was performed on the collected organic wastes by using a cutting mill was mixed with inoculum in a Digester-2. In order to achieve a squeezing for the cellular structure of organic wastes for the pretreatment prior to anaerobic digestion.

Fig.2: photographic view of collected Organic-waste.

Experimental procedure: -

For organic-waste with pulp: - The process of making a pulp of raw material (organic waste) was acted as a substrate for the digester-2.The grinding material of raw material was stored in a bowl and maintain the moisture content. In this 200gm of pulp was taken and mixed with 1800ml of water for a mixing ratio. The pulp was mixed in a container and it was poured in an inoculum present in a digester. The second digester biogas outlet was connected to the valve and it was kept for an inverted measuring jar of 1liter. These observations were carried by water displacement method.

Fig.3 Grinder that will used for the making of pulp of the raw material

For organic-waste without making pulp: The inoculum (cow dung) present in a Digester-1 was mixed with 10% of pulp and remaining 90% of water has to be mixed. The organic waste pulp was weighed with the help of weighing machine and it was carried in a bowl. The pulp was stored in a room temperature. The substrate of organic waste was mixed in a container of 400gm of pulp was added with addition of 3600ml water. These mixed inoculum was poured in a digester through inlet valve. The collection of biogas outlet valve was connected to the air tight bottle with tight rubber cork in order to prevent any leakages. The air tight bottle was containing with a volume of 1Liter measurements. These biogas production was observed by water displacement method.

Fig.4: Schematic Biogas batch digester.

Physico-chemical analysis: -

The physico-chemical properties of a cow dung samples from the digesters used from the study were collected in a sampling bottles and analyzed in a laboratory.

pH measurement: -

The 10gram of digester sample was injected into a sample cup. The slurry sample was mixed with a water of a 1:1 vol/vol ratio. These samples were kept for sometime so that it will allow for settling, and kept for vigorous stirring. The sample should be in room temperature for 1hr. Finally, the pH is measured by the pH meter.

Total solids(TS) and Volatile solids(VS): -

The collected digester sample was injected into the dried crucible cup. The weight of the empty crucible cup was determined at the beginning and after adding the sample in a container the weight should be determined. The container was kept in a furnace at 105^0 C temperature for half day to evaporate water for total solids(TS) calculations. The weight of the crucible cup was determined. The another sample was taken in a container was placed in a muffle furnace at 550^0 C temperature for 3 hrs. The weight of the sample was recorded for Volatile sample(VS) calculations. These sample of analysis were carried out using the (APHA 1995) standard methods and mathematical formulas of Total solids and Volatile solids are shown below.

$$\mathbf{TS} = \frac{M_1 - M_2}{M_3 - M_2}$$

$$\mathbf{VS} = \frac{(M_2 + M_1) - (M_2 + M_4)}{(M_2 - M_1)} - M_2$$

M_1: weight of dried sample after 12 h at 105 °C**, M_2:** weight of container, **M_3:** weight of wet sample, **M_4**: weight of burnt sample after 3 h at 550 °C.

Chemical oxygen demand (COD):-

Measurement of COD performed following closed reflux titrimetric method (standard method 5220C). The analytical procedure is based on the digestion of organic matter present in the sample with potassium dichromate(oxidant) and silver sulfate (catalyst) for 120minutes in acidic medium. Organic compounds are oxidized during the digestion. The digested sample is titrated with ferrous ammonium sulfate using ferroin indicator. The end point is the appearance of wine red color.

$$\mathbf{COD} = \frac{(B - S) * N * 8000}{\text{Volumeofsample}}$$

B: Ferrous ammonium sulfate consumed for blank (in mL). S: Ferrous ammonium sulfate consumed for sample (in mL). N: Normality of Ferrous ammonium sulfate.

Results and analysis: -

Raw material properties of Organic-waste: -

The sample of anorganic-waste material(pulp) was collected and mixed with water as a certain ratio of 10% of pulp and 90% of water. In this 10ml sample was taken to observe the physicochemical parameters of organic-waste sample values are shown in a table-1.

Table 1 Substrate characterization.

Properties	organic waste
pH	7.2
Total solids(mg/g)	87.92
Volatile solids(mg/g)	52.57
COD(mg/l)	6372.3

Biogas production: -

The production of biogas is observed for every three-days interval of time as plotted the graph for number of days vs biogas production. The study has observed that biogas production has lower at the beginning stage of the anaerobic digestion process. Initially the growth of methanogenic bacteria is almost equal to the rate of biogas production. The plotted graph shows that first 5 days of observation, there was less biogas production and mainly due to the lag phase of microbial growth. Whereas, in the range of 6 to 12 days of observation. The biogas production increases considerably because the rapid growth of methanogens bacteria. Highest biogas production rate of was measured on 12 to 18days of interval for both the digesters. This decrease in the level of biogas production in the digesters were observed because of the unregulated pH. The maximum amount of biogas is produced in the digester-1 is 2.45liters and similarly the maximum amount of biogas production in digester-2 is 1.55liters. The recorded values are tabulated as shown in Table-2.

Table 2: Production of biogas for Without pulp and with pulp.

No. of days	Digester-1	Digester-2
0	0	0
3	0.6	0.45
6	0.75	0.8
9	1.4	1.15
12	1.9	1.6
15	2.45	1.55
18	1.7	1.2
21	1.1	0.7
24	0.45	0.45
27	0.2	0.15

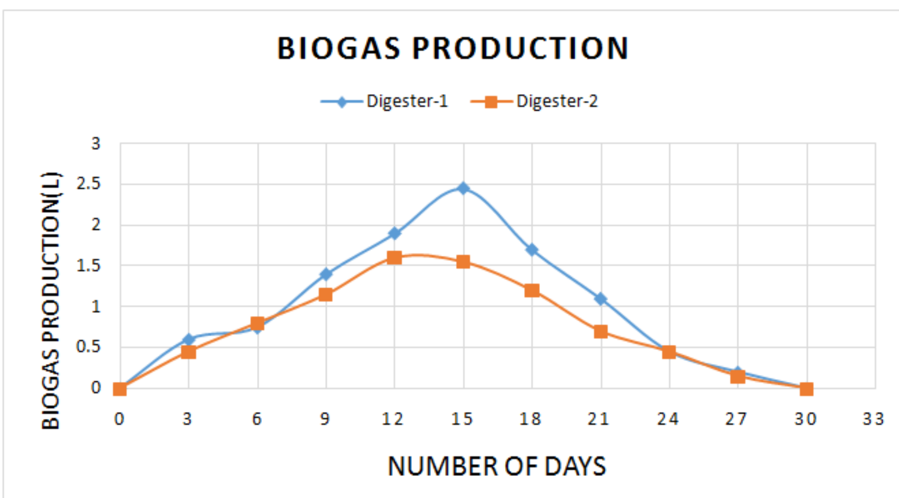

Fig.5 The graph was plotted between number of days vs biogas production in Liters.

Effect on pH:

The effect of pH observations reveals that in both the digesters are used in this study are little neutral in the first three days of observations as shown in a plotted graph in a number of days vs pH. These values are experienced that pH values are varied from 6 to 7.5. The fall may have been found because of the acid forming bacteria involved in the process of digestion for the production of gas. From the 10 to 20 days of the interval time pH is observed more for both the digesters and towards the end of the digestion process pH is again to neutrality. This may have been because of the exercises of the methanogenic bacteria, which could change over the result of acid forming bacteria to methanogenic bacteria to produce methane gas.

Table.3: pH analysis of without pulp and with pulp.

No. of days	Digester-1	Digester-2
1	6.5	6.8
5	6.7	7.3
10	6.9	7.4
15	7.5	7.6
20	7.3	7.4
25	6.6	6.9
30	6.3	6.6

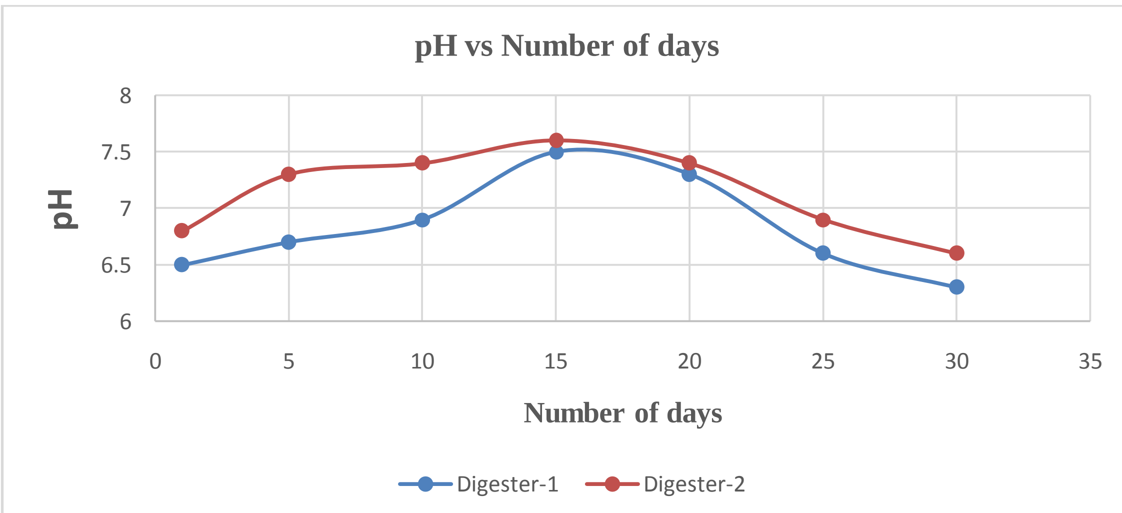

Fig.6 The graph was plotted between pH vs number days.

Total solids(TS) and Volatile solids (VS): -

TS and VS for Digester-1: -

Total solids(TS) and volatile solids(VS) are the main characteristics for evaluating during the process of anaerobic digestion process. The most effective performance in terms of volatile solids degradation was observed during the batch digestion process, probably through efficient hydrolysis in the acid phase. The observations have carried out on initial and final stages of the digestion period for the both digester-1 and digester-2. The values of total solids and volatile solids concentrations are 20.5% and 22% removal efficiency in digester-1. The graph was plotted between initial and final stages of the digestion process for both the digesters are shown in a fig

Table.4:TS and VS for Digester-1.

Days	Initial	Final
Total solids	70.68	61.38
Volatile solids	56.15	47.87

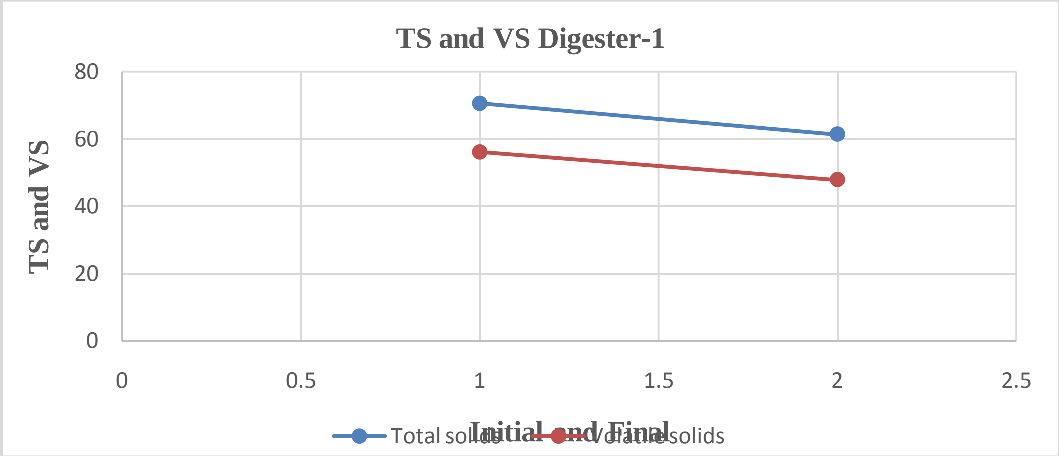

Fig.7 The graph was plotted between initial and final stages of Total solids(TS) and Volatile solids(VS) of digester-1.

TS and VS for Digester-2: -

The similar observations were carried out for the digester-2 with pulp are total solids and volatile solids concentrations are 27.4% and 35% of removal efficiency during the production of biogas. These values were tabulated in table.5 The graph was plotted between initial and final stages of the digestion process for both the digesters are shown in a fig.8

Table.5 TS and VS for Digester-2.

Days	Initial	Final
Total solids	81	71.39
Volatile solids	58.78	44.59

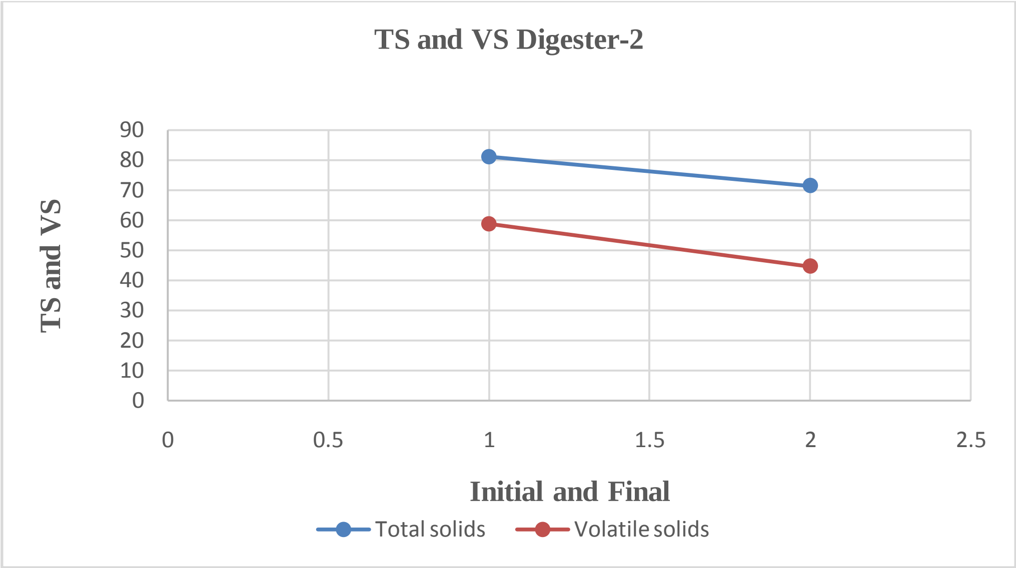

Fig.8 The graph was plotted between initial and final stages of Total solids and Volatile solids of digester-2.

COD analysis: -

At initial stage of the biogas production process, due to intense mineralization of the reactants a considerable decrease in COD occurred. By the end when microorganism does not exhibit a living behavior and the process stopped, the COD percentages decreased. COD was measured on initial and final days of the digestion period and the effect of COD was observed both the digesters are shown in table-6. The graph was plotted for initial and final stages of the digestion process for both the digesters are shown in a figure.

Table.6:COD analysis for without pulp and with pulp.

Digesters	Initial(mg/l))	final(mg/l)
Digester-1	5460	3800
Digester-2	6028	4230

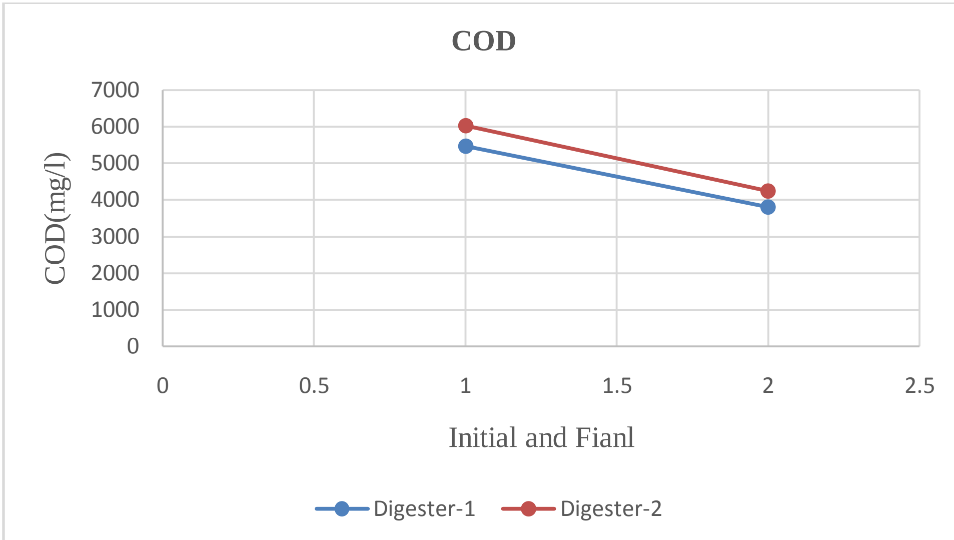

Fig.9 The graph was plotted for initial and final stages of COD in the digestion process for both the digesters.

Conclusion: -

In this research, these observations try to prove the fact that instead of using direct raw material, the process of using a pulp of the raw material (organic waste) is more useful for decomposition at the initial stages of anaerobic digestion processin order to maximize the biogas production. The usage of pretreated pulp is an efficient process to improve biogas and methane production.

Overall the present study is of great importance for the energy production and the efficient usage of any available raw materials like agricultural waste, kitchen waste, Fruit waste etc., Use of the pulp in the biodegradation of the agricultural wastes is the best option for rapid conversion of agricultural wastes and more suitable in bicycling.

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