INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Enhancement of Rate of Biodegradation of Organic Matter in Waste in Anaerobic Digestion

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Abstract: Anaerobic Reactor Landfills(ABLF) are being used by many developed nations for disposal of organic fraction of municipal solid waste.
The time duration for complete stabilization of the organic matter is considerable in such landfills & hence develops economic stress.
The present study focuses on enhancement of the anaerobic reactions in ABLF by pretreatment of the carbohydrates present in the organic matter within municipal solid waste. The organic matter having higher percentage in the organic waste for e.g. Green vegetables, rice, wheat, potato, etc.were used as a resource. The resources were subjected to the anaerobic reactions in the reactors. The physical & chemical characteristics of the constituents of the reactors were analyzed& monitored during the reactions. A comparative study of the reactors consisting of pretreated resource & non-pretreated resource based on the physical & chemical analysis of various parameters were drawn to the conclusion that pretreated resources gave results at a higher rate compared to non-pretreated resource.
Keywords: Anaerobic Digestion, Municipal Solid Waste, Pretreatment
Date of Submission:
Date of Acceptance:

I. INTRODUCTION

Anaerobic digestion is the transformation of organic matter having complex structure into simpler compounds through biochemical reaction of micro-organisms such as bacteria in absence of oxygen. The four key stages of anaerobic digestion involve hydrolysis, acidogenesis, acetogenesis & methanogenesis.

Through the hydrolysis, the complex organic molecules are broken into simple sugars, amino acids & fatty acids. The biological process of acidogenesisresults in further breakdown of remaining components by acidogenic bacteria. In acetogenesis phase, the simpler molecules of acidogenesis phase are further digested by acetogens to produce largely acetic as well as CO_2 & H_2. Later, in the terminal stage of anaerobic digestion, methanogens use the intermediate product of preceding stages and convert them into methane, CO_2, CH_4 and water.

These components make up the majority of biogas emitted from the system. The overall process can be described by chemical reaction, where organic material such as glucose is biochemically digested into CO_2 and CH_4 by anaerobic micro-organisms.

$$C_6H_{12}O_6 \longrightarrow 3CO_2 + 3CH_4$$

This process results into generation of carbon dioxide, methane and other contaminant gases. methane gas produced is directly used as fuel for cooking or heating. Unlike the production of methane from gas wells, anaerobic digestion is renewable source energy.

A. Objectives of the Research Work
1) To study the anaerobic digestion process and factors affecting it.
2) To identify and select the pretreatment method to enhance rate of biodegradation.
3) To perform the experimentation to enhance the rate of biodegradation.

II. EXPERIMENTATION

A. Waste Collection And Processing

Kitchen waste was desired to select for this project which majorly includes waste roti, rice, potatoes etc. (which constitute about near 70% of KW) which was directly dump into MSW, so we selected this waste items as our primary parameters. But on the other hand question arises that this waste is dump in MSW as a mixture so why don't we take mixture of this? And then the mixture of this item was also included in experiment. After gathering all the waste materials were cut into small size in order to get efficient biogas production for pre-treated reactors.

Sludge was collected from Akurdi STP for the project. Sludge collected was first tested in lab on the basis of physical parameters and then it was selected ensuring its reaction with sufficient reaction time.

Fig 2.1 :- Bottle filled with Sludge

B. Lab Scale Experiment

In lab scale experiment reactors were operated in batch reactor technique. Firstly eight digesters, two for each organic waste item respectively were prepared for conventional reactors. Out of total 16 reactors, of which 8 reactors were for pretreatment of organic matter and rest of reactors will be without any pretreatment i.e., Conventional reactors.

The total volume of single reactor was 750 ml out of which 600 ml was mixture of organic waste (Rice, potato, Roti, mix) and sludge in the proportion of 1:2. The proportion of mix is 1:1:1 of rice, roti and potato. The density of potato is 0.591 gm/ml hence its weight for 200 ml was 118 gm. The density of rice is 0.730 gm/ml hence weight for 200 ml was 146gm. The density of wheat is 0.770gm/ml hence its weight for 200 ml was 154 gm. The density of mix is 0.700gm/ml hence its weight for 200 ml was 140 gm.

Fig 2.2:- Conventional Potato

Fig 2.3:- Pretreated Potato

Fig 2.3Conventional Rice

Fig 2.4 Pretreated Rice

Fig 2.6:- Conventional Chapati

Fig 2.7:- Pretreated Chapati

Fig 2.8:- Conventional Mix

Fig 2.9:- Pretreated Mix

After design of the proposed reactor actual work of filling was started. In the initial stage the reactors were named and are attached with the reading strip to take the readings of settlement of organic matter over the time as shown in the following figure

Fig 2.12:- Reactors showing marking for settlement measurement

After preparing all the reactors the conventional reactors were filled with the adopted method to fill the reactor. It's very difficult to fill the reactors with the larger size as the inlet of reactors was very small, so organic matter were cut into small pieces so that can be filled in the reactors easily. As stated above organic matter were mixed with sludge in the ratio 1:2.after filling, reactors were placed for reaction in the lab where reactors will be at room temperature

For filling of pre-treated reactors all the organic wastes were shredded in the size range of 0.5mm to 1mm, so that it will helps to boost anaerobic reaction by increasing contact area with that of anaerobic bacteria. pH of all the reactors was measured after mixing with sludge with pH meter and then adjusted to required level which is of 7 to 8 on pH scale. pH was adjusted with 0.1 N NaOH. Below figure shows measurement of pH.
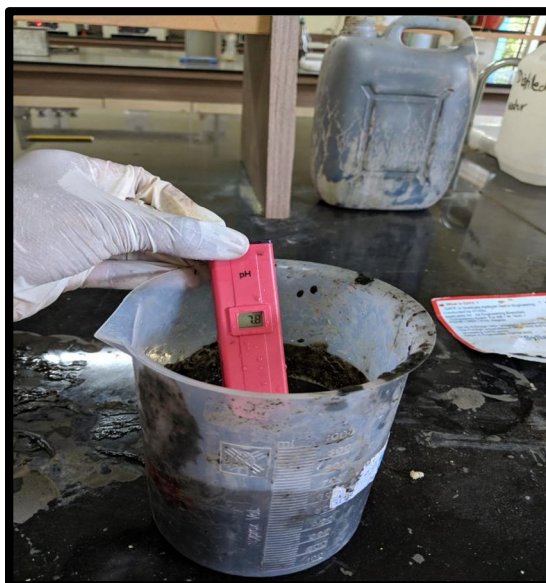

Fig 2.14:- Measuring the pH of sample with pH meter.

After filling of the reactors 50 gm sample from each of organic waste was taken in crucible and placed in oven for 24 hrs at 105^0 C for moisture content measurement of sample. And then after 24 hrs sample was taken out from oven and then placed in muffle furnace for 30 minutes at 550^0 C for measurement of total volatile solids of sample.

Fig 2.15 :- Sample from the oven at 105^0 C. Fig 2.16 :- Samples after muffle furnace.

All the reactors were sealed properly and checked for any leakage. After checking properly of any leakages all the reactors were placed at room temperature and were properly monitored till the end of reaction time. Following table showing methods adopted.

Table 3: Methods adopted for filling of reactors.

CONDITIONS	CONVENTIONAL	PRETREATED
No of reactors	2 each	2 each
Anaerobic sludge	Yes	Yes
Shredding	No	Yes
pH Adjustment	No	Yes

Below photo shows the implementation of experimentation.

Fig 2.17:- Actual arrangement of reactors.

Sixteen bottles were filled on 9 February 2019, and monitored for one week. Some bottles were not giving expected results due to leakage. Hence later, ten such bottles which were not giving results were filled again on 16 February 2019.
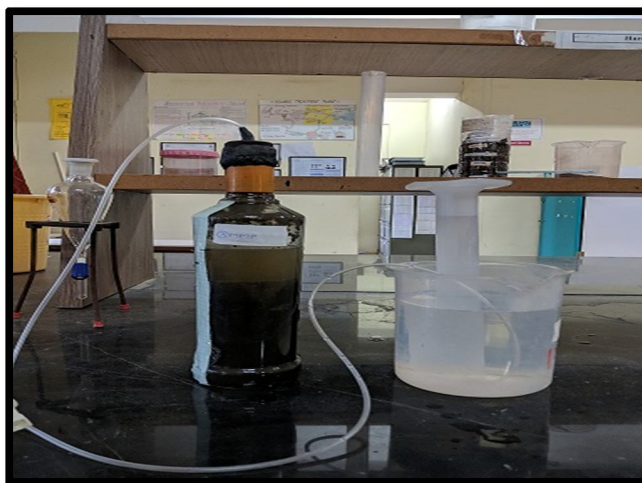
C.   Monitoring Of Reactors

Fig 2.18:-Water displacement method for measuring gas produced

1) Filled reactors were monitored and gas was measured on daily basis.

2) The water displacement method was used to measure the biogas gas produced using beaker and measuring cylinder assembly as shown above.

3) In which, pipe was put into the inverted measuring cylinder filled with water and knob of pipe is opened in which amount of water displaced is equal to the biogas gas produced.

4) In same way all other reactors were monitored and biogas gas produced was measured.

5) All the readings were noted down.

During monitoring it was observed some of the reactors were failed due to leakage and   due to extra pressure generated. Those failed reactors were filled again and were monitored.

D.   Results And Discussion

`Sample	Sample Type	Sample wt(gm) after 24 hrs Oven(105^0 C)	Sample wt(gm) after 30mins Muffle furnace(550^0)	TVS per gm of TS (gm/gm)
Wheat+ Sludge (1:2)	Conventional	2.954	0.37	0.103
	Pre-Treated	5.025	1.227	0.1517
Rice + Sludge (1:2)	Conventional	5.312	1.56	0.1501
	Pre-Treated	3.295	0.27	0.121
Potato + Sludge (1:2)	Conventional	3.742	1.397	0.0938
	Pre-Treated	4.085	0.83	0.1302
Mix (P+R+W) (1:2)	Conventional	1.868	0.37	0.0599
	Pre-Treated	3.875	1.05	0.113

Table No 1: Results of Total Volatile Solids (Before filling of reactors)

Sample	Sample Type	Sample wt(gm) after 24 hrs Oven(105^0 C)	Sample wt(gm) after 30mins Muffle furnace(550^0)	TVS per gm of TS (gm/gm)
Wheat+ Sludge (1:2)	Conventional	6.02	3.585	0.0565
	Pre-Treated	9.328	6.603	0.0646
Rice + Sludge (1:2)	Conventional	7.553	5.113	0.0603
	Pre-Treated	6.312	5.068	0.0292
Potato + Sludge (1:2)	Conventional	5.939	4.563	0.0383
	Pre-Treated	8.45	6.376	0.04227
Mix (P+R+W) (1:2)	Conventional	5.417	4.348	0.0177
	Pre-Treated	10.101	9.378	0.0167

Table No 2: Results of Total Volatile Solids (After opening of reactors)

Sample	Sample Type	Cumulative Reading after 30 days (ml)
Wheat+ Sludge (1:2)	Conventional	22
	Pre-Treated	582
Rice + Sludge (1:2)	Conventional	392
	Pre-Treated	534
Potato + Sludge (1:2)	Conventional	223
	Pre-Treated	628
Mix (P+R+W) (1:2)	Conventional	79
	Pre-Treated	249

Table No 3: Cumulative Readings of Biogas

III.   CONCLUSION

A. Anaerobic digestion was found to be one of the better option to dispose the organic matter from the municipal solid wastes.

B. Centralized anaerobic digestion in the form of anaerobic bioreactor landfill or decentralized anaerobic digestion in the form of 1 tonnes anaerobic digestion plants can be effectively used in cities.

C. Early stabilization of organic matter is possible by adopting and applying few steps. Control of pH , Shredding, Nutrients addition , maintaining moisture control etc where few measures that were found in literature.

D. Highest gas generation rate was achieved for substrate of pretreated potato plus sludge. The rate achieved was 64.27 lit/kg of TVS.

E. It was found that all the pretreated substrates behave better than their conventional version.

F. For substrate of wheat plus sludge , the conventional reactor yielded very low 5.564 lit/kg of TVS. The reason for this would have been leakage in the reactor.

G. It can be concluded from result that if pretreatment is provided for the substrate hydraulic process is accelerated resulting into enhanced gas production in lesser time

IV.   ACKNOWLEDGEMENT

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