GLOBAL SCHOLAR PUBLICATIONS

Global Journal of Research in
Life Sciences

Journal homepage: https://gsjournals.com/gjrls/

ISSN: 2980-4183 (Online)

(RESEARCH ARTICLE)

Check for updates

Effect of addition of certain substances during slurry preparation to optimize biogas production

Osuji malachy ikeokwu *, Chilakah godspower chukwuebuka, Anyanwu chukwubuikem Isaiah and Ndiukwu Precious Chinonso

Legacy University Okija, Anambra state, Nigeria.

Global Journal of Research in Life Sciences, 2022, 01(01), 044–050

Publication history: 04 September 2022; revised on 11 October 2022; accepted on 15 October 2022

Article DOI: https://doi.org/10.58175/gjrls.2022.1.1.0027

Abstract

Biogas from anaerobic digestion of organic substance has become the available replacement for the fossil fuel. This research was carried out to investigate the effect of certain substances added during slurry preparation to enhance biogas formation. The biodigester was locally fabricated using plastic container of 25liter capacity. The slurry was prepared by adding Calcium Sulphate, Chopped plantain leaf, and pretreated substrate. After 15 days of anaerobic fermentation, the slurry with $CaSO_4$ gave more biogas of 0.403kg followed by the pretreated which gave 0.270kg. The one with plantain leaf gave the least biogas. This is as a result of inhibition of enzyme activity by certain chemical substance from the leaf. Also, the amount of Calcium sulphate to be added should not exceed 200g to 1kg of substrate to be used for slurry preparation.

Keywords: Slurry; Digestion; Biogas; Anaerobic; Fermentation; Organic Biomass**.**

1. Introduction

Biogas is a renewable and an environmentally friendly form of energy which can substitute wood and fossil fuels in a number of applications and thus mitigate the rising costs of petroleum products and deforestation (1). Biogas is a combination of gases produced during anaerobic decomposition of organic materials of plant origin. It is produced from the organic wastes by a concerted action of various groups of anaerobic bacteria (2). The main gaseous by-product is methane, with relatively less carbon dioxide, ammonia and hydrogen sulphide (3). Methane is the principal constituent of natural gas and ranks first in the series of saturated hydrocarbons known as alkanes (1,4).

Energy generation through biogas has gained relevance in recent years due to its potential capacity as renewable energy source. An analysis of this technology from the life cycle thinking is essential for sustainable development. It does not have negative impact on the environment hence its friendly nature to the eco system rather it can be optimized if the byproduct of the biogas, like the Slurry are processed as condition to their usage as soil improver Biogas plant construction if encourage by the government and multinationals.

In Nigeria, one of the chief pathways in which food waste is disposed include open dumping and burning in dump sites and sometimes throwing away in landfills. Knowing the rapid biodegradability of food waste in the company of contaminating microbes, open dumping in dump sites or in landfills can be very questionable (5). Furthermore, the biological degradation of organic matter such as food waste and other types on dumpsites and inside landfills demands an enormous land space in which greenhouse gases such as carbon dioxide, methane, etc., are created with no profitable gained in terms of the energy created by the organic matter in the form of biogas (4,6). In addition, given the high moisture content of the food waste, open burning necessitates high amounts of energy with no energy recovery in most

* Corresponding author: Osuji malachy ikeokwu

circumstances (7). Both choices inflict adverse impressions on both man and his environment (2,6). This problems have led many countries to place an embargo on disposal options such as open dumping and open burning. Waste-to-energy techniques are habitually considered for the removal of organic wastes materials from the environment because they support the reduction of environmental impressions and fractional replacement of fossil reserves.

The conversion of complex organic compounds into methane and carbon dioxide requires different groups of microorganisms and is carried out in a sequence of hydrolysis, acidogenesis, acetogenesis and methanogenesis (8).

Biogas generation has been reported to be affected by different factors such as the nature of the substrate to be digested, the nature of the biodigester, temperature, pH, alkalinity, retention time, organic loading rate, carbon/nitrogen (C/N) ratio, nutrient availability, moisture, oxygen, ammonia, volatile fatty acids, microbial inoculum/substrate ratio, particle size, pretreatment of substrate and inhibitors such as organics, metals and secondary metabolites (9).

1.1. Aims and objectives of the research/ investigation

The aim of this investigation was to evaluate the effect of addition of

- Plantain leaf used wrapping oil bean for fermentation to take place.
- Hard water since it can be used in brewery to enhance fermentation in beer production
- Use of pre-treated substrate as described by Osuji (11)

2. Materials and methods

2.1. Collection of samples.

- The samples used in this investigation include (i) cow dung (ii) poultry dung.
- Some physical properties of the samples were tested.

2.2. Physical analysis of the three samples

Temperature and pH of the samples were tested using thermometer and pH meter. The values were recorded and shown in table 1 below

Table 1 Temperature and pH reading of the cow and poultry dungs

sample	Nature of sample	Temperature	pH
Cow dungs	Soft/solid	28	6.7
Poultry dungs	Soft/solid	32	6.3

2.3. Slurry preparation and digester fabrication

The digesters were fabricated using an empty 25 Litre container. They were made in such a way that they are water and air tight. Rubber hose and valve were used to connect them to vehicle tube. These were shown in figure 1 below.

The slurry for anaerobic digestion were prepared as follows

• 1000g of each of cow dungs and poultry dungs were mixed with 15 litres of water and thoroughly mixed to ensure homogeneity. This was done for each digester as shown below.

The slurry was dispensed as follows.

- Digester 1 : 10 litres of slurry without anything added (as control)
- Digester 2 : 10 litres of slurry with Some pieces of chopped plantain leaves
- Digester 3: 10 litres of slurry with 100g of $CaSO_4$ (permanent hardness)

Digester 4: 10 litres of pre-treated slurry.

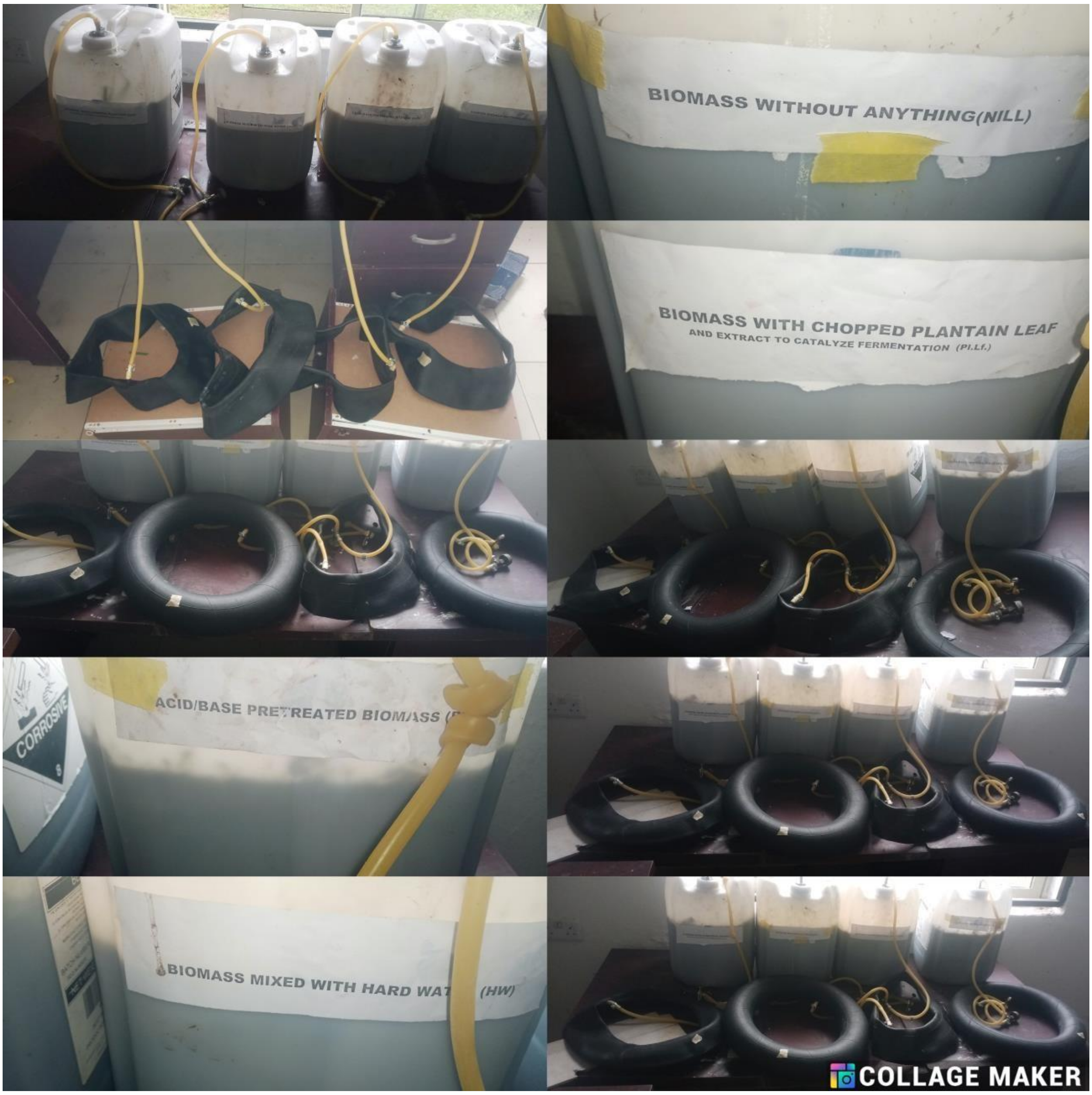

Figure 1 Locally fabricated digester with gas collection tubes fixed

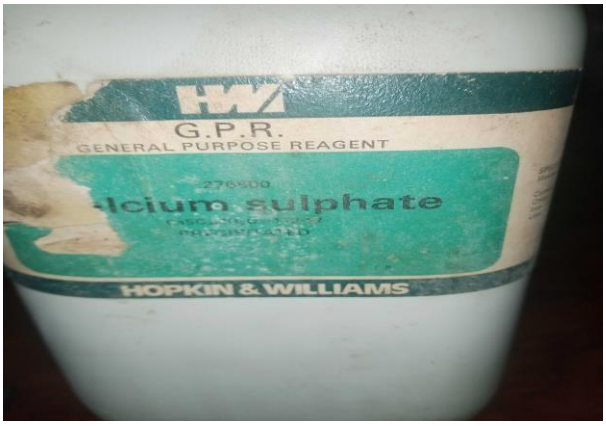

Figure 2 Calcium Sulphate added to digester 3 for hardness

3. Results

The four tubes were initially weighed at the first day recorded as day zero. The set ups were allowed to stay for 15 days. The tubes were weighed at Day 7-15 and the readings presented as follows.

Table 2 Weight of tube and gas from Day 0 to Day 15

Description of fermentation	Weight of tube (kg)	Weight of tube day 0 (kg)	Weight of tube day 7 (kg)	Weight of tube at day 10 (kg)	Weight of tube at day 14 (kg)	Weight of gasat day 0 (kg)	Weight of gas at day 7 (kg)	Weight of gas at day 10 (kg)	Weight of gas at day 15 (kg)
Substrate + water and nothing	0.420	0.420	0.510	0.600	0.672	0.00	0.090	0.180	0.252
Substrate + water+ $CaSO_4$	0.42	0.42	0.530	0.685	0.823	0.00	0.110	0.265	0.403
Substrate + water+ Plantain leaf	0.42	0.42	0.482	0.500	0.590	0.00	0.062	0.080	0.170
Pretreated Substrate + water	0.42	0.42	0.530	0.641	0.690	0.00	0.110	0.220	0.270

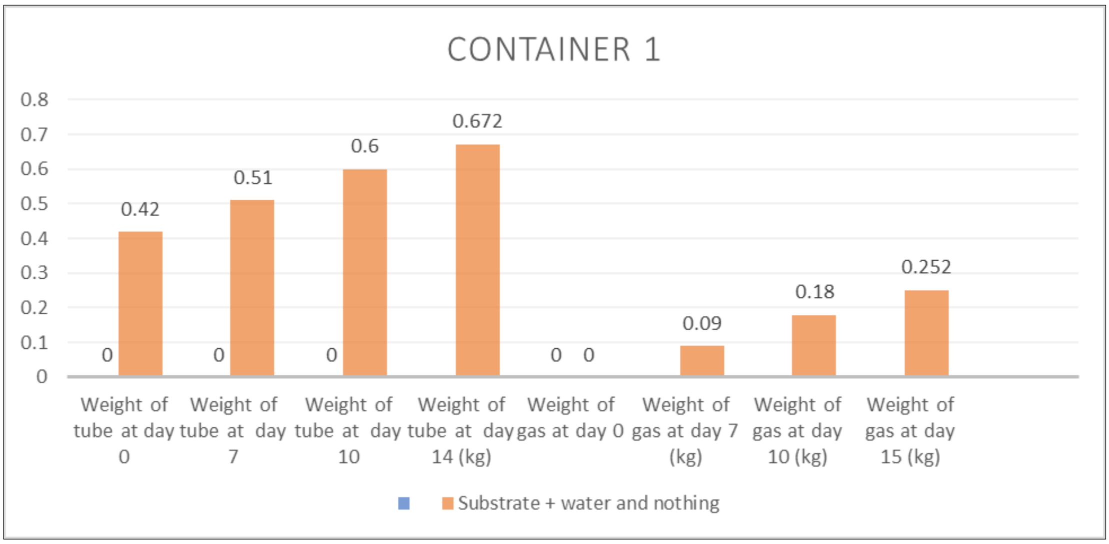

Figure 3 Weight of tube and gas from Day 0 to Day 15 of Substrate + water and nothing

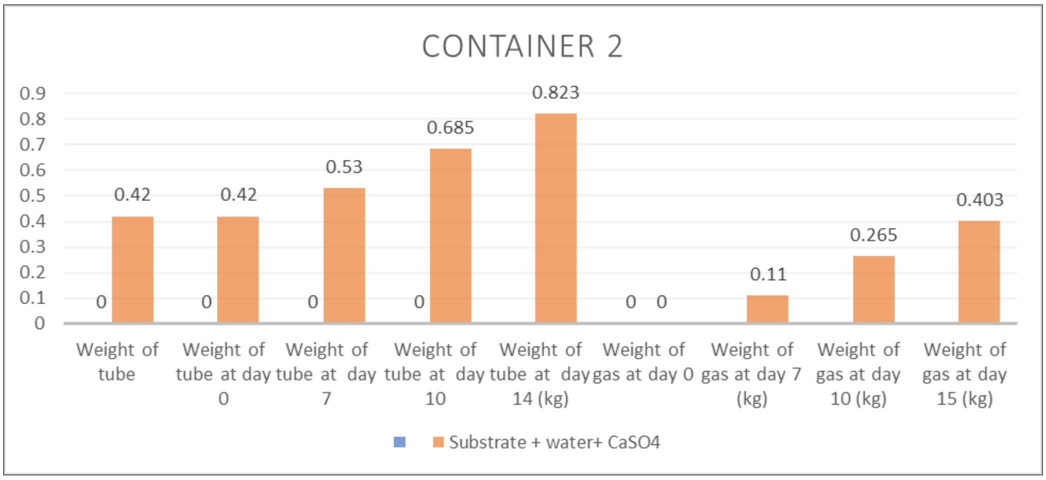

Figure 4 Weight of tube and gas from Day 0 to Day 15 of Substrate + water+ $CaSO_4$

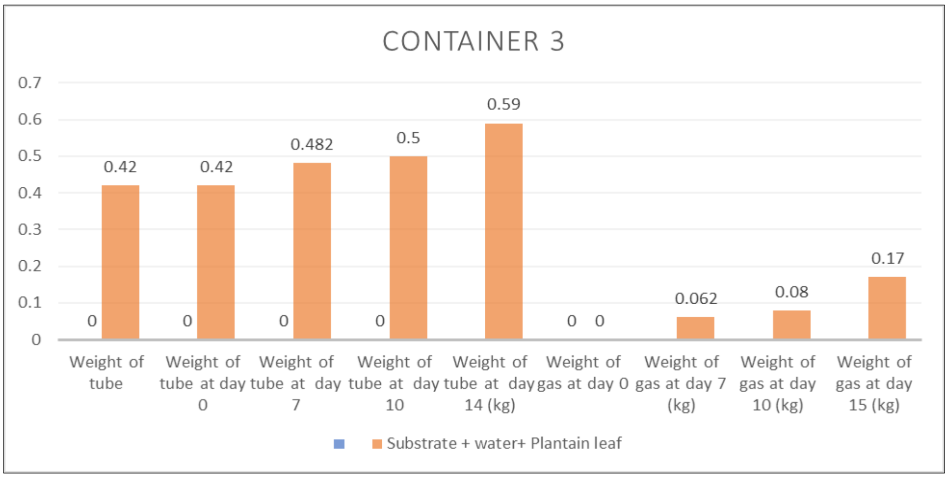

Figure 5 Weight of tube and gas from Day 0 to Day 15 of Substrate + water+ Plantain leaf

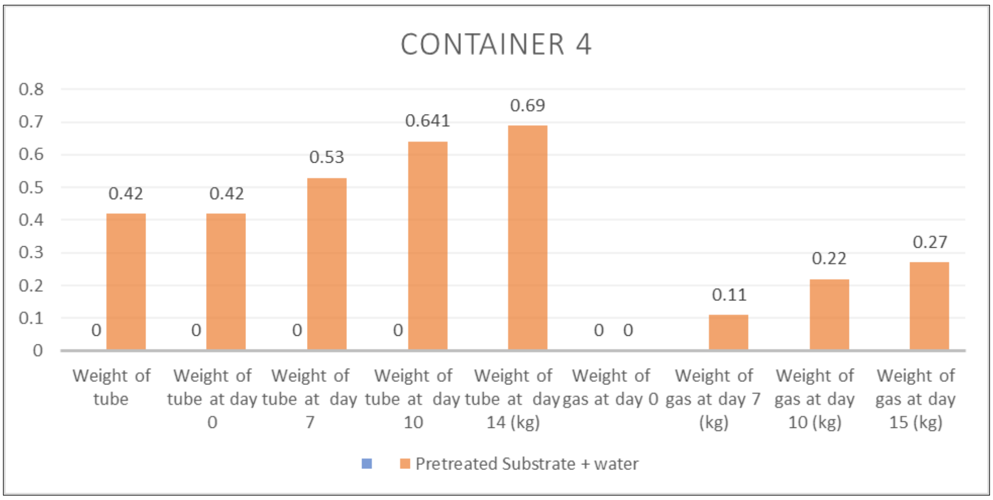

Figure 6 Weight of tube and gas from Day 0 to Day 15 of Pretreated Substrate + water

4. Discussion

The results of the anaerobic digestion were represented in the form of weight of tube with gas minus the weight of empty tube. This will give approximately the weight of the gas produced. This was presented in table 2 above. The weight of the tubes were recorded as 0.420kg.

For container 1 which is for substrate mixed with water only. The weight of the gas were 0.000, 0.090, 0.180 and 0.252 for day 0,7,10 and 15 respectively. For container 2 (substrate + water + Calcium Sulphate) 0.000, 0.110, 0.265 and 0.403 were recorded. Container 3 (substrate + water + plantain leaf) recorded 0.000, 0.063, 0.080 and 0.172. finally, container 4 (Pretreated substrate + water) recorded 0.000, 0.110, 0.220 and 0.270.

In the containers 1,2,3,and 4; when the process was set, no significant effect on the output. That was why the recording showed 0.000kg. from day 0 to 3, there was the process of hydrolysis. According to osuji (11), this hydrolysis is a limiting process. The cellulose-rich materials are converted to other intermediates. The giant molecules like polacharride, protein, and lipids are converted to oligomer and Manomers (sugar, amino acids and long chain fatty acid. This hydrolysis ifs a very slow process (13). It can be represented as $C_6H_{10}O_4 + H_2O$ ---------- $C_6H_{12}O_6 + H_2$.

From day 4 upwards, the process enters into Acidogenesis. This is the process by which the products of Hydrolysis are converted into other intermediate products like acetate, carbon dioxide and hydrogen. (6,14). This account to why the collection tube starts showing signs of increase in volume. Facultative anaerobic bacteria are usually at work. This can be represented as

$C_6H_{12}O_6$ --------------$2CH_3CH_2OH + CO_2$

$C_6H_{12}O_6 + 2H_2$ ------------ $2CH_3CH_2COOH + 2H_2O$

$C_6H_{12}O_6$ ---------------- $3CH_3COOH$

From day 7 to day 15, acetogenosis and methanogenesis came into play. In the of process of Acetogenesis, more Carbon dioxide and hydrogen were formed (15, 3).

During methanogenesis, the methanogens will mainly use hydrogen or the formate as an electron donor to reduce Carbon dioxide to methane (12, 15, 4). This is the reason the volume of methane increases. The methanogens will convert some acids produced during hydrolysis, acidogenesis and acetogenesis to methane and carbon dioxide gas. The methanogens are strict anaerobic bacteria (15)

$CO_2 + 4H_2$ ------------- $CH_4 + 2H_2O$

$2C_2H_5OH + CO_2$ --------------$CH_4 + 2CH_3COOH$

CH_2COOH ------------- $CH_4 + CO_2$

RECOMMENDATION AND CONCLUSION

Considering day 7 and 15 of different containers

Container	day 7	day 15
Container 1	0.090	0.252
Container 2	0.110	0.403
Container 3	0.062	0.170
Container 4	0.110	0.270

From the presentation above, container 2 which contains hardwater ($CaSO_4$), produces more gas at day 15, while the container 4 (pretreated substrate) was second with record of 0.403kg and 0.270kg respectively.

5. Conclusion

Based on the above, calculated amount of Calcium Sulphate (10-200 g) should be added to the substrate during slurry preparation. Alternatively, the substrate can be pretreated using acid/alkaline method. According to Osuji (11) this pre-treatment will release the sugar that is already trapped in the lignocellulose by the lignin and the ones in the cellulose and hemicellulose.

Compliance with ethical standards

Acknowledgments

The author is grateful to the final student of Microbiology Department of Legacy University Okija for their endeavours towards the success of the work.

Disclosure of conflict of interest

According to Uli (17), Calcium ion is an essential content for Anaerobic growth of bacteria. In his conclusion, hard above 200g/L will reduce Biogas formation. But this investigation showed that about 200g of Calcium Sulphate which was added to the slurry aided biogas production.

References

[1] Wang, Y.X., & Lu, Z.X. (2005). Optimization of processing parameters for the mycelialgrowth and extracellular polysaccharide production by Boletus sp. ACCC50328.Process Biochem., 40, 1043–1051

[2] Wang, J.L., & Wan, W. (2009b). Optimization of fermentative hydrogen productionprocess using genetic algorithm based on neural network and response surfacemethodology. Int J Hydrog Energy, 34, 255–261

[3] Wang, J.L., & Wan, W. (2009a). Factors influencing fermentative hydrogenproduction: a review. Int J Hydrog Energy, 34, 799–811

[4] Torkian, A., Eqbali, A., & Hashemian, S.J. (2003). The effect of organic loading rate on performance of UASB reactor treating slaughterhouse effluent. ResourcesConservation & Recycling, 40, 1–11.

[5] Singh, R. (2001). Biogas plant generating methane from organic waste. Ajitmalk Etawah. Globar Gas Research Station pp 33.

[6] Ahmad A, Shah S M U, Buang A, Othman M F, and Abdullah M A 2014 Evaluation ofaerobic and anaerobic co-digestion of tetraselmis suecica and oil palm empty fruitbunches by response surface methodology Adv. Mater. Res. 925 243–7

[7] Olugbenga LC, Ibileke C. Hybrid process for the conversion of lignocellulosoic material. ApplBiochemBiotechnol. 2011; 106: 1-9.

[8] de Vries R, Visser J. Aspergillus enzymes involved in degradation of plant cell wall polysaccharides. . Microbiology and Molecular Biology Reviews. 2001; 65(4): 497-522.

[9] Hagos K, Zong J, Li D, Liu C, and Lu X 2017 Anaerobic co-digestion process for biogas production: Progress, challenges and perspectives Renew. Sustain. Energy Rev. 761485–96

[10] Dhaked, R.K., Singh, P. & Singh, L. (2010) Biomethanation under psychrophilic conditions. Waste Management. 30:2490-2496.

[11] Osuji MI ., Ogbulie JN., Nweke CO & Nwanyanwu CE (2022) Acid-base pretreatmentof lignocellulosic biomass to facilitate recovery of fermentable sugar for anaerobicfermentation . Int.J. of Frontline Re. ST -01(01)-027

[12] Choong, Y.Y., Norli, I., Abdullah, A.Z. & Yhaya, M.F. (2016) Impacts of trace element supplementation on performance of anaerobic digestion process: a critical review. Bioresource Technology 209:369-379.

[13] Chen, Y., Cheng, J.J. & Creamer, K.S. (2008) Inhibition of anaerobic digestion process: A review. Bioresource Technology 99:40444064.

[14] Kim JS, Lee YY, Toeget RW. cellulose hydrolysis under extremely low sulphuricand high temperature conditions. Appl. BiochemBiotecnol. 2011; 91-93: 331-340

[15] Iranmahboob, J.; Nadim, F.; Monemi, S. Optimizing acid hydrolysis: A critical stepfor production of ethanol from mixed wood chips. Biomass Bioenergy. 2002; 22: 401–404

[16] Sen B, Chou PUS, Liu CM. pretreatment condition of rice straw for simultaneoushydrogen and ethanol fermentation: Int. Hydrogen Energ.41:44812