

# **Anaerobic Co-digestion of Kitchen and Agricultural Wastes with Preliminarily Treated Wastewater**

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**ABSTRACT:** Experimental investigations were conducted on the kitchen wastes and agricultural wastes with the preliminarily treated waste water in an anaerobic condition at mesophilic stage using laboratory scale photo bioreactor. This exploration was done in the presence of visible light throughout the retention period. The agricultural wastes produced least amount of biogas when compared with the kitchen wastes. Tomato wastes produced the maximum biogas yield of 112ml with optimum parameters 5.9 pH on the ninth day with  $34 \pm 2^\circ\text{C}$  temperature. The gas was measured using water-displacement method.

**KEYWORDS:** Mesophilic condition, agricultural wastes, visible light, retention period, biogas, photo bioreactor.

## **I. INTRODUCTION**

The waste generated is amplifying everywhere in the universe due to inflation in population. All natural things in the cosmos have some stupendous property even after its lifetime. The market wastes and the agricultural wastes can be properly availed to produce natural gas. The wastes disposed can be co-digested under mesophilic condition, in the absence of oxygen to generate beneficial gas. This method is completely eco-friendly and the term environmental pollution can be eradicated up to 50%. Instead of incinerating and dumping the bio-degradable wastes in landfill, a co-digestion of these wastes helps in biogas generation.

Many experimental investigations were conducted in the research articles by demonstrating the comparison between vegetable wastes and fruit wastes [1]. It has been proved that the voluminous vegetable wastes were perishable and the gas production can be increased by inherent co-digestion [2]. Cow dung and organic wastes were digested in the presence of light using magnesium metal catalyst to generate more amounts of hydrogen and methane [3]. An analytical approach was done using the vegetable wastes having unique pH [5]. A study was conducted by using the inoculum, waste and water by retaining at distinct temperatures to determine the biogas yield [10]. Tomato plant wastes were used for generating more amount of hydrogen gas by pyrolysis [12].

The organic wastes were hydrolysed and converted into basic monomers. Then monomers will be converted into volatile fatty acids (VFA) due to acidogenesis. This VFA will be converted into acetate and hydrogen by means of acetogenic bacteria. Finally, methane will be formed by methanogenesis. The above procedure is identical, if the organic wastes were co-digested in an anaerobic medium. Briquetting and gasification will not be the durable method to evict the fuel crisis. So, co-digestion is the perfect impetus to solve most of the environmental issues. The co-digested wastes after its retention time can be disposed near the trees by filling it with fine aggregate. This inherently adds good value to the soil and also forms natural manure for plant growth.

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## II. MATERIALS AND METHODOLOGY

### Sample Collection and Processing

The rotten tomato wastes, onion skins, garlic skins and sorghum plant wastes were taken for digestion. The rotten tomatoes were collected from the UzhavarSandhai, Salem, Tamilnadu, India. The onion and garlic skins were collected from the SonaCollegehostel canteen, Salem. The above wastes were considered as kitchen wastes. Sorghum plant waste was taken as agricultural wastes and they were collected from Mani agricultural farm, Salem. All the wastes were kept at room temperature until it was utilized. The above wastes were washed and grinded in mixer to make it as slurry. The preliminarily treated waste water [PTWW] was used for dilution to enhance the gas production. The PTWW was collected from sewage treatment plant [STP] at Thiagarajar Polytechnic College, Salem. Dilution was done based on the ratios proposed.

### Experimental Setup

The experimental set up is shown in the Fig 1 and was drawn using Computer Aided Drawing [CAD] software. It consists of a wooden box, three numbers of 500ml borosilicate bottles, an exhaust fan, an electric bulb, a temperature sensor and a temperature sensor board connection. The fabricating cost was low, as most commonly used materials were utilized. In order to conserve the above said condition, the temperature sensor was provided. If the temperature exceeds 40°C, the exhaust fan will start to run and the tungsten bulb will stop its blowing. Immediately, the temperature will be descended and the bulb will emit the light. The above process continues throughout the retention time. The above said condition was programmed in the temperature sensor board. 35-40°C must be maintained in the photo bioreactor.

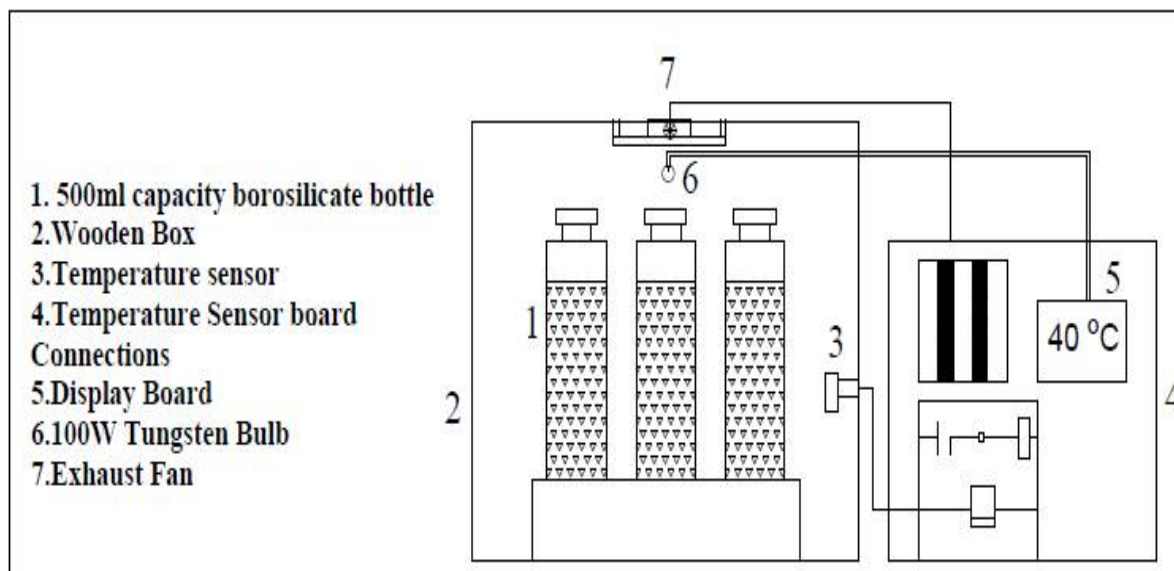


Fig 1: Schematic sketch showing the laboratory scale Photo Bioreactor

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### Proposed Choices for the Co-digestion

Fifteen days probe was done for three samples per batch study. In the 500ml borosilicate bottle capacity, 350ml of the working volume was used for digestion. Two batch studies were conducted and PTWW was mixed with both the proposed wastes. For the first batch study, OAGS [Onion skins and Garlic skins] and PS [Powdered sorghum] were taken for co-digestion and the suggested ratios are listed in the Table 1.

**Table 1**

BATCH STUDY 1			
SAMPLE	OAGS	PS	PTWW
A	4	-	3
B	-	4	3
C	2	2	3

For the batch study 2, the tomato waste [TW] and PTWW were taken and the ratios suggested are listed in the Table 2. The PTWW was mixed thoroughly with the grinded tomato wastes before placing the samples in co-digestion.

**Table 2**

BATCH STUDY 2		
SAMPLE	TW	PTWW
D	2	1
E	1.5	1
F	1	1

For the batch study 2, the tomato waste [TW] and PTWW were taken and the ratios suggested are listed in the Table 2. The PTWW was mixed thoroughly with the grinded wastes before placing the samples in co-digestion.

### Initial parameters

pH [Potential of Hydrogen], TS [Total Solid], TSS [Total Suspended Solid], TDS [Total Dissolved Solid], TFS [Total Fixed solid], TVS [Total Volatile Solid], BOD [Biochemical Oxygen Demand] and COD [Chemical Oxygen Demand] were tested in the Environmental Engineering Laboratory. pH value was tested using Digital pH meter. BOD and COD values were tested using titration method. TS, TSS, TDS, TFS and TVS were tested using gravimetric analysis. The TS, TSS and TDS were estimated by using IS 3025 (Part 15):2003, IS 3025 (Part 17):2002, IS 3025 (Part 16):2002 respectively. TFS and TVS were determined using IS 3025 (Part 18):2002.

## III. RESULTS AND DISCUSSION

### Daily biogas yield

The gas was measured on the daily basis by using the concept of water displacement method. The daily gas measured for the batch study 1 is shown in the Fig 2. When comparing with Sample B and Sample C, Sample A produces considerable amount of biogas in the retention period. Till fourth day of the retention period, there was no sign of gas production for all the three samples in the batch study 1. From fifth day onwards, there was a gradual climb in the gas production mechanism for all the samples. In the batch study 1, there was no anticipated result. It was mainly due to the lack of intrinsic characteristics.

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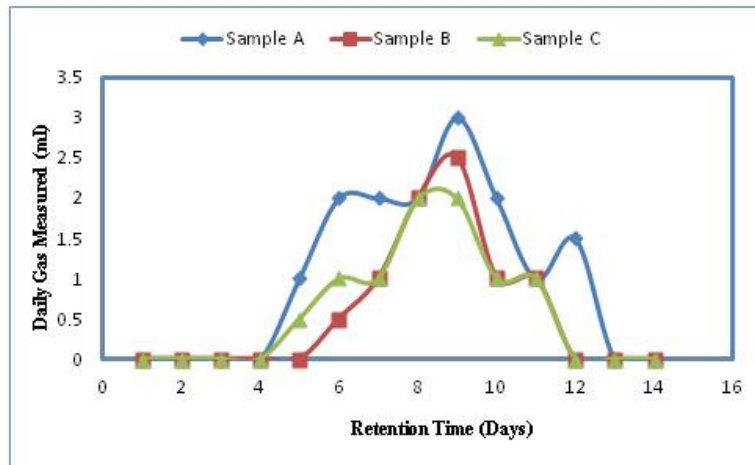


Fig 2: Comparison of daily biogas production versus retention time for batch study 1

The daily gas computed for the batch study 2 is shown in the Fig 3. It can be observed that the Sample D gets high yield of 112 ml on the ninth day when compared with the other two Samples in the batch study 2. In this batch study, the gas was produced from the first day of the retention period itself and then gradually increased till eighth or ninth day. After reaching the optimum limit, it decreases slowly.

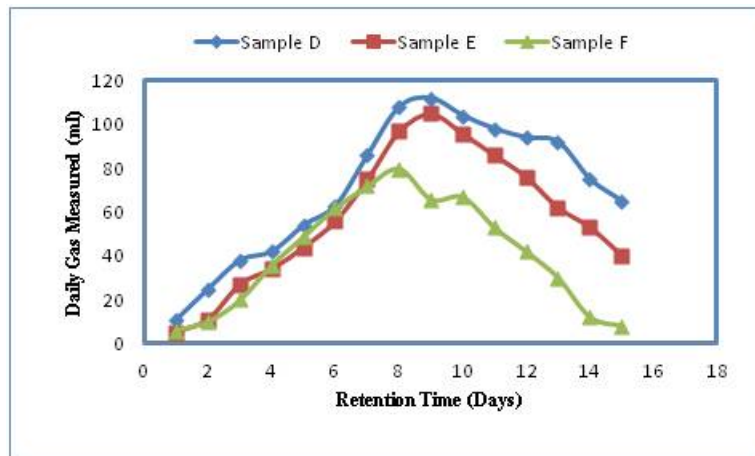


Fig 3: Comparison of daily biogas production versus retention time for batch study 2

### Cumulative biogas analysis

The cumulative biogas yield for the respective samples in the batch study 1 is shown in the Fig 4. Initially, there was no gas production but it increased gradually to some extent. Finally, it remained linear after tenth or eleventh day. It was mainly due to decrease in fermentation properties.

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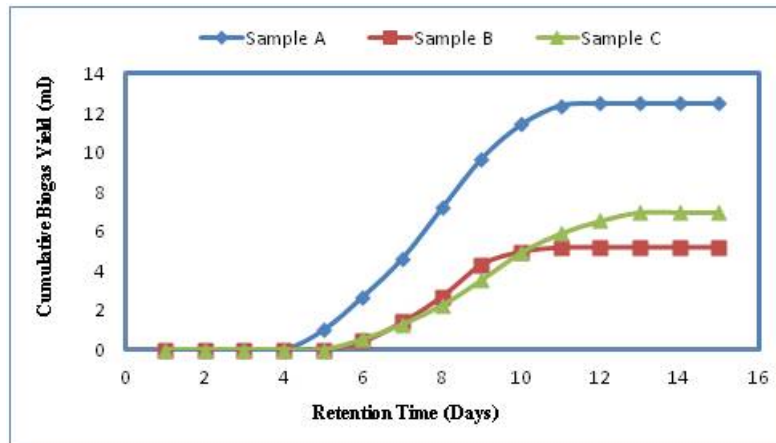


Fig 4: Cumulative gas production versus retention time for batch study 1

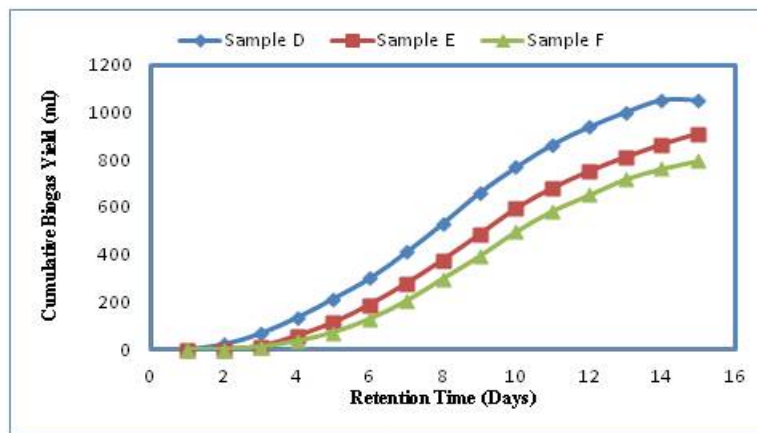


Fig 5: Cumulative gas production versus retention time for batch study 2

The cumulative biogas yield for the samples in the batch study 2 is shown in the Fig 5. The sample D gave high cumulative yield when compared with the other two samples. It increases throughout the retention period of fifteen days and will become constant after some days. It was due to higher concentration of the tomato wastes. The maximum yield of the sample varies according to the proportions taken.

### pHevaluation

The pH measured for the batch study 1 is shown in the Fig 6. As the retention time increases, the pH varies accordingly. pH value increases by providing a great influence in the gas production phenomenon. In an anaerobic process, pH is considered as one of the significant parameter during co-digestion.

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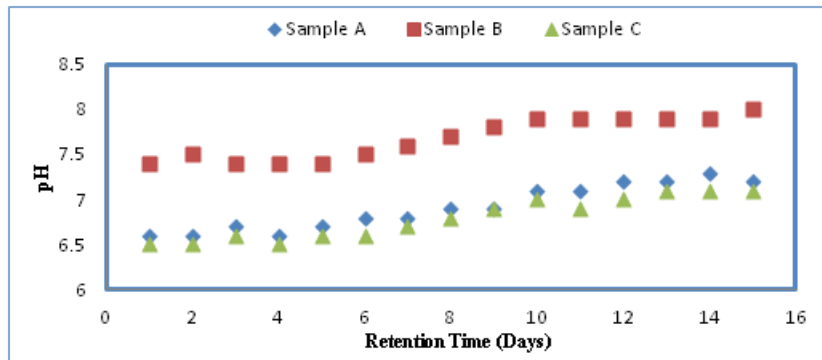


Fig 6: Daily pH versus retention time for batch study 1

The pH measured for the batch study 2 is shown in the Fig 7. The temperature plays a paramount role in the development of anaerobic bacteria and also helps in determining the changes in pH value. From the graph shown below, it can be concluded that pH will not be same at all the time due to distinct reasons.

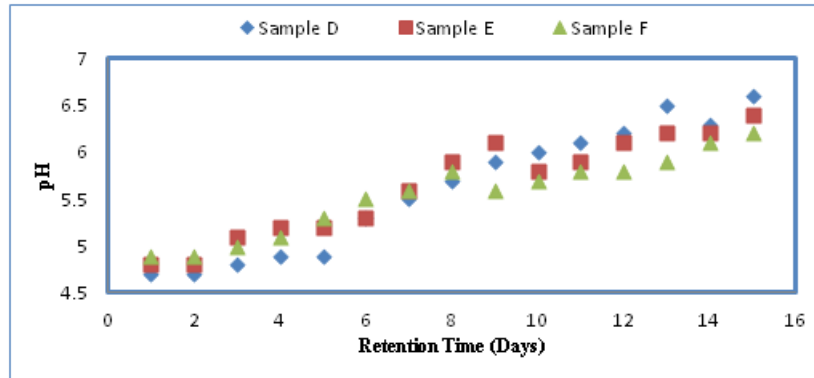


Fig 7: Daily pH versus retention time for batch study 2

## IV. COROLLARY OF PH, BOD, TEMPERATURE AND RETENTION TIME ON DAILY GAS OUTPUT

In an anaerobic co-digestion process, the pH level must be maintained to get more amount of yield in biogas production. From the experimental study, it can be appraised that optimum range should be conserved in the reactor to get good efficiency. Organic loading rate must be low for the wastes taken to get the abundant amount of biogas. Mesophilic condition should be retained throughout the retention time to get maximum output but is difficult to achieve due to the swag in ambient temperatures and seasonal changes. From the investigations, it was found that  $35 \pm 2^{\circ}\text{C}$  is the optimum temperature to be retained while executing the co-digestion. When studying about the retention period, it was noted that biogas production was maximum at eighth and ninth day of the entire retention period.

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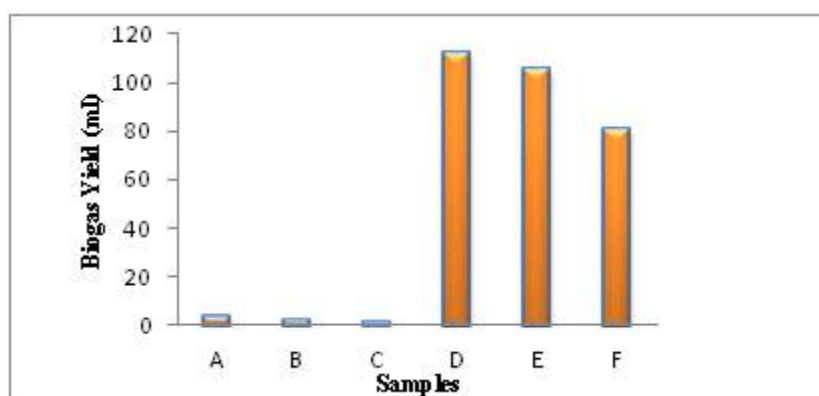


Fig 8: Maximum biogas yield for all the batch tests

The Fig. 8 shows the maximum amount of biogas yield during the co-digestion. Unprecedented results were seen in the batch study 2 due to the total solid concentrations.

### V. CONCLUSION

The batch study focussed at generating biogas from kitchen and agricultural wastes. The batch study 2 [TW: PTWW=2:1] gives maximum yield of 112ml. From the probe, it was clear that the batch study 2 gave more amount of biogas when compared with the batch study 1. After ninth day, the gas production decreased simultaneously the pH also increased. The moisture content and temperature played a crucial role in gas production mechanism. The temperature must be high during co-digestion to get abundant amount of biogas.

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