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WASTE FOOD REACTOR

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Abstract - *During the last decade, the amount of food waste worldwide has been increasing at an alarming rate. The high decomposition potential of food waste has fostered its recycling into valuable end-products instead of adding to the already convoluted landfilling problem. In our project, a single-stage anaerobic digester is developed to manage food waste at a household level. Anaerobic digestion is a naturally occurring decomposition process which breaks down organic matter into simpler chemical components in the absence of oxygen to produce biogas and digestate. Food waste, being mostly composed of many complex carbohydrates, proteins and lipids, is digested through a complex process that can be split into three distinctive phases, namely hydrolysis, cytogenesis, and methanogenesis. Hydrolysis is the first step where fermentative bacteria convert complex organic compounds into molecules that are soluble in water such as fatty acids, sugar and amino acids. During cytogenesis, the soluble molecules obtained in the first phase are converted into volatile fatty acids by acid-forming or acetogenic bacteria. In the final step, methanogenesis, methane is generated from the volatile fatty acids by methane producing bacteria or methanogens.*

By conducting above experiment using the developed model we are trying to extract the methane gas and the slurry what is generated is dried in the sunlight and is used as fertilizer.

***Key Words*: Methane, Anaerobic digestion, Hydrolysis, Acetogenesis, Decomposition.**

1. INTRODUCTION

As per one survey Indians waste as much food as the whole of United Kingdom consumes. Food wastage is an alarming issue in India. Our street and garbage bins, landfills have sufficient proof to prove it.

Weddings, hotels, hostel mess, social and family functions, households generate out so much waste food. According to the United Nations Development Programme, up to 45% of the food produced in India is wasted. About 21 million tons of wheat are wasted in India and 50% of all food across the world meets the same fate and never reaches the needy. In fact, according to the agriculture ministry, the food worth of Rs. 56,000 crore that is being produced is wasted every year in the country.

One of the major issue that every country is facing is the pollution problems. Might be water pollution or air pollution or any other to name. The waste that is generated by the cities is acting indirectly to these pollution problems. For instance, the waste if get mixed with the water bodies it will affect the quality of the water that is present in the same. The waste when get accumulated somewhere it will get fermented by the micro-organisms and the release of methane hydrogen disulfide and carbon mono oxide will take place. When these gases get oxidized they get converted into their oxidized form like carbon mono-oxide to carbon dioxide which is a greenhouse gas which results in greenhouse effect.

Due to scarcity of petroleum and coal it threatens supply of fuel throughout the world. So instead of letting the food waste, municipal waste, animal waste, food and vegetable waste to litter everywhere and letting the waste water to mix with the water bodies the same if treated with the proper conditions the methane can be extracted. The pollution can be prevented or reduced to greater extent. And the bi-product after the treatment is rich in organic component which will serve as fertilizer for the plants and can be used as same.

1.1 About Bio-Gas

Biogas consists of a mixture of different gases produced by the metabolic activity of organic matter in the absence of oxygen or in the presence of oxygen. If produced in the absence of the oxygen then it is called aerobic type if the same is produced in the absence of oxygen then it is called anaerobic type. Biogas could be produced from raw organic materials such as agricultural waste, animal waste, municipal waste , sewage waste or food waste. Biogas is a renewable energy source of energy.

Biogas can be produced by anaerobic digestion with methanogenic bacteria, and also by aerobic digestion which digest material inside a closed system, or fermentation of biodegradable materials. Biogas consist of methane, carbon-dioxide in major quantity and Hydrogen sulfide in small amounts. The gases Methane Hydrogen and carbon monoxide reacts with oxygen to give water or carbon dioxide or other bi-products. This generated energy released by the above process makes biogas to be used as a fuel, it can be used for any heating purpose, such as cooking. It can also be used in a gas engine to run the turbines; where the gas is burnt and the released heat is used to run turbines which produces electricity.

1.2 Concept Biogas production:

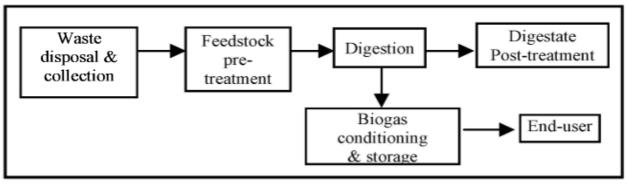

Fig 1: Experimental setup

- Waste disposal and collection

This step is most important step wherein if the separation of the degradable waste from non-degradable is not done properly it might affect the yield. Due to inefficient separation, the food waste can contaminate with undesirable material or toxic which harm the system such as plastic materials and other toxic materials. Care should be taken while separating the food waste the toxic items should not be mixed with the food that is sent in to the digester.

- Food waste pre-treatment

The pre-treatment processes compose of separation, shredding and feeding. The separation aims to remove inert material and hard particle such as bone or fruit skin. A sorting table is used for separation activity especially for wet digestion which requires carefully sorting. The sorting process consumes three to four hours in wet digestion; otherwise inert material interrupts the operation. In contrast to wet digestion, pre-treatment of dry digestion is less than half an hour since the system handle bigger particle.

- Digestion

Anaerobic digestion process is a natural process that decomposes organic matter in the absence of oxygen. There are several condition and variables that affect to the system performance. The operating parameters should be controlled a good environment for micro-organism. Normally, the complete degradation ranges from 15 to 30 days. Types of digester are different depending on experience, budget and available area.

- Biogas condition, storage and utilization

Different biogas treatments are applied depending on the end use of biogas. Some impurity in biogas can damage boiler or engines. Accordingly, biogas needs to be upgraded. Basically, moisture content and hydrogen sulfide removal are sufficient for cooking or heating purpose. Iron oxide, which has about 25% of removal efficiency, can be used to remove hydrogen sulfide due to its lower cost. Biogas supply should correlate to biogas requirement. Excess gas supply causes high pressure along the pipeline. The gas outlet of a biogas-stove should be modified to increase biogas flow rate and compensate for the lower heating value of biogas.

- Digestate post-treatment

Digestate is the fermented residue from anaerobic digestion process. The waste used slurry is sundried and it is made into dry cakes and is used as fertilizer for the plants.

2. OBJECTIVES AND METHODOLOGY

2.1 Objectives

- Conversion of waste food into fertilizer and to extract methane.
- By Anaerobic digestion.
- Reducing the environmental pollution by decreasing the waste generated.
- Implementation of design to get maximum output.

2.2 Methodology

The main objective of this method is to extract methane from waste food and to generate fertilizer. This can be made in two different ways; they are Aerobic and Anaerobic method of digestion.

Here we are using Anaerobic digestion method to convert waste food get desirable output. We have done desalination without painting the digester, with painting to compare the productivity of each system.

Fig 1: Experimental setup

Initially the waste food is collected and the food is grinded finely. The hence grinded slurry is mixed with the yeast. The slurry is mixed properly for the uniform distribution of the yeast. The mixed slurry is then poured from the inlet valve.

the valve is closed. The digester is maintained at the required conditions

3 EXPERIMENTAL SETUP

Fig -2: Experimental setup

Above picture shows the experimental setup which we have used and it consists of following parts:

3.1 Plastic can

It is used as digester which does not allow the air to come in or go out. Can of 15 liters is used in our project.

Fig 3: Plywood used in the experiment

3.2 Waste food

the waste food from the hostel mess is collected. The collected food is grinded.

Specifications:

- 0% cow dung.
- 75% cooked food.
- 25% vegetable waste.

Fig 4: Waste food

3.3 Mixer grinder

It is used to grind the food.

Specifications:

- Capacity – 1.75 liters jar.

Fig 5: Mixer grinder

3.4 Piping and valves and bend

The purpose of piping and valves is that it to regulate the flow. PVC pipes are used.

Specification:

- Diameter of pvc pipe - 25.4mm.
- Diameter of the inlet valve - 19.05mm
- Diameter of the gas outlet pipe - 6.35mm

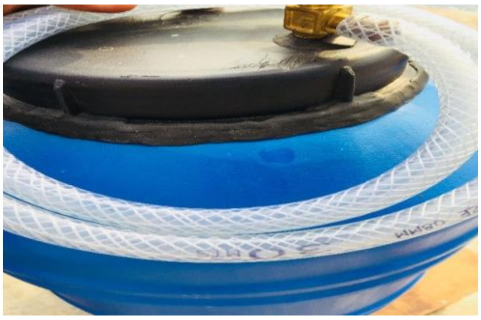

Fig 6: Gas pipe

Fig 7: Gate valve or slurry out let valve

Fig 8: Slurry inlet valve

3.5 Gas valve

It is used to remove the gas that is generated in the digester.

Fig 9: Gas valve.

Fig 10: Slurry collecting tray

4 EXEPERIMENTAL ANALYSIS OF DIGESTER

4.1 Volume of the digester

V=$\pi r^2 h$
r = radius of the cylinder
h = height of the cylinder

4.2 Reactions involved in food fermentation

The waste food mainly consists of sucrose which is converted into glucose and Fructose.

$C_{12}H_{22}O_{11} + H_2O = 2C_6H_{12}O_6$

- Yeast reaction

The yeast is added to fasten the process. The yeast converts Glucose and Fructose to ethyl alcohol and carbon dioxide is the byproduct.

$C_6H_{12}O_6 = C_2H_5OH + 2CO_2$

- Oxidation of alcohol to acetic acid and water

The oxidation of one mole of ethanol yields one mole each of acetic acid and water.

$C_2H_5OH + O_2 = CH_3COOH + H_2O$

4.3 Bacteria of alkaline fermentations

A third group of bacteria are those which bring about alkaline fermentations - the *Bacillus* species. Of note are *Bacillus subtilis, B. licheniformis* and *B. pumilius. Bacillus subtilis* is the dominant species, causing the hydrolysis of protein to amino acids and peptides and releasing ammonia, which increases the alkalinity and makes the substrate unsuitable for the growth of spoilage organisms. Alkaline fermentations are more common with protein rich foods such as soybeans and other legumes, although there are a few examples utilizing plant seeds.

4.4 Conditions required for bacterial fermentations

Sustainability of Micro-organisms vary in their optimal pH requirements for growth. Most bacteria require neutral pH. The varied pH requirements of different groups of micro-organisms is used to good effect in fermented foods where successions of micro-organisms take over from each other as the pH of the environment changes. Certain bacteria are acid tolerant and will survive at reduced pH levels and some will not. Notable acid-tolerant bacteria include *the Lactobacillus* and *Streptococcus* species, which play a role in the fermentation of dairy and vegetable products.

- Temperature

Different bacteria can tolerate different temperatures, which provides enormous scope for a range of fermentations. While most bacteria have a temperature optimum of between 20 to 30ºC, the thermophiles are the type of bacteria which prefer higher temperatures (50 to 55ºC) and those with colder temperature optima (15 to 20ºC). Most lactic acid bacteria work best at temperatures of 18 to 22ºC.

- Salt concentration

Lactic acid bacteria can tolerate high salt concentrations. The salt tolerance gives them advantage over other less tolerant species and allows the lactic acid fermenters to begin fermentation, which produces acid, which further inhibits the growth of non-desirable organisms. Leuconostoc is noted for its high salt tolerance and for this reason, initiates the majority of lactic acid fermentations.

- Water activity

In general, bacteria require a fairly high-water activity (0.9 or higher) to survive. Generally, the water to waste food content is in the ratio of 1:1. There are a few species which can tolerate water activities lower than this ratio, but usually the yeasts and fungi will act fast on foods with a lower water activity.

- pH.

The optimum pH range for most bacteria is near the neutral point that is pH 7.0. Certain bacteria are acid tolerant and will survive at reduced pH levels, as the pH level reduces the acidity will increase. Some acid-tolerant bacteria include *the Lactobacillus* and *Streptococcus* species, which play vital role in the fermentation of dairy products and vegetable products.

- Oxygen availability

Some of the fermentative bacteria are anaerobes, while others require oxygen for their metabolic activities. Some, lactobacilli in particular, are microaerophilic. That is they grow in the presence of reduced amounts of atmospheric oxygen. In aerobic fermentations, the amount of oxygen present is one of the limiting factors. It determines the type and amount of biological product obtained, the amount of substrate consumed and the energy released from the reaction. Acetobacter require oxygen for the oxidation of alcohol to acetic acid.

- **Nutrients**

All bacteria require a source of nutrients for metabolism. The fermentative bacteria require carbohydrates – either simple sugars such as glucose and fructose or complex carbohydrates such as starch or cellulose. The energy requirements of micro-organisms are very high. Limiting the amount of substrate available can check their growth.

5 RESULTS AND DISCUSSION

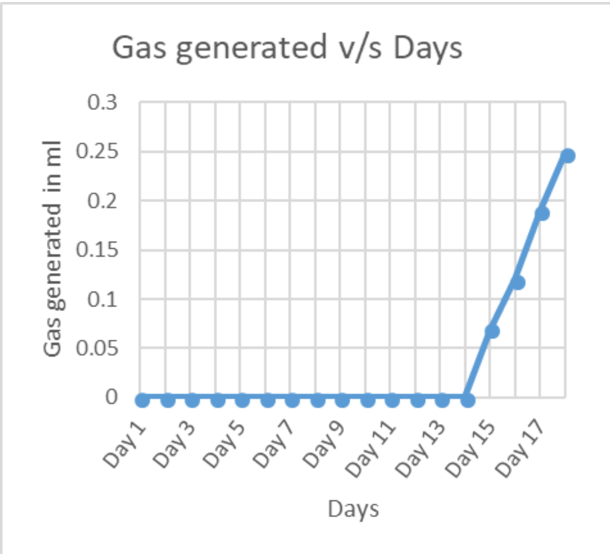

Chart -1: Gas Generated v/s Days

The above graph shows the gas generated in ml v/s days wherein the gas collected in the collector is measured. We used the balloon as the collector which got inflated as the gas produced. The circumference of the balloon is calculated and the volume of the balloon is calculated by considering the balloon as sphere.

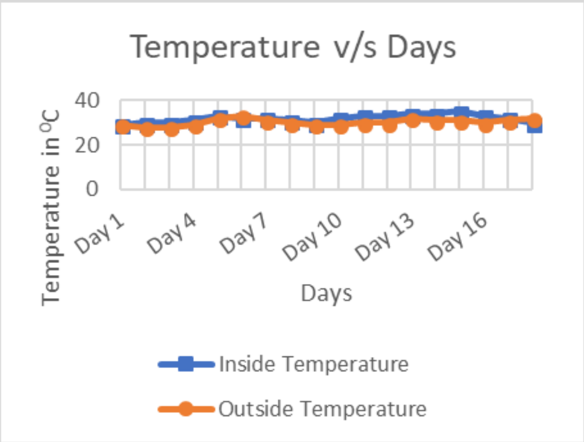

Chart -2: Temperature v/s Days

The above graph was obtained by noting the inner temperature of the digester and the external environmental temperature. We conducted the experiment for the room temperature range.

3. CONCLUSIONS

The experiment what we show that the methane can be produced from the food waste. The gas that produced by the waste food was 1kg of gas for every 20kg of waste food. We conducted the experiment for 5kg waste with 1:1 ratio of food and water. The gas obtained was 240ml.

The waste slurry was sundried and converted into food cakes which was later used as fertilizer. By this method the compressor that is required for the removal of the water from the slurry. By practicing this method, the overall budget what was required for the setup was decreased.

This method can be practiced in the homes and the gas can be generated and can be used for the daily purpose. Also, by practicing this method the wastage can be reduced and the effective use of the organic waste can be made.

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