

Biogas Generation from Domestic Waste with the help of Algal Sequestration

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ABSTRACT - Kitchen waste can be utilized to produce biogas due to its high biodegradability, calorific value and nutritive value to microbes, which will reduce our dependency on fossil fuels. The research work was conducted to investigate the production ability of biogas as an alternative energy from kitchen waste with co-digestion of cow manure through anaerobic digestion (AD). Firstly, digester was prepared to observe the individual degradation rate of kitchen waste, cow manure and the combination of co-digested kitchen waste with cow manure at room temperature and at temperature of mesophilic digestion respectively and observed the degradation rate for co-digested kitchen waste with cow manure was higher than kitchen waste and cow manure alone. Secondly, digester was constructed to observe the effect of alkalinity at mesophilic digestion temperature. Finally, a portable biogas reactor was fabricated for pilot-scale biogas production which included an agitator and heating system. This reactor was operated at both digestion temperature and room temperature. It is observed that the digestion rate was faster at mesophilic digestion than room temperature. The prime object of this work was to investigate the prospect of kitchen waste for biogas production and ultimate protection of environment from the bad effect of methane gas that would be produced by uncontrolled anaerobic digestion.

KEYWORDS: Biogas, anaerobic digestion, filtration, carbon sequestration

I. INTRODUCTION

Due to scarcity of petroleum and coal it threatens supply of fuel throughout the world also problem of their combustion led to research in different corners to get access the new sources of energy, like renewable energy resources. Solar energy, wind energy, different thermal and hydro sources of energy, biogas are all renewable energy resources. But, biogas is distinct from other renewable energies because of its characteristics of using, controlling and collecting organic wastes and at the same time producing fertilizer and water for use in agricultural irrigation. Biogas does not have any geographical limitations nor does it require advanced technology for producing energy, also it is very simple to use and apply.

II. METHODOLOGY

The methodology involved in the extraction of biogas from the domestic waste is starting from collection of sufficient amount of domestic waste(both solid and liquid) which includes leftover food, vegetable waste ,water used for washing hands etc. This is followed by testing the physical and chemical characteristics of the collected waste water. The waste water should be properly treated through organic method so that it could be effectively used in the biogas plant. After treatment the characteristics of the water is again tested to check the efficiency of the treatment process. Finally Carbon sequestration is carried out with the filtered water which is later mixed with domestic waste and the resultant inoculums is thus fed into the biogas plant for the anaerobic digestion to take place. The project execution follows the sequence of work mentioned below.

Stage 1-Physical Chemical Characterization of Domestic Waste Water

Reason: To know the characteristics of waste water so that quality of water can be analyzed.

Stage 2- Filtration of Waste Water

Reason: To make use of waste water instead of normal water for anaerobic digestion to take place.

Stage 3- Carbon Sequestration

Reason: To capture the carbon dioxide emitted as well as to from an algal biomass which will be used a stimulant in biogas production process instead of the conventional cow dung.

Stage 4- Biogas Production

III. PHYSICAL CHEMICAL CHARACTERIZATION OF WASTE WATER

Municipal wastewater is mainly comprised of water (99.9%) together with relatively small concentrations of suspended and dissolved organic and inorganic solids. Among the organic substances present in wastewater are carbohydrates, lignin, fats, soaps, synthetic detergents, proteins and their decomposition products. Municipal wastewater also contains a variety of inorganic substances from domestic and industrial sources, including a number of potentially toxic elements such as copper, lead, zinc, etc. Table 1 gives the physical chemical characteristics of raw waste water.

PARAMETERS	UNTREATED DOMESTIC WASTEWATER
SAMPLE DETAILS	WASTEWATER
APPEARANCE	A TURBID WATER
COLOR	DIRTY COLOR
ODOUR	UNPLEASANT ODOUR
TURBIDITY	5 NTU
TOTAL DISSOLVED SOLIDS	11593 ppm
TOTAL SUSPENDED SOLIDS	3493 ppm
ELECTRICAL CONDUCTIVITY	23.420 macro Siemens
pH VALUE	9.5
ALKALINITY	5.24
TOTAL HARDNESS	1035.6 ppm
CALCIUM	356.7 ppm
MAGNESIUM	982.3 ppm
SODIUM	1040.7 ppm
POTASSIUM	270.3 ppm
CHLORIDE	1987.5 ppm
FLUORIDE	6.3 ppm
IRON	10.5 ppm
AMMONIUM	140.3 ppm
NITRATE	145.6 ppm
SULPHATE	1198.2 ppm
COPPER	12.35 ppm
ZINC	21.93 ppm
PHOSPHORUS	20.4 ppm
NITRITE	12.56 ppm

IV. FILTRATION OF WASTE WATER

Waste Water treatment is the process of removing contaminants from waste water, primarily from household sewage. It includes physical, chemical, and biological processes to remove these contaminants and produce environmentally safe treated wastewater (or treated effluent). A by-product of the treatment is usually a semi-solid waste or slurry, called sludge, that has to undergo further treatment before being suitable for disposal or land application. So in our laboratory treatment setup, we used layers of 12mm aggregate, 20mm aggregate, orange peel powder and sand. Before introducing waste water into the filter media, screening process is done to remove the coarser particles. And Table 2 gives the characteristics of filtered water.

TABLE II PHYSICAL CHEMICAL CHARACTERIZATION OF FILTERED WATER

SAMPLE COLLECTION DATE	09/01/2017
SAMPLE DETAILS	DOMESTIC WATER
SAMPLE QUANTITY	10LITRES
APPEARANCE	VISIBLE SUSPENDED PARTICLES
COLOR	SLIGHT DIRTY COLOURLESS WATER
ODOUR	SLIGHT STINKY SMELL
TURBIDITY	5 NTU
TOTAL DISSOLVED SOLIDS	5934.5 mg/litre
TOTAL SUSPENDED SOLIDS	219.5 mg/litre
ELECTRICAL CONDUCTIVITY	15.49 macro Siemens
pH VALUE	8.45
ALKALINITY pH	5.12
TOTAL HARDNESS	574.6 mg/litre
CALCIUM	350.5 mg/litre
MAGNESIUM	975.3 mg/litre
SODIUM	1035.7 mg/litre
POTASSIUM	246.7 mg/litre
CHLORIDE	985.7 mg/litre
FLOURIDE	5.91 mg/litre
IRON	2.023 mg/litre
AMMONIUM	125.7 mg/litre
NITRATE	140.6 mg/litre
SULPHATE	1056.7 mg/litre
COPPER	10.2 mg/litre
ZINC	20.6 mg/litre
PHOSPHOROUS	14.3 mg/litre
NITRITE	10.1 ppm

V. CARBON SEQUESTRATION

In recent years, biomass-derived fuels have received increasing attention as a solution to the nation's continued and growing dependence on imported petroleum-based fuels, which exposes the country to the risk of critical disruptions in fuel supply and concern of climate changes. Some of the aspects of algal bio fuel production that have combined to capture the interest of researchers and entrepreneurs around the world include

- a) High productivity of biomass yields per acre of cultivation.
- b) Use of otherwise non-productive, no arable land, and avoids nutrients used for conventional agriculture.
- c) Non-food-based feedstock resources.
- d) Reduced competition for limited freshwater supplies by utilizing waste water, produced water, and saline water.

In this carbon sequestration we made a closed photo bioreactor provided algal species called *schenedesmus*. It is green algae through which bio sequestration is achieved. The CO₂ was incorporated at the amount of 5% to 90%. And it is observed that the tolerance limit of the bioreactor is 80%. Therefore the amount of carbon sequestered is 53.29% for *schenedesmus* species. And Table 3 gives the characteristics of the sequestered sample.

TABLE III. CHARACTERISTICS OF SEQUESTERED SAMPLE

ORGANISM	SCHENEDESMUS
SAMPLE COLLECTION DATE	10/02/2017
SAMPLE DETAILS	DOMESTIC WATER
SAMPLE QUANTITY	10 LITRES
APPEARANCE	Dark Green
ODOUR	Unpleasant odour
TURBIDITY	2 NTU
TDS	1067 mg/litre
TSS	767 mg/litre
TOTAL SOLIDS	1952 PPM
ELECTRICAL CONDUCTIVITY	5.0 macro Siemens
PH	6.63
ALKALINITY PH	5.09
TOTAL HARDNESS	550 mg/litre
CALCIUM	156 mg/litre
MAGNESIUM	67.7 mg/litre
SODIUM	498.7 mg/litre
POTASSIUM	98.7 mg/litre
CHLORIDE	287.9 mg/litre
FLUORIDE	2.4 PPM
IRON	0.98 PPM
AMMONIA	5.12 mg/litre
NITRATE	7.93 mg/litre
SULPHATE	45.7 PPM
COPPER	1.02 mg/litre
ZINC	0.91 PPM
NICKEL	Not detected
CADMIUM	In traces
CARBOHYDRATES	0.11 gm

LIPIDS	10.35 mg/litre
VITAMIN C	9.34 mg/litre
VITAMIN E	Nil
BOD	120.3 mg/litre
COD	255.3 mg/litre
VITAMIN B1	Nil
VITAMIN B2	Nil

VI. BIOGAS PRODUCTION

It is also referred to as biomethanization, is a natural process that takes place in absence of air (oxygen). It involves biochemical decomposition of complex organic material by various biochemical processes with release of energy rich biogas and production of nutritious effluents.

Various Biological process involved are

1. Hydrolysis
2. Acidification
3. Methanogenesis

A. Hydrolysis

In the first step the organic matter is enzymolysed externally by extracellular enzymes, cellulose, amylase, protease & lipase, of microorganisms. Bacteria decompose long chains of complex carbohydrates, proteins, & lipids into small chains. For example, Polysaccharides are converted into monosaccharide. Proteins are split into peptides and amino acids.

B. Acidification

Acid-producing bacteria, involved this step, convert the intermediates of fermenting bacteria into acetic acid, hydrogen and carbon dioxide. These bacteria are anaerobic and can grow under acidic conditions. To produce acetic acid, they need oxygen and carbon. For this, they use dissolved O₂ or bounded-oxygen. Hereby, the acid-producing bacteria create anaerobic condition which is essential for the methane producing microorganisms. Also, they reduce the compounds with low molecular weights into alcohols, organic acids, amino acids, carbon dioxide, hydrogen sulphide and traces of methane. From a chemical point, this process is partially endergonic (i.e. only possible with energy input), since bacteria alone are not capable of sustaining that type of reaction.

C. Methanogenesis

Methane-producing bacteria, which were involved in the third step, decompose compounds having low molecular weight. They utilize hydrogen, carbon dioxide and acetic acid to form methane and carbon dioxide. Under natural conditions, CH₄ producing microorganisms occur to the extent that anaerobic conditions are provided, e.g. under water (for example in marine sediments), and in marshes. They are basically anaerobic and very sensitive to environmental changes, if any occurs. The methanogenic bacteria belongs to the archaeobacter genus, i.e. to a group of bacteria with heterogeneous morphology and lot of common biochemical and molecular-biological properties that distinguishes them from other bacteria. The main difference lies in the makeup of the bacteria's cell walls.

D. Construction of Biogas Plant

For the construction of biogas plant, we used a water can of 20liters and polyvinylchloride pipes in order to create a anaerobic digester. And the digestion of organic materials takes place when the digester is maintained at 30°C to 40°C. Mix ratio of water and organic waste should be 1:1 that is 1Kg of waste is mixed with 1 liters of water. Tire tube is used as a pressure gauge for storage of gas.

VII. CONCLUSION

After the thorough study on the performance of reactor and evolution of acidogenic reactor, the following conclusion have been reached, As a result of the treatment of food effluent using microorganisms, the useful bi product, bio-gas has been produced with a considerable rate of decrease in the values of COD, BOD, pH, acidity and alkalinity. Through the successful anaerobic processing inside the reactor in 30days food waste treatment, methanogen gradually converts the organic acids into the methane gas and carbon dioxide, which indicates that the waste has better anaerobic biodegradability. Thus achieves a waste of resource utilization. The results show that reactor can treat food waste with high contaminated load.

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