An Efficient Way for Biogas Generation through Market Vegetable Waste

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Abstract—Biomethanation is feasible and effective method of treatment of fruits and vegetable waste generated. In this work the biodegradability of waste has been studied and the parameter affecting the anaerobic digestion process has been analyzed. It was found that the degradability of vegetable waste was 78.4% and degradability of fruit waste is 64% because lignin content in vegetable waste is more than the lignin content in fruit waste. The process of anaerobic digestion of fruits and vegetable waste as proceeds the stability of the process decreased and it lowers the gas production[1]. Due the lack of nutrient in waste it takes longer time to digest, it was balanced by adding the high nutritive matter like cow dung, urea (10% of waste) to lower the HRT and increases the gas production rate. The gas production rate was observed for both the waste for same HRT (30 days). The compositional analysis of waste was carried out to find the TS%, VS%, and nutrient (N, P, and K) before and after the digestion. The volatile solid removal efficiency of vegetable waste was higher than vegetable and fruits. The anaerobic digestion of fruits and vegetable waste found to be most viable and cost effective method of organic waste disposal for urban and rural areas where they are disposed to the lands for uncontrolled degradation process resulting in the atmosphere. The present work will help all academicians, rural and urban energy industry people in generating eco-friendly energy and maintaining environment too.

I. INTRODUCTION

According to a study from the United Nations (2007), the world population will likely increase by 2.5 billion over the next 40 years, passing from the current 6.7 billion to 9.2 billion in 2050. In contrast, the population of the more developed countries is expected to remain stable at 1.2 billion. More than half world’s population, 3.3 billion people, lived in urban areas. By 2030, the number is expected to increase by 5 billion. There were at least 23 mega cities with population more than 10 million. Most of these cities were located in developing countries (UNFPA, 2007). As a consequence to the increasing number of population and the improvement of living quality since the past three decades, the total amount of municipal solid waste is continuously rising. An annual rise of solid waste amount of about 2 - 3 % can be estimated out of which major organic waste is collected from house hold, Restaurants and Hotels in the form of Kitchen waste [1].

As a result, there are millions of tons of solid waste being produced every year which have to be disposed. Especially in the developing countries, caused by the lack of information about and financial support, most of the solid wastes are treated and disposed improperly. These practices lead to several problems such as aesthetical problems odour nuisance, turbid water health problems skin infection, diarrhea, breeding of pathogenic vectors, and environmental problems damage to surface or ground water due to leachate production, eutrophication, soil and air pollution due to improper incinerator or smoking landfills.

Due to the environmental problems caused by solid waste generation, solid waste management has become a major concern around the world. The main tool of solid waste management is solid waste management hierarchy. This management hierarchy consists of a comprehensive waste reduction, recycling, resources recovery (commonly known as 3R strategies) and final treatment/disposal. Waste reduction is aimed to prevent waste from being generated. The strategies of waste reduction include using less packaging, designing products to last longer, and reusing products and materials. Recycling of solid waste involves collecting, reprocessing, and/or recovering certain waste materials glass, metal, plastics, and paper to make new materials or products. Resources recovery includes recovery of organic materials which are rich in nutrients and can be used to improve soils (composting) and the conversion of certain types of waste into useful energy such as heat and electricity [2].

II. MATERIALS AND METHOD

2.1 Anaerobic Digestion of Vegetable and Fruit Waste

2.2 Process Description

Biomethanation potential is parameter which defines the methane releasing capacity of the waste. BMP of the waste is measured by anaerobic digestion of the waste. In this process organic waste in degraded in close digester in the absence of the air at mesophilic temperature (20 °C to 35°C) condition[3]. The evaluation of BMP includes following step:-
III. EXPERIMENTAL SETUP

Experimental setup developed 2 air tide 5 liters digesters installed at mesophilic temperature (35-40°C) for experimental work for 35 days in month of April- May.

IV. RESULTS AND DISCUSSION

Initial analysis shows high volatile solids content in vegetable fruits waste (VFW) and manure demonstrating the spent microbial activity from the original process vegetable and fruits waste showed fairly similar moisture contents. Experimental setup conduct in two digesters vegetable and fruit waste only in experimental setup 1 and vegetable fruits waste with cow manure (1:1) in experimental setup 2.

For the proper functioning of anaerobic digesters, the physical and chemical characteristics like Total solid, pH value, Temperature of the substrate are important as they affect the biogas production and the stability of the process[4,5].

4.1 Experimental observation for vegetable & fruit waste only

The characteristic found after the analysis of the vegetable and fruit waste sample shows that total solid content is 15.65% which shows that process would be wet anaerobic digestion[6]. The waste content 47% organic matter. The pH value is less than required value of 5-6 it indicates that waste is less acidic. The nutrient percentage in the waste is satisfying which represents good degradability of vegetable waste[7]. The vegetable waste than taken for lab scale studies and fed into the digester with equal amount of water (Waste: water is 1:1) and operated in atmospheric temperature. The temperature measured during the operation varies from 25 to 35 ºC which indicates the mesophilic temperature range. The 5 liter container had taken as digester sealed with M-seal and connected with two other same capacity bottle used for measurement of gas. One of the bottles is filled with water and other was kept empty.

4.2 Gas Observation

In this study the volume of the produced gas was measured by water displacement method considering the volume of the generated gas was equal to that of the expelled water in the water collector. The amount of the gas produce in digester is collected in the gas collecting bottle which is already filled with water[8]. The filled in the previous container displaced by gas pressure to the next bottle connected to it for collecting the water. The amount of water displaced to water bottle is measured in ml per day which indicated the amount of gas produce[9]. The amount of water displaced is equal to the gas produce in ml. The gas production start from 5th day of digestion and maximum production is observed 23th day. After the 25th day of operation, production of gas decreases due to drop in temperature.

4.3 Experimental observation for Vegetable Fruit Waste with cow manure

In previous case study it was found that single phase digestion of the vegetable and fruit waste was affected by various parameter and show different biodegradability. In the experimentation the ratio of FVW and cow dung (1:1) was used in container as digester.
The characteristic analysis of fruit waste had been done on the basis of same parameter as vegetable waste. The fruit waste taken for lab scale studies and fed into the bottle digester with equal amount of water (Waste: waster is 1:1) and operated in atmospheric temperature. The temperature measured during the operation varies from 25 to 35 ºC which indicates the mesophilic temperature range. The 5 liter bottle had taken as digester sealed with M-seal and connected with two other same capacity bottle used for measurement of gas. One of the bottles is filled with water and other was kept empty.

4.4 Gas Observation

The amount of the gas produce in digester is collected in the gas collecting bottle which is already filled with water. The filled in the previous bottle displaced by gas pressure to the next bottle connected to it for collecting the water. The amount of water displaced to water bottle is measured in ml per day which indicated the amount of gas produce[10]. The amount of water displaced is equal to the gas produce in ml. The gas production starts from 4th day of digestion and maximum production observed on 21st day of operation.

Addition of cow manure to VFW biomass increased the activity of methanogenic bacteria and it also increased the rate of degradation. When cow manure is mixed with VFW biomass, it balance the C/N ratio, and a balanced C/N ratio in substrate is likely to be beneficial to the methanogenic activity. It causes a decrease in VFA concentration that is more VFA is converted to Biogas. Comparison of the Biogas yield for different combinations of substrates is shown in above Figure. Hence, it can be concluded that as compared to the co-digestion of the two substrates with single subtract digestion of these developed a synergetic effect at mesophilic conditions in the reactor and it enhanced the biogas production by balancing the nutrient composition in the reactor.
We found 1745 ml cumulative biogas production through the experimental setup 1 (only algae subtract) but approximate same 2302 ml cumulative biogas production through the experimental setup 2 at 30 days.

4.5 Energy recovery from bio digester

The available energy from biogas is given by

\[ E = \eta \times H \times F \times V \]

Where \( \eta \) is efficiency of combustion (60%)  
\( H \) is heat of combustion per unit volume (calorific value) 20MJ/m\(^3\)

\( F \) is fraction of methane in biogas (49-55%)

\( V \) is volume of biogas 0.17 m\(^3\)/kg in first experimental setup and 0.23 m\(^3\)/kg

\( E \) is energy recovered from digester MJ/day for first experimental setup

\[ E = 0.6 \times 20 \times 0.49 \times 0.17 \]
\[ = 0.99 \text{ MJ/day} \]
\[ = 0.99 \times 10^3 \text{kJ/day} \]

\[ E = 0.6 \times 20 \times 0.49 \times 0.23 \]
\[ = 1.35 \text{ MJ/day} \]
\[ = 1.35 \times 10^3 \text{kJ/day} \]

V. CONCLUSION

This study assessed the potential of fruits and vegetable waste to generate bio gas and effectiveness of anaerobic digestion process to treat the high moisture fruits and vegetable waste. The peelings of vegetable and fruit, rotten fruits and unused vegetable are major constituents of kitchen waste content large amount organic matter can be utilized for the biogas recovery. The main conclusions reached in this study are following:-

(a) The fruits and vegetable waste is energy rich and highly degradable feedstock that can be produce high methane yield but its content may vary the methane yield in anaerobic digestion due to imbalance of nutrient and other non biodegradable matter present in fruit waste. The biodegradability of vegetable and fruit waste found to be 77% and for vegetable fruit waste it was 85%.

(b) The anaerobic digestion of VFW with cow manure generates high gas compare to VFW because of degradability of VFW is less than VFW with cow manure and hence the HRT of VFW longer then VFW with cow manure. The gas production found to be 0.23 m\(^3\)/kg for experimental setup 2 VFW with cow manure is higher to experimental setup 1 VFW gas production found to be 0.17 m\(^3\)/kg.

(c) The stability of the anaerobic digestion process highly depends upon the temperature it is affected by variation of temperature.

(d) The co digestion of vegetable and fruit waste with cow dung reduces the digestion time and increases the gas yield. The co digestion provides the nutrient rich environment in digester and increases the stability of the process.

REFERENCES


