

Performance Analysis of Biogas Production Using Different Biodegradable Materials

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ABSTRACT: Biogas, which is composed of methane and carbon dioxide, is a product of anaerobic degradation. The proper functioning of biogas systems provides a promising way to overcome the problem of waste treatment. This paper deals with the study and evaluation of the parameters influencing biogas production from rubber sheet processing effluent and co-digestion of rubber effluent with kitchen waste. As the effluent is organic in nature it could be treated anaerobically to produce methane. For enhancing the biogas production from rubber effluent by increasing the population of microbes in the digester it is modified by attaching an inert medium. This method is widely recognized as a cost-effective process for producing biogas which is a renewable energy source. The experimental results show that co-digestion of rubber effluent with kitchen waste provides the highest biogas potential with a methane of 74.6%. The result shows that temperature, pH and feeding ratios had a great influence in biogas production. The slurry produced is rich in manure value. Also the biogas produced could be used as cooking fuel or for other purposes like heating, electricity generation etc.

KEYWORDS:rubber waste water ,kitchen waste, co-digestion, biogas

I. INTRODUCTION

Energy is one of the most important factors to global prosperity. It is an essential input for economic growth, social development, human welfare and improving the quality of life. In today's energy demanding lifestyle the need for exploring and exploiting new sources of energy which are renewable sustainable as well as eco-friendly is a must. Consumption of energy has also resulted in the country becoming increasingly dependent on fossil fuels such as coal, oil and gas. Increased use of fossil fuels has led to global climate change, environmental pollution and degradation, thus leading to human health problems both locally and globally.

K V V S Kudaligama and P A J Yapa[1] discussed about anaerobic digestion is the most important method for waste water treatment due to its simplicity, low cost. Anaerobic treatment mainly converts biodegradable organic matter into methane, carbon dioxide, water and other traces of elements. MitraMohammadi et al.[3] in their work various technologies that have been used for treatment of rubber sheet processing effluents. Combined aerobic and anaerobic digestions have been used for biogas production from rubber wastewater. ThaniyaKaosol and NarumolSohrrathok[6] aim of this study was to analyse the effect of the biogas yield performance in biogas production using various parameters. The three main parameters in this study were the raw materials, the mixing and the temperature. KarthikRajendran et al[8]gave an overall review of different aspects of the design and operation of small scale, household, biogas digesters. It covered different digester designs, materials used for construction, important operating parameters and applications of the biogas. Jyothilakshmi. R et al[9]efforts were made in the development and analysis of the household portable type digester to make it more efficient

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and produce methane gas. They mainly concentrated on the economic aspect and were concerned about the structure strength, durability, ergonomic factor, convenience and flexibility of usage in different weather conditions.

Biogas technology offers a very attractive route to utilize certain categories of biomass for meeting partial energy needs. Being a source of renewable natural gas it has been adopted as one of the best alternatives for fossil fuels. Biogas is a gas produced after anaerobic digestion of organic matter by the microorganisms. Biogas the metabolic product of anaerobic digestion is a mixture of methane and carbon dioxide with small quantities of other gases such as hydrogen sulphide, hydrogen, nitrogen and moisture. It can also be used in anaerobic digesters where it is typically used in a gas engine to convert the energy in the gas into electricity and heat. Biogas can be compressed much like natural gas and used to power motor vehicles. The composition of biogas varies depending upon the origin of the anaerobic digestion process. Advanced waste treatment technologies can produce biogas with 55–75% methane, which can be increased to 80-90% methane. Environmental contamination is an inevitable consequence of human activity. Unlike other industries agro-based industries generate enormous solid and liquid wastes of carbonaceous and nitrogenous origin. Natural rubber is no exception in this regard. Rubber tree is the most important commercial source of natural rubber. With the increase in area under this crop considerable advancement in latex and rubber processing technology is also taking place. Various field management practices and processing of the raw materials are known to cause environmental damage. The most noticeable level of pollution in rubber plantation is caused by effluents from sheet processing units containing sizeable amounts of non rubber substances besides unreacted processing chemicals. These effluents are highly polluting and can produce severe negative effects to the environment if they are discharged without sufficient treatment. Due to the presence of highly degradable organic matter it could be treated anaerobically to produce biogas which serves as a good source of renewable energy.

II. BIOGAS GENERATION

Biogas is produced by extracting chemical energy from organic materials in a sealed container called anaerobic digester by the biological process in the absence of oxygen. It is a naturally occurring microbiological process that converts the organic matter to methane and carbon dioxide. The anaerobic biological conversion of organic matter occurs in three steps. The first step involves hydrolysis where transformation of insoluble organic material and higher molecular mass compounds such as lipids, polysaccharides, proteins, fats, nucleic acids, etc. into soluble organic materials, i.e. to compounds suitable for the use as source of energy and cell carbon such as monosaccharide, amino acids and other simple organic compounds. Next step involves acid formation where group of microorganisms ferments the break-down products to acetic acid, hydrogen, carbon dioxide and other lower weight simple volatile organic acids like propionic acid and butyric acid which are in turn converted to acetic acid. Third step where the anaerobic bacteria called as methane formers converts the organic acids formed in second stage into biogas having its main constituents as methane and carbon dioxide with other small traces of H_2S , H_2 and N_2 .

A. Factors Affecting Biogas Production

The performance of biogas plant can be controlled by studying and monitoring the variation in parameters like pH, temperature, loading rate, agitation, etc. Any drastic change in these can adversely affect the biogas production. So these parameters should be varied within a desirable range to operate the biogas plant efficiently. Various factors such as biogas potential of feedstock, design of digester, inoculums, nature of substrate, pH, temperature, total solid contents, loading rate, hydraulic retention time (HRT), C:N ratio, uniform feeding, volatile fatty acids (VFA) etc. influence the biogas production.

B. Co-Digestion

Co-digestion is a waste treatment method in which different wastes are mixed and treated together. Co-digestion is preferably used for improving yields of anaerobic digestion of solid organic wastes due to its numeral benefits. Dilution of

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toxic compounds, increased load of biodegradable organic matter, improved balance of nutrients, synergistic effect of microorganisms and better biogas yield are the potential benefits achieved in co-digestion process. Co-digestion of an organic waste also provides nutrients in excess which accelerates biodegradation of solid organic waste. Additionally the benefits are the facilitation of a stable and reliable digestion performance and production of a digested product of good quality and an increase in biogas yield. It has been observed that co-digestion of mixtures stabilizes the feed to the bioreactor thereby improving the carbon to nitrogen ratio and decreasing the concentration of nitrogen. The use of a co-substrate with a low nitrogen and lipid content waste increases the production of biogas due to complementary characteristics of both types of waste thus reducing the problems associated with the accumulation of intermediate volatile compounds and high ammonia concentrations.

III. RUBBER WASTE WATER TREATMENT METHOD

Management of contamination by agro-industries so as to mitigate or eliminate pollution problems is rather complicated but essential. Natural rubber industry is no exception in this regard. Natural rubber is an elastic hydrocarbon polymer that is originally derived from a milky colloidal suspension, or latex of *Hevea brasiliensis*. However environmental damages generated from this sector has become a big issue. Natural rubber processing sector consumes large volumes of water and energy. However the most noticeable level of pollution in rubber plantation is caused by effluents from processing units containing sizeable amounts of non rubber substances containing small amounts of uncoagulated latex, serum with small amounts of proteins, carbohydrates, lipids and salts. Without proper treatment discharge of waste water to the environment may cause serious and long lasting consequences.

A. Primary Treatment Process

Aerobic and anaerobic treatment is the most common biological method used in treating rubber wastewater as it is an inexpensive treatment method with high efficiency. The system consists of improved anaerobic processes. Coconut fibre as a new medium was selected for rubber wastes treatment. The rubber wash water contains many solid substrates. These particles should be removed before feeding to the plant. Therefore, the wash water is fed through a coir mesh (coconut fibre) where the bigger sized particles are filtered out. It is termed as pre-treatment process.



Fig 1: Stages of Pretreatment (1) Effluent Fed through the Coir Mesh (2) Bigger Sized Particles Collected in Coir Mesh

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B. Attached Growth Systems

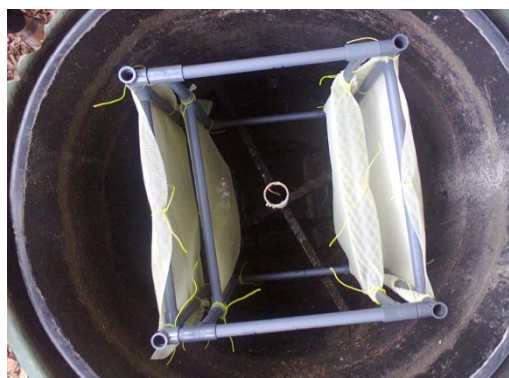


Fig 2: Attached growth system installed inside portable biogas digester

Attached growth systems have been used for the treatment of waste water where they have helped to reduce the hydraulic retention time. This system utilizes an internal chamber which helps in enhancing the performance of waste water treatment systems by providing an increased surface area for attached growth of the microbes in the form of a fixed film on an inert medium leading to increased population of microbes in the reactor and their retention in the digester even after the digested slurry flows out. Attached growth technique has been used commonly for substrates of very low solids content where filters of very large surface area are used. The material should be non-biodegradable. The structure of the attached growth system should also be mechanically stable. Materials should be easily available in the local market at a reasonable cost. Different materials like nylon sponges, PVC, clay pipes etc. had been used as support medium for attached growth systems.

IV. EXPERIMENTAL SETUP

Initially a mini biogas digester, having 25l capacity, was setup to ensure biogas production from the effluents coming from rubber sheet processing. Further, three sets of experiments were carried out separately. The plant used was a floating portable type biogas digester of 1000l capacity. One of the plants was modified using an attached growth system with several vertical partitions that holds media for enhanced bacterial growth. The bio-digester was fed periodically using different substrates at different ratios, with rubber waste water alone, 75percent rubber waste water and 25percent kitchen waste, 50percent of both rubber waste water and kitchen waste.

Table 1: Proportion of Different Treatments

Treatments	Substrates	Mixture proportions
A	100% Rubber effluent	1:0
B	75% Rubber effluent and 25% kitchen waste	3:1
C	50% Rubber effluent and 50% kitchen waste	1:1

It was initially fed with an inoculum (slurry of cow manure) in water through the inlet until the digester was about 80% filled with slurry. The plant was left unused for 10-15 days. During this period anaerobic fermentation took place in the presence of water and produced biogas in the digester. This was to ensure the anaerobic condition in the gas space inside the digester. After the first filling both the inlet and outlet were covered and gas valve to the gas holder was opened. The first 15 days was the transient phase of the biogas production and it acted as a batch reactor. Biogas being lighter rises up

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and started collecting in the gas holder. The gas holder started moving up. Up on successful startup of biogas from inoculum after a period of 15 days substrates in different ratios as mentioned above were fed periodically and biogas composition was analyzed using liquid displacement method.

Another experiment conducted was to know the highest heating capacity of biogas being produced. It was done by taking a 500ml water in a steel tumbler and boiling it to a temperature of 90°C using the biogas produced and the time taken were noted for each experiment. The parameters measured were pH, total solid contents, temperature, and moisture. The purpose of measuring these parameters was to know their effects on the performance of anaerobic digestion and biogas production.

V. RESULT AND DISCUSSION

In this study, it has been observed that the production of biogas is dependent upon the parameters such as temperature, pH and the feeding ratio of the substrates.

Table-2: Analysis Showing Heating Capacity of Biogas for Different Treatments

Treatments	Time taken to boil 500ml of water to reach a temperature of 90°C
100% rubber effluent	5min 15 sec
75% rubber effluent & 25% kitchen waste	5min 7 sec
50% rubber effluent & 50% kitchen waste	5min 10sec

The analysis was conducted to know the highest heating capacity from different treatments. The biogas production from co-digestion of 75% rubber effluent and 25% kitchen had the highest heating capacity followed by 50% rubber effluent and 50% kitchen waste and rubber effluent alone.

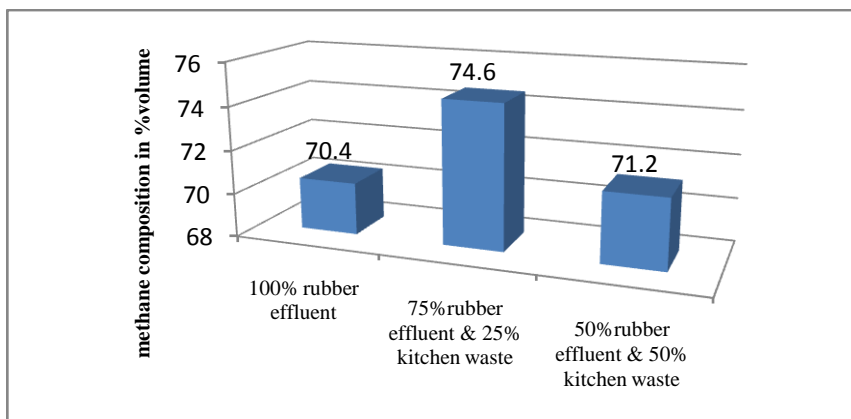


Chart-1: Graph Showing Methane Production from Different Treatments

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The above graph gives the details regarding highest methane yield for different treatments. Co-digestion of 75% rubber effluent with 25% kitchen waste gave the maximum yield with a methane volume of 74.6%. This was followed by treatment of 50% rubber effluent and 50% kitchen waste with a methane yield of 71.2% and rubber effluent alone with a methane yield of 70.4%. It was observed that the methane production reached the optimum level when the temperature within the digester ranged between 27°C to 32°C.

Table-3: pH Value for Different Treatments

Treatments	Initial pH	Final pH
100% rubber effluent	5.5	7.09
75% rubber effluent & 25% kitchen waste	5.93	7.3
50% rubber effluent & 50% kitchen waste	6.31	7.11

The above table gives the value of pH for different treatments. The result shows that the experiment was conducted within the pH range for optimum methane production for different treatments and measuring the final pH of the substrates, it was observed that it had a good fertilizer value, since the value of pH was within a range of 6.5 to 7.5.

VI. CONCLUSION

The aim of this project was to analyze the effect of the biogas production using various parameters. Three main parameters analyzed in this project were the pH, feeding ratio and the temperature. There are large variations among the raw materials studied regarding degradability. The highest biogas yield was obtained only by co-digestion with other raw materials. The co-digestion of 75% rubber effluent and 25% kitchen waste had a stimulatory effect on methane gas productions and are at highest efficiency than that of 100% rubber effluent and 50% rubber effluent and 50% kitchen waste. The experimental result shows that anaerobic co-digestion of rubber waste water with organic kitchen waste is a feasible process in the stabilization of waste and in increasing the potential of waste water to biogas production. The possibility of utilizing liquid waste from rubber sheet processing as well as solid waste like sawdust from rubber wood processing for generation of biogas is a good option. The experimental results reveal that co-digestion was more effective than mono-digestion.

The anaerobic digestion of wastes by microorganisms is not only energy generating and environment friendly but also provides organic manure rich in plant nutrients. The pH of slurry from different treatments showed that it had good fertilizer value. By utilizing these wastes in efficient manner a renewable source of energy can be produced in low cost without harming the environment.

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