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Quality Improvements & Increase in Electricity Generation through Anaerobic Digestion in Rural Areas; a Feasibility Report

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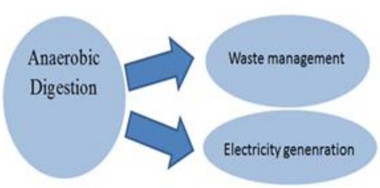
Graphical Abstract



Abstract

Availability of electricity is one of the basic necessities in rural areas. In an energy-deprived country, there is a need for new and workable development of good quality energy generation systems to meet the economic demands because of population increase. Most of the rural areas are facing wastage control and dumping issues because of this increase in population. Furthermore, the rural areas are also facing severe energy crises of electricity unavailability or low voltages. Anaerobic Digestion is basically a practical technology that does not only resolve the issue of waste disposal, but is also helpful in producing energy through these wastes. The major focus of this research work is the provision of a feasibility report that will aid in the introduction of anaerobic digesters in rural areas to minimize the electricity burden. With proper use of anaerobic digesters, quality energy can be made available for domestic use, thereby contributing an overall decrease in the amount of load-shedding experienced by rural people.

Keywords: Quality improvements, electricity generation; anaerobic digestion, Waste control

Abstrak

Kehadiran elektrik adalah salah satu keperluan asas kawasan luar bandar. Dalam sebuah negara kurang maju sistem penjanaan tenaga yang berkualiti diperlukan untuk memenuhi permintaan ekonomi. Kawasan luar bandar menghadapi krisis ketiadaan elektrik atau voltan rendah. Pencernaan anaerobik pada dasarnya teknologi yang sangat praktikal yang bukan sahaja menyelesaikan isu pelupusan sampah, tetapi juga membantu untuk menghasilkan tenaga melalui sisa ini. Penyelidikan ini mengenai laporan daya maju bagi memperkenalkan pencerna anaerobik di kawasan luar bandar untuk mengurangkan beban elektrik. Dengan penggunaan pencerna anaerobik yang betul, tenaga boleh disediakan untuk kegunaan domestik, melalui penurunan jumlah catuan kepada pengguna luar bandar.

Kata Kunci: Pembaikan Kualiti, penjanaan elektrik, pencernaan anaerobik, kawalan sisa

1.0 INTRODUCTION

Anaerobic digestion is a collection of processes employed by various microorganisms in breaking down organic, biodegradable materials in the absence of oxygen—the word anaerobic refers to the lack of oxygen [1]. As a result of this phenomenon, biogas is released [2]. Biogas can be combusted to release energy that can be used to produce renewable electricity [3]. It can also be purified to standards of natural gas or further processed into compressed natural gas (CNG) fuels [1, 4]. Anaerobic digestion is employed in the manufacturing of food and beverages from its fermentation products [4]. Not only this, but it leads to the removal and proper management of organic wastes from farms in rural sectors. Figure 1 explains anaerobic advantages of anaerobic digestion.

Currently, the energy obtained from biogas is not used on a large scale but can act as an energy source for atmospheric and environmental sustainability; however, it can be targeted at meeting domestic demands of rural inhabitants rather successfully [5]. Moreover, clean energy most definitely alleviates the burden on finite fuel sources such as petrol and natural gas [4, 6]. The applications of anaerobic digesters are numerous and substantial for the generation of electricity [7]. Not only does it lead to a production of biogas that is equipped with the capacity to replace fossil fuels for domestic heating purposes in areas isolated from main electrical grids but it also results in other side products, one of which is dig estate [8]. The dig estate can be employed in farming sectors where it is combined with other synthetic chemicals to be used as fertilizers. With the advancement in current technologies, greater efficiency has been achieved in anaerobic digesters, particularly in the production of electricity from biogas based on animal manure.

The anaerobic digestion is based on four systematic processes, which are hydrolysis, acidogensis, acetogensis and methonogenesis. Figure 2 clearly indicates these processes in series. In hydrolysis, the cessation of chains of hydrocarbons takes place whereby it is diluted from large chains of hydrocarbons into smaller molecular structures.

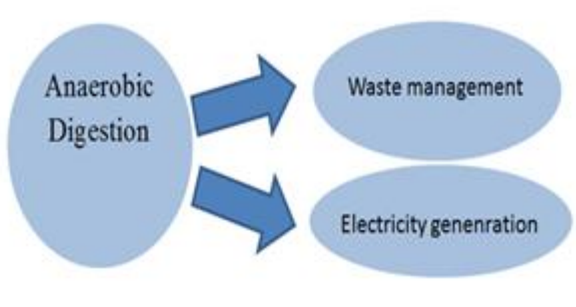


Figure 1 Advantages of anaerobic digestion

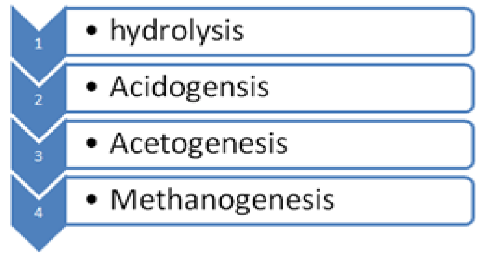


Figure 2 Process of anaerobic digestion

After hydrogenesis, the next phase is acidogenesis in which this breakdown process continues and results in smaller components. This process is also known as the fermentation process [9]. After acidogenesis, there is a process of acetogenesis in which carbon dioxides, acetic acids and hydrogens are produced. Lastly, the process of methonogenesis takes place in microorganisms thus producing methane, which is the main product of this entire process that helps to produce electricity [9].

Methane is also known as biogas, which is ultimately the required product of anaerobic digestion. Methane usually carries small volumes of hydrogen sulfide, carbon dioxide and hydrogen components. Methane or biogas usually accumulates in the digesters at the top. The methane produced is helpful in running turbines of reciprocating engines that results in generation of power in the form of heat and electricity. Another product from this process is digestate, which can be utilized as fertilizers because of constituents of nitrates and ammonia. Digestate is usually found in the form of mild solid and fibrous liquid. One more product from this process is waste water, which is basically moisture. Moisture is further treated through oxidation process. Figure 3 clearly indicates the products of anaerobic digestion.

Anaerobic digesters are available in many different types like complete mix, plug flow, fixed film and covered lagoon. [4]. Figure 4 clearly indicates types of anaerobic digesters. All of these are dependent on the application perspectives and each carries installation complications as per requirements.

Keeping these aspects in view, the major aims of this research work is to study anaerobic digestions and determination of factor interrelationships such as increase in generation and quality of electricity required and their dependencies.

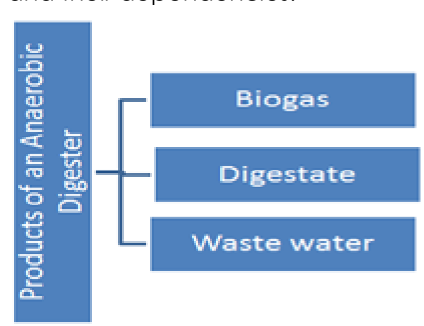


Figure 3 Products of anaerobic digestion

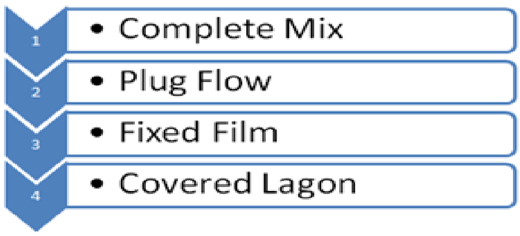


Figure 4 Types of anaerobic digesters

2.0 PROCESS SCHEME OF ANAEROBIC DIGESTORS

In order to attain a strong basis, previous research works like internet resources, journal articles, readable materials and related books are utilized. Most of the data structured in the result section is on the basis of some previous works from authors and sources available on internet [10, 11]. The methodology first involves the basic understandings of anaerobic digesters and techniques that are being utilized for determining alkalinity and assessing the technical feasibility of anaerobic digesters. In -depth understanding of anaerobic processes is also required; this includes the range of raw materials, parameters to consider, proper selection of feed material, storage of anaerobic digesters and an overview of the interrelationships between them. Figure 5 elaborates the process scheme of anaerobic digestors. The feed material is dumped in the storage tank of the digesters to attain biogas, which will be utilized to produce electricity through electricity units like turbines. It is also important to consider the factors that affect anaerobic digestion processes, including temperature, pH and retention times.

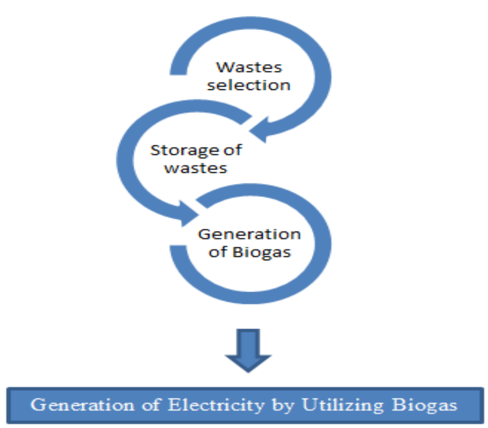


Figure 5 Process scheme of anaerobic digestors

3.0 RESULTS AND DISCUSSION

For the proper supply and generation of electricity, a co-relation is required between feedstock materials, digester storage and electricity load calculations. It is observed that for rural areas there is no exact calculation and allocation of total load of electricity as all the previous calculations were based on estimation and there were severe voltage drops. This wrong estimation affects the entire system such that when electricity is provided to any area, the voltage drop seems to affect the system because of the increase in requirements as compared to production. In the case of anaerobic digestion, feed materials are considered to be one of the leading aspects of anaerobic digestion as biogas generation is attained through feed materials and furthermore, good quality of biogas generation is the leading tool to attain maximum power generation. Most common feedstock materials are cattle manures, agriculture slurries and kitchen wastes. The emphasis is on the utilization of kitchen wastes. Kitchen wastages are considered to be one of the good feed materials because of its good potential of biogas generation. But these kitchen stocks are required in bulks and a big storage area is required for the dumping of these wastages. Keeping this issue in view, the construction of storage tanks for anaerobic digestion should be made in such a way that there is maximum collection of kitchen wastages with generation of biogas. Furthermore transmission system of biogas to the power section is very important to attain positive results in terms of electricity generation and to attain maximum voltages of electricity as per requirement. The problem is not only in the generation of electricity but also in fulfilling energy requirements of rural areas and to solve voltage tripping issues, which another important aspect. Figure 6 further summarizes these results and this clearly indicates that a deep interrelationship is required between proper estimation of electricity requirements, feed stock material selection and digester storage in order to achieve good production of electricity.

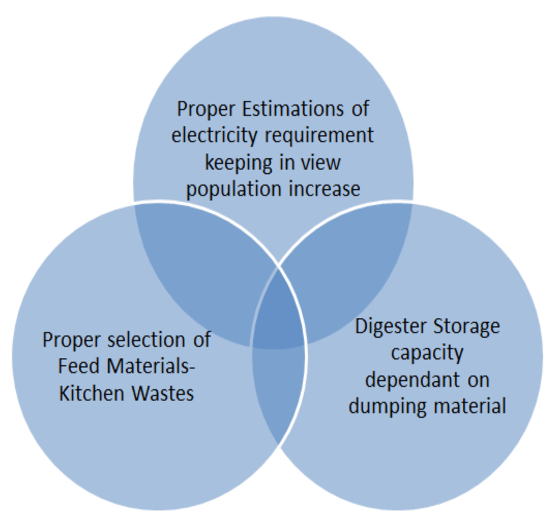


Figure 6 Interrelationships between Feed material, Storage capacity and electricity estimations

4.0 CONCLUSION

This research work puts emphasis on the generation of electricity and its provision with low voltage drops for rural areas. Most of the rural areas of underdeveloped countries are witnessing high levels of power shortfall due to wrong estimation of power generation and the increase in population. The implementation of anaerobic digesters in the rural areas is one of the solutions to resolve this issue and also helpful to handle wastes. However, in order to improve this situation, proper selection of feed material and installation of anaerobic digesters with increased storage area is very important to attain increase in electricity generation and quality, which will be helpful to handle the current situation of energy requirement faced and experienced by rural individuals.

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